Offshore Wind Ports: Cumulative Vessel Traffic Assessment

Final Report | Report Number 22-11 | August

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Offshore Wind Ports:
Cumulative Vessel Traffic Assessment

Final Report

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NYSERDA Report 22-11 NYSERDA Contract 111670 August 2022

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Abstract

This study supplements a collection of studies prepared on behalf of NYSERDA to provide information related to a variety of environmental, social, economic, regulatory, and infrastructure-related issues implicated in planning for future offshore wind energy development off the coast of New York State. This study provides an assessment of offshore wind port uses for the State's 9-gigawatt offshore wind energy commitment through evaluation of key inputs that span the five currently active offshore wind related ports as well as the development of a design envelope representing key regions and offshore wind activity types within the State. This study also includes development and analysis of a vessel traffic density model that provides understanding of the level of impact on vessel traffic that may be seen as a result of future State offshore wind activity. NYSERDA's intent is to facilitate the principled planning of future offshore development, to provide a resource for the various stakeholders, and to support the achievement of State offshore wind energy goals.

Keywords

Offshore wind, vessel, port, traffic, model, project design envelope, AIS, navigation

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Acronyms and Abbreviations

The following acronyms and abbreviations are used throughout this document.

AIS	Automatic Identification System
BOEM	Bureau of Ocean Energy Management
CAGR	Compound Average Growth Rate
COD	Commercial Operation Date
COG	Course Over Ground
CTV	Crew Transfer Vessel
EPSG	European Petroleum Survey Group
EST	Eastern Standard Time
FEMA	Federal Emergency Management Agency
ft	feet
GB	Gigabyte
GIS	Geographic Information System
GW	Gigawatt
LAT	Latitude in decimal degrees
LOA	Length Overall
LON	Longitude in decimal degrees
m	Meter
MMSI	Maritime Mobile Service Identity
MW	Megawatt
NAD83	North American (horizontal) Datum of 1983
NAIS	Nationwide Automatic Identification System
nm	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Lab
NYC	New York City
NYCEDC	New York City Economic Development Corporation
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance
OSS	Offshore Substation
OSW	Offshore Wind
OWF	Offshore Wind Farm
PAMT	Brooklyn Port Authority Marine Terminal
PANYNJ	Port Authority of New York and New Jersey
PARS	Port Access Route Studies

Pass.	Passenger vessel type
PDE	Project Design Envelope
RFP	Request for Proposal
RFQL	Request for Qualifications
RPSDM	Regional Ports Supply and Demand Model
QGIS	Quantum Geographic Information System
SBMT	South Brooklyn Marine Terminal
SOG	Speed Over Ground
SOV	Service Offshore Vessel
SOW	Scope of Work
SUNY	State University of New York
TP	Transition Piece (upper component of MP foundation type)
TWO	Task Work Order
U.S.	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
UTM	Universal Transverse Mercator
VTS	Vessel Traffic Services
WEA	Wind Energy Area
WGS	World Geodetic System of 1984
WTG	Wind Turbine Generator
WTIV	Wind Turbine Installation Vessel

Summary

S.1 Context

New York State Energy Research and Development Authority (NYSERDA) is leading the coordination of offshore wind opportunities in New York State and is supporting the development of 9,000 megawatts of offshore wind energy by 2035 in a responsible and cost-effective manner. The State's ambitious and comprehensive climate and clean energy legislation, the Climate Leadership and Community Protection Act (Climate Act), calls for 70 percent of State electricity to come from renewable sources by 2030. Offshore wind (OSW) will be a crucial step to a carbon-neutral economy and a critical component in achieving the expanded Clean Energy Standard.

S.2 Scope

For this project, BTMI Engineering, PC (COWI) was tasked by NYSERDA to provide an assessment of potential 9-gigawatt offshore wind port uses and analyses of the expected increase in vessel traffic resulting from OSW. The assessment relied on projections for committed and hypothetical offshore wind facilities slated to become operational by year 2035. COWI's technical approach consisted of the following tasks:

- **Assessment of Potential 9-Gigawatt Offshore Wind Port Uses:** A key deliverable for the study was the delineation of a Project Design Envelope (PDE). The PDE is a package of facts, assumptions, and associated studies used as inputs to this study which in turn create the basis for estimating impacts of a 9 GW OSW industry in New York State. Specific to this study, the PDE captures the State's key regions and offshore wind activity types for both known and potential future offshore wind-related port uses, including the Capital Region (manufacturing), the Upper Hudson Valley (manufacturing and assembly), New York City Harbor (manufacturing, assembly, staging, and operations and maintenance [O&M]), and the North Shore of Long Island (O&M). The PDE compiles a list of facility locations and functions that is assumed to be representative of potential port activities associated with the State's 9 GW OSW goal. The PDE and its characteristics make up a baseline framework within which State port activity can be evaluated over time.

- **Vessel Traffic Model and Comparative Assessment:** A Vessel Traffic Model (VTM) was developed with the goal of estimating the future effects of a fully developed New York State offshore wind supply chain on vessel traffic within the State waters (i.e., within 3 nm of shoreline). A model developed by the State University of New York (SUNY) Maritime College was used to assess yearly increases in vessel traffic, exclusive of OSW vessel traffic. The results were summarized in a series of yearly baseline increases. The team then developed a separate and parallel VTM estimating OSW-related traffic. By superimposing both forecasts, the combined VTM was then used to perform a series of comparative assessments at select locations referred to as Passage Lines. Passage Lines are defined in areas where vessel densities show change due to the introduction of OSW of vessel traffic. Passage Lines are used as discreet locations where the change in vessel densities is quantified in order to determine the impacts of future OSW traffic.

S.3 Summary of Findings

A summary of the study and results is presented in the following two sections.

S.3.1 Assessment of Potential 9-Gigawatt Offshore Wind Port Uses

The PDE details one potential scenario of a fully developed offshore wind supply chain within New York State. Locations and functions proposed within the PDE are hypothetical only and not intended to endorse any specific port location. A tabulation of port facilities included within the PDE is provided in Table 9.

At the time this report was published, the State's 9 GW commitment represents 22% of the total United States East Coast OSW commitments and goals (41 GW by 2035). The OSW supply chain is anticipated to span across State boundaries, i.e., some port related activities supporting New York OSW projects will happen inside and outside of NYS; likewise, some OSW projects outside of New York will be supported by ports outside and inside of the State. The PDE developed for this assessment is based on NYS ports capturing a proportional share (22%) of OSW fabrication and construction port activity, resulting in approximately eight State port facilities . Factoring in the currently active in State offshore wind ports, this assumption results in an additional five hypothetical facilities. Capital construction port-specific functions and locations proposed for the PDE scenario are based on the peak deficit in facility numbers for each supply chain activity. In lieu of actual port commitments, the facilities that responded to Request for Qualification (RFQL) 4259 were chosen as representative hypothetical future offshore wind ports with arbitrarily selected end uses. This resulted in the following proposed scenario of combined representative and currently active OSW-related capital construction ports (see also Table 9):

- Representative:

  Arthur Kill Terminal: Wind Turbine Generator (WTG) Staging
  Port Ivory: Offshore Substation (OSS) Fabrication
  NYS Wind Port (East Greenbush): Blade Manufacturing
  Cortland: Nacelle Manufacturing
  Tomkins Cove: Cable Manufacturing

- Active:

  South Brooklyn Marine Terminal: WTG and Foundation Staging
  Port of Albany: Tower Manufacturing
  Port of Coeymans: Foundation Fabrication

The proposed number of NYS operations and maintenance (O&M) ports is based on the quantity of O&M vessels estimated to be in-service and the number of ports required to host these vessels is six facilities. Factoring in the currently active NYS offshore wind ports and assumed use of South Brooklyn Marine Terminal as an O&M hub in conjunction with its use as a capital construction facility, results in a proposed additional three facilities. Hypothetical O&M port locations were selected based on the following: facilities identified in the NYSERDA 2018 Ports Assessment: Offshore Wind Operations and Maintenance Port Facilities, facilities belonging to agencies that have publicly expressed previous interest in OSW, and proximity to announced BOEM Wind Energy Areas (WEAs). Selection based on BOEM WEAs follows the assumption that O&M strategy will be service operations vessel (SOV)-based. The resulting proposed scenario of combined representative and currently active OSW-related O&M ports follows (see also Table 9):

- Representative:

  Homeport Pier: SOV-based
  Brooklyn Navy Yard: SOV-based
  Brooklyn Port Authority Marine Terminal: SOV-based

- Active:

  Port Jefferson: SOV-Based
  Port Montauk: Crew Transfer Vessel (CTV)-Based
  South Brooklyn Marine Terminal (SBMT) (Assumed): SOV-Based

Overall, the proposed PDE provides a scenario of a fully developed offshore wind supply chain within the State. The port locations and functions proposed for the PDE served as input to the Vessel Traffic Model.

S.3.2 Vessel Traffic Model

This task involved the development of Vessel Traffic Model required to analyze effects of OSW traffic for years 2017 to 2040. The VTM served as a platform capable of handling two types of vessel traffic, namely non-OSW vessel traffic and OSW vessel traffic. Together, these components comprise an integrated model of future projected vessel traffic and form a basis to carry out the comparative assessment.

S.3.2.1 Vessel Traffic Model Development and Non-OSW Baseline Vessel Traffic

A VTM platform was built. The platform allows the visualization, processing, and extraction of Automated Information System (AIS) data provided by United States Coast Guard (USCG) through Marine Cadastre, as well as synthetic data created by COWI to forecast future vessel traffic. Existing non-OSW vessel traffic data was loaded for representative year 2017. Data for this year was downloaded, processed, and analyzed via an AIS data management platform. This included:

- Definition of study area (New York State waters, 3 nautical miles [nm] from coastline).
- Downloading and processing raw AIS data for the area.
- Generation of individual vessel tracks from the raw AIS data.
- Generation of transit count (density) map for a hexagonal grid developed within model extents.

The VTM enabled the estimation of baseline non-OSW vessel traffic at any location within the area delineated in the PDE. The VTM also enabled the visualization and processing of synthetic OSW vessel data. The data compiled and processed by the VTM served as a basis to perform all subsequent tasks within the study.

S.3.2.2 Non-OSW Vessel Traffic Forecast

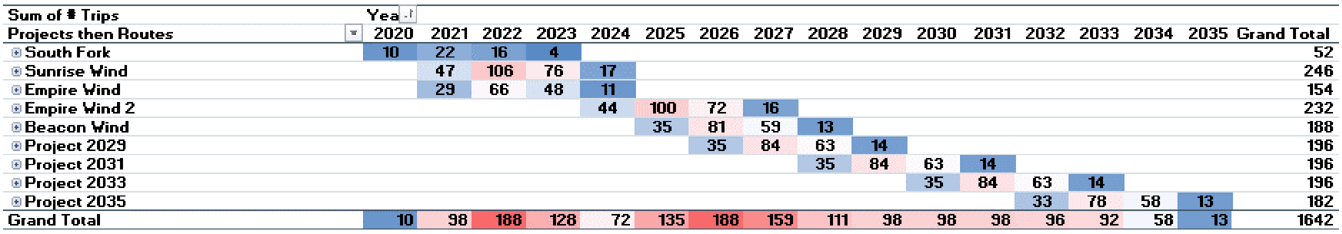
Expected future non-OSW vessel traffic was developed for years 2017 (existing) to 2040, inclusive, based on Vessel Traffic System (VTS) data. The future traffic estimates are to be used to benchmark the impacts of traffic incurred by the proposed OSW projects. COWI and SUNY Maritime acknowledge the inherent uncertainties related to variables such as climate change, logistics, political climate, industry trends, and others determining future conditions. With that said, the assumed vessel traffic growth rate for all vessel categories was estimated at 0.8% per year.

S.3.2.3 OSW Vessel Traffic Forecast

COWI compiled results from an OSW Vessel Traffic Forecast Model. The results were summarized in the form of yearly vessel trip quantities for both capital construction and O&M activities. A summary of the total number of vessel trips for the capital construction activities is provided in Figure S-1and Figure 32. A summary of the total number of vessel trips for O&M activities is provided in Figure S-2 and Figure 33. These yearly vessel trip quantities are applied to routes drawn in Geographic Information System (GIS) between port locations proposed within the PDE and OSW project locations. In addition, COWI determined likely waypoints and navigation routes (collectively referred to as “synthetic tracks” in this report) that the OSW vessels will be taking to complete their assignment. These synthetic tracks were used to incorporate future OSW trips into the Vessel Traffic Model Platform developed by COWI, and to conduct in-depth traffic analysis at passage lines.

Figure ES-1. Results: Snapshot of Capital Construction Vessel Round Trips per Year Incurred by Offshore Wind Projects

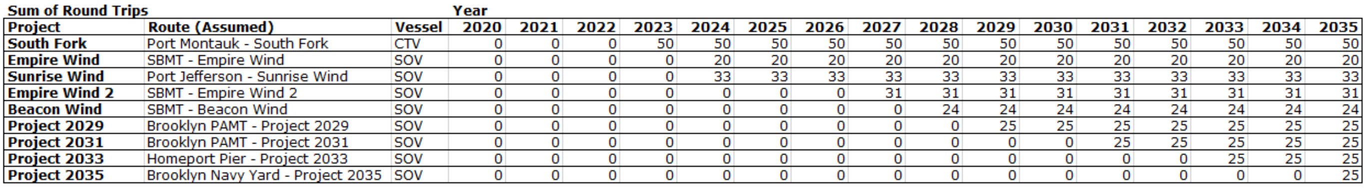
Source: COWI (December 2021)



Sum of # Trips	Yea																
Projects then Routes	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Grand Total
⊞ South Fork	10	22	16	4													52
⊞ Sunrise Wind		47	106	76	17												246
⊞ Empire Wind		29	66	48	11												154
⊞ Empire Wind 2					44	100	72	16									232
⊞ Beacon Wind						35	81	59	13								188
⊞ Project 2029							35	84	63	14							196
⊞ Project 2031									35	84	63	14					196
⊞ Project 2033											35	84	63	14			196
⊞ Project 2035													33	78	58	13	182
Grand Total	10	98	188	128	72	135	188	159	111	98	98	98	96	92	58	13	1642

Figure ES-2. Results: Snapshot of Operations & Maintenance Round Trips per Year Incurred by Offshore Wind Projects

Source: COWI (December 2021)



Sum of Round Trips			Year															
Project	**Route (Assumed)**	**Vessel**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
South Fork	Port Montauk - South Fork	CTV	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50
Empire Wind	SBMT - Empire Wind	SOV	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20
Sunrise Wind	Port Jefferson - Sunrise Wind	SOV	0	0	0	0	33	33	33	33	33	33	33	33	33	33	33	33
Empire Wind 2	SBMT - Empire Wind 2	SOV	0	0	0	0	0	0	0	31	31	31	31	31	31	31	31	31
Beacon Wind	SBMT - Beacon Wind	SOV	0	0	0	0	0	0	0	0	24	24	24	24	24	24	24	24
Project 2029	Brooklyn PAMT - Project 2029	SOV	0	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25
Project 2031	Brooklyn PAMT - Project 2031	SOV	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25
Project 2033	Homeport Pier - Project 2033	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	25
Project 2035	Brooklyn Navy Yard - Project 2035	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25

S.3.2.4 Comparative Assessment OSW versus Non-OSW Traffic and Study Take-Away Items

By comparing the results of the OSW traffic analysis and the non-OSW forecast analysis performed with the support of SUNY Maritime, COWI quantified the projected relative increase in vessel traffic resulting from OSW traffic at selected passage lines. The results presented in this section represent the culmination of the entire computational and analytical framework developed in the project to assess the relative impacts of OSW projects on overall traffic conditions in the project area.

Figure S-3 through Figure S-5 provide an overview of the existing vessel traffic (blue hues), ports considered for OSW (red dots), investigated passage lines (black) and the expected vessel routes for offshore vessels (red lines).

Figure S-3. Extraction of In-Depth Data for Selected Passage Lines

OSW traffic is shown in the figure as thick black lines. Passage lines represented by cyan circles with PL in brackets. Potential and existing facilities are shown as red and green circles accordingly. Background colors represent transit counts with yellow representing higher transit count and dark blue/magenta representing lower transit count.

Source: COWI (December 2021); ESRI Ocean; Google Earth; NOAA

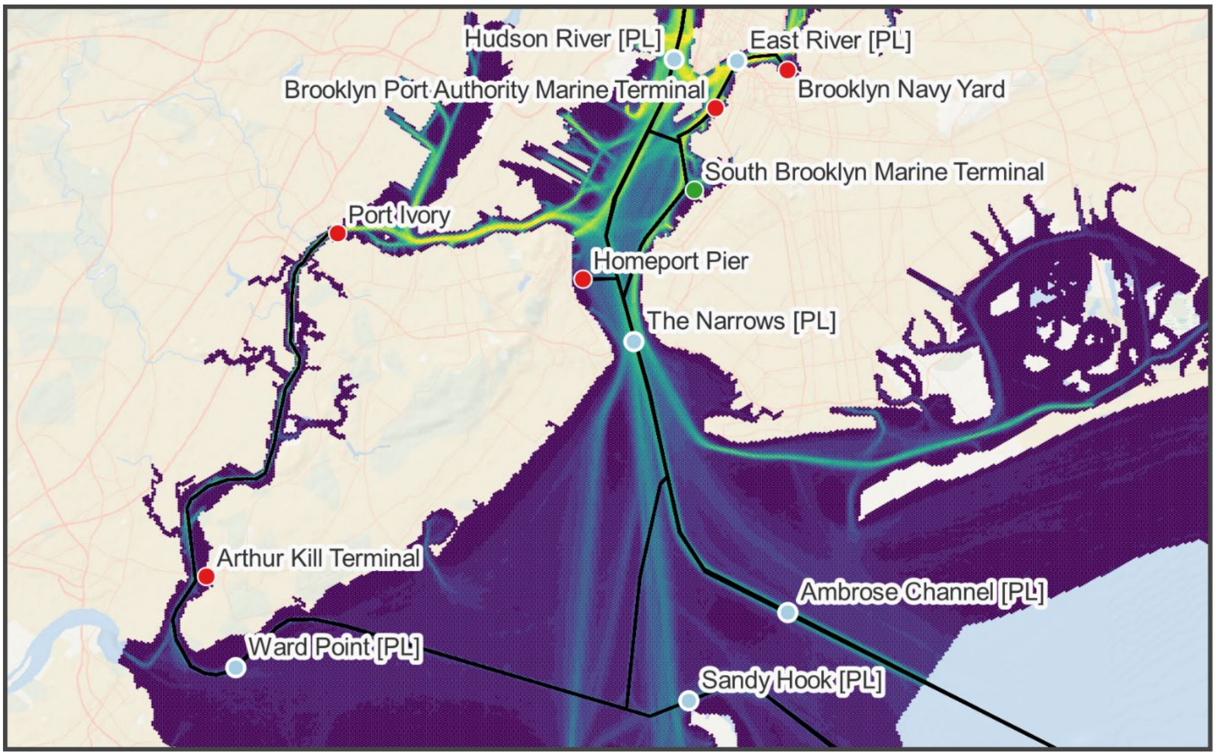


Figure S4. Extraction of In-Depth Data for Select Passage Lines (Continued)

OSW traffic is shown in the figure as thick black lines. Passage lines represented by cyan circles with PL in brackets. Potential and existing facilities are shown as red and green circles accordingly. Background colors represent transit counts with yellow representing higher transit count and dark blue/magenta representing lower transit count.

Source: COWI (December 2021); ESRI Ocean; Google Earth; NOAA

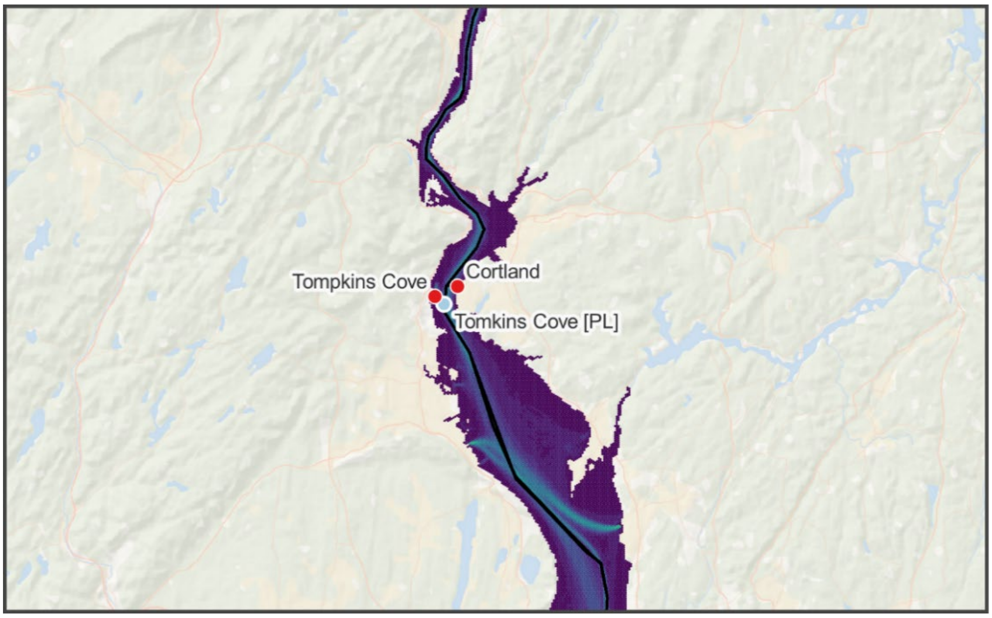
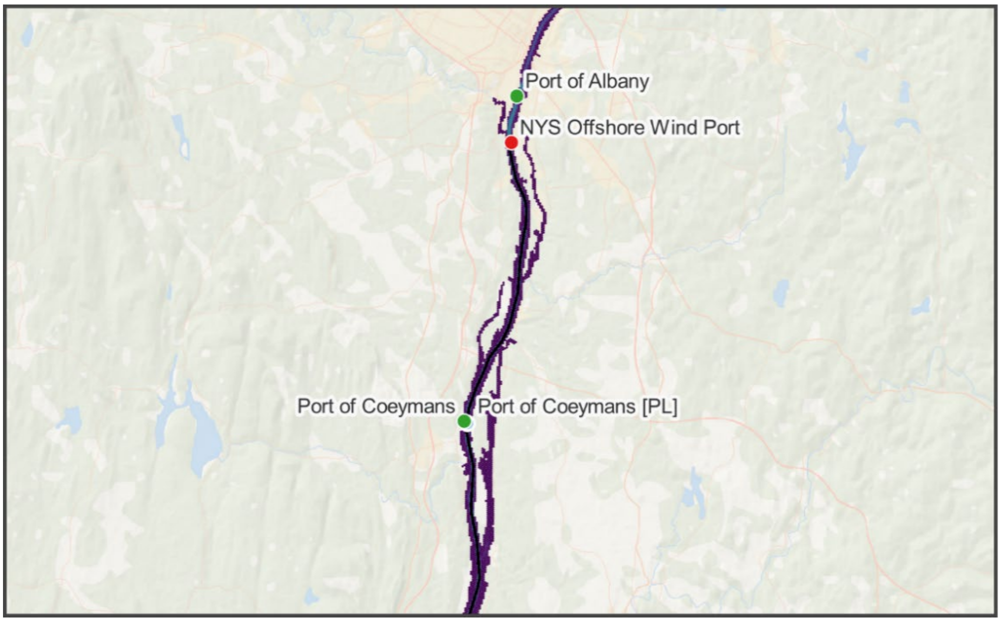


Figure S-5. Extraction of In-Depth Data for Select Passage Lines (continued)

OSW traffic is shown on the figure as thick black lines. Passage lines represented by cyan circles with PL in brackets. Potential and existing facilities are shown as red and green circles accordingly. Background colors represent transit counts with yellow representing higher transit count and dark blue/magenta representing lower transit count.

Source: COWI (December 2021); ESRI Ocean; Google Earth; NOAA



For each passage line, COWI compared the expected traffic incurred by the various OSW projects planned for construction between 2020 and 2040, to the projected non-OSW vessel traffic for the same period.

Table 1 below captures the non-OSW traffic counts at each passage line and the forecast traffic incurred by OSW projects. The relative contribution of OSW-induced traffic toward the total traffic volume is shown in Table 2. It is seen that the relative increase is largest at Tomkins Cove and Port of Coeymans with a 3–4% increase in vessel traffic resulting from OSW vessels.

Table S-1. Future OSW and Non-OSW Vessel Traffic for each Passage Line

(Shown as Counts) For years 2017 through 2040

Year	Hudson River		The Narrows		Ambrose Channel		East River		Sandy Hook		Ward Point		Tomkins Cove		Port of Coeymans	
	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW
2017	137,697	0	49,859	0	11,821	0	110,536	0	3,648	0	2,357	0	5,750	0	4,303	0
2020	141,028	0	51,065	0	12,105	0	113,211	0	3,735	0	2,414	0	5,889	0	4,407	0
2025	146,760	188	53,140	130	12,599	130	117,812	0	3,888	0	2,513	0	6,130	188	4,587	180
2030	152,727	142	55,300	278	13,111	246	122,599	0	4,046	16	2,614	48	6,378	142	4,774	114
2035	158,933	0	57,548	358	13,644	358	127,582	48	4,211	16	2,721	16	6,637	0	4,967	0
2040	165,393	0	59,887	348	14,198	348	132,769	48	4,382	0	2,831	0	6,907	0	5,168	0

Table S-2. Future OSW Vessel Traffic at Passage Lines

Relative increase in traffic counts.

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2020	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2025	0.13%	0.24%	1.03%	0.00%	0.00%	0.00%	3.07%	3.92%
2030	0.09%	0.50%	1.88%	0.00%	0.40%	1.84%	2.23%	2.39%
2035	0.00%	0.62%	2.62%	0.04%	0.38%	0.59%	0.00%	0.00%
2040	0.00%	0.58%	2.45%	0.04%	0.00%	0.00%	0.00%	0.00%

Vessel traffic at several of the passage lines is dominated by smaller local ferries or pleasures crafts. While these are relevant to consider, in many cases they are likely not the ones most impacted by the OSW traffic. Therefore, a comparison is also made to "large vessels," which are defined as vessels longer than 60 meter (m) or tugs irrespective of size. Tugs are included because they potentially can be towing a barge and hence, in some cases, the combined tug/barge unit may be larger than 60 m.

Excluding tugs would underestimate the large vessel traffic significantly, particularly in areas where barge traffic is dominating. Table 3 shows the relative increase a passage lines when considering only large vessels as defined above. The relative increase in traffic is most significant at the Hudson River and The Narrows passage lines. Generally, the relative increase from OSW traffic is found to be between 0–5% per year.

It should be emphasized that considering only tugs and vessels larger longer than 60 m is just one possible metric for comparison. Changing the filter with length or excluding tugs can have a significant impact on the results.

Table S-3. Future OSW Vessel Traffic at Passage Lines

Relative increase in traffic count when comparing to tugs or vessels larger than 60 m length overall (LOA).

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
2020	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
2025	**0.13%**	**0.24%**	**1.03%**	**0.00%**	**0.00%**	**0.00%**	**3.07%**	**3.92%**
2030	**0.09%**	**0.50%**	**1.88%**	**0.00%**	**0.40%**	**1.84%**	**2.23%**	**2.39%**
2035	**0.00%**	**0.62%**	**2.62%**	**0.04%**	**0.38%**	**0.59%**	**0.00%**	**0.00%**
2040	**0.00%**	**0.58%**	**2.45%**	**0.04%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

Below are the main take-away items from the analysis:

- The relative increase in vessel traffic incurred by the OSW projects at each passage line is small compared with the total volume of vessel traffic anticipated over time. The largest increase is found at Ambrose Channel, Tomkins Cove, and Port of Coeymans where OSW vessels correspond to an increase of 2–4%.
- If only tugs and all other vessels larger than 60 m in length are considered, the relative increase is between 1–5% for all selected Passage Lines except East River which experiences an insignificant increase of less than 0.5%.

1 Introduction

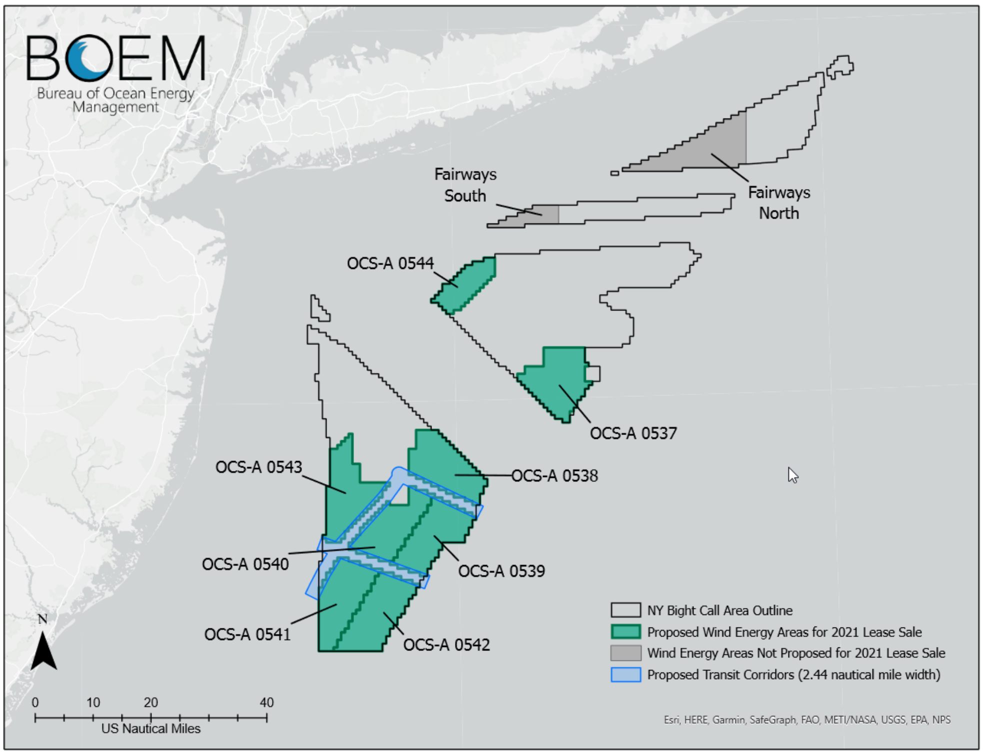
1.1 Context and Approach

The New York State Energy Research and Development Authority (NYSERDA) is leading the coordination of offshore wind opportunities in New York State and is supporting the development of 9,000 megawatts of offshore wind energy by 2035 in a responsible and cost-effective manner. Offshore wind will be a crucial step on the path to a carbon-neutral economy and a critical component in achieving the expanded Clean Energy Standard, whereby 70 percent of New York State's electricity will come from renewable sources by 2030 under the Climate Leadership and Community Protection Act (Climate Act), the State's ambitious and comprehensive climate and clean energy legislation. BOEM New York Bight OSW lease area overview, and ATLW-8 OSW lease area maps are provided in Figures 1 through 3.

For this project, BTMI Engineering, PC (COWI) was tasked by NYSERDA to provide an assessment of potential 9-gigawatt offshore wind port uses and analyses of the expected increase in vessel traffic resulting from OSW. The assessment relied on projections for committed and hypothetical offshore wind facilities slated to become operational by year 2035. COWI's technical approach included assessment of potential 9-gigawatt offshore wind port uses through delineation of a project design envelope (PDE), and development of a vessel traffic model (VTM) in collaboration with SUNY Maritime to estimate the future effects of a fully developed New York State offshore wind supply chain on vessel traffic in State waters.

Figure 1. New York Bight Overview Map

Source: BOEM (November 2021)



Note that Figure 1 is included because it includes Fairways North and Fairways South, which are two of the arbitrarily selected locations for future projects used only for the purpose of vessel traffic analysis. It is acknowledged that at the time this analysis was performed, these WEAs are not proposed for lease sale. However, it is noted that unknown future project lease areas (e.g., "Project 2029" and "Project 2031") were chosen only with the intent to set a mostly arbitrary offshore end point for the vessel track and include the Fairways South and Fairways North locations with the intention to provide a balanced geographical spread of arbitrary project locations and capture one of the possible vessel traffic scenarios.

Figure 2. ATLW-8 Final Lease Areas

Source: Federal Register Vol. 87 No. 10, January 14, 2022

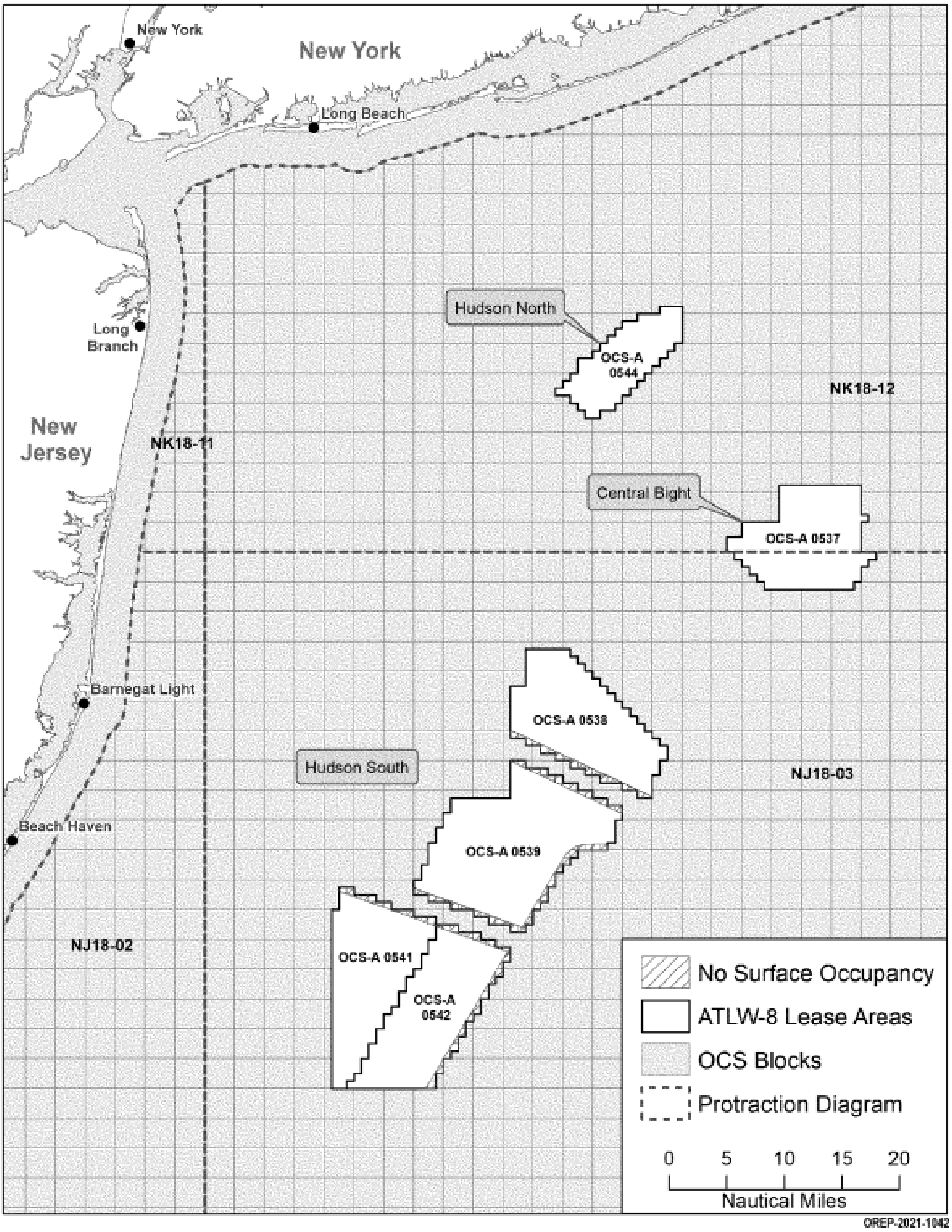
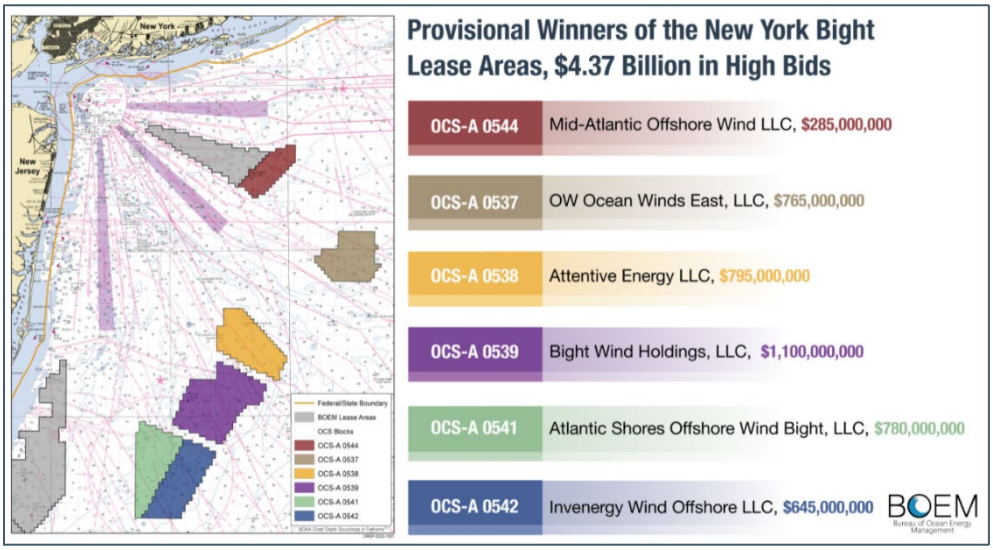


Figure 3. ATLW-8 Final Lease Areas

Source: BOEM (February 2022)



1.2 Purpose

New York State's waterways are an essential resource to the State's existing maritime industries. For that reason, evaluating the effect of shared use in waterways while these industries coexist with the developing offshore wind industry will be vital for the establishment of a safe and reliable State-based offshore wind supply chain while continuing to maintain safe navigation conditions.

1.3 Scope of Work

For this project, COWI was tasked by NYSERDA to carry out the following:

1. Assessment of Potential 9-Gigawatt Offshore Wind Port Uses slated for construction by year 2035.
2. Development of a VTM serving as a platform to perform vessel traffic analyses at selected passage lines defined as areas that potentially are affected by the introduction of OSW vessel traffic.

The Assessment of Potential 9-Gigawatt Offshore Wind Port Uses partly serves as input for a Ports Cumulative Impacts Study (Henningson Durham and Richardson Architecture and Engineering, 2022) and partly to provide input regarding OSW vessel traffic to the VTM.

The VTM and vessel traffic analysis will also be used as a tool to inform a Vessel Traffic Risk Assessment that will be issued in a supplementary report. Further details on the scope and methodology of the two tasks are found in the following section.

1.3.1 Assessment of Potential 9-Gigawatt Offshore Wind Port Uses

This task includes the definition of a Project Design Envelope (PDE). The PDE represents the key regions and offshore wind activity types within New York State for both known and potential future offshore wind-related port uses. The key regions and activity types comprising the PDE are provided in section 2. The PDE and its characteristics make up a baseline framework within which port activity in the State can be evaluated over time. The PDE encompassed the five known NYS ports and a scenario of additional ports that were quantified and located to satisfy the demands for port facilities in advancement of the State's 9-GW offshore wind goal. At the time this study was conducted, New York State's 9-GW commitment represented approximately 22% of United States East Coast commitments (40.7 GW). Therefore, the assumptions delineated in the PDE were crafted in order to capture this same proportional share of port activity within the State. This results in an estimate of ports and associated vessel traffic consistent with realizing the 9-GW OSW energy goal. The assumption acknowledges that NYS OSW projects are likely to be serviced by ports on a regional basis, not necessarily confined within the State, and conversely in-State port facilities are likely to service out-of-state OSW projects.

The PDE hypothesizes on size, geographic location, and end use of the additional facilities that were identified in the project. The additional facilities are considered unknown to the State, and this report does not intend to endorse specific location or characteristics to these facilities; rather, it provides a plausible scenario which can be used to determining cumulative impacts.

The PDE was used, as appropriate, by both the ports cumulative impacts study as well as the navigation study to evaluate both current and prospective port uses and the associated impacts in service of New York State's offshore wind goals. Assumptions regarding end-use functionality for certain ports were necessary to fully assess and model the impacts to navigation from the State’s development of ports needed to reach its 9-GW OSW goal.

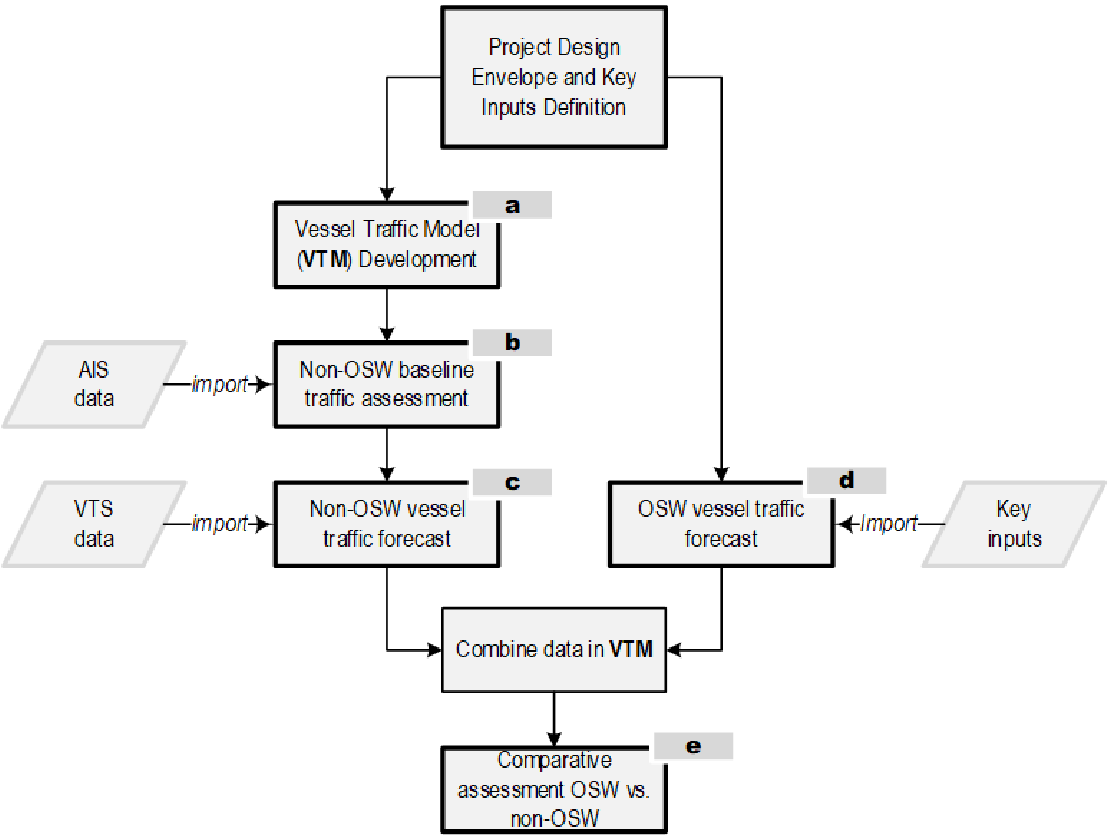
An assessment of key inputs that span the currently active offshore wind-related ports in the State was performed. A list of ports anticipated for use was prepared. These key inputs will be used by the environmental cumulative impacts study in combination with the PDE.

1.3.2 Vessel Traffic Model

The scope of this task is to develop a VTM with the goal of understanding the future effects of fully developed offshore wind supply chain on vessel traffic density within New York State waters. The process to develop the VTM encompasses several key components, orchestrated per the illustration shown in Figure 4, and elaborated upon below.

Figure 4. Overview of the Vessel Traffic Model and Analysis

Source: COWI (December 2021)



Following the numbering in the figure, the process for developing and utilizing the VTM is outlined.

a. **Vessel Traffic Model Development**
The VTM was built using the Python language and uses a dedicated Spatial PostgreSQL (referred to as PostGIS) to broker spatial information to third-party applications. In this iteration, the VTM is coupled to a Geographic Information System (GIS) to enable the development of traffic density heat maps and other visuals.

b. **Non-OSW Baseline Vessel Traffic Assessment (2017)**
VTM was used to calculate the baseline non-OSW vessel traffic statistics for the region delineated within the PDE. Specifically, the extent of the model was bounded within 3 nm of NYS shorelines.

c. Non-OSW Vessel Traffic Forecast
COWI worked with the State University of New York, Maritime College, to assess yearly increases in vessel traffic within the PDE, exclusive of OSW vessel traffic. The estimation of a reasonable compound average growth rate (CAGR) for yearly increase in vessel traffic is the main deliverable associated with this task.

d. **OSW Vessel Traffic Forecast**
A yearly forecast of OSW-incurred vessel traffic was developed using the PDE and Key Inputs defined in the previous task (see section 2). The projected OSW traffic was synthetized and re-ingested by the VTM, which served as a platform for performing comparative assessment, as described below. The generation of annual vessel trip counts on select projected routes was the main deliverable associated with this task.

e. **Comparative Assessment of OSW versus Non-OSW Traffic**
This task serves to compare the forecast traffic volumes and assess the relative contribution of OSW-induced traffic as a fraction of the total traffic over time. Special areas of interest referred to as passage lines will be identified utilizing the density (transit count) maps generated using the VTM, which compared baseline (non-OSW) existing (2017) and future vessel traffic and vessel traffic increase incurred by the OSW projects. The generation of key statistics at each identified passage line, comparing the non-OSW vessel traffic versus OSW-incurred vessel traffic is the main deliverable associated with this task. This comparative assessment will serve as input for the Vessel Traffic Risk Assessment (COWI, 2022).

1.4 Assumptions

COWI's analysis was predicated upon certain assumptions that shaped its outcome. Assumptions include core assumptions as well as technical assumptions.

1.4.1 Core Assumptions

Core assumptions apply to the framework of the study itself and outline key points to acknowledge while reviewing this document, specifically the proposed PDE. These assumptions establish overarching guiding points used to develop the proposed PDE and describe the intentions fulfilled by the PDE.

> The PDE accounts for New York State commitment to achieve 9 GW of OSW by 2035. COWI has assumed that the number of facilities hosted by the State is proportionate to a fraction of State procurement over total procurement of the east coast. Based on public announcements, the total United States east coast procurement goal is 40.7 GW. New York State's procurement commitment is 9 GW by the year 2035, therefore the State captures 22% of the OSW market. Thus, for the purpose of defining the PDE, this study proposes that the State aims to hosts a proportional share (22%) of the total U.S. east coast required number of ports.
>
> The capital construction portion of the PDE is intended to present a scenario of baseline vicinities for capital construction port locations. Building the VTM required that definitive locations be specified. The RFQL 4259 respondent locations were used to select these specific locations for model input. Therefore, while the PDE does include a list of specific locations, the list is not intended to endorse any specific port.

- Raw materials manufacturing and shipping is not considered within the PDE due to the large amount of uncertainty in location and mode of transportation that cannot be accounted for in a model of this scale.

The operations and maintenance (O&M) portion of the PDE is intended to present a scenario of baseline vicinities for O&M port locations. Similar to the capital construction portion, model inputs dictate that definitive locations be specified. The facilities identified in the NYSERDA 2018 Ports Assessment: Offshore Wind Operations and Maintenance Port Facilities, as well as any additional facilities belonging to agencies that have publicly expressed previous interest in OSW (e.g., Port Authority of New York and New Jersey's [PANYNJ's] Port Master Plan 2050, New York City Economic Development Corporation's [NYCEDC's]) Request for Proposal (RFP) for Homeport Pier, etc.) were used to select these locations for model input. Therefore, while the PDE does include a list of specific locations, the list is not intended to endorse any specific port.

1.4.2 Technical Assumptions

Technical assumptions are considered specific inputs that were utilized in the development of the updated Regional Ports Supply and Demand Model (RPSDM) and the PDE. These assumptions contribute specifically to the methodology used in determining specific quantities, locations, and functions of ports proposed for the PDE.

- PDE is selected to represent the following four key regions initially outlined in the Scope of Work (SOW), which include:
    Capital Region
    Upper Hudson Valley
    NYC Harbor
    North Shore of Long Island
- The RPSDM developed by COWI and used to inform the development of the PDE excluded the following:
    Install cables—assume direct ship from manufacturing facility to Offshore Wind Farm (OWF)
    Install OSS—assume direct ship from manufacturing facility to OWF
- PDE: Capital Construction
    Five known ports include:
    SBMT (Foundation and WTG Staging)
    Port of Albany (WTG Tower Manufacturing)
    Port of Coeymans (Foundation Fabrication)
    Port Jefferson (O&M) *Specific location unconfirmed
    Port of Montauk Harbor (O&M)

- PDE: Operations and Maintenance (O&M)

  Assume a service operations vessel (SOV) strategy-based approach for newly proposed ports due to typical distances between Wind Energy Areas (WEAs) and onshore locations available for base ports.

  Assume actual O&M strategy will be specific project-to-project.

  Number of predicted SOVs to service NYS OSW projects is based mainly on data provided in the National Renewable Energy Lab (NREL) Operations and Maintenance Technical Report (Maples, Saur, Hand, van de Pietermen, & Obdam, 2013).

  Assume South Brooklyn Marine Terminal (SBMT) is a known O&M Port based on publicly available renderings by Equinor. Therefore, number of known O&M ports within NYS is assumed to be three.

- PDE Supplemental Findings:

  To summarize a PDE and develop the VTM, specific points on a map must be chosen to develop vessel routes. Eight capital construction ports are summarized as the PDE scenario. The scenario is intended to present baseline vicinities, which are assumed to represent hypothetical future port locations. Points in space used to represent these hypothetical port locations were selected based on the locations of the RFQL 4259 respondents. While a port may be an RFQL 4259 respondent, it is not guaranteed that any of the hypothetical facilities will be developed to service the offshore wind industry. Therefore, these ports are not selected with the intent to endorse specific port locations but used only as baseline locations; port productivity and other facility specifics are not considered. The intent of identifying specific ports is to provide a scenario for a supply chain fully developed in New York State. As such, the PDE serves as an approximation of industry, not a strict construction plan, and is intended to capture approximate locations within State key regions, and not to prescribe a specific set of port facility characteristics that contribute to component-specific throughput rates.

1.4.3 Impacts from the COVID-19 Global Pandemic

As stated in the 9-GW Port Uses and Navigational Assessment report prepared by State University of New York, Maritime College (SUNY Maritime) for COWI, the pandemic has been impacting economic activities since February 2020. The future economic impact is still not clear because the pandemic’s impact is yet to be settled. The trends and conclusions of this report are inherently tied to pre-COVID conditions. It is possible that post-COVID conditions may challenge these assumptions. For this reason, it is recommended that regular updates to the long-term forecast presented herein be conducted.

2 Assessment of Potential 9-Gigawatt Offshore Wind Port Uses

2.1 Project Design Envelope

A PDE is developed representing key regions and offshore wind activity types within New York State for both known and potential future OSW-related port uses. The key regions and main associated supply chain activity types are tabulated in Table 4. The proposed PDE accounts for the State's commitment to achieve 9 GW of offshore wind by 2035, and the associated goal of becoming the nation's hub of the offshore wind industry.

Table 1. Key Regions and Supply Chain Activity Types

Key Region	Supply Chain Activity Type
Capital Region	Manufacturing
Upper Hudson Valley	Manufacturing; Assembly
New York City Harbor	Manufacturing, Assembly, Staging, O&M
North Shore of Long Island	O&M

2.1.1 Regional Port Infrastructure, Ports Supply, and Demand Model

2.1.1.1 Background and Updates

The first version of the Regional Port Infrastructure, Supply, and Demand Model (RPSDM) was prepared and submitted to NYSERDA on April 16, 2020. The model is intended for use as a tool to understand the needs and deficit/surplus capacity of U.S. port facilities to support construction related aspects of offshore wind farms, including manufacturing, fabrication, and construction staging; the results of the model may support potential policy and funding decisions. Since the first version, new public information pertaining to the offshore wind industry in the northeast U.S. has become available. This information includes newly announced State OSW commitments and goals, OSW projects, port facility upgrades or commitments, and higher-capacity wind turbine generators (WTGs). COWI has utilized this information to recalibrate the model to more accurately capture the supply versus capacity results at these ports. An up-to-date summary tabulation of port facilities assumed to be online for OSW-related use in capital construction activities is provided in Table 2. The model intends to capture the following port-related supply chain activities, which are considered capital construction activities:

- Fabricate foundations—model currently considers only monopile-type foundations (including transition piece), model may be expanded to consider additional foundation types.
- Install foundations.
- Manufacture cables.
- Fabricate offshore substations (OSS).
- Manufacture WTG, including:

  Manufacture nacelles.
  Manufacture blades.
  Manufacture towers.

- Install WTG.

The following activities are not included in the model:

- Install cables-assume direct ship from manufacturing facility to offshore wind farm (OWF) site.
- Install OSS-assume direct ship from manufacturing facility to OWF site.
- Operations and Maintenance activities are not considered in the supply/demand model but are considered elsewhere in the PDE.

This report acknowledges that other port-related activities are critical to the installation and operation of offshore wind farms, including O&M and shipbuilding and repair. However, those activities have historically used port facilities independent of the specific supply chain listed above. O&M ports in particular are typically project-specific, and while they will be captured in the PDE, are therefore not included in the RPSDM.

Table 2. Facilities with Announced In-Service Dates

Facility Location	Owner	In-Service Year	References
Brayton Point Somerset, MA	Anbaric Development Partners	2022	(Durakovic, Mayflower Wind to Hook Up to Brayton Point, 2021), (reNEWS.biz, 2020), (Commercial Development Company, 2018).
New Bedford Marine Commerce Terminal New Bedford, MA	MassCEC	2015	(Massachusetts Clean Energy Center, n.d.).
ProvPort Providence, RI	ProvPort	2022	(Kuffner, Offshore wind developers announce ProvPort facility, 2021).
Port of Davisville/Quonset Business Park North Kingston, RI	Quonset Development Corporation	2022	(King, 2020), (NPM, 2020)
Barnum Landing Bridgeport, CT	Barnum Landing LLC	2024	(Park City Wind, 2021)
State Pier New London, CT	CT Port Authority	2022	(Gateway Terminals, n.d.)
Port of Albany Albany, NY	Port of Albany - Rensselaer	2024	(NYSERDA, 2020)
Port of Coeymans Coeymans, NY	Carver Companies	2021	(Buljan, 2021), (Carver Companies, 2021).
South Brooklyn Marine Terminal Brooklyn, NY	NYCEDC, RHCT, IC	2023	(The Real Deal, 2021), (Carleton, 2021).
Arthur Kill Terminal Staten Island, NY	Atlantic Offshore Terminals	2027	
New Jersey Wind Port Ph. I Lower Alloways Creek, NJ	PSEG	2023	(USACE Philadelphia District & Marine Design Center, 2020), (New Jersey Economic Development Authority).
New Jersey Wind Port Ph. II Lower Alloways Creek, NJ	PSEG	2026	(USACE Philadelphia District & Marine Design Center, 2020), (New Jersey Economic Development Authority).
Port of Paulsboro Paulsboro, NJ	EEW	2023	(New Jersey Business Magazine, 2021), (Area Development News Desk, 2020).
Sparrows Point Sparrows Point, MD	Tradepoint Atlantic	2023	(Ørsted, 2019), (Tradepoint Atlantic, 2021).
Portsmouth Marine Terminal Portsmouth, VA	VA Port Authority	2022	(Lake, 2020)
Nexans – Bushy Park Bushy Park, SC	Nexans Cable	2022	(Wren, 2018)

Note, the Arthur Kill Terminal in-service year is not confirmed. Development of this site, or any future OSW port site, may be accompanied by significant environmental challenges based on location-specific existing conditions. Therefore, while the site is selected as a model input, uncertainty regarding development and construction timing remains. Based on public backing by U.S. Congress for development of the site as New York State's currently only planned capital construction OSW port with unrestricted air draft, COWI utilized the site as a model input under the assumption that the site (or one in a similar location) could be in-service by 2027. All future OSW ports—including Arthur Kill Terminal, should its development advance—will be subject to the full regulatory review and approval process.

2.1.1.2 Functionality and Projections

The model joins the following inputs to formulate projections on the deficit/surplus capacity of U.S. port facilities. Input data is based on publicly available information:

- Procurement: Announced projects and U.S. State commitments.
- Ports: Known facilities with announced intent for development in support of the OSW industry, their expected in-service years, and size (in acres).
- The assumed fabrication and installation schedule for each type of capital construction component.
- Data on production rates of existing manufacturers and facilities that support the offshore wind industry, used to develop estimates of land area required for fabrication and installation uses for the U.S. market.
- Component capacities: Assumptions about the capacities of WTG, OSS, and transmission cables by year.

Figure 5 demonstrates the RPSDM result for the total U.S. east coast procurement pipeline up to and including the year 2035. This graph represents the most up-to-date cumulative OSW commitments and goals both in terms of megawatts and WTG and foundation units commercial operation date (COD). The graph also illustrates the annual procurement in megawatts (MW) versus COD. Project CODs, as well as port expected initial years of operability, are subject to change as the offshore wind industry progresses. At the time of this report, COWI assumed CODs for each OSW project and initial operability years for each port that were based on current publicly available information. Updates to CODs may result in shifting of the peak demand and capacity years projected by the model. To account for this expected maturation of available data, COWI recommends that future iterations of the modeling exercise continue to incorporate available updates on CODs of offshore wind projects and port facilities.

Figure 5. Total United States East Coast Pipeline in Megawatts

Source: COWI (December 2021)

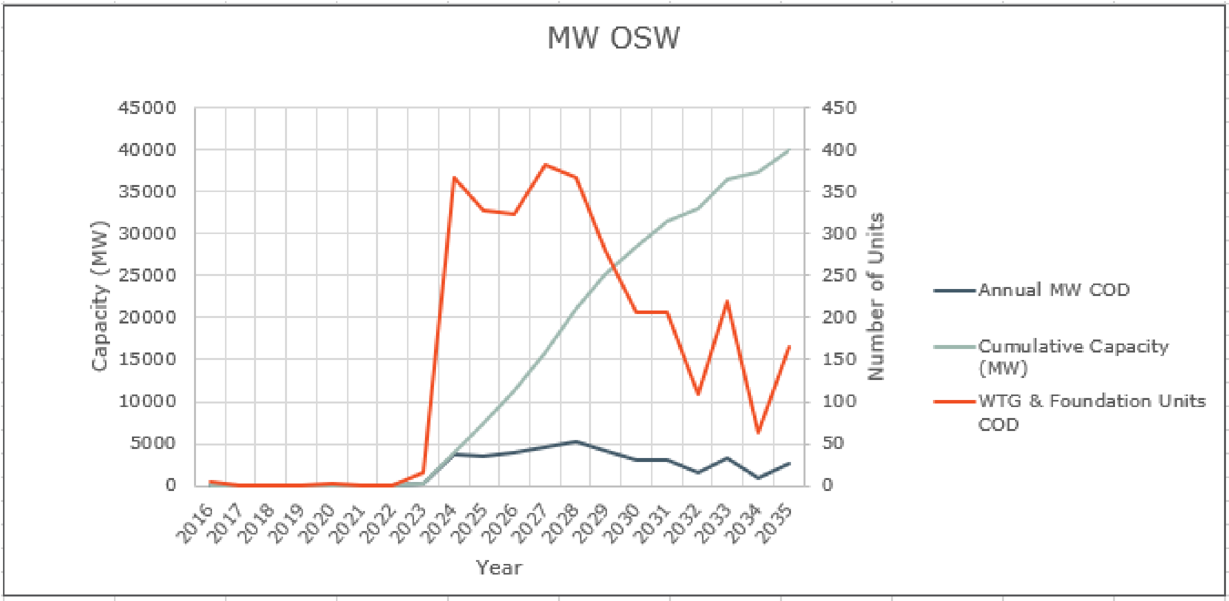
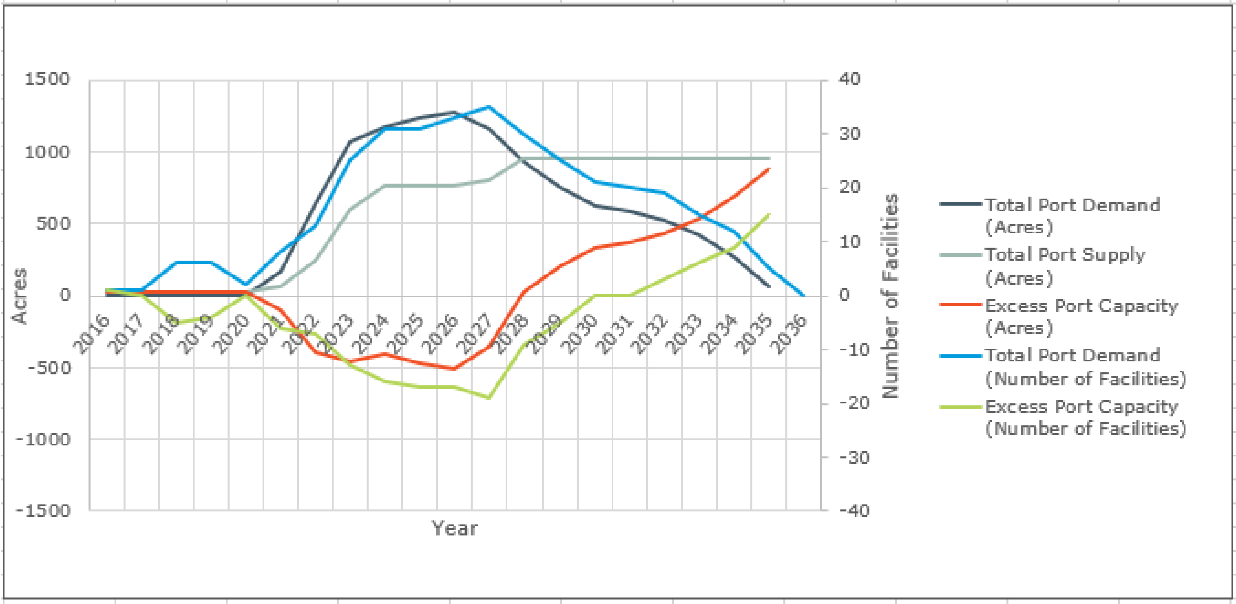


Figure 6 demonstrates the model result for total port demand, total port capacity, and resulting "excess" port capacity for any given year, both in units of acres and number of facilities. Negative values of "excess" capacity signify a deficit that must be filled by the addition of new sites or repurposing of existing sites that are found to be surplus (positive values).

Figure 6. Total Port Demand and Capacity for United States East Coast

Source: COWI (December 2021)



Overall, the model results show a peak deficit in total ports capacity versus demand between 2027 and 2028. Demand on ports for any given project is predicted to begin approximately two to three years before the COD. A COD of 2030 is specified for many State procurements that have been announced; therefore, as expected, the peak port demand begins to decrease according to the State commitments. While additional commitments are anticipated from varying states, those future projects are not captured in this model.

Individual results for port excess/deficit capacity versus demand based on supply chain activity are also obtained. The number and operational year of facilities identified for each activity varies, as does the production rate on a unit/acre/year basis. Therefore, results for peak deficit and peak deficit year varies across the activity types. However, most peak deficit years still hover close to the 2027–2028 timeframe.

The model assumes that all supply chain activity will take place in the United States without international support. It is well understood in the industry that initial projects will benefit from an international supply chain; however, the intent of this analysis is to estimate the impacts of a mature domestic supply chain and therefore international support is not considered. A tabulation of the port-related supply chain activities that are captured and the demand results from the model is provided in Table 3.

Table 3. Model Conclusion Summary

Facility Supply Chain Activity	Peak Demand (each)	Peak Deficit (each)
Total	35	19
Manufacture WTG: Nacelles	3	3
Manufacture WTG: Blades	1	1
Manufacture WTG: Towers	2	2
Manufacture Cables	5	4
Fabricate OSS	11	11
Fabricate Foundation (Monopile)	4	4
Install WTG	6	-1[b]
Install Foundations	4	2

[a] The total peak deficit will not necessarily add up to the sum of the individual supply chain activity deficits, as the years in which the peak deficit for each activity type occurs may vary from the peak deficit year for the total U.S. East Coast pipeline.

[b] At the point of greatest demand versus capacity, model predicts a surplus of one installed WTG facility.

2.1.1.3 Results and Application

The RPSDM indicated in a peak demand of 35 and associated peak deficit of 19 capital construction port facilities for the U.S. east coast, projected to occur within the year 2027–2028 based on publicly available data. The peak demand figure of 35 ports will be used to determine the proposed number of port facilities to be hosted by New York State.

2.1.2 Number of Facilities

2.1.2.1 Capital Construction Facilities

The results of the updated RPSDM, which includes the entire United States east coast region of offshore wind, are used to inform the proposed PDE. The model does not generate recommendations but identifies overall need in the OSW industry. The model is focused on capital construction because operations and maintenance port locations are project specific. Therefore, the recommendations for number and supply chain activity type of new facilities focus on capital construction, encompassing the manufacturing, assembly, and staging activities.

Based on public announcements at the time of this assessment, the total U.S. east coast procurement goal is 40.7 GW by 2035. The State's procurement commitment is 9 GW by the year 2035; therefore, NYS accounts for 22% of the OSW market. Thus, for the purpose of defining the PDE, this study proposes that the State aim to host a proportional share (22%) of the total U.S. east coast required number of ports. The total required number of ports is predicted by the model and provided in Table 7 as 35 each. As a result, the assumed number of ports focused on capital construction to be hosted is eight.

Table 4. Proposed Number of New York State OSW Port Facilities

Capital Construction

U.S. East Coast Procurement	NYS Procurement	NYS % Procurement	U.S. East Coast Peak Demand (each)	NYS # Facilities
41 GW	9 GW	22%	35	8

The State is currently host to five active offshore wind-related ports as follows:

- South Brooklyn Marine Terminal (Staging)
- Port of Albany (Manufacturing)
- Port of Coeymans (Fabrication)
- Port Jefferson (O&M)
- Port of Montauk Harbor (O&M)

The first three ports in this list support the capital construction activities of OSW. Therefore, to meet the proposed total number of eight capital construction port facilities, the State is recommended to provide an additional five port facilities that will support the capital construction supply chain activities.

It is noted that functions of the above-listed facilities ("known" facilities) are subject to shift as the offshore wind industry matures in the State. Specifically, for the capital construction ports, it can be expected that the supply chain activities are subject to change, or additional activities may be added to a facility. At the time of this report, COWI assumed supply chain activities for each known facility that was based on the current publicly available information and that would provide the most closely realistic input for the VTM. COWI recommends that future iterations of the modeling exercise continue to incorporate available updates on supply chain activities at known port facilities.

2.1.2.2 Operations and Maintenance Facilities

The O&M strategy adopted for servicing an OWF typically takes one of two approaches: Crew Transfer Vessel (CTV) or SOV-based. CTVs are used for daily transport of personnel and equipment. These vessels are smaller compared to SOVs and are typically of aluminum or composite construction on the order of 60 ft to 100 ft in length, with drafts between 4 ft to 8 ft CTVs typically host 12 technicians at once (BVG Associates, 2014), (4C Offshore, n.d.), with additional space used to transport tools and spare components. Transit speeds range from 15 to 25 kn (4C Offshore, n.d.); however, transit tends to be limited by metocean conditions with a typical restricting significant wave height on the order of 1.6 ft to 5 ft (0.5 to 1.5 m).

An SOV's primary function is to be a self-contained project site consisting of crew, materials, and equipment capable of remaining at the project site for extended periods of time. SOVs are typically 225 ft to 300 ft in length and capable of hosting up to 60 technicians at once, usually performing regular port calls once every 10 to 30 days (Siemens Gamesa, 2021). Developer information and data from European projects indicate that an SOV typically remains offshore, at the project site, for approximately 14 days per trip. An example of this scenario in use will be the O&M strategy employed by Ørsted and Eversource, who have publicly announced that the Port Jefferson O&M Port will host an SOV to service Sunrise Wind and South Fork Wind (Durakovic, Orsted and Eversource Setting Up Offshore Wind O&M Hub on Long Island, 2020).

Based on the typical distances between the WEAs and the onshore locations available for base ports, transit times limit the opportunities for a CTV strategy approach, where a CTV facility would serve as a local headquarters for managing day-to-day O&M. As such, an offshore-based strategy is assumed for proposed operations and maintenance facilities in the PDE. This involves longer-term O&M campaigns launched and managed out of SOV facilities consisting of periodic major maintenance and overhauls.

While an SOV-based strategy is assumed for the proposed O&M facilities in the PDE, facilities already planned (Port Montauk and Port Jefferson) maintain their own strategies. Port Montauk is planned to service South Fork OWF (Walsh, 2019). Based on the steaming distance from Port Montauk to South Fork, it is assumed that a CTV-based approach will be taken from this location. Port Jefferson is planned to service Sunrise Wind OWF (Sunrise Wind, 2020). Based on public announcement, Port Jefferson will serve as home port to an SOV for O&M operations. A tabulation of the assumed strategy and assumed number of vessels to be hosted by each port within the PDE is provided in Table 5.

Assuming the strategies as outlined above, the number of SOVs expected to be required in New York State waters to service the 9 GW of offshore wind energy was determined. Based on the available data, which primarily includes numbers of SOVs used to service existing OWFs in Europe, it was found that the number of SOVs correlates most directly to the number of turbines in the OWF. Since O&M strategy is specific from project-to-project, the number of data points available is limited. Based on findings, the typical number of turbines that can be serviced per SOV ranges from 80 turbines per SOV to 120 turbines per SOV. As such, COWI has assumed that one SOV may service up to an average of 100 turbines.

This one SOV per 100 turbine assumption was then applied to U.S. projects whose O&M ports have a known upland area, allowing an approximation of the O&M port area (acres) required per SOV. Again, because O&M port selection is specific for each project, the number of available data points was limited. However, a relatively consistent average required port area per SOV was found.

The total number of turbines to be installed for the State was then determined based on a combination of publicly available numbers for known projects (listed below) or derived based on the procurement goal or commitment for a given year and the expected average WTG capacity for that year. The known projects include:

South Fork Wind:	132 MW	COD: 2023
Empire Wind 1:	816 MW	COD: 2024
Sunrise Wind:	932 MW	COD: 2024
Empire Wind 2:	1,260 MW	COD: 2027
Beacon Wind:	1,230 MW	COD: 2028

As explained earlier, project CODs—as well as port expected initial years of operability—are subject to change as the offshore wind industry progresses. At the time of this report, COWI assumed CODs for each OSW project and initial operability years for each port that were based on current publicly available information.

After the number of turbines for each year was determined, the turbines were added cumulatively through the years. This results in the number of turbines installed for each year, subject to requiring service by SOV.

Applying the assumption of one SOV per an average of 100 turbines, the cumulative number of SOVs for New York State was then found for each year. Based on findings, a total of eight SOVs are assumed to be required in the State by the year 2035. This translates to approximately one SOV per wind farm and assumes that there is potential for sharing SOVs between projects (e.g.: Empire Wind 1 and Empire Wind 2, by the same developer, are expected to share an SOV out of the same O&M port facility). Utilizing this number and the average port acreage required per SOV, it was found that a total of six O&M ports will be required to support the operations conducted by the eight SOVs, assuming that some ports will be capable of hosting more than one SOV. The assumption that some ports may host more than one SOV is based mainly on available existing or potential quay length of the ports. For example, SBMT is assumed to host two SOVs based on renderings released by Equinor that shows one SOV berth on the eastern end of the north side of the 35th Street Pier, potentially leaving available the western end of the same pier face for another SOV berth location (Carleton, 2021). Since it is assumed that Port Montauk will host CTVs only, the eight SOVs must be distributed between five ports. At other O&M ports, the assumption is based on the quantity of piers or waterfront length potentially available for SOV berth locations.

Since CTVs are assigned only to Port Montauk as the main O&M vessel type for this study, determination of CTV quantity is simplified. Based on typical observed industry standard and the Maryland Offshore Wind Ports Assessment, it is assumed that a minimum of three CTVs will be required to service South Fork from Port Montauk.

Two O&M Port Facilities have been identified: Port Jefferson and Port Montauk. Additionally, renderings publicly released by Equinor suggest that SBMT will be utilized as an O&M hub (Pereira, 2021); therefore, it is assumed SBMT will be used to service at least Empire Wind 1 and 2 for O&M. As such, an additional three facilities are recommended for inclusion in the PDE.

2.1.3 Function and Location of Facilities

2.1.3.1 Capital Construction Facilities

The proposed five additional capital construction facilities are each assigned a unique supply chain activity. Recommendations are based on the facility end use needs specified by the RPSDM, which are then cross-referenced with facilities that responded to RFQL 4259. The RFQL 4259 respondent locations are generally representative of State key regions (see Table 4). Based on the peak deficit in facility numbers for each supply chain activity, COWI proposes the following:

- (1) Blade Manufacturing Port
- (1) Nacelle Manufacturing Port
- (1) Cable Manufacturing Port
- (1) OSS Fabrication Port
- (1) WTG Staging Port

The capital construction portion of the PDE is intended to present a scenario of baseline vicinities for capital construction port locations—building the VTM required that definitive locations be specified. The RFQL 4259 respondent locations were used to select these specific locations for model input. Therefore, while the PDE does include a list of specific locations, the list is not intended to endorse any specific port. The overall PDE is provided in Table 6.

2.1.3.2 Operations and Maintenance Facilities

Unlike CTV ports, SOV port facilities do not need to be near WEAs. The longer sailing distances capable of SOVs allow for a wider range of eligible O&M port sites. The primary criteria for SOV facilities are sufficient berthing and navigational access to the offshore wind farms. As mentioned previously, O&M ports in particular are typically project-specific; therefore, the operations and maintenance portion of the PDE is intended to present a scenario of baseline vicinities for O&M port locations. Similar to the capital construction portion, VTM inputs dictate that definitive locations be specified. The facilities identified in the NYSERDA 2018

Ports Assessment: Offshore Wind Operations and Maintenance Port Facilities—as well as any additional facilities belonging to agencies that have publicly expressed previous interest in OSW (e.g., PANYNJ's Port Master Plan 2050, NYCEDC's RFP for Homeport Pier, etc.)—were used to select these locations for model input. Therefore, while the PDE does include a list of specific locations, the list is not intended to endorse any specific port.

While proximity to the project site is not the most important aspect of an SOV-based O&M strategy, a closer proximity is still preferred where possible; therefore, the recommended locations consider the announced BOEM WEAs. Due to these considerations, along with the already announced OSW O&M facilities, it is expected that additional O&M facilities will be geographically distributed mainly within New York City Harbor. A tabulation of the O&M portion of the PDE and assumed O&M strategy for each port is provided in Table 5.

Table 5. Operations and Maintenance Port Assumptions

Port	O&M Strategy (Assumed)	Number of Vessels
Port Jefferson	SOV	1
Port Montauk	CTV	3
SBMT	SOV	2
Brooklyn Navy Yard	SOV	2
Brooklyn PAMT	SOV	2
Homeport Pier	SOV	1

2.1.3.3 Proposed Project Design Envelope

Table 6. Proposed Project Design Envelope

	Port Location	Supply Chain Activity	NYS Region
KNWON [a]	South Brooklyn Marine Terminal	Staging WTG & Foundation O&M	NYC Harbor
	Port of Albany	Manufacturing Towers	Capital Region
	Port of Coeymans	Fabrication Foundations	Capital Region
	Port Jefferson	O&M	North Shore LI
	Port of Montauk	O&M	North Shore LI

Table 6 continued

	Port Location	Supply Chain Activity	NYS Region
REPRESENTATIVE PROPOSED FOR PDE	Arthur Kill Terminal	Staging WTG	NYC Harbor (Staten Island)
	Port Ivory	Fabrication OSS	NYC Harbor (Staten Island)
	Homeport Pier[b]	O&M	NYC Harbor (Staten Island)
	Brooklyn Navy Yard	O&M	NYC Harbor (Brooklyn)
	Brooklyn Port Authority Marine Terminal (PAMT)[c]	O&M	NYC Harbor (Brooklyn)
	NYS Wind Port (East Greenbush)	Manufacturing Blades	Capital Region
	Cortland	Manufacturing Nacelles	Upper Hudson Valley
	Tomkins Cove	Manufacturing Cables	Upper Hudson Valley

[a] Considered to be New York State's currently active OSW related ports.

[b] Identified by NYCEDC's RFEI issued for Offshore Wind companies, service providers, manufacturers, and developers.

[c] Identified by PANYNJ's Port Master Plan 2050 as a suitable port facility to support offshore wind needs.

The ports listed in the table above serve as direct inputs to the VTM (detailed in following sections of the report). Based on transit time limitations due to typical distances between the WEAs and the onshore locations available for base ports, it is assumed that selection of a CTV-based approach and associated selection for a port location would be project-specific beyond the study scope. Therefore, additional CTV strategy-based O&M facilities, in hypothetical locations that may be outside the New York State key regions as previously defined (such as Hempstead Public Works Area on the South Shore of Long Island), could be selected and developed for O&M port use on a project-specific basis. Speculation on port selection incorporating this level of project specificity is beyond the current scope of the study, and a proposed CTV port is therefore not included as an input to the VTM due to the high level of uncertainty that would be surrounding the specified location.

Some port facilities listed in Table 6 within the list of hypothetically proposed locations for the PDE may be accompanied by significant environmental resource concerns. The list provided is not intended to endorse the development of any specific port facility, but rather is used for model inputs within the VTM and serves as a hypothetical scenario of the distribution of ports throughout New York State. All ports listed in the above table, as well as any other OSW port that may be identified in the future, are assumed subject to the full regulatory review and approval process.

2.1.4 Summary of Findings

The assumed number of New York State capital construction ports based on the proportional share (22%) of State offshore wind megawattage versus total U.S. east coast projected megawattage is eight facilities. Factoring in the three currently active offshore wind capital construction ports (see 2.1.2.1), this results in a proposed additional five facilities to comprise a total of eight. Capital construction port-specific functions and locations proposed for the PDE scenario are based on the peak deficit in facility numbers for each supply chain activity and consider facilities that responded to RFQL 4259, resulting in the following proposed scenario (in addition to the State's currently active OSW ports):

- Arthur Kill Terminal: WTG Staging
- Port Ivory: OSS Fabrication
- NYS Wind Port (East Greenbush): Blade Manufacturing
- Cortland: Nacelle Manufacturing
- Tomkins Cove: Cable Manufacturing

The assumed number of NYS O&M ports required, based on the quantity of O&M vessels estimated to be in-service, is six facilities. Factoring in the two currently active New York State offshore wind O&M ports and assuming the use of SBMT as an O&M hub in conjunction with its use as a capital construction facility, results in a proposed additional three facilities. Hypothetical O&M port locations were selected based on facilities identified in the NYSERDA 2018 Ports Assessment: Offshore Wind Operations and Maintenance Port Facilities, facilities belonging to agencies that have publicly expressed previous interest in OSW, and proximity to announced BOEM WEAs following the assumption that O&M strategy will be SOV-based. A resulting summary of the O&M port scenario proposed for the PDE is as follows (in addition to the State currently active OSW ports):

- Homeport Pier: O&M-SOV-based
- Brooklyn Navy Yard: O&M-SOV-based
- Brooklyn Port Authority Marine Terminal: O&M-SOV-based

Overall, the proposed PDE provides a scenario of a fully developed offshore wind supply chain within the State. The port locations and functions proposed for the PDE served as input to the VTM.

3 Vessel Traffic Model Development

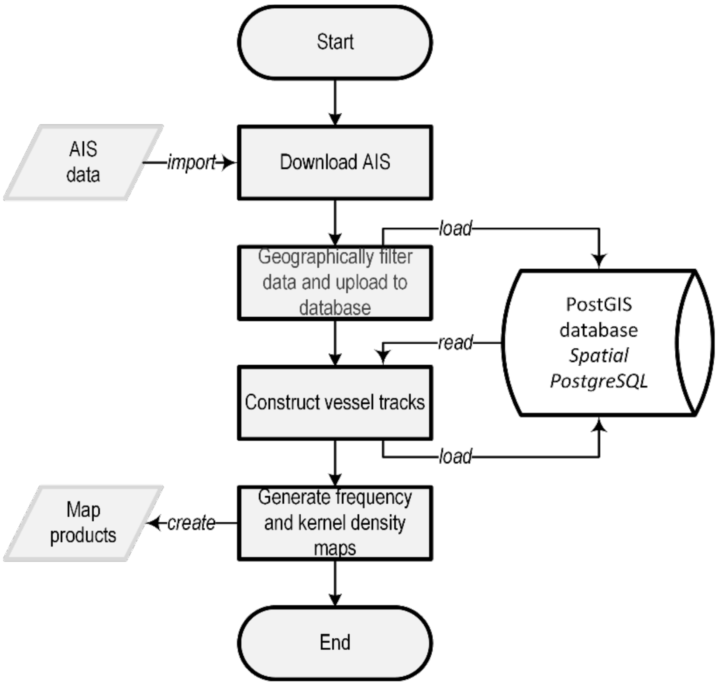
3.1 Overall Approach

COWI developed a platform to process and analyze data provided via the Marine Cadastre. The platform is the foundation upon which the baseline and future non-OSW vessel traffic assessments were performed. It is also the interface through which OSW vessel traffic forecast are visualized and further analyzed. This section focuses on the three major technical components making up the VTM:

- Downloading, pre-processing, and storing AIS data from the Marine Cadastre using the VTM platform.
- Generation of distinct vessel tracks (voyages) using the VTM platform.
- Generation of transit count maps on a hexagonal grid defined earlier using the open-source Quantum Geographic Information System (QGIS) software program.

Figure 7. Vessel Traffic Model Workflow

Source: COWI (July 2022)



These steps established the groundwork and the infrastructure necessary to develop future OSW and non-OSW VTM and to identify passage lines and collect relevant statistics.

3.1.1 AIS Disclaimer

As mentioned in the 2022 Port Access Route Study (PARS) for New Jersey, there are inherent limitations associated with using AIS data to estimate and provide insights into vessel traffic:

"AIS traffic data does not capture all vessels that operate in the study area. Federal and international carriage regulations stipulate only certain vessels are required to send and/or receive AIS signals. This includes but is not limited to: vessels of 65 feet or greater, towing vessels of 26 feet or greater, vessels certificated for 150 or more passengers, dredging vessels near a channel, fishing vessels, and vessels over 300 gross tons on an international voyage. A full description of applicability and general United States requirements can be found in 33 CFR 164.46. Despite these limitations, AIS traffic data provides a satisfactory representation of the traffic in the study area. Deep draft and large vessels are required to broadcast an AIS signal; the counts of these vessels as well as their geographic locations area assumed to be accurate. The transit patterns for vessels that are not required to broadcast on AIS, such as small recreational vessels, are apparent even if these vessels are undercounted in the data set. This is based on the assumption that since a portion of the population of vessels not required by law to carry AIS voluntarily comply, these vessels provide a representative sample of the whole population.

3.2 Model Physical Extents

The first step when preparing the VTM was definition of the model extents. This study is primarily based on New York State waters, data for which was obtained from the Marine Cadastre website. State waters generally extend up to 3 nm seaward from the coastline. A graphical illustration of the area is presented in Figures 8 and 9.

Figure 8. New York State Waters (1/2)

Source: COWI (December 2021); ESRI Ocean

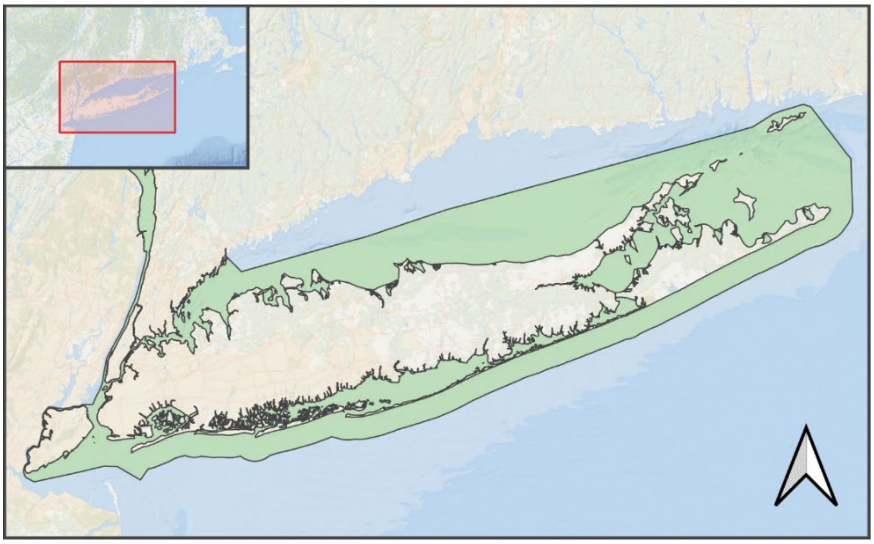
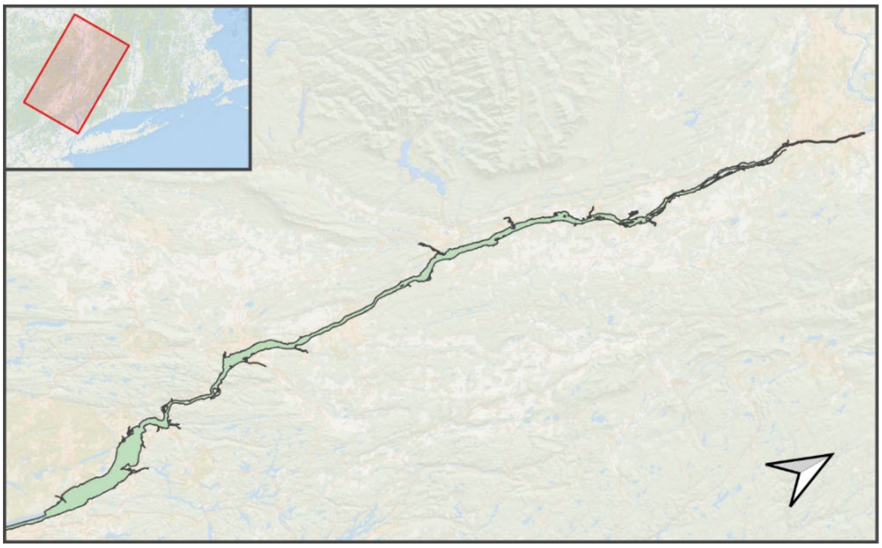


Figure 9. New York State Waters (2/2)

Source: COWI (December 2021); ESRI Ocean



3.2.2 Grid Extents

To capture the entirety of the New York Bay and to ensure that enough area within each of the existing and potential future OSW ports is captured, the VTM was extended to the New Jersey State waters. COWI has developed in-house tools to process and analyze AIS data, which allowed analysis of the entire study area within a single model.

To generate the grid for the study area, two sub-grids were first prepared. Each sub-grid was created in a projected coordinate system (State planes) to increase local precision, then converted to a geographic coordinate system (EPSG:4326)—then merged into a single grid representing the entire study area. This was done to avoid spatial distortion of grid cells located outside of the corresponding coordinate system projection area. The following sub-grids were created and shown in Figure 10 and Figure 11:

- Sub-grid South (EPSG:6538, NAD83(2011)/New York Long Island).
- Sub-grid North (EPSG:6536, NAD83(2011)/New York East).

The final production VTM is defined by the sum of these two sub-grids. It should be noted that for actual analysis of AIS data, a single merged grid was used—sub-grids were only used during grid generation.

Figure 10. Sub-grid South (EPSG:6538)

Source: COWI (December 2021); ESRI Ocean

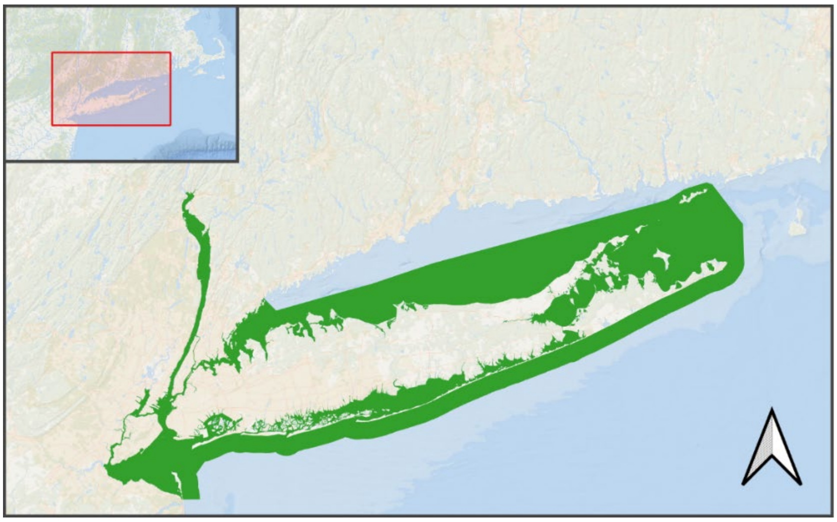
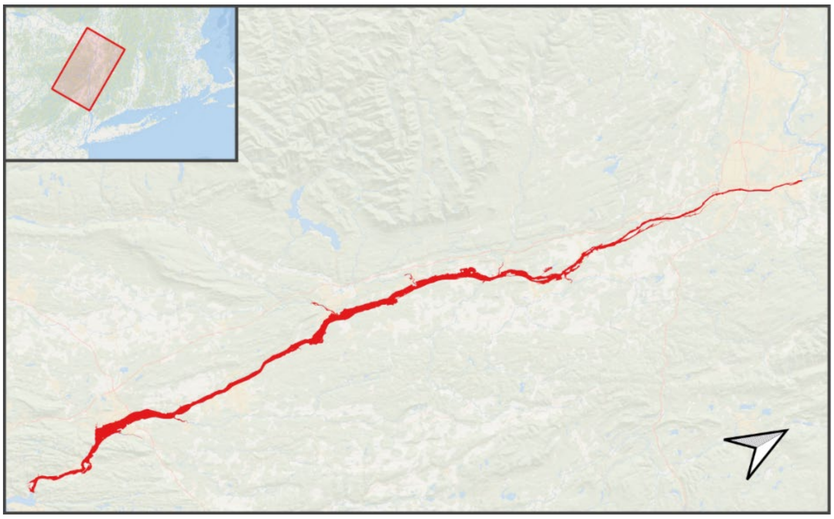


Figure 11. Sub-grid North (EPSG:6536)

Source: COWI (December 2021); ESRI Ocean



3.2.3 Grid Generation

The grid within each of the sub-domains shown earlier was generated as regular hexagonal (honeycomb) grid with a 100-meter resolution, consistent with similar analyses performed by the Marine Cadastre. The hexagon grid was chosen because, unlike the square grid, which has point contact between diagonal cells, all neighbors in a hexagonal grid are identical and, as a consequence of this, the resulting density maps generated upon such grid are more homogenous and exhibit less distortions caused by the grid having a preferred direction. Since the sub-domains were generated in different coordinate systems, they cannot be connected without creating a seam, as shown in Figure 13. This seam was created outside of the area of interest and has no effect on the analysis.

Figure 12. Grid Near the Southern End of Manhattan

Source: COWI (December 2021); Google Earth

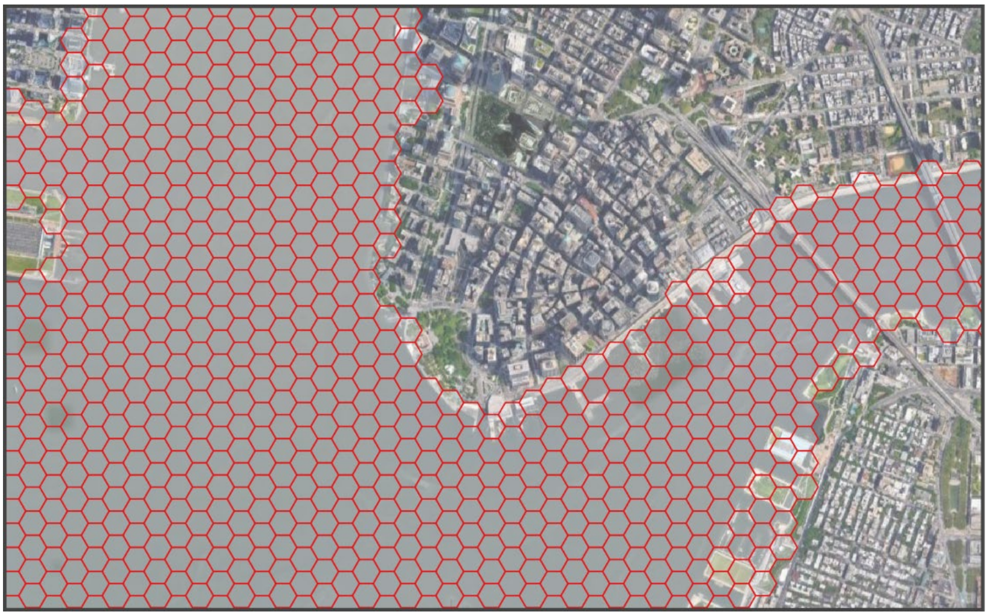
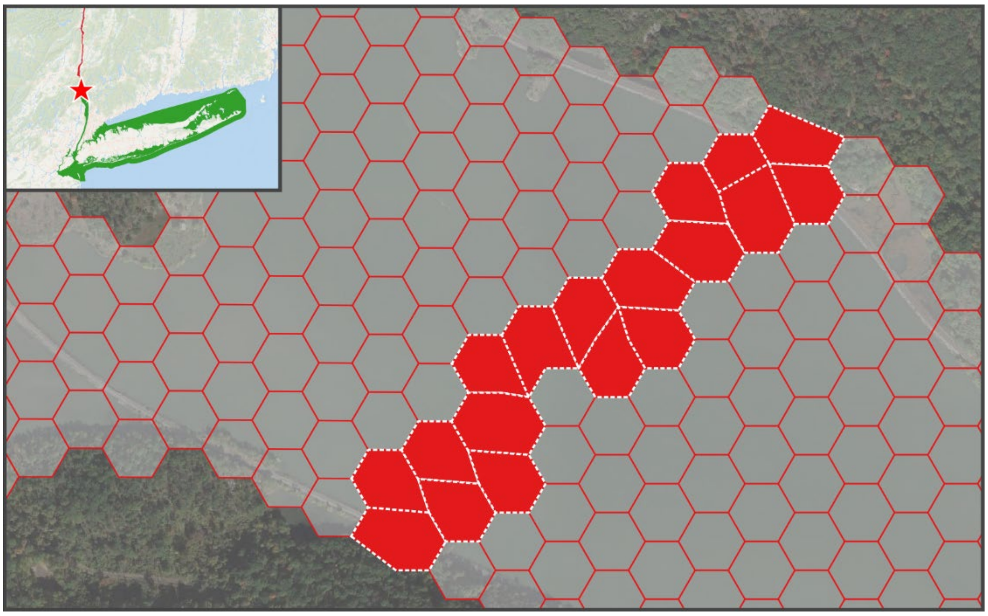


Figure 13. Seam between the Sub-Grids North and South

Source: COWI (December 2021); ESRI Ocean; Google Earth



3.2.4 OSW Ports

As per the scope of work, the overall goal of this task was the development of a vessel traffic density model capturing New York State's navigable waterways, inclusive of the facilities detailed in the PDE. Known and potential offshore wind ports as part of the PDE are shown in Figure 14 through Figure 17. More information about these facilities can be found in section 2, Table 6.

Figure 14. Known (Green) and Potential Future (Red) OSW Ports (1/4)

Source: COWI (December 2021); Google Earth

Figure 15. Known (Green) and Potential Future (Red) OSW Ports (2/4)

Source: COWI (December 2021); ESRI Ocean; Google Earth

Figure 16. Known (Green) and Potential Future (Red) OSW Ports (3/4)

Source: COWI (December 2021); ESRI Ocean; Google Earth

Figure 17. Known (Green) and Potential Future (Red) OSW Ports (4/4)

Source: COWI (December 2021); Google Earth

3.3 AIS Data Source

AIS data is the primary input to the VTM and was used to obtain a baseline estimate of non-OSW vessel traffic for the regions contained within the PDE.

3.3.1 Data Source

AIS data was obtained from the MarineCadastre.gov a platform jointly developed by the U.S. Department of Commerce’s National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management and the U.S. Department of the Interior’s Bureau of Ocean Energy Management (BOEM). AIS data available through the MarineCadastre.gov was collected by the U.S. Coast Guard (USCG) through its national network of AIS receivers. This data is processed and distributed by the MarineCadastre.gov in a form of CSV files as follows:

- Grouped by month and Universal Transverse Mercator (UTM) zone for years 2015 to 2017.
- Grouped by day (entire U.S. waters) for years 2018 to 2021 (latest by the time of this report).

Data prior to 2015 had vessel Maritime Mobile Service Identity (MMSI) codes encrypted and not corrected using the Authoritative Vessel Identification Service which was applied to all subsequent years.

3.3.2 Baseline Year 2017

This report focuses on establishing long-term trends for traffic increase caused by a combination of both OSW and non-OSW drivers. COWI's choice to select 2017 as baseline year was predicated on the following:

- COWI performed a qualitative comparison between 2017 and 2018 traffic using two different traffic data sources. COWI did not observe notable differences between years 2017 and 2018. Therefore, for the purpose of estimating long-term projections in traffic, 2017 and 2018 constitute an equally sound basis for anchoring these long-term trends.
- At the onset of this project, from a computational standpoint using 2017 data as baseline presented clear advantages over 2018 data due to a change in the data structure retained by the Marine Cadastre starting in 2018. Data in 2017 required significantly less computational power than 2018, which was critical to successfully deliver the platform COWI needed to perform the long-term estimations contained herein. However, throughout project execution, COWI has acquired capabilities to analyze years 2018 and beyond using cloud computing resources.

3.3.3 Impacts from the COVID-19 Global Pandemic

Years 2020 and 2021 exhibited noticeable vessel traffic anomalies, as per the data provided via the Vessel Traffic System (VTS) and made available to COWI via SUNY Maritime. These years were removed from our long-term estimation process. COWI did not compare AIS data for years 2020 and 2021, as this was outside the scope of work for this project.

3.3.4 AIS Data Features and Properties

Technical details about existing AIS data are provided in appendix B. AIS data features relevant to the analysis described further in this report can be summarized as shown in the Table 7.

Table 7. Summary of AIS Data Features Used in the Analysis

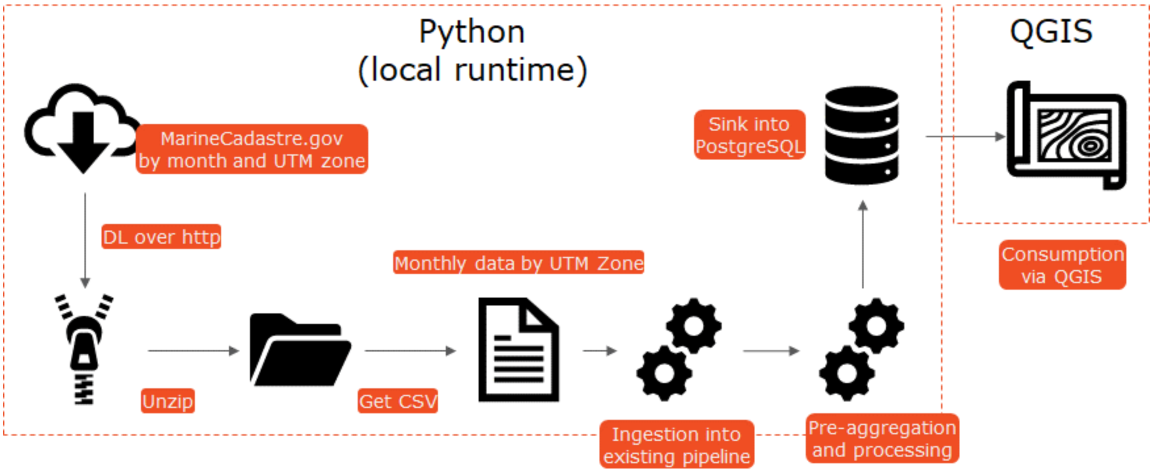
Feature	Description
MMSI	Unique vessel identification code.
Base DateTime	Universal Time Coordinated datetime of AIS entry (ping).
LAT	Latitude in decimal degrees.
LON	Longitude in decimal degrees.
SOG	Speed over ground in knots.
VesselType	Vessel type per NAIS classification (integer 0 to 1025). Was used to infer vessel group (e.g., fishing, passenger, etc.) and cargo classification using the "AIS Vessel Type and Group Codes used by the Marine Cadastre Project 2018 -05-23."

3.4 Vessel Traffic Model Platform

Because of the massive data challenges posed by the manipulation of large AIS data sets, COWI opted for development of in-house processing pipeline to meet the requirements of the project and to overcome challenges associated with high-throughput data streams using dedicated on-premises AIS data management system. A schematic of the VTM platform developed by COWI is shown in Figure 18.

Figure 18. Schematic of the Vessel Traffic Model Platform Developed by COWI

Source: COWI (December 2021)



3.4.1 PostGIS Database

A PostgreSQL relational database with PostGIS spatial extension allowing efficient storage and access to geospatial data was used as the central element of the AIS data management system. The database allows for convenient storage, retrieval, using programmatic access or third-party applications, such GIS.

3.4.2 Logic and Workflow

Additional processing capabilities were developed by COWI using programming language Python. AIS data from MarineCadastre.gov for 2017 was uploaded to the database system as follows:

- Data for each month for UTM zones 18 and 19 was downloaded from MarineCadastre.gov (ZIP archives with CSV files storing the data). UTM zones 18 and 19 fully cover the study area.
- Data from each of the CSV file was clipped to geographic extents of the model as defined earlier:

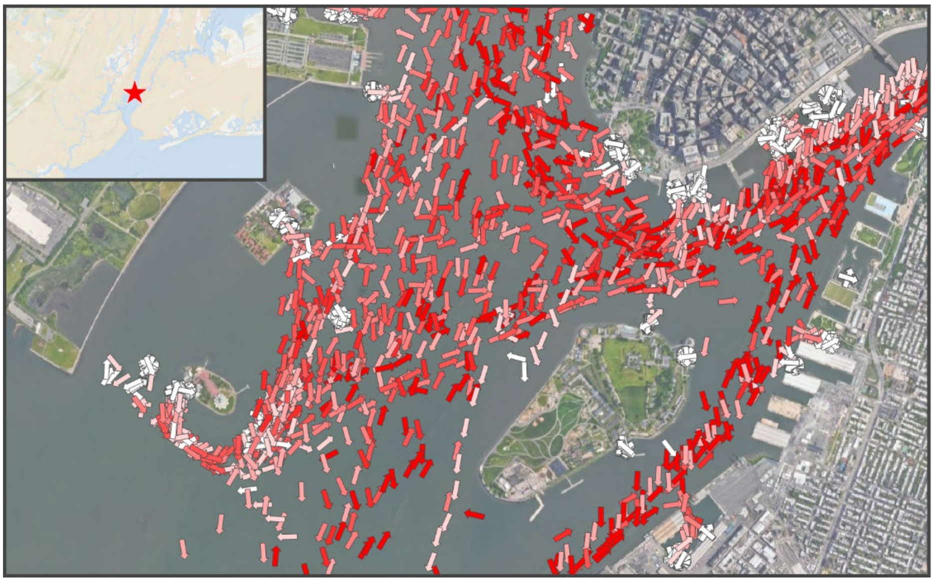
  Longitudes from -74.40 to -71.60 degrees
  Latitudes from 40.40 to 42.90 degrees

- Duplicate entries were removed. Uniqueness of each entry was defined by MMSI and datetime. If duplicate entries were found, only the first one was kept. Duplicate entries were typically observed between zones and months when the same data "spilled over" to adjacent data chunk.
- Resulting data was uploaded to the database. An example of the existing data uploaded to the database visualized using QGIS is shown in Figure 19.

Figure 19. Existing AIS Data near the Southern Tip of Manhattan

Two hours of data. Vectors are colored using speed over ground (SOG) and oriented using course over ground (COG).

Source: COWI (December 2021); ESRI Ocean; Google Earth



3.4.3 Vessel Coordinate Reference Systems

Vessel coordinates provided via AIS have a coordinate reference system given by European Petroleum Survey Group (EPSG) code 4269, which stands for North American Datum of 1983. Vessel coordinates are stored in the database using EPSG:4326 (WGS84), which is a global system and stands for World Geodetic System 1984.

3.5 Summary of Findings

A VTM platform was built. The platform is powered by the Python language and allows the visualization, processing, and extraction of Automated Information System (AIS) data provided by the Marine Cadastre, as well as custom data created by COWI as part of the OSW vessel traffic forecast. The VTM platform comprises a PostGIS database connected to a GIS for visualization and consumption. Existing non-OSW vessel traffic data was loaded for representative year 2017. Data for this year was downloaded, processed, and analyzed via an AIS data management platform. This included:

- Definition of study area (New York State waters, 3 nm from coastline).
- Downloading and processing raw AIS data for the area.
- Generation of individual vessel tracks from the raw AIS data.
- Generation of transit count (density) map for a hexagonal grid developed within model extents.

The VTM enabled the estimation of baseline non-OSW vessel traffic at any locations within the area delineated in the PDE. The VTM also enabled the visualization and processing of OSW data developed as part of this task and documented in the subsequent sections. The VTM served as a basis and key infrastructure element required to perform all subsequent tasks within this study.

4 Non-OSW Traffic Assessment

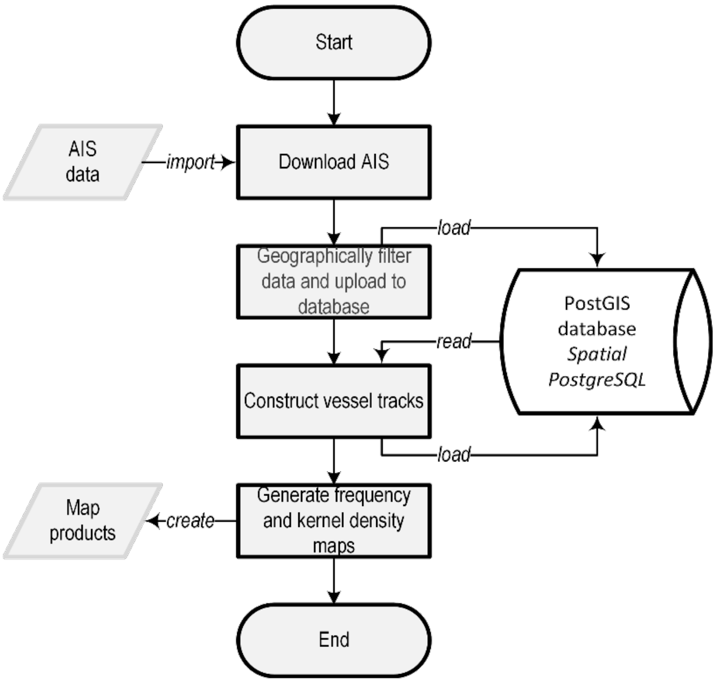
4.1 Baseline Non-OSW Traffic Assessment

4.1.1 Approach

Using the VTM presented earlier, COWI generated vessel tracks, which were used to estimate baseline non-OSW traffic. That estimate is exclusive of any OSW-induced traffic. A visual representation of the approach for filtering and processing AIS data points is shown below.

Figure 20. Illustration of Processes, Input, Output, and Relation to the PostGIS Database

Source: COWI (December 2021)



After the AIS data was uploaded to the database the next step was to connect raw AIS pings into vessel tracks. To do that, data was first grouped by MMSI to separate pings for unique vessels. Only entries with MMSI codes starting from two to seven and having nine digits were processed—according to the Recommendation M.585 by the International Telecommunication Union, only MMSI codes meeting these criteria correspond to individual ships.

4.1.2 Generation of Vessel Tracks

To accurately analyze vessel traffic COWI has generated vessel tracks. A vessel track is defined as a sequence of AIS pings ordered by time corresponding to ship travelling between two locations. AIS pings not assigned to the tracks are assumed to be idle, i.e., when vessel is not in motion (such as anchored, moored, aground, etc.). Vessel tracks were generated via the following procedure:

- AIS pings are sorted by time and then split into segments separated by either 30 minutes or 1610 meters (one statute mile). The assumption is that any pings separated by such time or space cannot be a part of the same continuous track. This is consistent with methodology employed by the Marine Cadastre when separating independent vessel voyages.

For each of these segments, periods of idling were identified using the following criteria:

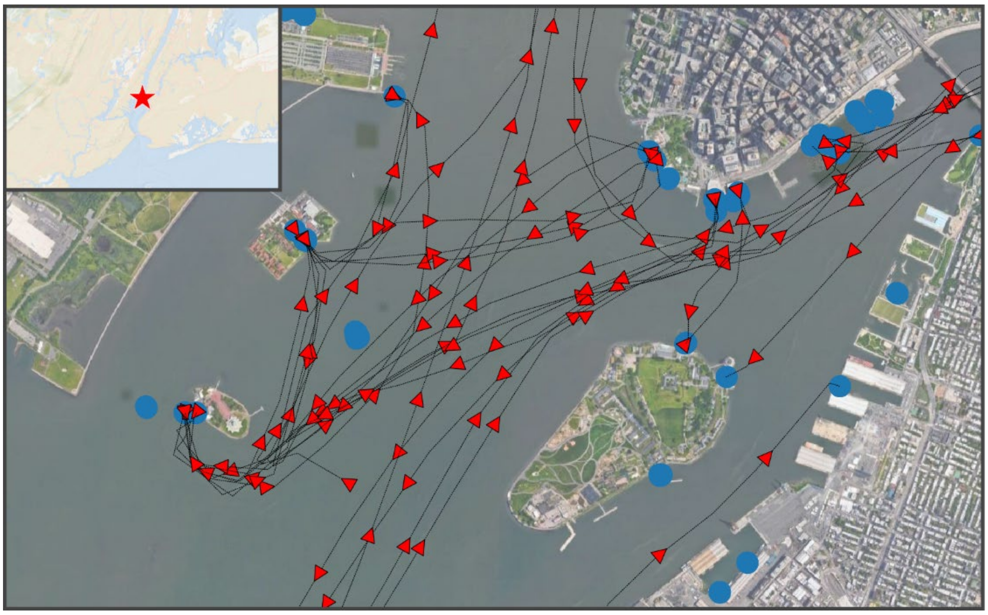
- SOG smaller than 0.5 knots and idling duration is 5 minutes or longer.
- Continuous sequences of pings which are not separated by periods of idling are then connected together to form vessel tracks.
- Tracks shorter than 3 minutes or 300 meters are filtered out.
- Remaining vessel tracks are then uploaded to the database.
- AIS pings which were not used to build vessel tracks are marked as idle and saved in the database separately. This was done to avoid registering anchored, moored, or drifting vessels in the spatial analysis. With New York State as a major marine hub, most AIS data entries correspond to vessels that are idle (moored or anchored).

An example of vessel tracks generated using the procedure above is shown in Figure 21. Due to the analytical procedure, it was impossible to separate independent tracks with 100% accuracy–for example, a ferry would often stop only for a few minutes which would be represented by a single entry in the AIS data, and the entire daily operational cycle for such ferry would be represented by a single track. Only once the vessel is moored for the night is it marked as idle. However, this has no effect on the spatial model or risk analysis, as demonstrated further in this report.

Figure 21. Vessel Tracks Generated for Existing AIS Data

One hour of data. Red arrows represent direction of vessel movement (does not always match reported heading). Areas of idling are shown in blue.

Source: COWI (December 2021); ESRI Ocean; Google Earth



4.1.3 Spatial Analysis

Spatial analysis in this study entails generation of transit count maps using grid and vessel tracks generation of which was covered in the previous sections. Vessel transit counts were developed instead of making point density maps due for a more accurate and easily interpretable approach. The biggest issue with traditional density maps where AIS pings are used instead of tracks—a derivate of pings—is that areas with more pings are given higher priority while those with fewer pings get less weight despite potentially having the same or larger number of vessel passages. This can happen due to vessel travelling at higher speeds and reporting positions at specific time intervals, thus not registering in those cells it passed without "pinging." It should be pointed out that over a long record these are expected to average out and have lesser effect on the plot, but transit counts allow the team to avoid dealing with this issue altogether.

Transits are counted for each grid cell individually, hence the vessel is counted in all of the grid cells it passes through on its way from its departure location up to its destination. Within each of the individual cells a transit is defined using the following rules:

- Vessel enters and then exits a cell (most frequent).
- Vessel starts a voyage within a cell and then exits the cell.
- Vessel starts a voyage outside a cell, then enters it and ends its voyage while inside the cell.

Many vessels have complex tracks where a vessel can enter and exit the same cell multiple times within a single track. A common example of this is a ferry that travels back and forth between two locations (remember, short stops are not detected and result in long tracks for such vessels), a fishing vessel which often drifts in the same area, or a tug that performs multiple tasks in an area before going idle (mooring, anchoring, etc.).

A detailed description about how transits are identified and counted is provided in appendix C.

Transit counts were calculated for each grid cell and for each vessel and then aggregated by the following vessel groups (consistent with the USCG Port Access Route Studies reports and Marine Cadastre classification):

- All vessels
- Cargo
- Fishing
- Passenger
- Tug-Tow
- Tanker
- Other

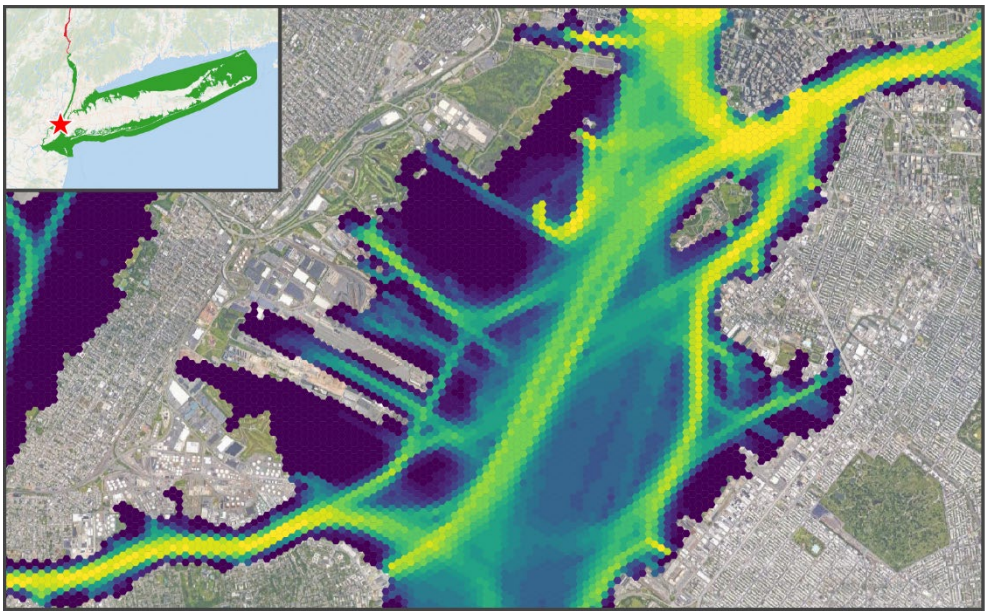
4.1.4 Traffic Density Estimation

This task has culminated in development of a model representing vessel traffic density (transit counts) for the study area for existing conditions defined in this study as year 2017. This model can be visualized using a heatmap where each cell is colored depending on number of transits for a given vessel type. Figure 22 illustrates that concept. More information about grid generation is given in appendix C.

Figure 22. Existing Vessel Traffic Density (2017)—All Vessels

Colormap is green with brighter (yellow) colors indicating higher transit counts.

Source: COWI (December 2021); ESRI Ocean; Google Maps



4.2 Future Non-OSW Traffic Assessment

This section provides a summary of methodology used in and results of the future non-OSW vessel traffic assessment. Future non-OSW traffic was projected on an annual basis up to 2040 inclusively using publicly available data and reports and using an estimate of the compound average growth rate provided by SUNY Maritime, see appendix A.

4.2.1 Impact from the COVID-19 Global Pandemic

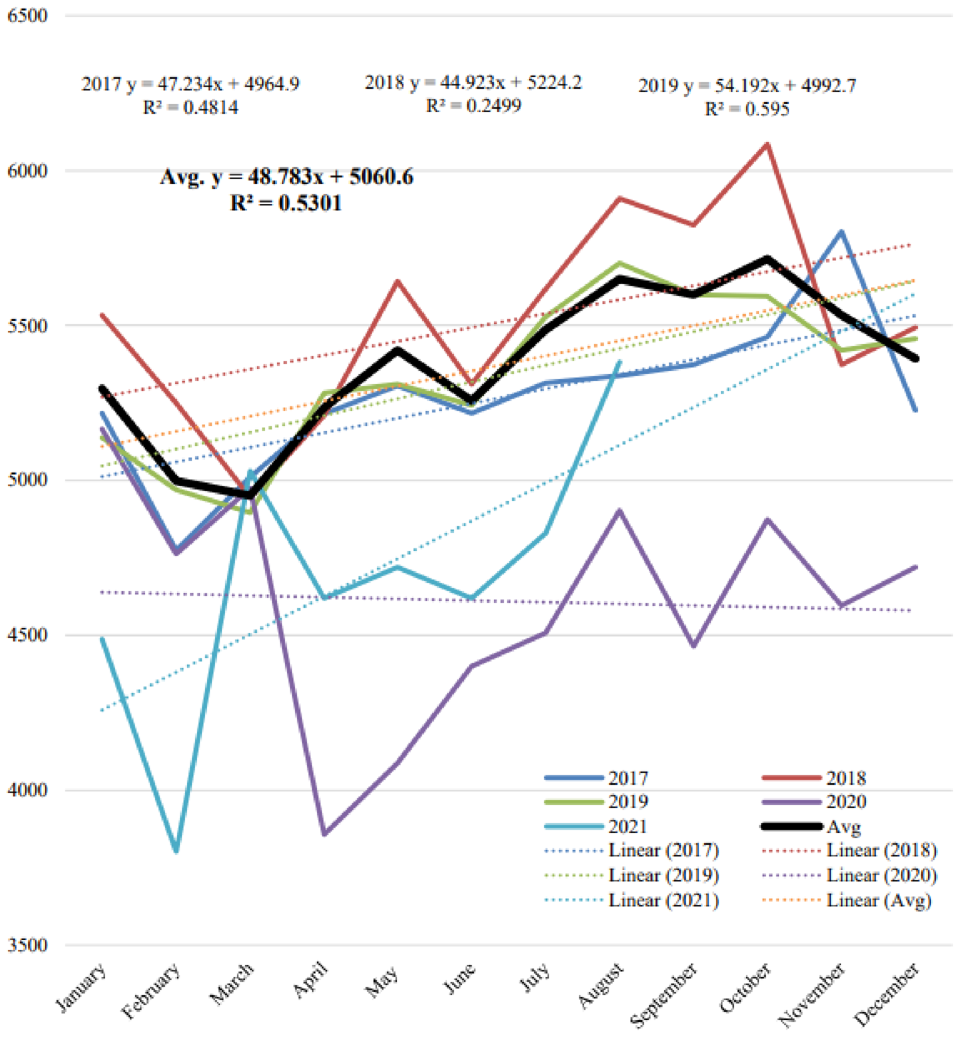
As stated in the 9-GW Port Uses and Navigational Assessment report prepared by SUNY for COWI, the pandemic has been impacting economic activities since February 2020.

The future economic impact is still not clear because the pandemic's impact is still not settled; this might take some time. The pandemic has been causing irregularities in the activities of the Port of New York, as recorded by VTS, illustrated in the figure below, and noted in the national supply chain. The figure shows that both 2020 and 2021 traffic volumes at key locations within the project area continue to exhibit significant departures from yearly trends in traffic. Therefore, the projections provided in the report were built on years up to 2019.

Figure 23. Monthly Analysis of VTS In-and-Out of the New York State Region

Provided by SUNY Maritime for COWI. See appendix A for more details.

Source: SUNY Maritime (December 2021)



4.2.2 Compound Average Growth Rate Assessment

Notwithstanding challenges posted by the COVID-19 impacts on vessel traffic, SUNY Maritime developed a methodology to estimate the rate of growth of vessel traffic using VTS data obtained by SUNY via the USCG. Based on the date provided, SUNY Maritime and COWI determined that a reasonable, average compound growth rate (CAGR) for all vessel classes is 0.8%. That is, on any given year, vessel traffic increases by about 0.8% year over year. For a detailed description of the analysis conducted by SUNY to determine long-term estimates, refer to appendix A.

4.2.3 Growth Rate by Vessel Type

In this project a growth rate was calculated using VTS data provided by the Coast Guard and analyzed by SUNY (see appendix A). In this iteration a flat rate was calculated for all vessel types. That said, it is acknowledged that some factors may unevenly affect vessel types. For instance, fishing permits will condition how many fishing vessels are allowed to operate in the project area. In this case, the flat rate approximation is mitigated by the fact that fishing vessels represent a very small share of all traffic in the project area. Passenger vessels respond to demand caused by urban growth, while cargo or tanker vessel traffic ultimately respond to demand from industrial activity. Generally, those two types of drivers tend to be in lock step, which provides further support for applying a uniform growth rate.

This project is focused on capturing the overall long-term trends affecting traffic in the project area, and it was considered reasonable to apply the same rate of growth for all vessel types. The approach retained for estimating long-term trends does provide the opportunity to fine-tune projections per vessel type, as is described below. This opens the way for refinement in the analysis in future iterations of this project.

4.2.4 Future Vessel Traffic Model

Spatial models for future vessel traffic were developed using existing 2017 model as baseline by multiplying transit counts within each grid cell by an appropriate factor (1 meaning no change, 1.1 meaning +10% increase relative to 2017). These factors were based on the model developed by SUNY and comprise a transfer operator (matrix) shown in Table 8. Total traffic density is estimated via summation of all other classes (including Other). The computational framework built to calculate future vessel traffic allows for the application of different factors for each vessel type, should the need arise.

Table 8. Future Vessel Traffic Transfer Operator

Year	Other	Cargo	Fishing	Passenger	Tanker	Tug-Tow
2017	1.000	1.000	1.000	1.000	1.000	1.000
2020	1.024	1.024	1.024	1.024	1.024	1.024
2025	1.066	1.066	1.066	1.066	1.066	1.066
2030	1.109	1.109	1.109	1.109	1.109	1.109
2035	1.154	1.154	1.154	1.154	1.154	1.154
2040	1.201	1.201	1.201	1.201	1.201	1.201

4.3 Summary of Findings

4.3.1 Baseline Non-OSW Vessel Traffic Assessment

The VTM was fed one year (2017) of AIS data maintained by the United States Government and available freely from marinecadastre.gov. The processing of AIS data is the main deliverable associated with this task. Transit count maps were developed and informed the selection of Passage Line locations. Transit count maps are presented in appendix D.

4.3.2 Future Non-OSW Vessel Traffic Assessment

Future non-OSW vessel traffic was developed for years 2017 (existing) to 2040 inclusive. The future traffic estimates are to be used to benchmark the impacts of traffic incurred by the proposed OSW projects. COWI and their partner SUNY Maritime acknowledge the inherent uncertainties related to variables such as climate change, logistics, political climate, industry trends, and others determining future conditions. With that said, the assumed vessel traffic growth rate for all vessel categories as defined in PARS was estimated at 0.8% per year.

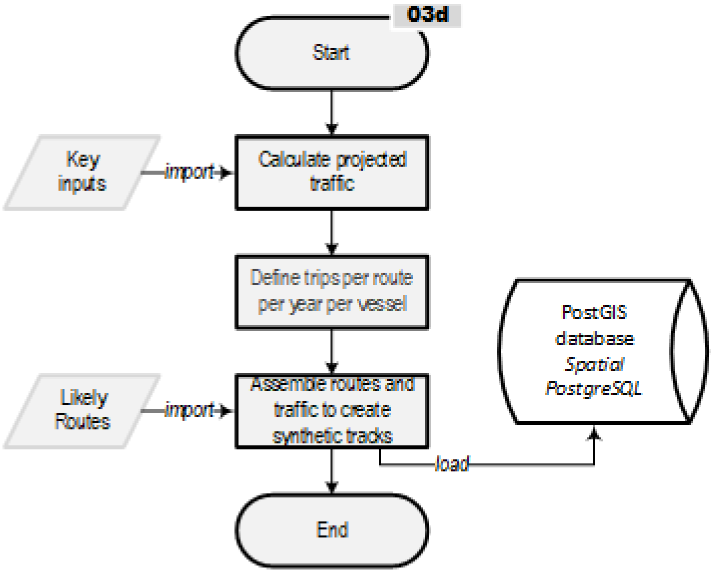
5 OSW Vessel Traffic Forecast

5.1 Approach

The approach to estimating OSW-induced Vessel Traffic comprises two steps. The first step consisted of estimating traffic as a result of constructing the OSW projects. That traffic is usually contained within a few years leading to project delivery. The second step consisted of estimating traffic incurred by operations and maintenance. That traffic usually spanned the entire planned design life of the OSW projects considered in the study. Survey and site characterization vessels are not included. The OSW-induced traffic was applied to synthetic vessel tracks that represented expected navigation routes.

Figure 24. Illustration of Processes, Input, Output, and Relation to the PostGIS Database

Source: COWI (December 2021)



5.2 Capital Construction

5.2.1 Methodology

To synthesize the number and location of vessel trips induced by OSW capital construction activities within the State, a number of variables and relationships were defined. These variables, such as port location, project size and location, capital construction component, and activity type, were then joined with relationships, such as WTG capacity to time, component to activity, activity to time, component to vessel, and component to route (see section 5.2.2), to produce an overall result of OSW vessel trip quantity and route, which serves as input to the GIS model and superimposed with the non-OSW. Based on the typical construction methodology of an OWF, it was determined that the vessel trips are most clearly defined based on the transportation flow of specific components (see (c) components below). The flow for all components included in an OWF was determined, where each flow follows the component from its fabrication/manufacturing stage to its installation stage at the OWF. Raw materials arriving to the manufacturing/fabrication facility are not considered due to the large amount of uncertainty in location and mode of transportation that cannot be accounted for in a model of this scale.

Once the logical flow of each component from its fabrication/manufacturing to installation was determined, a model incorporating project- and year-specific data was developed to establish vessel trips. Overall, the quantity of vessel trips will depend on the quantity of components being transported, while the route of vessel trips will depend on the start and end points (either a port or an OWF). Flowcharts demonstrating the basic logic behind component flow for each of the component types are included below, where the numbers indicate the number of components assumed to be transported by each vessel. It is noted that since vessel trip quantities for component transportation are not affected by whether a transit or feeder strategy is selected, only the transit strategy is included. The flow charts depict the scenarios assumed for this analysis based on a fully developed State supply chain (i.e., the year reflective of the year 2035). In reality, there may be variations on component flow strategy that deviate from what the flow charts depict. The author acknowledges that varying T&I strategies may be implemented increase or decreasing the quantity of vessel trips. Note that the intent of the flow charts and thereby the log behind the component transportation flow is to capture a likely scenario to develop the offshore wind induced VTM.

Figure 25. Foundation Component Flow Scenario

Source: COWI (December 2021)

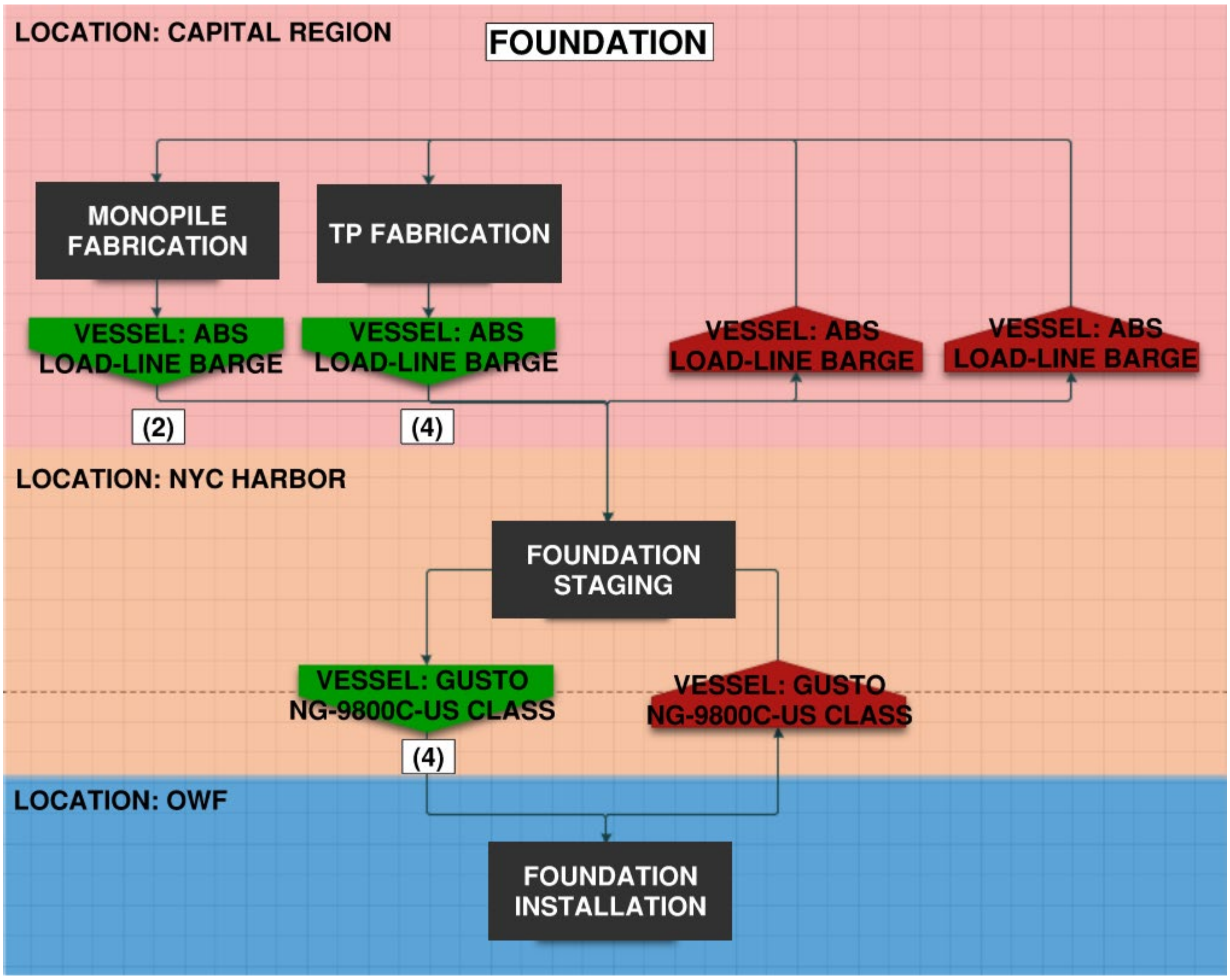


Figure 26. Cable Component Flow Scenario

Source: COWI (December 2021)

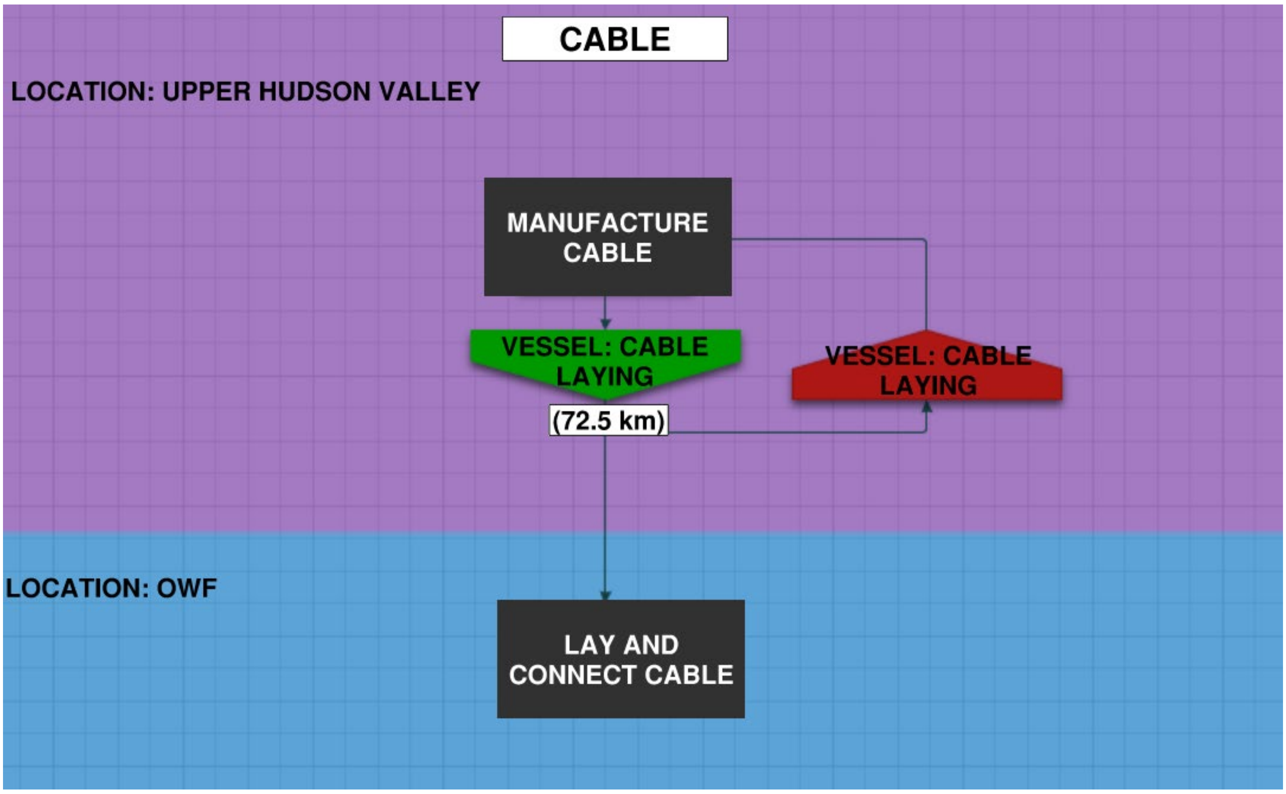


Figure 27. Offshore Substation Component Flow Scenario

Source: COWI (December 2021)

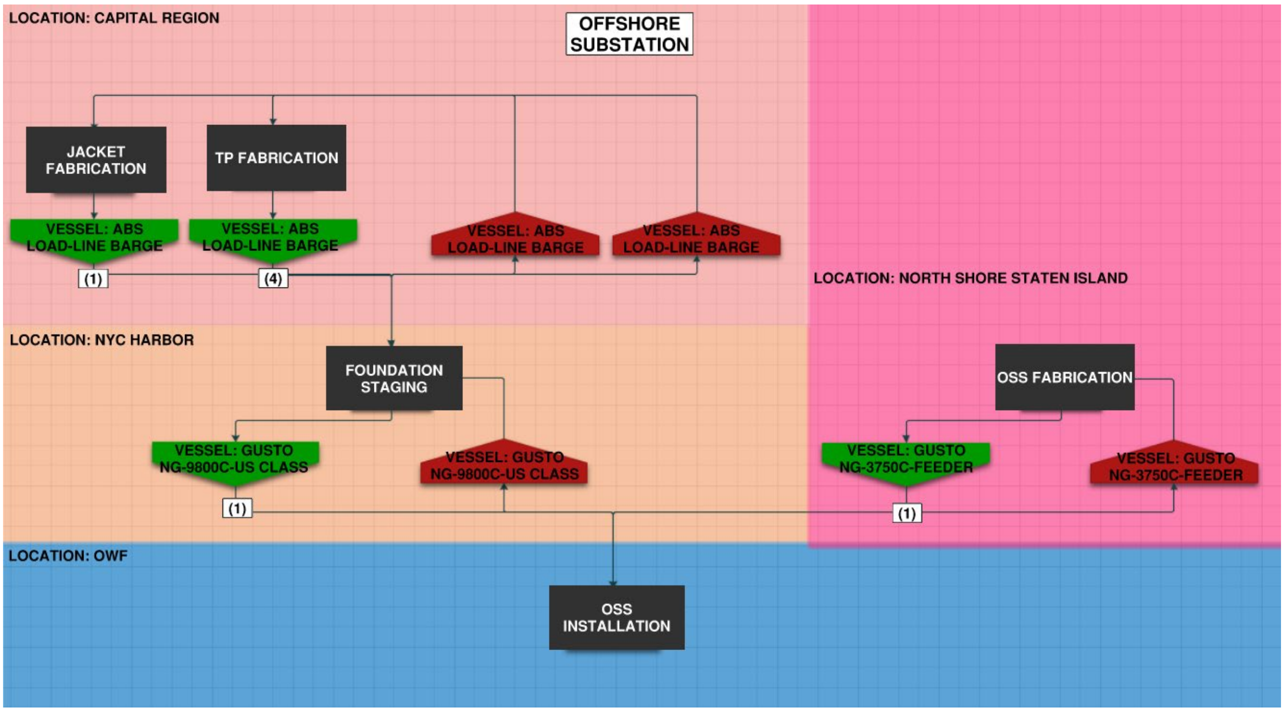
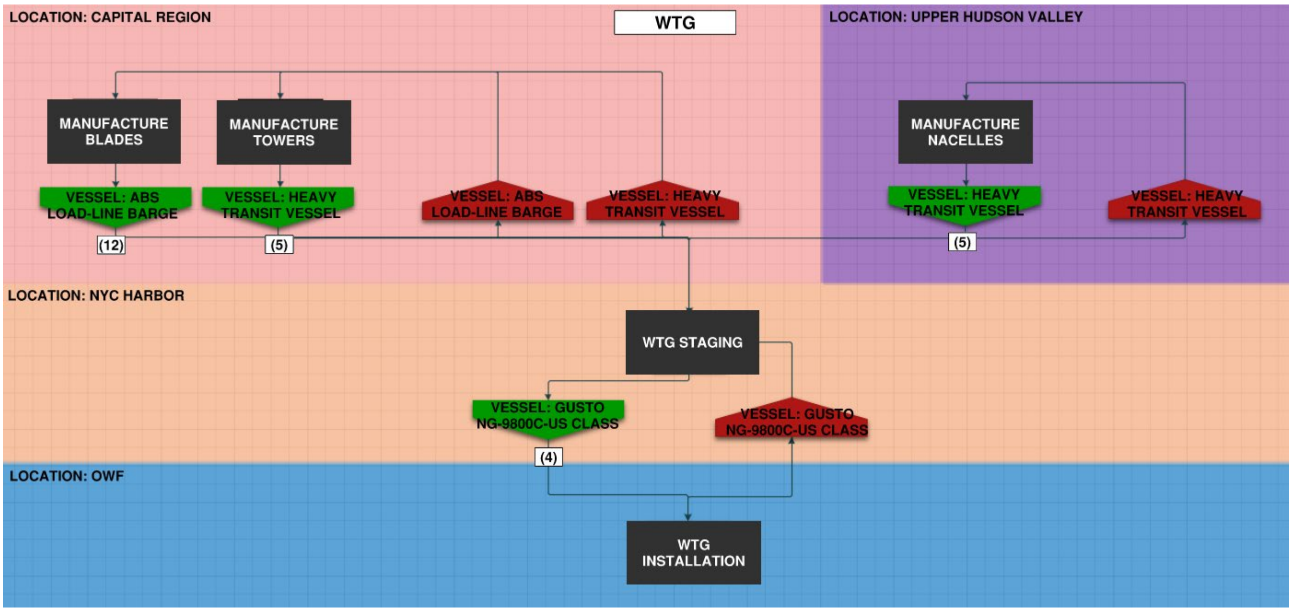


Figure 28. Wind Turbine Generator Component Flow Scenario

Source: COWI (December 2021)



Ultimately, the quantities and start/end points of components (and thereby the vessel trips) will depend on the year in focus. The quantity is dependent on year due to the planned procurement (MW) specific to each year, the unique fabrication/installation schedules that match each component, and the evolving average component capacity over time. The routes are dependent on year due to the availability of ports and announced project-specific commitments to ports (if any). Together, this combines to summarize that, excluding project-specific commitments, vessel trips can be related back to the relationship between the planned procurement in New York State for a given year and the status of the State supply chain of that same year.

5.2.2 Model Inputs and Functionality

The synthesized vessel trips were developed using a data model built using Power Query in Excel containing several unique variables and relationships that are joined to predict the number of vessel trips due to OSW activities.

The variables used in determination of vessel trips are user-defined immovable objects with defined characteristics. The variables and their respective functionalities within the model are described in the following sections.

5.2.2.1 Ports

The ports identify locations that vessels transit between as they transport OWF components, prior to final transit to the OWF. These include those in the PDE as previously defined (section 2.1.3). The New York State supply chain is not expected to be fully developed for several more years; therefore, there are instances where components will be transported from ports outside the State. Because the study area is confined to New York State, an additional location denoted "Outside NYS" is added to account for ports that are not within the study area. Each port is tabulated with its expected initial year of operability (named COD in the table and herein for simplicity), activity type, location, and area (acres). This information is used to inform where components are transported to and from, as well as the fraction of each component expected to be hosted at each location.

Table 9. Port Locations for Vessel Traffic

Port	COD[a]	Activity Type	Location	Area (acres)
SBMT	2023	Staging: WTG	NYC Harbor: South	30
SBMT	2023	Staging: Foundation	NYC Harbor: South	30
Port of Albany	2024	Manufacture: WTG–Tower	Capital Region	81.6
Port of Coeymans	2021	Fabricate: Foundation	Capital Region	33
Arthur Kill Terminal	2027	Staging: WTG	Staten Island: West	32
Port Ivory	2024	Fabricate: OSS	Staten Island: West	38
NYS Wind Port (East Greenbush)	2026	Manufacture: WTG–Blade	Capital Region	30
Cortland	2026	Manufacture: WTG–Nacelle	Upper Hudson Valley	40
Outside NYS	2017	Any	Outside NYS	Any

[a] Expected first year operable

5.2.2.2 Projects

Projects are defined based on State procurement. This includes both announced projects and those assumed based on State commitments or goals for OSW procurement, paired with respective in-service dates. This is the same procurement used to inform the RPSDM. Based on its capacity (MW), each project will have an associated number of components transported.

Table 10. Projects for Vessel Traffic

Project	Capacity (MW)	COD	Anticipated WTG Capacity (MW)[a]
South Fork	132	2023	8
Empire Wind	816	2024	12
Sunrise Wind	932	2024	8
Empire Wind 2	1260	2027	12
Beacon Wind	1230	2028	15
Project 2029[b]	1250	2029	15
Project 2031[b]	1250	2031	15
Project 2033[b]	1250	2033	15
Project 2035[b]	1250	2035	16

[a] These capacities are representative of the data available at the time of analysis, and actual WTGs used for projects are subject to change as projects undergo the development process. Since it is expected that WTG capacities for projects, if they are to change, will increase, the WTG capacities included in this table are considered conservative assumptions for use in the VTM, whose quantities of vessel trips are dependent on number of turbines installed for projects.

[b] Projects 2029 and beyond are indicative for the purposes of analysis only. The project years, capacity, COD, anticipated WTG Capacity, and location should not be used as an inference of New York State policy or procurement intentions.

As noted in section 3, project CODs are subject to change as the offshore wind industry progresses. At the time of this report, COWI assumed CODs for each OSW project and initial operability years for each port that were based on current publicly available information.

5.2.2.3 Components

This variable defines the components comprising an OWF and considers all major pieces required to construct a viable OWF. As described above, the flow of components from fabrication to installation is the basis for determining vessel trips.

Table 11. Components Comprising each Offshore Wind Foundation

Component	Notes
WTG	WTG = Nacelle + Tower + Blade
Nacelle	---
Tower	---
Blade	---
Foundation	Foundation = TP + Monopile
TP	---
Monopile	Monopiles are the assumed foundation type.
Foundation (OSS)	Foundation (OSS) = TP (OSS) +Jacket (OSS)
TP (OSS)	---
Jacket (OSS)	Assume OSS foundation is jacket based on typical standard.
OSS	---
Cable	---

5.2.2.4 Activities

This variable defines the static activities that occur at each port location in support of OWF development. Each activity is associated with a component as defined in Table 11.

Table 12. Component-Based OSW Port Activities

Activity	Notes
Fabricate Foundation	Monopile type foundations, including transition pieces (TPs) for turbines. For purpose of this study, OSS foundation assumed to occur at same location.
Install Foundation	Foundation is assembled from components (monopiles and TPs) at staging port and installed as a whole.
Manufacture Cable	Assume direct ship of cable from manufacture facility to OWF.
Fabricate OSS	Assume direct ship of OSS topside unit from manufacture facility to OWF.
Manufacture WTG: Nacelle	Manufacturing of the components that comprise a WTG takes place at unique locations.
Manufacture WTG: Tower	
Manufacture WTG: Blades	
Install WTG	WTG unit is assembled from components at staging port and installed as a whole.

The relationships used in determination of vessel trips are also user-defined and are used in combination with the variables. These typically provide links between the variables and time, or between the variables themselves. The relationships and their respective functionalities within the model are described in the following sections.

5.2.2.5 Wind Turbine Generator to Time

The average WTG nameplate capacities are expected to continue increasing over time. The schedule of capacities assumed is based initially upon the McClellan, 2019 study and is calibrated based upon industry observations (including announcements by developers, when available, of selected WTGs).

The nameplate capacity of a WTG in any given year directly correlates to the number of nacelles, towers, blades, and assembled WTGs required to construct an OWF. As previously discussed, the number of components is significant in that it defines the number of required vessel trips. Clearly stated, as the nameplate capacity of WTGs increases, less components should be required, as the total project capacity (MW) will be divided by a larger WTG capacity (MW), resulting in less vessel trips.

While WTGs increase in nameplate capacity and resultingly decrease in number of moveable components, their sizes are also expected to increase at least somewhat. This increase in size may affect the number of components that are able to fit on a given vessel. This is addressed in 5.2.2.8.

5.2.2.6 Component to Activity

The purpose of the component-to-activity relationship used in the model is to connect each project component to its activity(ies). This essentially links the component to the applicable activities and is used in determining start and end points for the component since each activity is linked to a specific port location. Table 12 above supplements the logic in defining the component to activity link.

Table 13. Component-to-Activity Relationship

Component	Activities
WTG	Install WTG
Nacelle	Manufacture WTG: Nacelle
Tower	Manufacture WTG: Tower
Blade	Manufacture WT: Blade
Foundation	Install Foundation
TP	Fabricate Foundation
Monopile	Fabricate Foundation
Foundation (OSS)	Install Foundation
TP (OSS)	Fabricate Foundation
Jacket (OSS)	Fabricate Foundation
OSS	Fabricate OSS
Cable	Manufacture Cable

5.2.2.7 Activity to Time

The activity to time relationship consists of the Fabrication and Installation Schedule used in the RPSDM. The relationship is unique for each activity and consists of decimal values that sum to unity, signifying the fraction of the activity that will be completed in one year. The years are identified as the number of years prior to the commercial operation date (COD).

The fraction of an activity completed in a year will determine the fraction of the associated component that is transported in the given year. For example, the activity Fabricate Foundation takes place over 2 years: COD-3 years, and COD-2 years. Based on this, half the foundations will be shipped following fabrication in the COD-3 year, and the other half will be shipping in the COD-2 year.

5.2.2.8 Component to Vessel

The component-to-vessel relationship links each component to a vessel type, vessel class, and vessel capacity for the component. The vessel type is assigned to each type of component based on studied transportation methods typical of industry practice and the NYSERDA U.S. Jones Act Compliant Offshore Wind Turbine Installation Vessel Study (GustoMSC, 2017). The vessel class is also assigned based on the Atlantic Coast Port Access Route Study (ACPARS) (United States Coast Guard, 2015) study and was determined by matching the assigned vessel type with the most closely matching USCG vessel class. The vessels considered are outlined in the table following. Vessel draft was used to inform generation of OSW traffic tracks.

Table 14. Capital Construction Vessels Used for Analysis

Vessel	Draft (ft)	ACPARS Class
WTIV (Gusto NG-9800C-US Class)	19	Other
Heavy Transport Vessel (HTV)	26.6	Cargo
ABS Load-Line Barge	14.3	Other
Jack-Up Feeder Barge (Gusto NG-3750C-FEEDER)	19	Other
Cable-Lay Vessel	25	Other

The vessel capacities are determined based on industry knowledge and experience, calculations based on component size and weight versus vessel size and load capacity.

Vessel capacity (in number of units) for a given component will depend on the component size and weight. As mentioned in 5.2.2.5 above, WTG nameplate capacity will increase with time. While the relationship between nameplate capacity and WTG size is not absolutely linear, it is assumed that WTG size will increase with nameplate capacity. However, as the offshore wind industry evolves, larger vessels are also being designed and constructed to specialize in accommodating the transport of not only larger components, but larger quantities of components. An example of this is the *Zhi Xian Zhi Xing,* which was used to transport 156 Vesta V120 turbine blades in one trip from China to Europe (Lee, 2019).

Based on the concurrent, continuing evolution of both WTG size and vessel capacities and due to uncertainty in what specific vessels will be utilized in the New York State OSW supply chain, a clear relationship between increasing WTG nameplate capacity and vessel component capacity cannot be accurately defined for use in the model. Instead, to more accurately obtain values for vessel capacities based on component, a representative WTG was selected.

The WTG-to-time relationship results in an average WTG capacity between 14–15 MW over the study years. Based on this and considering the WTG capacities that have been announced for forthcoming projects, a representative WTG of 14–15 MW was considered in determining vessel capacities for components. The component sizes and weights for this representative turbine are based on information provided by turbine manufacturers, including the GE Haliade X-14 (de Vries, 2019).

Based on the vessel classes and vessel capacities, the relationships for component to vessel were developed as given in the following table.

Table 15. Component-to-Vessel Relationship

Component	Vessel Type	Vessel Class	Capacity (#)
WTG	WTIV (Gusto NG-9800C-US Class)	Other	4
Nacelle	HTV	Cargo	5
Tower	HTV	Cargo	5
Blade	ABS Load-Line Barge	Other	12
Foundation	WTIV (Gusto NG-9800C-US Class)	Other	4
TP	ABS Load-Line Barge	Other	4
Monopile	ABS Load-Line Barge	Other	2
Foundation (OSS)	WTIV (Gusto NG-9800C-US Class)	Other	1
TP (OSS)	ABS Load-Line Barge	Other	4
Jacket (OSS)	ABS Load-Line Barge	Other	1
OSS	Jack-Up Feeder Barge (Gusto NG-3750C-FEEDER)	Other	1
Cable	Cable-Lay Vessel	Other	72.6 [a]

[a] Cable vessel capacity is measured in km of cable.

5.2.2.9 Project Component to Route

The project component to route relationship charts the vessel route of a component from the start to end point on each leg of its overall journey from its origin (fabrication/manufacturing) to its final destination. This data is used directly to determine the vessel routes for the study. The start and end points for the vessel routes are comprised of the ports (as defined in 5.2.2.1) and the offshore wind farms. As described in the methodology above, each component will originate at a specific port, then be transported to a destination. A tabulation of the generic start- and endpoints for components is provided below. The VTM considers each trip to between origin and destination to be a round trip (RT).

Table 16. Component Origins and Destinations

Component	Origin	Destination
Nacelle	Port: Manufacture Nacelle	Port: Staging WTG
Blade	Port: Manufacture Blade	Port: Staging WTG
Tower	Port: Manufacture Tower	Port: Staging WTG
Monopile	Port: Fabricate Foundation	Port: Staging Foundation
TP	Port: Fabricate Foundation	Port: Staging Foundation
Jacket (OSS)	Port: Fabricate Foundation	Port: Staging Foundation
TP (OSS)	Port: Fabricate Foundation	Port: Staging Foundation
WTG	Port: Staging WTG	OWF
Foundation	Port: Staging Foundation	OWF
Foundation (OSS)	Port: Staging Foundation	OWF
OSS	Port: Fabricate OSS	OWF
Cable	Port: Manufacture Cable	OWF

With the generalized component origins and destinations established, specialization was then performed for each project planned to occur within the study period. The projects are based on the procurement schedule (specifically for NYS) utilized for the RPSDM, which is a combination of announced OSW projects and State commitments. As in the RPSDM, there is uncertainty regarding the timing and size of future procurements; however, the COD and size assumptions utilized in the model are assumed to sufficiently represent the State OSW procurement schedule.

The development status of the State OSW supply chain is unique based on year. The specified origins and destinations for the components in each project reflect this. As the NYS supply chain matures, more ports will be online; therefore, more vessel trips between New York State ports and between the OWFs and State ports will occur. In determining the component routes specific to each project, the following was considered:

- Project COD.

  Known for announced projects, otherwise assumed per discussion on procurement schedule (Table 16.).

- Component lead time on project COD.

  Based on activity to time relationship (fabrication and installation schedule) as discussed in 5.2.2.7.

- Port COD.

  Announced for some known ports, otherwise assumed.

- Port area (acres).

The quantity of components fabricated/manufactured or staged at a port is controlled by the available area at that port. In turn, vessel trip quantity is controlled.

- Port commitments.

Announcements of project-specific port commitments are considered.

5.2.3 Model Outputs

The final product of the model is a tabulation of the vessel trips, which is utilized as input to the GIS WTM. The MS-Excel based model combines the variables defined above using pivot table functions to create an ultimate table of vessel trips organized by:

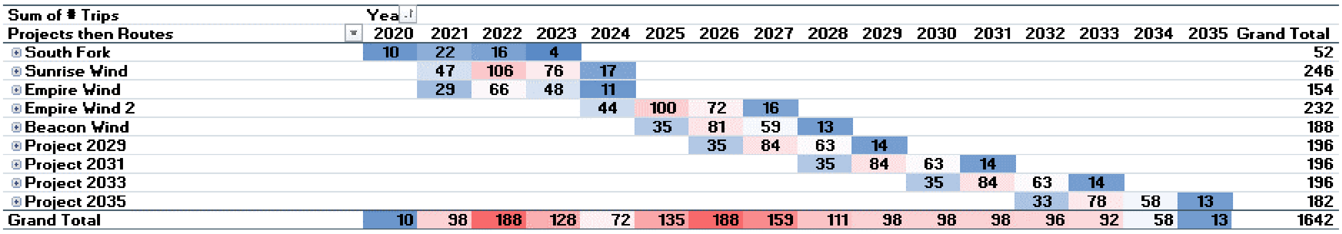
- Project
- Route
- Year
- Vessel Class
- Annual Transported Component Quantity on Route
- Annual Quantity of Trips on Route

Compilation of this information into a table for use as input allows the GIS model to demonstrate, by year, the vessel traffic volumes caused by OSW capital construction activities within State waterways. See the following for sample products. Figure 29 shows the expected capital construction vessel round trip for each project, for each year. Figure 30 shows the annual quantity of capital construction vessel round trips for each unique assumed vessel route.

As noted in section 2, project CODs, as well as port expected initial years of operability, are subject to change as the offshore wind industry progresses. At the time of this report, COWI assumed CODs for each OSW project and initial operability years for each port that were based on current publicly available information. Updates to CODs may result in shifting of the peak periods of construction activity and O&M activity. To account for this expected maturation of available data, COWI recommends that future iterations of the modeling exercise continue to incorporate available updates on CODs of offshore wind projects and port facilities.

Figure 29. Results: Snapshot of Capital Construction Vessel Round Trips per Year Incurred by OSW Projects

Source: COWI (December 2021)

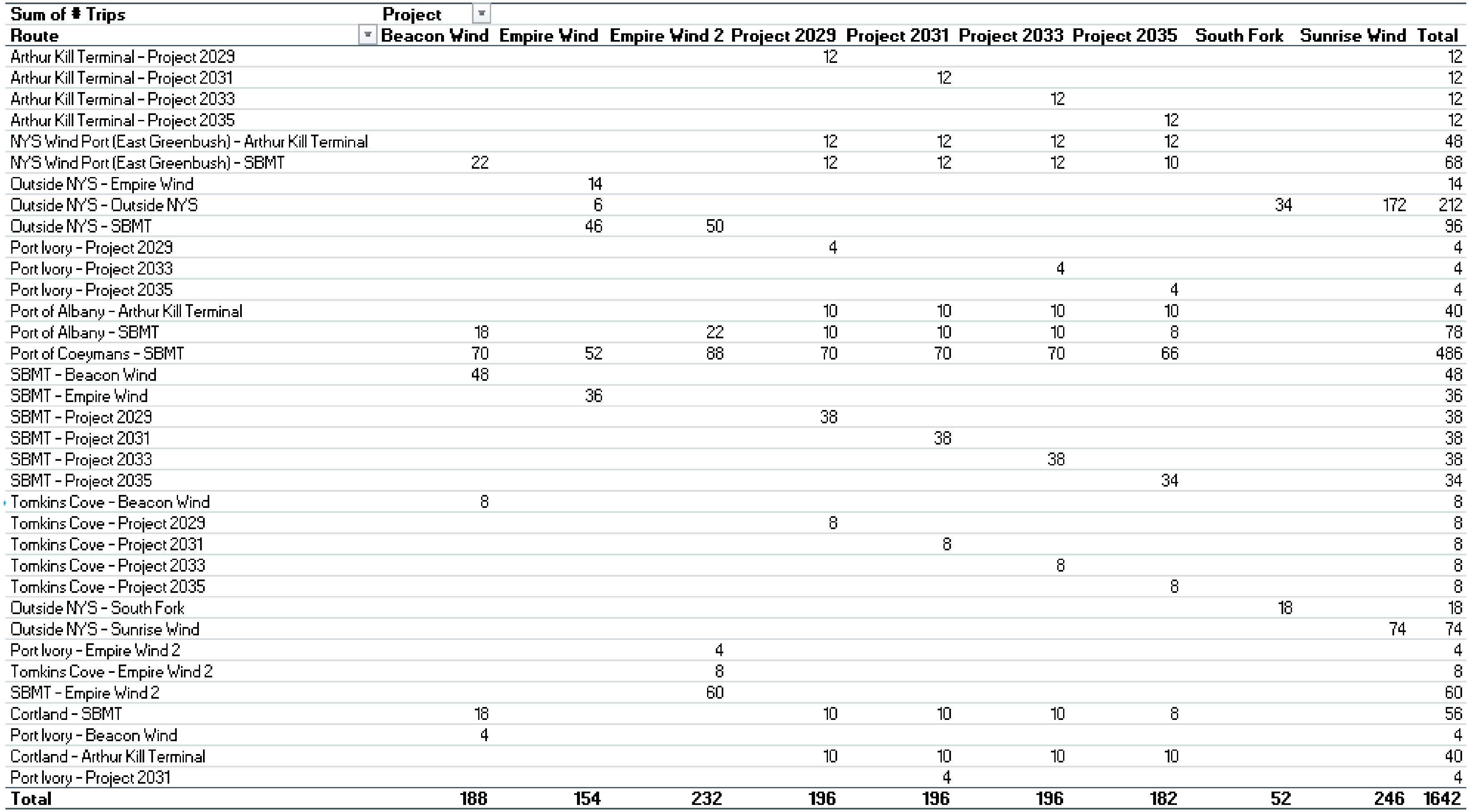


Sum of # Trips	Yea																
Projects then Routes	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Grand Total
⊞ South Fork	10	22	16	4													52
⊞ Sunrise Wind		47	106	76	17												246
⊞ Empire Wind		29	66	48	11												154
⊞ Empire Wind 2					44	100	72	16									232
⊞ Beacon Wind						35	81	59	13								188
⊞ Project 2029							35	84	63	14							196
⊞ Project 2031									35	84	63	14					196
⊞ Project 2033											35	84	63	14			196
⊞ Project 2035													33	78	58	13	182
Grand Total	10	98	188	128	72	135	188	159	111	98	98	98	96	92	58	13	1642

Figure 30. Results: Summary of Annual Capital Construction Vessel Round Trips Incurred by the Projects over the Study Period

Grouped by routes.

Source: COWI (December 2021)



Sum of # Trips	Project									
Route	**Beacon Wind**	**Empire Wind**	**Empire Wind 2**	**Project 2029**	**Project 2031**	**Project 2033**	**Project 2035**	**South Fork**	**Sunrise Wind**	**Total**
Arthur Kill Terminal - Project 2029				12						12
Arthur Kill Terminal - Project 2031					12					12
Arthur Kill Terminal - Project 2033						12				12
Arthur Kill Terminal - Project 2035							12			12
NYS Wind Port (East Greenbush) - Arthur Kill Terminal				12	12	12	12			48
NYS Wind Port (East Greenbush) - SBMT	22			12	12	12	10			68
Outside NYS - Empire Wind		14								14
Outside NYS - Outside NYS		6						34	172	212
Outside NYS - SBMT		46	50							96
Port Ivory - Project 2029				4						4
Port Ivory - Project 2033						4				4
Port Ivory - Project 2035							4			4
Port of Albany - Arthur Kill Terminal				10	10	10	10			40
Port of Albany - SBMT	18		22	10	10	10	8			78
Port of Coeymans - SBMT	70	52	88	70	70	70	66			486
SBMT - Beacon Wind	48									48
SBMT - Empire Wind		36								36
SBMT - Project 2029				38						38
SBMT - Project 2031					38					38
SBMT - Project 2033						38				38
SBMT - Project 2035							34			34
Tomkins Cove - Beacon Wind	8									8
Tomkins Cove - Project 2029				8						8
Tomkins Cove - Project 2031					8					8
Tomkins Cove - Project 2033						8				8
Tomkins Cove - Project 2035							8			8
Outside NYS - South Fork								18		18
Outside NYS - Sunrise Wind									74	74
Port Ivory - Empire Wind 2			4							4
Tomkins Cove - Empire Wind 2			8							8
SBMT - Empire Wind 2			60							60
Cortland - SBMT	18			10	10	10	8			56
Port Ivory - Beacon Wind	4									4
Cortland - Arthur Kill Terminal				10	10	10	10			40
Port Ivory - Project 2031					4					4
Total	**188**	**154**	**232**	**196**	**196**	**196**	**182**	**52**	**246**	**1642**

5.3 Operations and Maintenance

5.3.1 Assumptions

O&M demands for offshore wind projects are unpredictable by nature compared to capital construction activities. For the purpose of this study, only maintenance/repair activities necessitating visits to the turbines for repairs are considered. Typically, O&M activities are considered to consist of two types:

- Corrective: unplanned maintenance/repairs resulting from failure or malfunction.
- Preventative: planned (typically routine) maintenance activities.

O&M activities are considered for the OSW turbines and foundations. Repairs to export and array cables are not considered for the purpose of this study, as this repair type is typically observed to occur on a highly specific basis and is expected to necessitate low numbers of vessel trips in comparison to the turbine and foundation repairs.

Trip quantities will differ based on the O&M strategy utilized. The assumed number of vessel trips is separately determined for CTV- versus SOV-based strategies.

5.3.2 Methodology

With the number of annual required visits per turbine established as an assumption, an approximation in quantity of SOV and CTV trips to each project annually can be determined.

5.3.3 Model Inputs and Functionality

5.3.3.1 Project to Service Operations Vessel Trips

As mentioned in section 2.1.2.2, an SOV remains offshore at the OSW project site for a finite amount of time per trip. This duration offshore therefore provides a finite number of hours, which are based on the number of technicians transported by the SOV and their working shift lengths in hours, that can be allocated toward performing repairs. Thus, the annual number of SOV trips made to an OWF depends on the annual number hours that are required to be spent repairing the for the OWF.

The average time spent offshore by an SOV at the OWF is assumed to be 14 days based on developer information and typical industry standard observed for European projects.

In lieu of more recent data for larger turbines, the failure rates reported for a 5 GW turbine per NREL Operations and Maintenance Technical Report (Maples, Saur, Hand, van de Pietermen, & Obdam, 2013) are adopted for this study. The combined failure rate for the turbine components is taken as 4.5 failures per year. An additional three failures per year is reported for the foundations, summing to a total of 7.5 failures per year requiring corrective action visits by vessels. The failure rates of components are assumed constant over time.

Additional sources cite a total of five to 15 annual maintenance trips to each turbine annually. Considering the 7.5 failures cited prior as requiring corrective actions and considering this five to 15 range, it is assumed that an additional 2.5 preventative activities may occur per year, for a base assumption that, at minimum, 10 required repairs will be required for each turbine per year. This base number is multiplied by the number of turbines in a project, then times the average number of hours required for each repair, to determine the annual number of required repair hours for each OSW project.

To determine the final round trip quantity of SOV trips required per project per year, the annual number of required repair hours for each project is converted to days, then divided by the 14-day offshore duration of the SOV trip.

Based on increasing WTG capacities and projected megawatt capacity of each upcoming OSW project, the maximum number of turbines in an NYS OWF is predicted to be 110 turbines (Sunrise Wind). Therefore, since it is assumed that each OWF will be serviced by one SOV, and each turbine within the OWF requires 10 separate instances of repairs annually, it is assumed within the model that each NYS OWF project (excluding South Fork) will receive 10 SOV visits per year.

For the purpose of this study, this assumption is intended for use as a baseline to capture the likely scenario. In reality, maintenance and repair requirements vary unpredictably across turbine and foundation design and manufacturer, as well as OWF environmental conditions. Therefore, while it is not feasible to predict a definitive number of annual SOV trips for future years, the number presented in the assumption is taken to represent the range that may occur.

5.3.3.2 Project-to-Crew Transfer Vessel Trips

As described in Operations and Maintenance Facilities, CTVs are smaller in size than SOVs, and therefore have smaller capacity for technicians, tooling, and components. As such, a larger quantity of CTV trips will be required than SOV trips. The number of CTV trips to be made in a year can be scaled up from the assumed number for SOV trips. Following the assumption that each OWF requires 10 SOV visits per year, and assuming each SOV carries 60 technicians as mentioned in Operations and Maintenance Facilities, a total of 600 technicians is transported to each OWF annually to perform repairs. Since a CTV can carry only 12 technicians at once, this scales to 50 CTV trips per year.

5.3.3.3 Port to Project

It is assumed that each OWF project will be serviced by a vessel from a designated O&M port facility. The O&M port facilities outlined in the PDE are utilized to map SOV vessel routes from port to project. Some projects are already committed to specific O&M port facilities, while ports assigned to the remaining projects were assumed. A further specific tabulation of each NYS OWF project and the designated O&M port facility is provided below, building on the tabulation included in Table 5. Further detail on the selection of O&M port facility locations for the hypothetical PDE scenario is provided in section 2.1.3.2.

Table 17. Project-to-Operations and Maintenance Port

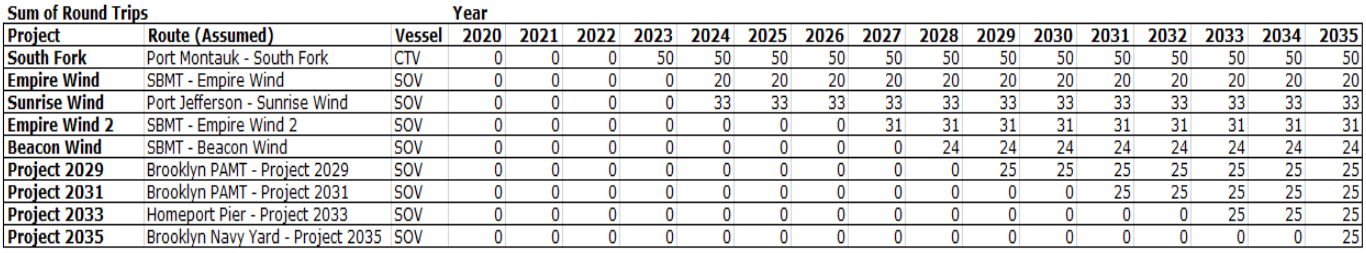
Project	MW	COD	O&M Port	Rationale
South Fork	132	2023	Port Montauk	Publicly announced (Kuntz, 2019).
Empire Wind	816	2024	SBMT	Publicly announced/rendered (Carleton, 2021), (businesswire, 2021).
Sunrise Wind	932	2024	Port Jefferson	Publicly announced (Durakovic, Orsted and Eversource Setting Up Offshore Wind O&M Hub on Long Island, 2020).
Empire Wind 2	1260	2027	SBMT	Publicly announced intention that Equinor will use SBMT as O&M hub (in addition to other developers) (businesswire, 2021).
Beacon Wind	1230	2028	SBMT	
Project 2029	1250	2029	Brooklyn PAMT	Assume Brooklyn PAMT will be capable of hosting (2) SOVs, (1) servicing each project.
Project 2031	1250	2031	Brooklyn PAMT	
Project 2033	1250	2033	Homeport Pier	Assume Homeport Pier will be capable of hosting (1) SOV.
Project 2035	1250	2035	Brooklyn Navy Yard	Assume Brooklyn Navy Yard will be capable of hosting (2) SOV.

5.3.4 Model Outputs

Based on the assumptions outlined in the previous section, SOV routes and the yearly quantity of trips along each route can be determined for input to the GIS model. As discussed in section 1.4 Assumptions, the number of SOV trips for each project remains constant over time, therefore the resulting input to the VTM is 10 annual SOV round trips along each route, where each route is defined with its start point (O&M port) and end point (OWF project). Similarly, the number of CTV trips (only assumed for South Fork) are also assumed constant over time, resulting in an input to the VTM of 50 CTV round trips along the respective route. Figure 31 summarizes this data. It shall be noted that despite the figure showing data only up to the end study year, O&M trips for OSW wind projects are expected to continue for the entire project lifetime—therefore, unlike capital construction vessel trips, which are expected to occur for the finite duration of a project's construction phase, O&M vessel trips are assumed to occur over a longer duration, based on a project's service life. Thus, a grand total value for vessel round trips is not provided for O&M, since continuation of yearly O&M vessel trips beyond the end study year renders the value arbitrary.

Figure 31. Results: Snapshot of O&M Round Trips per Year Incurred by OSW Projects

Source: COWI (December 2021)



Sum of Round Trips **Year**

Project	Route (Assumed)	Vessel	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
South Fork	Port Montauk - South Fork	CTV	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50
Empire Wind	SBMT - Empire Wind	SOV	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20
Sunrise Wind	Port Jefferson - Sunrise Wind	SOV	0	0	0	0	33	33	33	33	33	33	33	33	33	33	33	33
Empire Wind 2	SBMT - Empire Wind 2	SOV	0	0	0	0	0	0	0	31	31	31	31	31	31	31	31	31
Beacon Wind	SBMT - Beacon Wind	SOV	0	0	0	0	0	0	0	0	24	24	24	24	24	24	24	24
Project 2029	Brooklyn PAMT - Project 2029	SOV	0	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25
Project 2031	Brooklyn PAMT - Project 2031	SOV	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25
Project 2033	Homeport Pier - Project 2033	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	25
Project 2035	Brooklyn Navy Yard - Project 2035	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25

5.4 Further Offshore Wind Activities

There are additional activities beyond capital construction and O&M that are associated with offshore wind farm development. Due to the nature of the study, there were limitations on the types of OSW vessel traffic that could be predicted. The following sections discuss other OSW activity types that are also expected to contribute to vessel traffic within the study area.

5.4.1 Investigation

Each project will require its own investigation campaign prior to construction in order to satisfy site assessment and survey needs. These investigations may include, but are not limited to:

- Geophysical/Geotechnical investigation
- Hydrographic survey
- Biological resource characterization
- Guard Vessels
- Law enforcement/patrol vessels
- Others

These investigative efforts will require vessel transit between a given onshore location and the OSW project location. Vessel trips incurred by these efforts are not included within the study scope due to the project-specific nature of the activity. The hypothetical vessel routes, for example, cannot be clearly assumed: selection of the service provider who will perform the investigative effort is project-specific, and these providers tend not to be grouped by their service in locations within New York State. Therefore, an onshore vessel origin point cannot reasonably be assumed, and a vessel route cannot be formulated. Additionally, since investigative efforts are so project-specific, predicting the number of vessel trips using modeling methodology like the capital construction or O&M methodologies is not feasible.

Therefore, while this study limits the vessel transit predictions that can be made for vessels associated with this activity type, it should be assumed that investigative activities will contribute to vessel trip quantities along the respective activity- and project-specific routes.

5.4.2 Supplementary Vessels during Construction

During a project's construction phase, it is expected that additional support vessels, similar to CTVs, that are smaller in size compared to the capital construction vessels assumed in Table 14 will be required to transit between onshore facilities and the offshore wind farms. Similar to 5.4.1, vessel routes and trip quantities associated with construction support activities are highly project specific. The number of support vessel trips will depend on project-specific construction methodology and unique challenges that may be encountered during construction. Therefore, prediction of this number of vessel trips reaches beyond what the nature of this study allows; however, it is acknowledged that these supplementary vessels will also contribute to vessel trip quantities along the respective project-specific routes.

5.4.3 Decommissioning

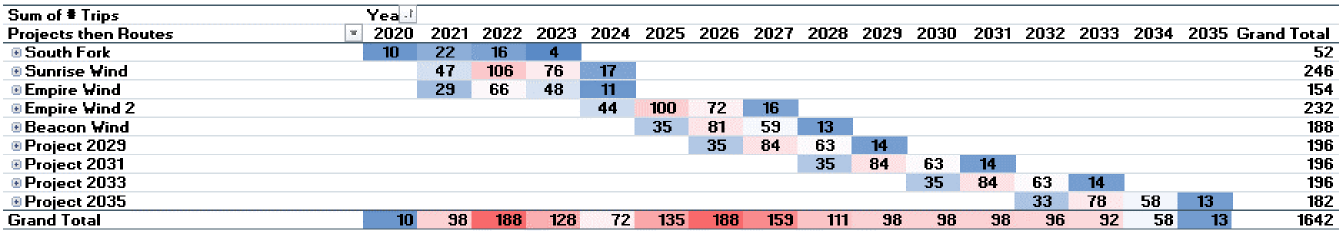
Decommissioning is not considered as part of this assessment as it is assumed that decommissioning of any of the projects considered will occur beyond the final study year (2040). It is assumed that vessel traffic induced by the decommissioning process will not exceed that induced by initial construction of the OWF.

5.5 Summary of Findings

COWI compiled results from an OSW Vessel Traffic Forecast Model. The results were summarized in the form of yearly vessel trip quantities for both capital construction and O&M activities. A summary of the total number of vessel round trips for the capital construction activities is provided in Figure 32. A summary of the yearly O&M vessel round trips is provided in Figure 33. The vessel round trip quantities are applied to routes drawn in GIS between port locations proposed within the PDE and OSW project locations. COWI formulated these routes, collectively referred to as synthetic tracks in this report, considering likely waypoints and known navigation routes (e.g., using NOAA Navigation Maps). These synthetic tracks were used to incorporate future OSW trips into the VTM developed by COWI.

Figure 32. Results: Snapshot of Capital Construction Vessel Round Trips per Year Incurred by OSW Projects

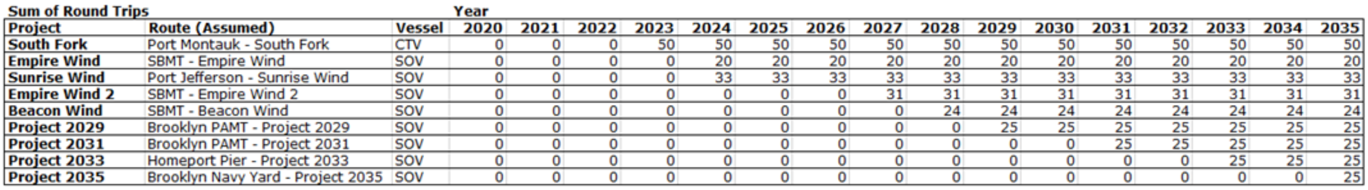
Source: COWI (December 2021)



Sum of # Trips	Year																
Projects then Routes	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Grand Total
⊞ South Fork	10	22	16	4													52
⊞ Sunrise Wind		47	106	76	17												246
⊞ Empire Wind		29	66	48	11												154
⊞ Empire Wind 2					44	100	72	16									232
⊞ Beacon Wind						35	81	59	13								188
⊞ Project 2029							35	84	63	14							196
⊞ Project 2031									35	84	63	14					196
⊞ Project 2033											35	84	63	14			196
⊞ Project 2035													33	78	58	13	182
Grand Total	10	98	188	128	72	135	188	159	111	98	98	98	96	92	58	13	1642

Figure 33. Results: Snapshot of O&M Round Trips per Year Incurred by OSW Projects

Source: COWI (December 2021)



Sum of Round Trips			Year															
Project	**Route (Assumed)**	**Vessel**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
South Fork	Port Montauk - South Fork	CTV	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50
Empire Wind	SBMT - Empire Wind	SOV	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20
Sunrise Wind	Port Jefferson - Sunrise Wind	SOV	0	0	0	0	33	33	33	33	33	33	33	33	33	33	33	33
Empire Wind 2	SBMT - Empire Wind 2	SOV	0	0	0	0	0	0	0	31	31	31	31	31	31	31	31	31
Beacon Wind	SBMT - Beacon Wind	SOV	0	0	0	0	0	0	0	0	24	24	24	24	24	24	24	24
Project 2029	Brooklyn PAMT - Project 2029	SOV	0	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25
Project 2031	Brooklyn PAMT - Project 2031	SOV	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25
Project 2033	Homeport Pier - Project 2033	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	25
Project 2035	Brooklyn Navy Yard - Project 2035	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25

6 Comparative Assessment of OSW versus Non-OSW Traffic

6.1 Approach

Leveraging the results of the OSW and non-OSW vessel traffic forecast, a comparative assessment was performed. To provide meaningful insights, that comparative assessment was conducted along specific lines located in areas referred to as "passage lines." These passage lines were selected specifically for their value in identifying potential bottlenecks or navigational hazards that could challenge traffic safety over time. The selection process was realized by COWI in partnership with SUNY Maritime. The results presented in this section are the culmination of the entire framework developed in the project to assess the relative impacts of OSW projects on overall traffic conditions in the project area.

6.2 Area Definition

For the purpose of this study, passage lines are defined using transects—lines that extend perpendicularly across a navigation channel (such as Ambrose channel) or junction (such as the Narrows). Defining passage lines allows us to obtain scalar numerical representation of how much traffic passes through a given location. Locations for the passage lines used in this study were selected via a visual interpretation of the existing transit count maps generated earlier (see appendix D), in cooperation with SUNY. SUNY provided recommendations based on their extensive knowledge of vessel traffic patterns and trends in the New York Harbor. It is acknowledged that there are additional areas exhibiting high levels of existing vessel traffic congestion which were not included in this report (e.g., Kill van Kull, Robbins Reef area, etc.). These areas were not included as the OSW vessel routes specified by the PDE (see section 2) are not projected to pass through those areas and the intent of the analysis is to estimate the change due to OSW traffic.

6.3 Passage Line Locations

Coordinates for the selected passage lines are given in Table 18. Passage lines are shown in Figure 34 to Figure 40. Passage line transects overlayed over transit count maps can be seen in appendix D.

Table 18. Locations of Selected Passage Lines

Coordinate System: WGS84

Passage Line Designation	Start		End	
	Lat [deg]	Lon [deg]	Lat [deg]	Lon [deg]
The Narrows	-74.0543	40.6035	-74.0346	40.6098
Hudson River (at NYC Battery)	-74.0349	40.7072	-74.0168	40.7057
East River	-73.9999	40.7086	-73.9931	40.7032
Ambrose Channel	-73.9748	40.5081	-73.9711	40.5136
Sandy Hook	-74.0194	40.4807	-74.0184	40.4785
Ward Point	-74.2300	40.4918	-74.2281	40.4904
Tomkins Cove	-73.9805	41.2532	-73.9644	41.2536
Port of Coeymans	-73.7890	42.4824	-73.7839	42.4822

Figure 34. Passage Line Locations: Overview

Red dots show locations of passage lines and black lines show tracks along which the OSW vessels travel between the potential offshore wind installations and port facilities.

Source: COWI (July 2022); ESRI Ocean

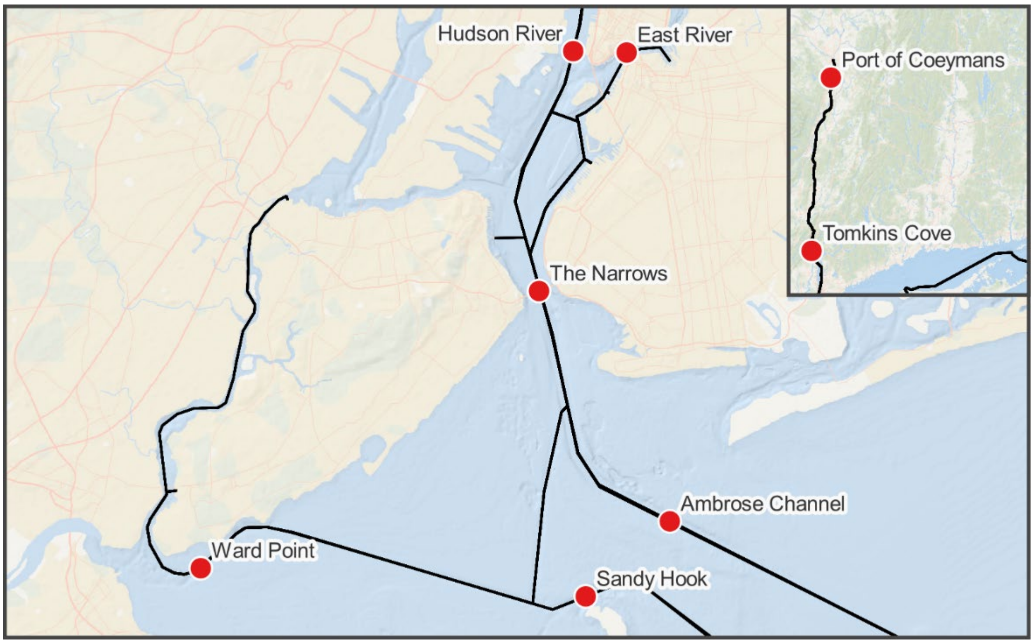


Figure 35. Passage Line Locations: Ambrose Channel and Sandy Hook

Source: COWI (July 2022); ESRI Ocean; NOAA RNC

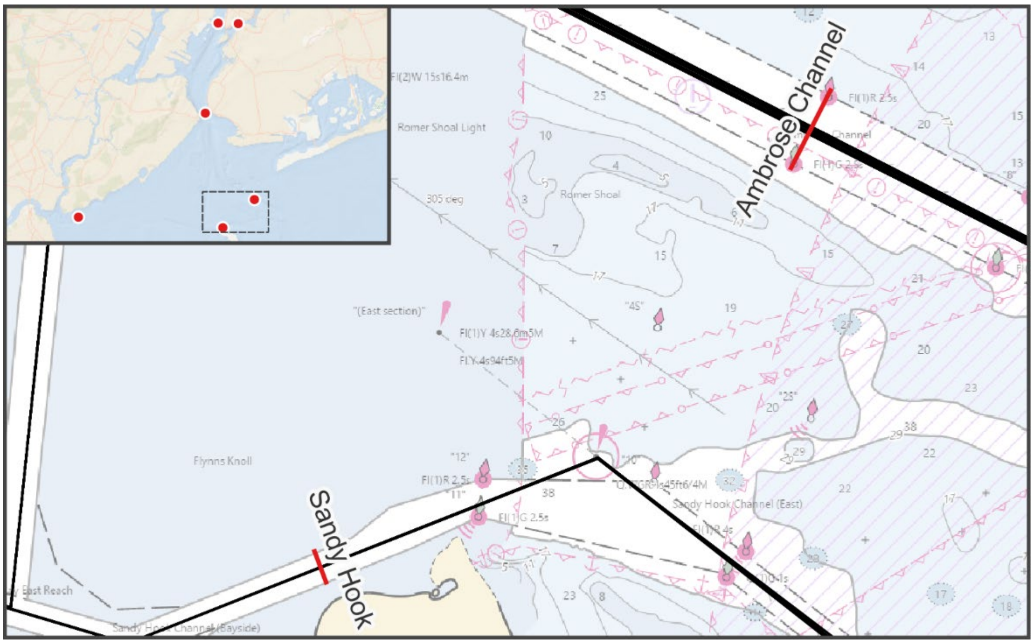


Figure 36. Passage Line Locations: Ward Point

Source: COWI (July 2022); ESRI Ocean; NOAA RNC

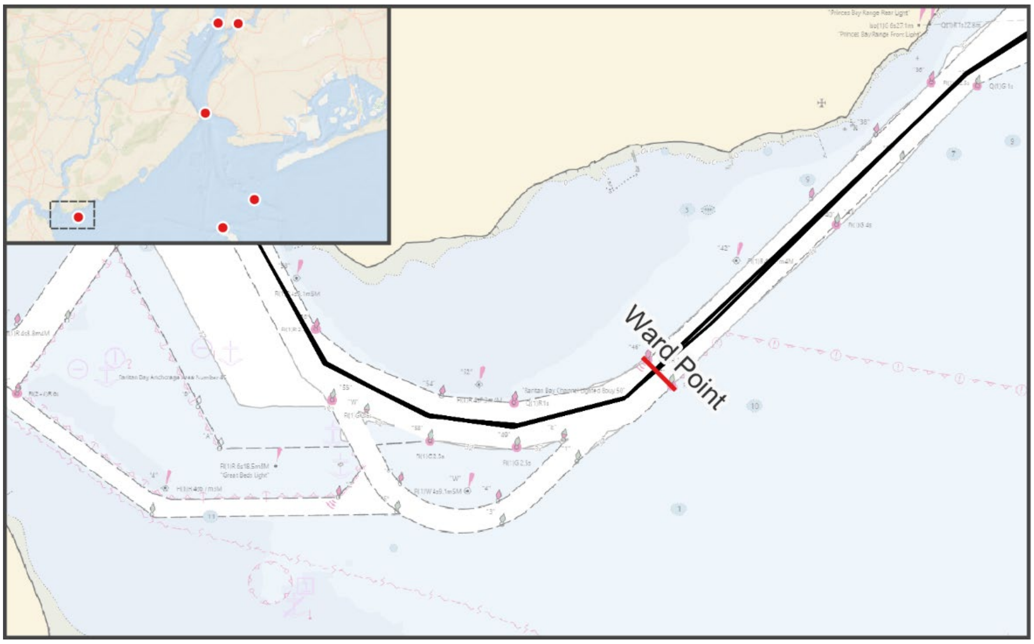


Figure 37. Passage Line Locations: Hudson River and East River

Source: COWI (July 2022); ESRI Ocean; NOAA RNC

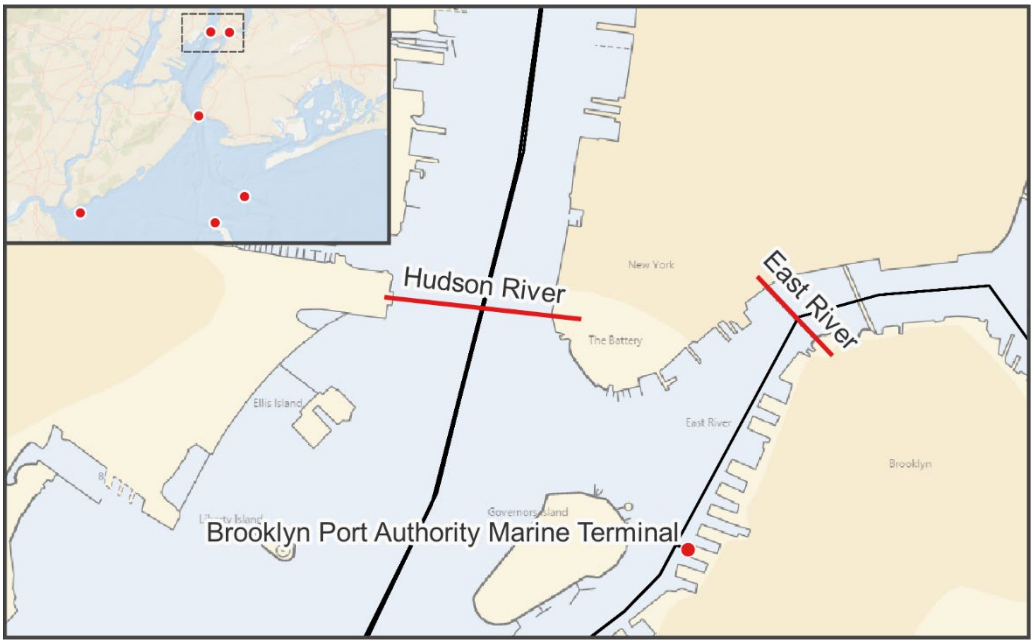


Figure 38. Passage Line Locations: The Narrows

Source: COWI (July 2022); ESRI Ocean; NOAA RNC

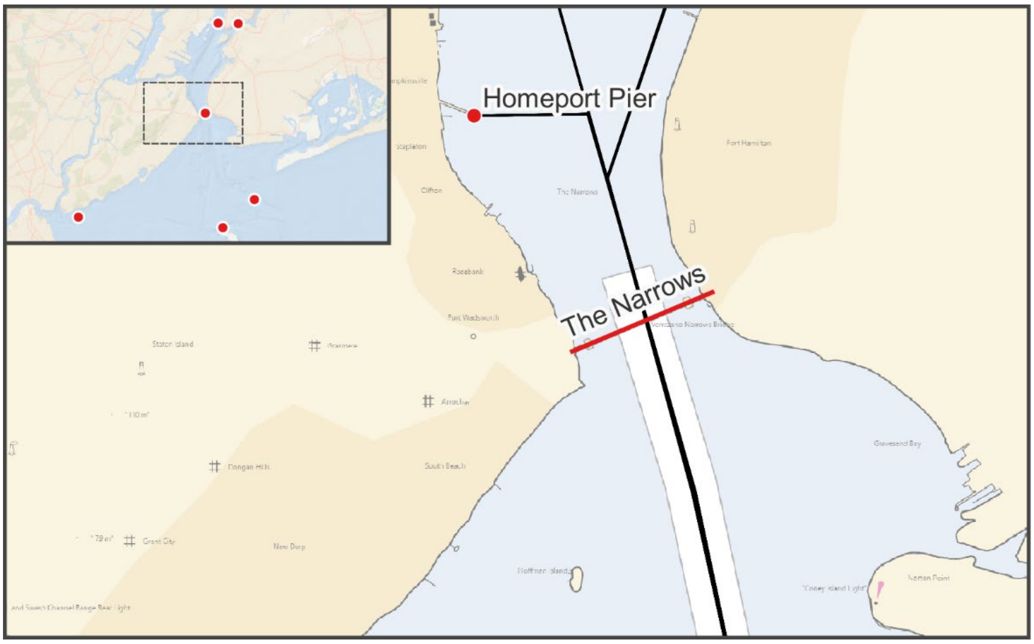


Figure 39. Passage Line Locations: Tomkins Cove

Source: COWI (July 2022); ESRI Ocean; NOAA RNC

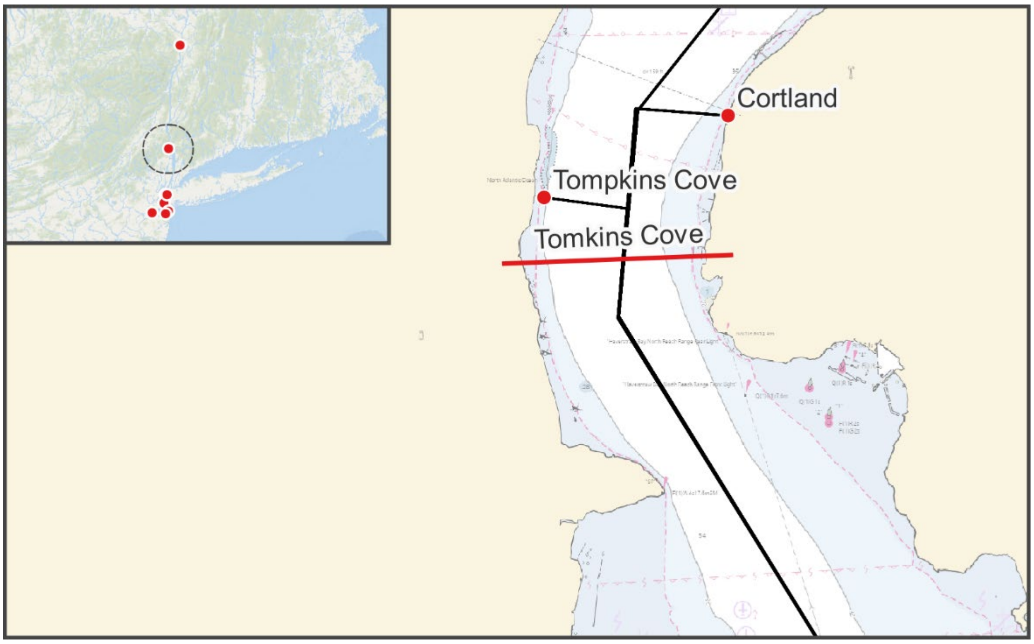


Figure 40. Passage Line Locations: Port of Coeymans

Source: COWI (July 2022); ESRI Ocean; Google Maps

6.4 Data Extraction

Data for each of the passage lines was extracted from the model in the same manner as it was done for the transit count grid generation:

- Select a passage line (e.g., The Narrows).
- For each vessel track find the number of times its track crosses a passage line using the approach described in appendix C.
- Aggregate transit counts (crossings) across years (2017 to 2040) and per PARS vessel types.
- Merge non-OSW and OSW transits to obtain a comprehensive representation of the projected future vessel traffic at that location.
- Perform statistical calculations to evaluate the relative contribution of OSW-incurred traffic over background, non-OSW induced traffic.

6.5 Baseline Non-OSW Vessel Traffic

Baseline vessel traffic counts were extracted at the proposed passage lines. These counts are representative of baseline year 2017 and are summarized in Table 19 and the relative distribution is graphically illustrated in Figure 41. It is observed that the vessel mix at each location differs significantly, with cargo and tankers dominating traffic at the Ambrose Channel while making a small fraction of the total vessel traffic at Hudson River and East River locations. At those locations, traffic is dominated by passenger vessels. Further up the Hudson River at Tomkins Cove and Port of Coeymans, tugs are the dominating vessel type. It is noted that non-self-propelled barges are not recorded explicitly and hence, the recording of a tug will in many cases represent a tug towing a barge.

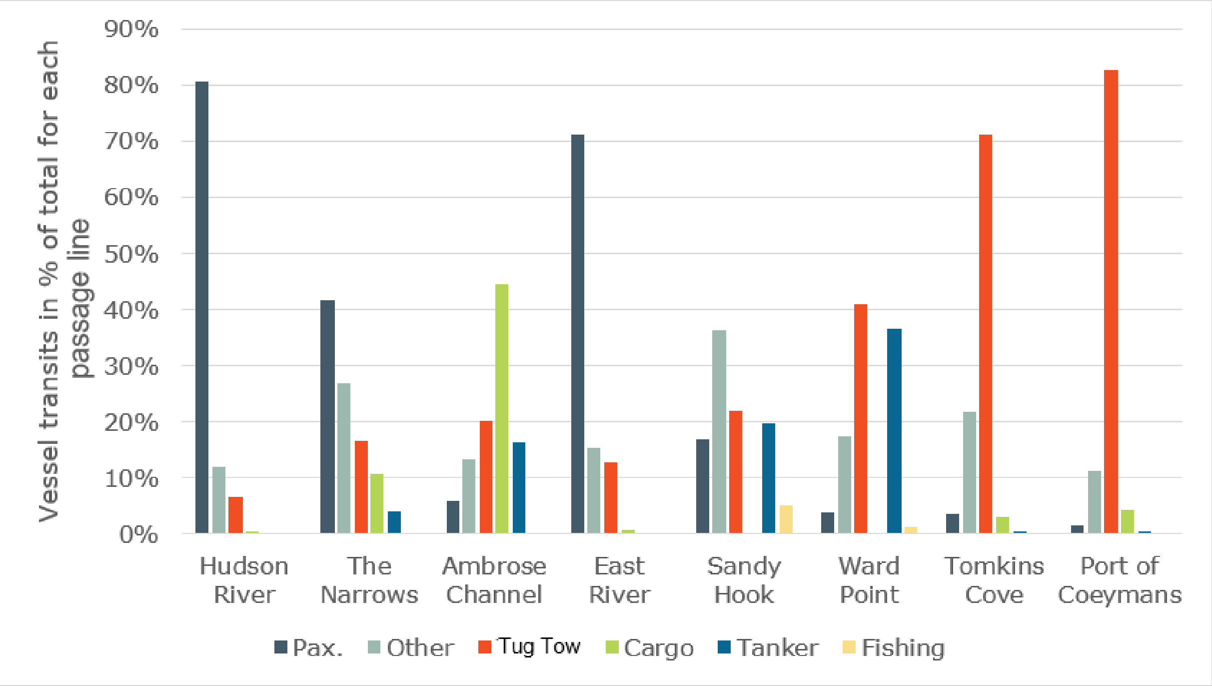
Table 19. Baseline Non-OSW Vessel Traffic for Each Passage Line Area

(Shown as Counts) For year 2017

Vessel Type	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
Pass.	111,024	20,790	679	78,565	616	89	210	61
Other	16,442	13,445	1,576	17,019	1,321	412	1,246	484
Tug-Tow	9,059	8,224	2,374	14,169	802	966	4,095	3,553
Cargo	785	5,309	5,262	707	4	0	175	181
Tanker	381	2,064	1,921	68	721	862	24	24
Fishing	6	27	9	8	184	28	0	0
Total	137,697	49,859	11,821	110,536	3,648	2,357	5,750	4,303

Figure 41. Relative Distribution of Vessel Types at Passage Lines

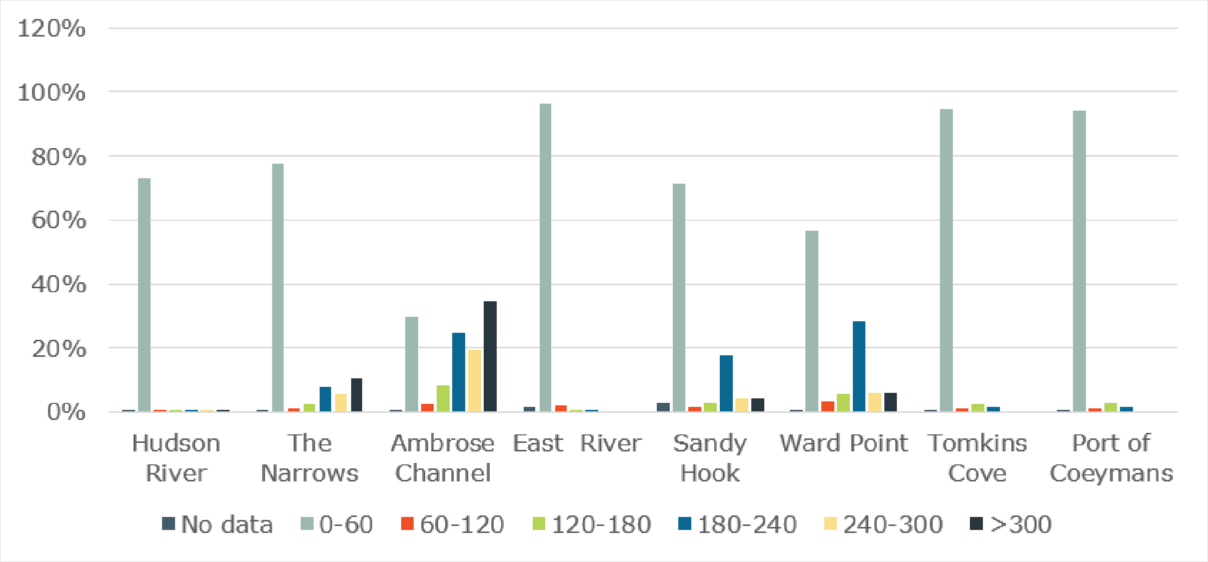
Source: COWI (July 2022)



Distribution of vessel lengths as provided by the AIS data is shown in appendix E.1 Table E-1 for all passage lines. An overview of the relative length distribution for all passage lines is provided in Figure 42. It is noted that smaller vessels less than 60 m (~200ft) are dominating at all passage lines aside from the Ambrose Channel. Reviewing these vessels shorter than 60 m reveal that the majority is either ferries/passenger boats or tugs. Towing operations are in the AIS data only registered with the tug and the barge and its size is not registered.

Figure 42. Relative Distribution of Vessels Length at Passage Lines

Source: COWI (July 2022)



To be able to evaluate and analyze the vessel traffic increases resulting from offshore wind traffic, the non-OSW vessel traffic is defined as either small or large based on the definition below.

- Small: Vessels < 60 m (excluding all tugs).
- Large: Vessels > 60 m and all tugs irrespective of size.

Tugs are included as large because it is not possible to identify whether or not they are towing a barge. Excluding tugs would likely underestimate the vessel traffic significantly, in particular in areas where barge traffic is dominating.

6.6 Future Non-OSW Vessel Traffic

Using the approach described in section 0, future non-OSW traffic was estimated. A time-based vessel traffic count for each passage line is presented in Table 20 for all vessel groups and in Table 21 for large vessels (length > 60 m) and tugs only. The first row (2017) in the tables corresponds to the total row in Table 19. As seen in these tables, the Hudson River and East River passage lines have significantly larger counts due to active passenger traffic in those areas. Once we look at large vessels only we can see numbers across these two passage lines to come closer to others.

Table 20. Future Non-OSW Vessel Traffic for Each Passage Line Area

(Shown as Counts) For Years 2017-2040

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	137,697	49,859	11,821	110,536	3,648	2,357	5,750	4,303
2020	141,028	51,065	12,105	113,211	3,735	2,414	5,889	4,407
2025	146,760	53,140	12,599	117,812	3,888	2,513	6,130	4,587
2030	152,727	55,300	13,111	122,599	4,046	2,614	6,378	4,774
2035	158,933	57,548	13,644	127,582	4,211	2,721	6,637	4,967
2040	165,393	59,887	14,198	132,769	4,382	2,831	6,907	5,168

Table 21. Future Non-OSW Vessel Traffic for Each Passage Line

Large Vessels (> 60 m) and Tugs Only (Shown as Counts) For Years 2017—2040

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	10,635	16,252	10,111	15,980	1,565	1,882	4,321	3,785
2020	10,892	16,645	10,356	16,367	1,603	1,928	4,426	3,877
2025	11,335	17,322	10,777	17,032	1,668	2,006	4,605	4,034
2030	11,796	18,026	11,215	17,724	1,736	2,087	4,793	4,198
2035	12,275	18,758	11,670	18,444	1,806	2,172	4,987	4,369
2040	12,774	19,521	12,145	19,194	1,880	2,261	5,190	4,546

6.7 Future OSW Vessel Traffic and Relative Increase

Future OSW-induced traffic counts were extracted at the passage lines. Values were quality-controlled by manually checking future OSW transit counts for several of the passage lines using QGIS. The vessels anticipated to support the construction and operation of OSW projects only belong to the “cargo” and “other” classes. Select years are shown in an effort to simplify interpretation. Results are presented in absolute and relative terms in Table 22 and Table 23. The relative increase in traffic is calculated as $\Delta_{\%} = 100 \cdot \mathrm{OSW}/(\mathrm{OSW} + \text{non-OSW})$ for each given combination of year and passage line. The results show that the largest increase in vessel traffic are on the order of 4% at Port of Coeymans.

Table 22. Future OSW Vessel Traffic at Passage Lines

Absolute Traffic Counts

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0
2025	188	130	130	0	0	0	188	180
2030	142	278	246	0	16	48	142	114
2035	0	358	358	48	16	16	0	0
2040	0	348	348	48	0	0	0	0

Table 23. Future OSW Vessel Traffic at Passage Lines

Relative Increase in Traffic Counts

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2025	0.1%	0.2%	1.0%	0.0%	0.0%	0.0%	3.1%	3.9%
2030	0.1%	0.5%	1.9%	0.0%	0.4%	1.8%	2.2%	2.4%
2035	0.0%	0.6%	2.6%	0.0%	0.4%	0.6%	0.0%	0.0%
2040	0.0%	0.6%	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%

Vessel traffic at several of the passage lines are dominated by smaller local ferries or pleasures crafts. While these are relevant to consider in many cases they are likely not the ones most impacted by the OSW traffic. Therefore, a comparison is also made to large vessels defined as vessels larger than 60 m or tugs irrespective of size. Tugs are included because they potentially can be towing a barge and hence indirectly be larger than 60 m. Excluding tugs would underestimate the large vessel traffic significantly, particularly in areas where barge traffic is dominating. Table 24 and Figure 43 shows the relative increase at passage lines when considering only large vessels as defined above. The relative increase in traffic is most significant at the Hudson River and The Narrows passage line. Generally, the relative increase from OSW traffic is found to be between 0–5% per year.

It should be emphasized that considering only tugs and vessels longer than 60 m is just one possible metric for comparison. Changing the filtering with length or excluding tugs can have a significant impact on the results below.

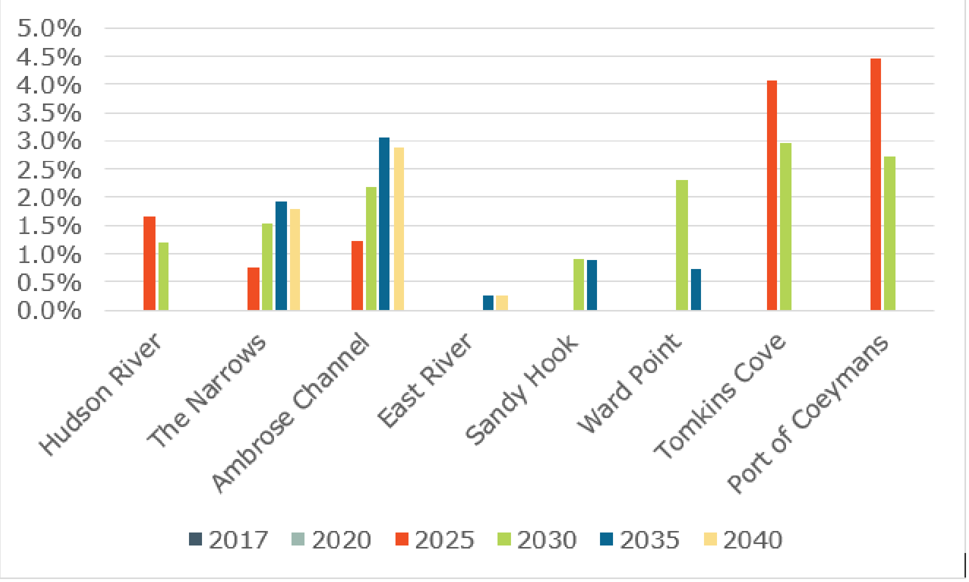
Table 24. Future OSW Vessel Traffic at Passage Lines

Large Vessels (> 60 m) and Tugs Only. Relative Increase in Traffic Counts

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2025	1.7%	0.8%	1.2%	0.0%	0.0%	0.0%	4.1%	4.5%
2030	1.2%	1.5%	2.2%	0.0%	0.9%	2.3%	3.0%	2.7%
2035	0.0%	1.9%	3.1%	0.3%	0.9%	0.7%	0.0%	0.0%
2040	0.0%	1.8%	2.9%	0.3%	0.0%	0.0%	0.0%	0.0%

Figure 43. Future OSW Vessel Traffic at Passage Lines: Large Vessels (> 60 m) and Tugs Only

Relative Increase in Traffic Counts



6.8 Summary of Findings

By combining the results of the non-OSW forecast analysis performed with the support of SUNY Maritime, and using them to estimate future vessel traffic, COWI compared the projected relative increase in OSW-incurred traffic. The results presented in this section represent the culmination of the entire computational and analytical framework developed in this project to assess the relative impacts of OSW projects on overall traffic conditions in the project area.

For each passage line, COWI compared the traffic trends incurred by the various OSW projects planned for construction between 2020 and 2040, to those trends caused by other factors (such as overall increase in economic activity, greater reliance on the blue economy, population, growth, industrial activity, etc.). The annual rate of growth as determined by COWI and SUNY Maritime was determined to be 0.8% per year, applicable to all vessel types. At each step, the data was organized so that non-OSW- and OSW-induced traffic projection layers remained segregated.

Below are the main takeaway items from the analysis:

- COWI identified and analyzed areas of traffic at eight locations, referred to as passage lines and identified as potentially being impacted by OSW vessel traffic. These were Ambrose Channel, East River, Hudson River, Sandy Hook, The Narrows, Ward Point, Tomkins Cove, Port of Coeymans.
- COWI performed a comparative assessment that covered five-year intervals between 2020 and 2040, with additional details available for each passage line.
- The relative increase in vessel traffic incurred by the OSW projects at each passage line is compared to the total volume of vessel traffic anticipated over time. The largest increase is found at Ambrose Channel, Tomkins Cove and Port of Coeymans where OSW vessels correspond to an increase of 2–4%.
- If only tugs and all other vessels larger than 60 m in length are considered the relative increase from OSW vessel traffic is between 1–5% for all selected passage lines except East River which still experience an insignificant increase of less than 0.5%.

On the basis of the vessel traffic analysis presented in this report, a Vessel Traffic Risk Assessment is carried out and documented in a supplementary report (COWI, 2022).

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Appendix A. Port Uses and Navigational Assessment (SUNY Maritime)

Offshore Wind Ports: Vessel Traffic Risk Assessment Supplement

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Our Mission:

Advance clean energy innovation and investments to combat climate change, improving the health, resiliency, and prosperity of New Yorkers and delivering benefits equitably to all.

Offshore Wind Ports: Vessel Traffic Risk Assessment Supplement

Final Report

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Abstract

This study supplements a collection of studies prepared on behalf of NYSERDA to provide information related to a variety of environmental, social, economic, regulatory, and infrastructure-related issues implicated in planning for future offshore wind energy development off the coast of New York State. This study provides an assessment of the changes in risk on vessel traffic that may be seen as a result of future offshore wind activity within the State. NYSERDA's intent is to facilitate the principled planning of future offshore development to provide a resource for the various stakeholders and to support the achievement of the State's offshore wind energy goals.

Keywords

Offshore wind, vessel, port, traffic, model, AIS, navigation, risk

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Acronyms and Abbreviations

The following acronyms and abbreviations are used throughout this document.

AASHTO	American Association of State Highway and Transportation Officials
AIS	Automatic Identification System
AWOIS	Automated Wreck and Obstruction Information System
ATON	Aids to Navigation
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
COD	Commercial Operation Date
CTV	Crew Transfer Vessel
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigation Charts
ft.	feet
GIS	Geographic Information System
GW	Gigawatt
IMO	International Maritime Organization
LOA	Length Overall
M	Meter
MISLE	Marine Information for Safety and Law Enforcement
MLLW	Mean Lower Low Water
MMSI	Maritime Mobile Service Identity

MW	Megawatt
nm	Nautical Mile
NAVD	North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NSRA	Navigation Safety Risk Assessment
NVIC	Navigation and Vessel Inspection Circular
NYC	New York City
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance
OREI	Offshore Renewable Energy Installation
OSW	Offshore Wind
OWF	Offshore Wind Farm
PANYNJ	Port Authority of New York and New Jersey
PARS	Port Access Route Studies
PDE	Project Design Envelope
SOV	Service Offshore Vessel
TSS	Traffic Separation Scheme
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
VHF	Very High Frequency
VTM	Vessel Traffic Model
VTS	Vessel Traffic Services

Executive Summary

This vessel traffic risk assessment identifies navigation risks associated with the introduction of new vessel traffic from a series of known and hypothetical offshore wind (OSW) projects and associated ports. The area of interest is physically limited to be New York State waters and therefore considers only the vessel transit activity to/from ports within the State and the portions of the vessel trips to the offshore wind farms (OWF) within State waters. This study does not serve as the formal navigation safety risk assessment (NSRA) that must be carried out as part of the permitting process for any specific OWF project. This study provides insight and decision support to evaluate the cumulative change in risk expected within State waters resulting from increases in vessel traffic.

This assessment builds upon the NYSERDA Offshore Wind Ports: Cumulative Vessel Traffic Assessment (COWI 2022) in which future known and hypothetical port uses related to OSW vessel traffic are assessed and a vessel traffic model (VTM) is developed to analyze current and future vessel traffic patterns. Eight locations, referred to as passage lines are selected and used to evaluate changes in vessel traffic resulting from potential future OSW vessel traffic.

This vessel traffic risk assessment includes a description of the considered waterways including obstructions and historical incidents. The existing vessel traffic and traffic patterns from 2017 Automatic Identification System (AIS) data, including vessel characteristics and detailed information about vessel size and types, is also presented. Information regarding expected future vessel traffic resulting from both non-OSW and OSW developed in the Cumulative Vessel Traffic Assessment is reiterated herein due to its importance when evaluating risks.

While there can be many risks associated with the introduction of an OWF, this study is limited to the impact from changes in vessel traffic within New York State waters. The main risks identified and evaluated are therefore:

1. Vessel allision with fixed object(s).
2. Ship-ship collision.

This report presents the methodology for evaluating the above risks and presents a semi-quantitative evaluation based on available vessel traffic information. The probability of either type of risk is generally found as the product of causation probability (the probability of aberrancy that potentially can lead to collision/allision), geometrical probability for a vessel to be on collision course, and number of vessels and risk reducing measures. Within this equation, most of the variables are not expected to change significantly when introducing the estimated OSW vessel traffic. The overall number of vessels will increase and, as a result, cause an increase in collision/allision frequency.

The expected increase in vessel allisions with fixed objects is roughly proportional to the increase in vessel traffic which typically is 1–5% above baseline at the considered locations (passage lines). The individual risk per vessel passage is assumed to be unchanged by a vessel increase of this magnitude.

In the case of ship-to-ship collisions the number of meeting situations increase with the square of the vessel traffic increase and hence the increase in ship-to-ship collision probability is found to be slightly higher for this scenario and generally between 1–10% above baseline. It is observed that the expected increase in risk resulting from assumed development in non-OSW vessel traffic vastly exceeds that associated with OSW vessel traffic.

This evaluation is contingent upon a series of assumptions related to the determination of future OSW and non-OSW vessel traffic, all presented in NYSERDA Offshore Wind Ports: Cumulative Vessel Traffic Assessment. It would be beneficial to re-evaluate the input and assumptions for this study when more information on expected OSW ports and traffic is available. It should also be emphasized that a project specific NSRA is expected to be developed for each OWF to provide detailed evaluation of the risks associated with the individual project and the Offshore Renewable Energy Installations (OREIs).

1 Introduction

1.1 Purpose

This vessel traffic risk assessment identifies navigation risks associated with the introduction of new vessel traffic from known and hypothetical offshore wind (OSW) projects and associated ports. The area of interest, referred to as the study area, is physically limited to New York State waters and therefore only considers the vessel transit activity to/from ports within the State and the portions of the vessel trips to the offshore wind farms (OWF) within State waters. Thus, this study does not serve as the formal navigation safety risk assessment (NSRA) that is required for any wind farm project but instead provides insight and decision support to evaluate the cumulative change expected within the State waters resulting from increases in vessel traffic.

The vessel traffic risk assessment builds upon the NYSERDA Offshore Wind Ports: Cumulative Vessel Traffic Assessment which has already been carried out and documented in that report (COWI 2022). It includes a description of the considered waterways, the existing vessel traffic, including vessel characteristics and movements data from 2017 AIS data, as well as vessel traffic patterns and detailed information about vessel size and types. Information on expected future vessel traffic resulting from OSW is also developed as part of this study and only key information is reiterated.

Additional information specifically for the purpose of the risk assessment is analyzed and presented in this report along with the identification and evaluation of risks associated with the increase in vessel traffic from OSW in the study area.

1.2 Approach to the Work

Per United States Coast Guard (USCG) 2019 Circular, an NSRA is to be performed to assess impacts of a specific Offshore Renewable Energy Installation (OREI) on marine navigation safety (United States Coast Guard 2019, 3). This study does not assess a specific OREI and instead aims to perform an assessment of potential cumulative impacts on existing navigational channels generated by a series of potential OREI's located at offshore sites outside of the study area. These OREIs are collectively referred to as "OSW projects" in the document. With the scope and general nature of this study in mind, Cumulative Vessel Traffic Assessment’s goal was to identify and analyze areas experiencing the largest increase in vessel traffic as a result of the potential future OSW development in the region.

1.3 Contents

This study seeks to answer specific questions that are directly relevant to vessel navigation and safety concerns. The report outline is as follows:

- Waterway Characteristics: Section 3 provides an overall description of the existing waterway characteristics including climate considerations, sea states, channels, overall traffic patterns, and existing aids to navigation within the study area.
- Vessel Characteristics and Traffic: Section 4 provides an overview of vessel traffic characteristics now and projected into the future. This includes frequency of passages at key locations, vessel types, typical uses, etc. In this section, select locations referred to as "passage lines" are analyzed in greater detail.
- Potential Effects on Safe Navigation: Section 5 provides an overview of the baseline (existing) and projected impacts of the increase in vessel traffic. The main risks associated with the introduction of OSW vessel traffic are identified and evaluated.
- Potential Mitigation Strategies: Section 6 presents navigational risks associated with the increase in traffic and provides potential changes in navigational waterways to manage those risks.

1.4 Assumptions

The results of this analysis are predicated on assumptions made on future OSW projects and locations. These are described in detail in the Cumulative Vessel Traffic Assessment (COWI 2022).

1.5 Consistency with the 01-19 Navigation and Vessel Inspection Circular Recommendations

Changes in vessel traffic patterns within a navigation route have the potential to increase the existing risks associated with vessel traffic in that route. Understanding the hazards posed by increased vessel traffic quantity due to offshore wind farms and, furthermore, mitigating the risks associated with the hazards, is necessary to ensure the continued safe practice of vessel navigation within the study area.

1.5.1 Risk Assessment Approach

Per the Navigation and Vessel Inspection Circular (NVIC) 02-07 (United States Coast Guard 2019), the risk assessment approach adopted for this study employs a "change analysis" technique, where the potential impacts of offshore wind vessel traffic are compared to the baseline situation, which is defined as the vessel traffic forecast for the study area that will occur without offshore wind vessel traffic. The study area for this analysis is confined to New York State waterways as defined in Cumulative Vessel Traffic Assessment (2022) and has been performed with the intent to understand the impact of offshore wind vessel traffic specifically in this area. As such, the areas impacted by OSW vessel traffic are within existing New York State navigation channels.

Employing this technique and adapting the risk assessment guidelines as outlined in the NVIC to account for the specificity of the study area, the focus, which is traditionally specific to offshore wind project sites, is pivoted to selected locations within the study area, analyzed through defined passage lines. This allows the study team to assess the effects of increased traffic density within the study area.

1.5.2 Navigational Impacts

To determine impacts to navigational safety and employ appropriate mitigative measures, the USCG must be made aware of, "the characteristics and number of waterway users, the routes used, the channel dimensions, bottom conditions, etc.," (United States Coast Guard 2019). By implementing the data and models as discussed in the NYSERDA Offshore Wind Ports: Cumulative Vessel Traffic Assessment, the risk assessment uses the passage lines outlined in section 4.3 to analyze the impacts on navigational risk within the context of section 1.5.1.

2 Projects Description

Future offshore wind project characteristics including location, size (megawatt [MW] capacity and turbine quantity), and Commercial Operation Date (COD) was developed in the Offshore Wind Ports: Cumulative Vessel Traffic Assessment and is the basis for evaluating the impact from offshore wind vessel traffic. This section will present the key assumptions regarding location of OSW port facilities and OWF locations as well as the resulting OSW induced vessel traffic.

2.1 Assumed Port and Offshore Wind Farm Locations

Vessel traffic incurred by offshore wind activity will take place along specific routes between ports or between port and project. Routes were developed between the locations that are part of the proposed Project Design Envelope (PDE) per the Cumulative Vessel Traffic Assessment. Locations for future projects (projects 2029–2035) and ports were assigned to best of the assessment's information at the time of preparing this report and represent one hypothetical scenario.

The following projects used in determining the offshore wind vessel traffic routes are as follows:

Table 1. Table Projects for Vessel Traffic

Project	Capacity (MW)	COD
South Fork	132	2023
Empire Wind	816	2024
Sunrise Wind	932	2024
Empire Wind 2	1260	2027
Beacon Wind	1230	2028
Project 2029[a]	1250	2029
Project 2031[a]	1250	2031
Project 2033[a]	1250	2033
Project 2035[a]	1250	2035

[a] Projects 2029 and beyond are indicative for the purposes of analysis only. The project years, capacity, COD, anticipated WTG Capacity, and location should not be used as an inference of New York State policy or procurement intentions.

Port locations used to develop the vessel traffic routes are those included in the PDE as defined in the Cumulative Vessel Traffic Assessment. The port locations are summarized in Table 2. below. Additional background on the selection of these ports can be found in the 2022 assessment.

Table 2. Port Locations per Cumulative Vessel Traffic Assessment

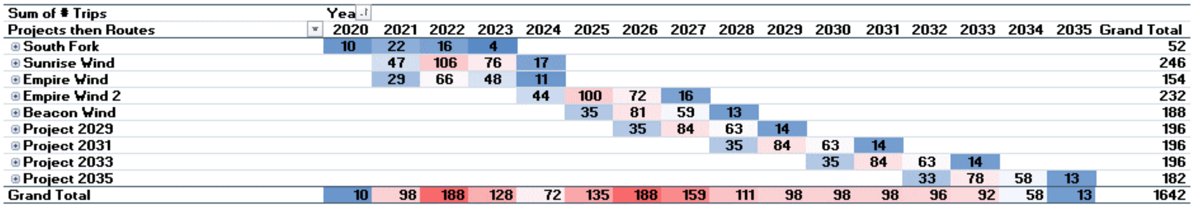
	Port Location	NYS Region
KNWON	South Brooklyn Marine Terminal	NYC Harbor
	Port of Albany	Capital Region
	Port of Coeymans	Capital Region
	Port Jefferson	North Shore LI
	Port of Montauk	North Shore LI
REPRESENTATIVE PROPOSED FOR PDE	Arthur Kill Terminal	NYC Harbor (Staten Island)
	Port Ivory	NYC Harbor (Staten Island)
	Homeport Pier	NYC Harbor (Staten Island)
	Brooklyn Navy Yard	NYC Harbor (Brooklyn)
	Brooklyn Port Authority Marine Terminal (PAMT)	NYC Harbor (Brooklyn)
	NYS Wind Port (East Greenbush)	Capital Region
	Cortland	Upper Hudson Valley
	Tomkins Cove	Upper Hudson Valley

2.2 Anticipated Vessel Traffic for Construction and Operation

The effects of an OREI on vessel traffic density differ based on whether the construction phase or operational phase of the OREI is under consideration. The hypothetical port locations comprise the PDE and provide a scenario of a fully developed offshore wind supply chain within New York State. The project locations provide a hypothetical scenario of number and locations of projects needed for the State to achieve 9 gigawatt (GW) of offshore wind energy by 2035. Using the port and project details outlined above, the Cumulative Vessel Traffic Assessment developed an OSW vessel traffic forecast model and estimated the anticipated offshore wind vessel traffic in State waterways. A summary of the resulting total number of vessel trips for the capital construction and O&M activities is provided in Figure 1 and Figure 2.

Figure 1. Snapshot of Number of Trips per Year Incurred by Offshore Wind Capital Construction Activities

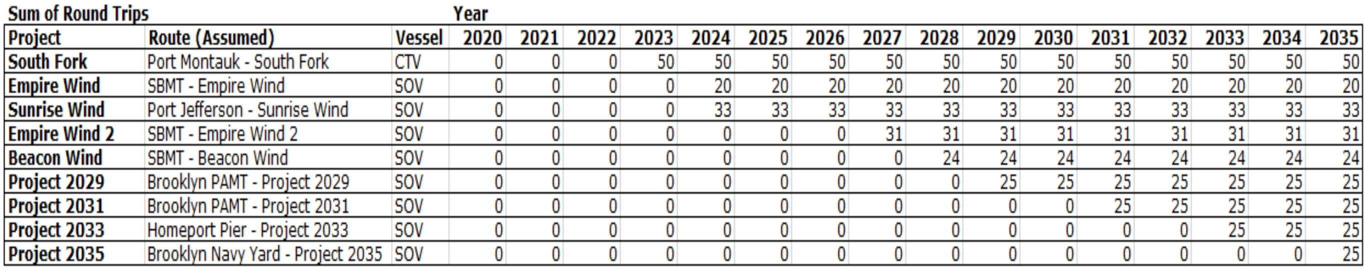
Source: COWI (December 2021)



Sum of # Trips	Yea															
Projects then Routes	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Grand Total
⊞ South Fork	10	22	16	4													52
⊞ Sunrise Wind		47	106	76	17												246
⊞ Empire Wind		29	66	48	11												154
⊞ Empire Wind 2					44	100	72	16									232
⊞ Beacon Wind						35	81	59	13								188
⊞ Project 2029							35	84	63	14							196
⊞ Project 2031									35	84	63	14					196
⊞ Project 2033											35	84	63	14			196
⊞ Project 2035													33	78	58	13	182
Grand Total	10	98	188	128	72	135	188	159	111	98	98	98	96	92	58	13	1642

Figure 2. Results: Snapshot of Number of Operations and Maintenance Round Trips per Year Incurred by Offshore Wind Projects

Source: COWI (December 2021)



Sum of Round Trips — **Year**

Project	Route (Assumed)	Vessel	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
South Fork	Port Montauk - South Fork	CTV	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50
Empire Wind	SBMT - Empire Wind	SOV	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20
Sunrise Wind	Port Jefferson - Sunrise Wind	SOV	0	0	0	0	33	33	33	33	33	33	33	33	33	33	33	33
Empire Wind 2	SBMT - Empire Wind 2	SOV	0	0	0	0	0	0	0	31	31	31	31	31	31	31	31	31
Beacon Wind	SBMT - Beacon Wind	SOV	0	0	0	0	0	0	0	0	24	24	24	24	24	24	24	24
Project 2029	Brooklyn PAMT - Project 2029	SOV	0	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25
Project 2031	Brooklyn PAMT - Project 2031	SOV	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25
Project 2033	Homeport Pier - Project 2033	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	25
Project 2035	Brooklyn Navy Yard - Project 2035	SOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25

2.3 Passage Lines

For the purpose of the Offshore Wind Ports: Cumulative Vessel Traffic Assessment and this study so-called passage lines were defined. These passage lines were selected specifically for their value in identifying potential bottlenecks or navigational hazards that could challenge traffic safety over time. The passage lines extend perpendicularly across a navigation channel (such as Ambrose channel) or junction (such as the Narrows), allowing for a numerical representation of the vessel traffic passing through a given location. Comparative assessment was conducted for these passage lines in the Cumulative Vessel Traffic Assessment and are also the basis for the risk evaluation in this supplemental study.

Table 3 lists the considered passage lines along with the relevant navigation channel and its width. Figure 3, Figure 4, and Figure 5 display the location of all passage lines together with the hypothetical OSW port and expected OSW vessel routes.

Table 3. Passage Line Navigation Channel Widths

Passage Line–Name	Navigation Channel	Channel Width (at Passage Line) [ft]
The Narrows	Ambrose Channel	2,000
Hudson River	Hudson River Channel	2,000
East River	East River Channel	1,000
Ambrose Channel	Ambrose Channel	2,000
Ward Point	Ward Point Bend West Reach	600
Sandy Hook	Sandy Hook Channel – Bayside Reach	800
Tomkins Cove	Hudson River Channel	2300
Port of Coeymans	Hudson River Channel	400

Figure 3. Overview of Vessel Traffic, Passage Lines, and Offshore Wind Ports and Vessel Traffic

OSW traffic is shown on the figure as thick black lines. Passage lines represented by cyan circles with PL in brackets. Potential and existing facilities are shown as red and green circles accordingly. Background colors represent transit counts with yellow representing higher transit count and dark blue/magenta representing lower transit count.

Source: COWI (December 2021); ESRI Ocean; Google Earth; NOAA

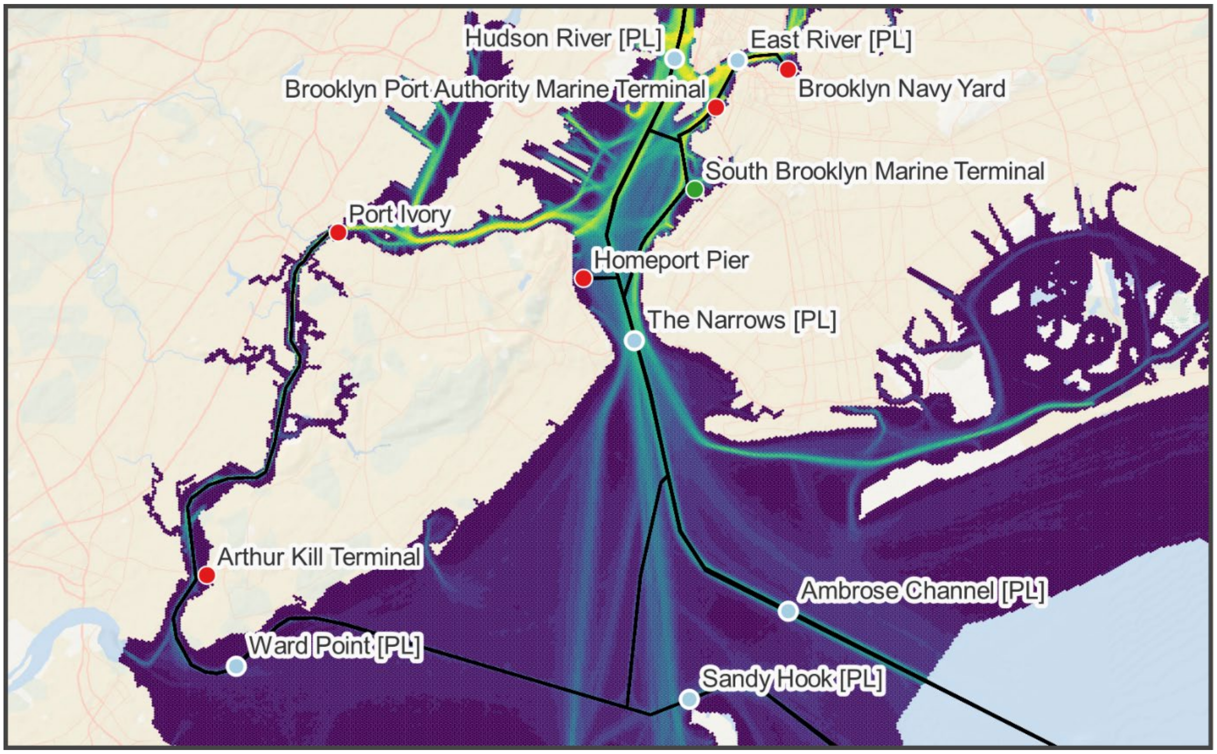


Figure 4. Overview of Vessel Traffic, Passage Lines, and Offshore Ports and Vessel Traffic (Continued)

OSW traffic is shown on the figure as thick black lines. Passage lines represented by cyan circles with PL in brackets. Potential and existing facilities are shown as red and green circles accordingly. Background colors represent transit counts with yellow representing higher transit count and dark blue/magenta representing lower transit count.

Source: COWI (December 2021); ESRI Ocean; Google Earth; NOAA

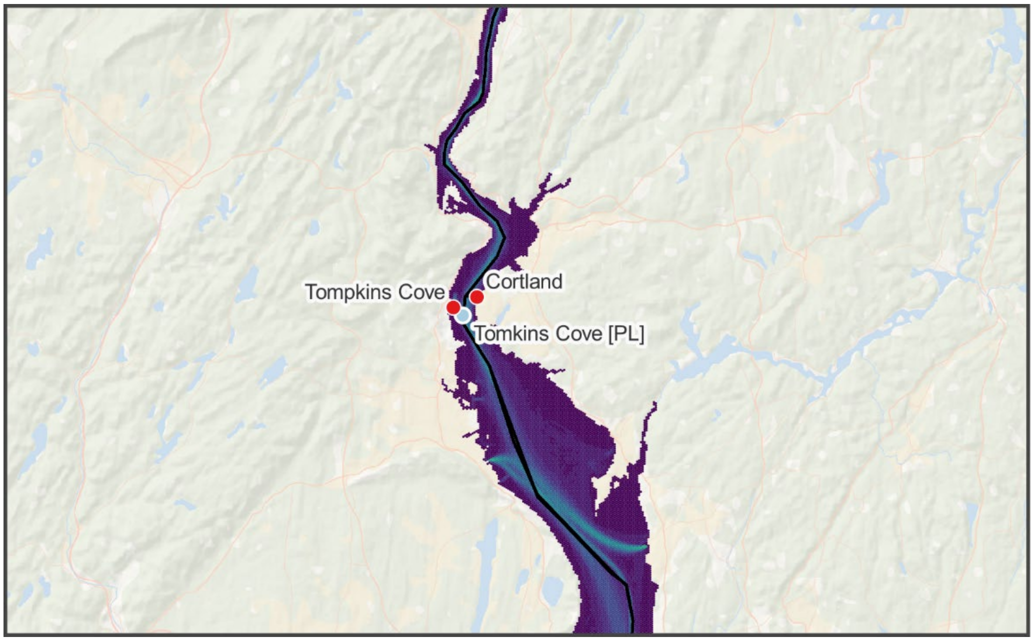
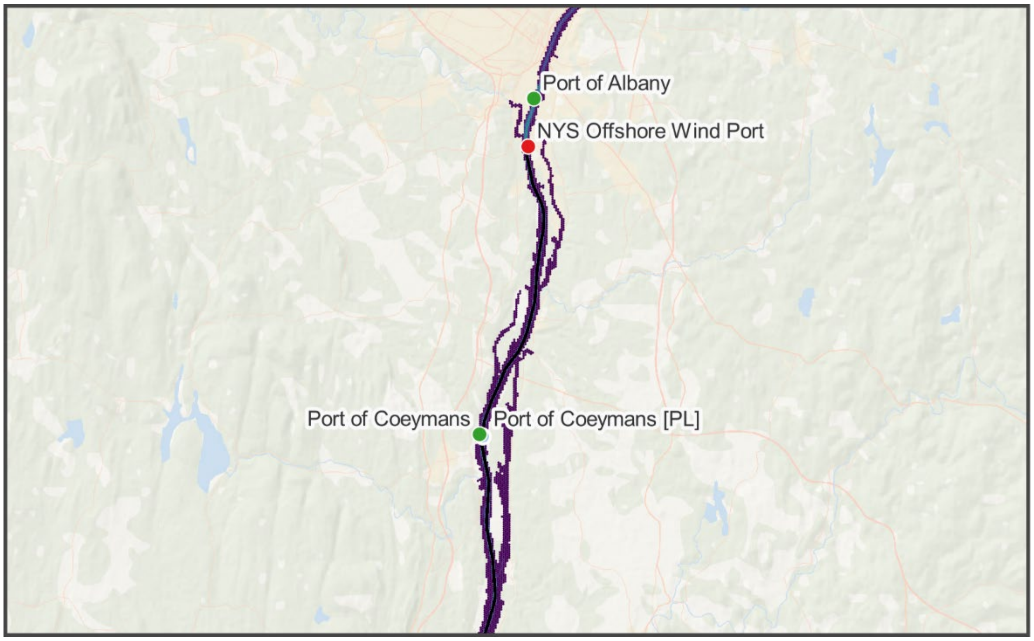


Figure 5. Overview of Vessel Traffic, Passage Lines, and OSW Ports and Vessel Traffic (Continued)

OSW traffic is shown on the figure as thick black lines. Passage lines shown by cyan circles with PL in brackets. Potential and existing facilities are shown as red and green circles accordingly. Background colors represent transit counts with yellow representing higher transit count and dark blue/magenta representing lower transit count.

Source: COWI (December 2021); ESRI Ocean; Google Earth; NOAA



3 Waterway Characteristics

Navigational operations in New York Bight near the study area are affected by metocean conditions, channel size and configuration, obstructions, and aids to navigation. Each of these factors is addressed in the following subsections together with a review of historical incidents in the area.

3.1 Metocean Conditions

Metocean and environmental conditions such as wind, wave, current, and tidal information are relevant when evaluating navigational safety and risks associated with the introduction of OREIs. Dominating wind and current directions may directly influence the risk of vessel aberrancy potentially leading to collisions or allisions. For any specific OREI it is expected that a review of relevant metocean and environmental conditions be presented and assessed as part of the project specific NSRA.

For this study, the focus is on impacts from increases in vessel traffic and wind, current, and wave conditions are not directly relevant when evaluating the change in risk. It is assumed that the existing metocean condition allow for safe navigation in the study area. A simple overview of metocean and environmental conditions for the study area is included in appendix A.

3.2 Navigation Channel Size and Configuration

Per the assumptions stated in the introduction, the anticipated OREI project locations will be seaward of the entrance to the Ambrose Channel, the main shipping channel in and out of the Port of New York and New Jersey. The Ambrose Channel is part of the Lower New York Bay located several miles off the coasts of Sandy Hook, New Jersey, and Breezy Point, Queens, NY. It starts at Ambrose Anchorage and connects to the Anchorage Channel at the north, which extends further north to connect with the Hudson River Channel and East River Channel. Figure 6 shows the layout of the navigation channels into the Port of New York and New Jersey.

In relation to the defined passage lines, the associated relevant navigation channels are as follows:

- Ambrose Channel
- Hudson River Channel
- East River Channel
- Ward Point Bend West Reach
- Sandy Hook Channel—Bayside Reach

The layout and characteristics of each of these channels will be presented in the following.

3.2.1 Ambrose Channel

The length of Ambrose channel is approximately 16.9 miles, and its approximate width is 2000 feet (USACE 2020). It ends about 2000 feet north of the Verrazano Narrows Bridge. Traffic in the Ambrose Channel is two-way for deep-draft vessels, with an occasional overtaking of one vessel by another in the same direction. The depth of Ambrose Channel at its mouth is greater than 90 feet below Mean Lower Low Water (MLLW), while its authorized depth is 53 feet below MLLW. The channel is commercially mined for sand. Inbound vessels reduce their speed to about 12 to 14 knots when entering Ambrose Channel from sea.

3.2.2 Hudson River Channel

The Hudson River Channel, which connects to the Anchorage Channel at the south, maintains a 45-foot depth MLW from Upper New York Bay to West 40th Street, Manhattan, and thence a 48 feet depth MLW to 59th Street. It is approximately 2000 feet wide (USACE, 2020). The width of Hudson River Channel at Port Coeymns is approximately 400 feet (NOAA 2010). The federally authorized navigable depth at Port Coeymans for Hudson River Channel is 32 feet MLLW (COWI 2019).

The width of Hudson River Channel near Tomkins Cove is approximately 2500 feet with a water depth of approximately 65 feet MLLW (NOAA 2020).

3.2.3 East River Channel

The East River Channel, which connects the Hudson River with Long Island Sound, is 40 feet deep, 1000 feet wide from Upper New York Bay to the former Brooklyn Navy Yard, and thence 35 feet deep, 550 to 1000 feet wide to Throgs Neck, NY. It has a total length of 16 miles approximately (USACE, USACE Fact Sheet - East River South Brother Island Channel, New York 2021).

3.2.4 Ward Point Bend West Reach

The Ward Point Bend Reach of the New York and New Jersey channels has an authorized depth of 35 feet and is generally 600 to 800 feet wide with widening at the bend (USACE 2018). The Ward Point Bend West Reach spans from about 4,200 feet seaward of bouy #2 (RED #2 W/LIGHT EBB) to the approximate location of bouy #56 (RED #56 W/LIGHT EBB) with a length of 1.29 miles (USACE 2021). There is unrestricted anchorage area west of Ward Point Bend West Reach (Office for Coastal Management 2022).

3.2.5 Sandy Hook Channel—Bayside Reach

Sandy Hook Federal Navigation Channel provides a secondary route from the ocean to Lower New York Bay. It connects with Raritan Bay Channel to the westward, Chapel Hill Channel to the north, and Terminal Channel to the south. Entrance to Sandy Hook Channel is marked by Scotland Lighted Horn Buoy equipped with a radar beacon (NOAA n.d.). The channel extends 7.1 miles long and has an authorized depth of 35 feet MLLW. It is 800 feet wide and widens at the junction with the Main Ship Channel and at the bend between the East Section and the Bayside Section. (USACE 2022) There is unrestricted anchorage area north of Sandy Hook Channel—Bayside Reach (Office for Coastal Management 2022).

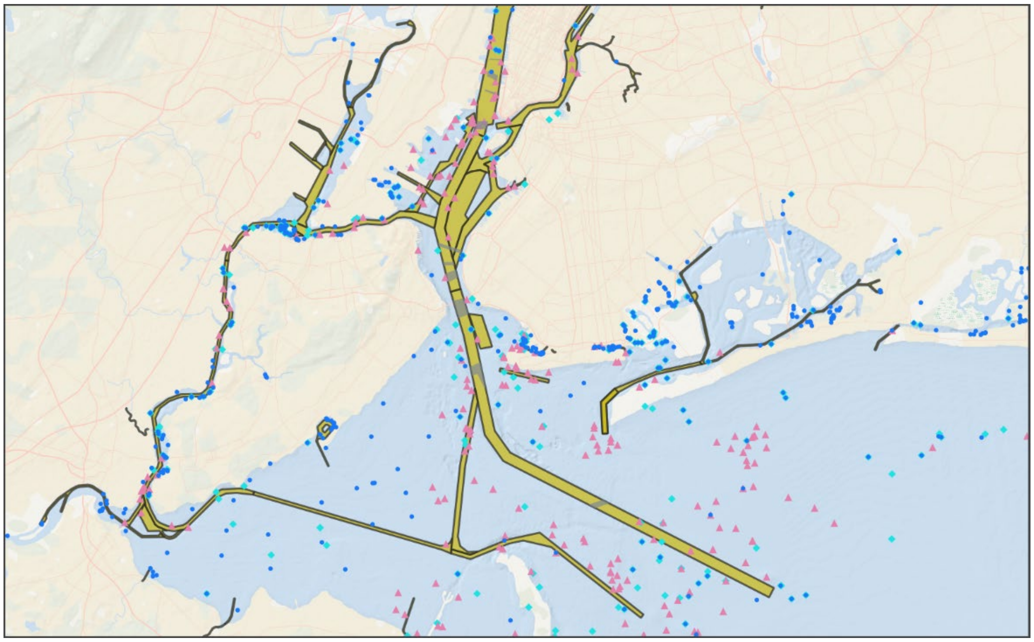
3.3 Obstructions

NOAA's Automated Wreck and Obstruction Information System (AWOIS) and Electronic Navigation Charts (ENC) were consulted to identify submerged wrecks and obstructions in the navigation channels (Figures 3–7). The NOAA Navigational Chart (#12327) was also used to determine the pipeline areas, tunnels, and the cable areas. Information pertaining to obstructions may be relevant when evaluating the navigation risks from OREIs and OSW vessels, in particular if new vessel traffic and routes are introduced. Within the study area for this assessment new waterways are not introduced. OSW vessels are expected to follow existing waterways and the size of the expected vessel traffic is not expected to be different from current users.

Figure 6. National Oceanic and Atmospheric Administration Obstructions

Cyan diamond: AWOIS Wrecks; Pink triangle: AWOIS Obstructions; Blue dots: ENC Wrecks; Grey polygon: NOAA Nautical Chart pipeline and cable areas and tunnels.

Source: COWI (December 2021); ESRI Ocean; Google Earth



3.4 Incident Reports

This section summarizes the screening of an incident report that has been gathered for the relevant channels within the study area. This data can be used to identify areas of high risk and to evaluate the historical probability of vessel aberrancy, collisions, and allisions.

Code of Federal Regulations (CFR) under 46 CFR 4.03 and 33 CFR 153.203 mandate any maritime craft report incidents to the UCSG through an automated system. The instances are reported under the Marine Information for Safety and Law Enforcement (MISLE) database which is managed by the USCG. Information input into this system includes law enforcement, pollution, and, more relevant to this study, marine accidents across the United States major waterways and intercoastal regions. In relation to this report, a high-level investigation of the currently reported instances is portrayed in the table below regarding the channels of interest in the New York State region. Each individual passage line or channel location for potential incidents was investigated and the total reported instances from 20012015 to establish a baseline of total incidents per year. Overall results are listed in Table 4 and filtered to include only larger vessels (vessels larger than 60-meter (m) length overall (LOA) and all tugs).

Table 4. Marine Information for Safety Law Enforcement Data 2001–2015

MISLE Data 2001—2015			
Navigation Channel	**Passage Line Locations**	**Total Potential Incidents***	**Total Incidents Per Year**
Ambrose	The Narrows	27	1.93
Hudson***	Hudson River	80	5.71
East River	East River	32	2.29
Ambrose	Ambrose Channel	27	1.93
Ward**	Ward Point	0	0.00
Sandy Hook**	Sandy Hook	10	0.71

* Total Potential Incidents include reported: allision, manueveability, grunding, environmental damage, capsizes, sinking, collisions, evasive manuevers, and loss of electrial power.

** No offical incidents reported in the Database.

*** The Hudson River Channel is taken from Upper New York Harbor to Albany.

Total reported incidents per year from 2001 through 2015 are presented in Table 5. No yearly trends were observed in this data.

Table 5. Reported Incidents in Area of Interest per Year

Year	Number of Reported Incidents
2014	4
2013	7
2012	7
2011	4
2010	5
2009	5
2008	7
2007	12
2006	11
2005	7
2004	12
2003	12
2002	10
2001	4
2000	4

4 Vessel Characteristics and Traffic

4.1 Approach

The New York Metropolitan Area is one of the busiest maritime hubs in the world, with heavy traffic in all major vessel categories such as cargo and container, tanker, passenger, fishing, military, and recreational. A comprehensive assessment of existing and future vessel traffic for each of the major USCG vessel categories was performed by Cumulative Vessel Traffic Assessment for non-OSW (baseline) and OSW vessels. Results of this assessment formed the vessel quantity inputs into the risk analysis summarized in this report.

Baseline traffic conditions represent existing vessel traffic in the study area. For the purpose of this analysis, 2017 was selected as the baseline year for this study. AIS data for the year was collected, processed, and analyzed as discussed in this section and served as an input for the future vessel traffic conditions projection and evaluation.

Future traffic conditions were developed for years 2017 to 2040 (inclusive) for both non-OSW (baseline) and OSW vessel traffic. The two projections were then compared to assess significance of the future OSW-induced traffic increase in each of the key areas (passage lines).

4.1.1 AIS Disclaimer

As mentioned in the 2022 Port Access Route Study (PARS) for New Jersey, there are inherent limitations associated with using AIS data to estimate and provide insights into vessel traffic:

“AIS traffic data does not capture all vessels that operate in the study area. Federal and international carriage regulations stipulate only certain vessels are required to send and/or receive AIS signals. This includes but is not limited to: vessels of 65 feet or greater, towing vessels of 26 feet or greater, vessels certificated for 150 or more passengers, dredging vessels near a channel, fishing vessels, and vessels over 300 gross tons on an international voyage. A full description of applicability and general United States requirements can be found in 33 CFR 164.46. Despite these limitations, AIS traffic data provides a satisfactory representation of the traffic in the study area. Deep draft and large vessels are required to broadcast an AIS signal; the counts of these vessels as well as their geographic locations area assumed to be accurate. The transit patterns for vessels that are not required to broadcast on AIS, such as small recreational vessels, are apparent even if these vessels are undercounted in the data set. This is based on the assumption that since a portion of the population of vessels not required by law to carry AIS voluntarily comply, these vessels provide a representative sample of the whole population."

4.2 Future Non-OSW Traffic

Future non-OSW (baseline) traffic was projected on an annual basis from 2017 up to 2040. The methodology is described in detail in the Cumulative Vessel Traffic Assessment together with a detailed presentation of the results. Overall results are listed in Table 6 and filtered to include only larger vessels (vessels larger than 60 m in length over all [LOA] and all tugs) in Table 7**.** To provide an overview of the scale of the vessel traffic at the eight passage lines, Figure 7 shows the average number of vessels passing the passage lines per hour. Seasonal trends are not considered and would likely most affect smaller pleasure crafts. It is observed that the Hudson River, East River, and The Narrows passage lines experience the highest volume of hourly vessel traffic in the range of five to 20 vessels per hour. When only vessels larger than 60 m LOA and tugs are considered, the average hourly passages is between 0.2 and 2.2 at all the considered passage lines.

Table 6. Future Non-Offshore Wind Vessel Traffic, Shown as Counts for Each Passage Line

For Years 2017–2040

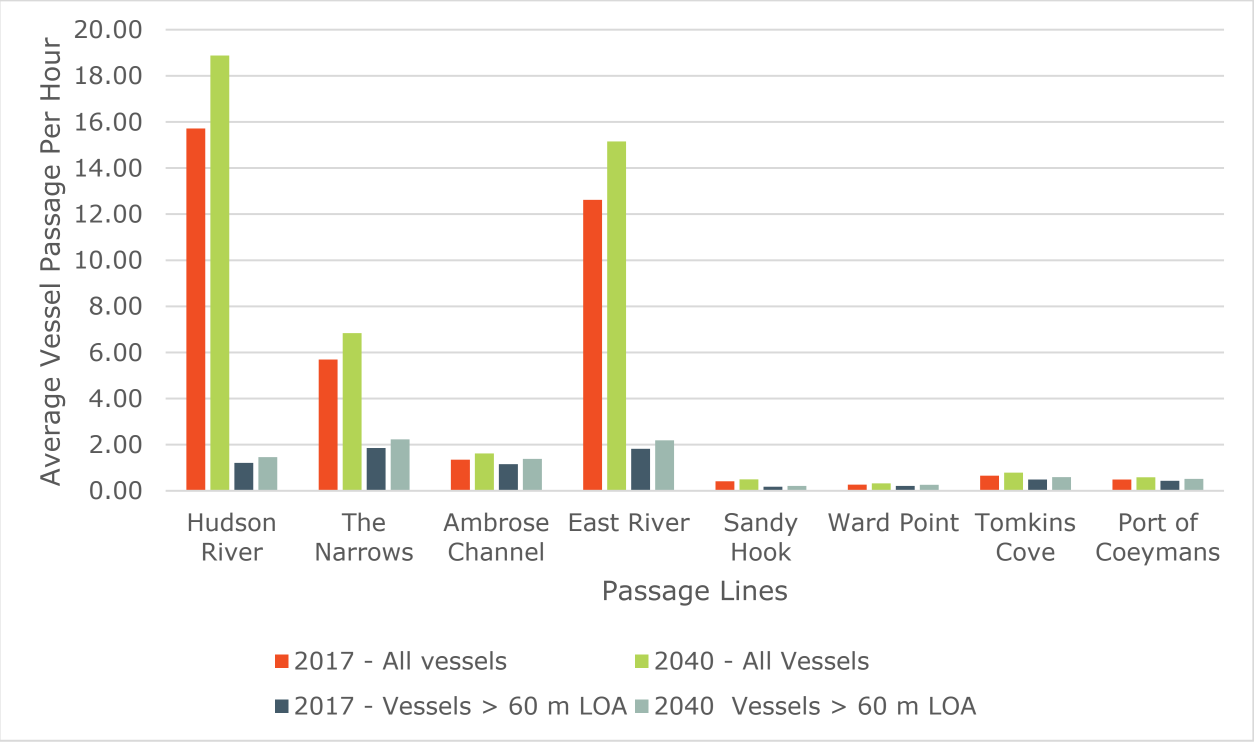
Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	137,697	49,859	11,821	110,536	3,648	2,357	5,750	4,303
2020	141,028	51,065	12,105	113,211	3,735	2,414	5,889	4,407
2025	146,760	53,140	12,599	117,812	3,888	2,513	6,130	4,587
2030	152,727	55,300	13,111	122,599	4,046	2,614	6,378	4,774
2035	158,933	57,548	13,644	127,582	4,211	2,721	6,637	4,967
2040	165,393	59,887	14,198	132,769	4,382	2,831	6,907	5,168

Table 7. Future Non-Offshore Wind Vessel Traffic Greater than 60 Meters LOA, Shown as Counts for Each Passage Line

For Years 2017–2040

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	10,635	16,252	10,111	15,980	1,565	1,882	4,321	3,785
2020	10,892	16,645	10,356	16,367	1,603	1,928	4,426	3,877
2025	11,335	17,322	10,777		1,668	2,006	4,605	4,034
2030	11,796	18,026	11,215	17,724	1,736	2,087	4,793	4,198
2035	12,275	18,758	11,670	18,444	1,806	2,172	4,987	4,369
2040	12,774	19,521	12,145	19,194	1,880	2,261	5,190	4,546

Figure 7. Hourly Baseline (2017) and Future (2040) Non-Offshore Wind Vessel Traffic for Each Passage Line



4.3 Comparing Future Non-Offshore Wind and Future Offshore Wind Vessel Traffic

Future non-OSW (baseline) traffic was projected on an annual basis from 2017 up to 2040 inclusively using publicly available data and reports and using an estimate of the compound average growth rate of 0.8% provided by SUNY Maritime in the Offshore Wind Ports: Cumulative Vessel Traffic Assessment (COWI 2022).

The Cumulative Vessel Traffic Assessment created an analytical OSW VTM which was used to estimate future OSW vessel traffic in the study area. The results were summarized in the form of yearly vessel trip quantities between hypothetical ports and project locations for both capital construction and O&M activities. See section 2.2.

Leveraging the results of the OSW and non-OSW vessel traffic forecast, a comparative assessment was conducted along eight specific lines located in areas referred to as passage lines, which were identified in Cumulative Vessel Traffic Assessment and reiterated in section 2.3. The projected vessel traffic for both OSW and non-OSW at each passage line by year is presented in Table 8.

A summary of transit count increase for each of the passage lines for all vessels is shown in Table 9. It is evident that the largest relative traffic increase is observed at Tomkins Cove, Port of Coeymans and in the Ambrose Channel Passage Line—this is because the other passage lines contain a large amount of passenger traffic, which mainly consist of ferries moving passengers between New Jersey and boroughs of New York State, while the area at Tomkins Cove, Port of Coeymans and the Ambrose Channel primarily handles commercial traffic from locations outside of the New York Harbor.

Table 8. Projected Vessel Traffic for OSW and non-OSW by year and Passage Line

Year	Hudson River		The Narrows		Ambrose Channel		East River		Sandy Hook		Ward Point		Tomkins Cove		Port of Coeymans	
	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW	Non-OSW	OSW
2017	137,697	0	49,859	0	11,821	0	110,536	0	3,648	0	2,357	0	5,750	0	4,303	0
2020	141,028	0	51,065	0	12,105	0	113,211	0	3,735	0	2,414	0	5,889	0	4,407	0
2025	146,760	188	53,140	130	12,599	130	117,812	0	3,888	0	2,513	0	6,130	188	4,587	180
2030	152,727	142	55,300	278	13,111	246	122,599	0	4,046	16	2,614	48	6,378	142	4,774	114
2035	158,933	0	57,548	358	13,644	358	127,582	48	4,211	16	2,721	16	6,637	0	4,967	0
2040	165,393	0	59,887	348	14,198	348	132,769	48	4,382	0	2,831	0	6,907	0	5,168	0

Table 9. Fraction of Vessel Traffic Increase Incurred by the OSW Projects, by Year and Passage Line, Relative to the Total Combined Estimated Traffic (non-OSW + OSW)

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2025	0.1%	0.2%	1.0%	0.0%	0.0%	0.0%	3.1%	3.9%
2030	0.1%	0.5%	1.9%	0.0%	0.4%	1.8%	2.2%	2.4%
2035	0.0%	0.6%	2.6%	0.0%	0.4%	0.6%	0.0%	0.0%
2040	0.0%	0.6%	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%

With the abundance of smaller recreational crafts and passenger vessels at many of the passage lines, it is considered relevant to provide a comparison that excludes these relatively small vessels. Therefore, large vessels are defined consistently in the Cumulative Vessel Traffic Assessment to be vessels with a LOA larger than 60 m and all tugs irrespective of size as they may be towing a barge. It is observed that the relative impact from OSW vessels increases particularly at the Hudson River and The Narrows passage lines when comparing values in Table 9 and Table 10. However, the overall increase is still between 0–5% across all passage lines.

Table 10. Future Offshore Wind Vessel Traffic at Passage Lines

Large vessels (> 60 m) and tugs only relative increase in traffic counts.

Year	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
2017	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2025	1.7%	0.8%	1.2%	0.0%	0.0%	0.0%	4.1%	4.5%
2030	1.2%	1.5%	2.2%	0.0%	0.9%	2.3%	3.0%	2.7%
2035	0.0%	1.9%	3.1%	0.3%	0.9%	0.7%	0.0%	0.0%
2040	0.0%	1.8%	2.9%	0.3%	0.0%	0.0%	0.0%	0.0%

5 Potential Effects on Safe Navigation

5.1 Risk Identification

Changes in vessel traffic patterns within a navigation route have the potential to increase the existing risks associated with vessel traffic in that route. Understanding the hazards posed by increased vessel traffic quantity due to offshore wind farms and, furthermore, mitigating the risks associated with the hazards, is necessary to ensure the continued safe practice of vessel navigation within the study area.

Within the confines of the pre-determined study area (i.e., within New York State waterways), the vessel navigation characteristic most affected by construction and operation of an offshore wind farm is vessel traffic density. In alignment with the nature of this study, the cumulative effects of the offshore wind projects on vessel traffic quantity were analyzed in this section to assess the impact on vessel navigation over time.

Risks associated with changes in vessel traffic density in existing waterways is grouped into two main hazards, namely:

1. Allision with fixed object (drifting or motorized).
2. Ship-to-ship collision.

The following sections will address how the two groups may be impacted by the introduction of new OSW vessel traffic. This involves an evaluation of the baseline risk in a situation where OSW vessels are not introduced as well as the future situation where OSW vessel are present. A combination of qualitative and quantitative evaluations will be adopted to provide a nuanced and relevant overview of the impact from offshore wind vessels. Furthermore, the principles for calculating collision and allision frequencies are outlined and discussed. Similar methodology could potentially be applied when carrying out a NSRA for a specific OWF project.

5.2 Allision with Fixed Object

Allision with objects will, in the context of this study and associated study area generally be bridges, reefs, the shoreline, or other fixed structures. When carrying out the NSRA for a specific OREI the most predominant allision scenario will likely be with the OSW turbines. Irrespective of the object of impact, the methodology for calculating allision frequency *P* can be described by the following expression:

$P = N \cdot Pc \cdot G \cdot R$

where:

- N is the frequency of ships within the considered timeframe.
- Pc is the causation probability (the probability of aberrancy that potentially can lead to allision or collision. For drifting vessels this may be the blackout frequency).
- G is the geometrical probability of a vessel heading towards an object.
- R is the combined effect of accident risk reduction factors arising from e.g., Vessel Traffic Services (VTS), Traffic Separation Scheme (TSS), Electronic Chart Display and Information System (ECDIS)—and/or pilotage.

The principles behind the estimation of the above parameters and the impact OSW vessels may have on them will be outlined in the following.

The main factor considered to be influenced by the introduction of OSW vessels is the frequency of ships N. The frequency of vessel allisions with fixed objects is expected to increase proportional to the increase in vessel traffic (see Table 9 and Table 10) i.e., approximately 1–5% depending on the considered passage line and whether or not only large vessels are considered.

The causation probability, P_C, is the probability of a ship being aberrant or failing to correct to intended course on the navigation route. Factors that may influence the causation probability are the visibility, wind, current, traffic density and waterway characteristics. The literature suggests a number of different values and methods to be used for the causation probability. The American Association of State Highway and Transportation Officials (AASHTO) guideline used to calculate probability of impact with bridges suggests that the causation probability be based on accident statistics or alternatively it be taken as 0.6×10^{-4} per passage for ships and 1.2×10^{-4} per vessel passage for barges.

Considering the incident statistics extracted and presented in section 4.4 the causation probability can be estimated to be in the range of 1×10^{-4} to 5×10^{-4} per vessel passage. Vessel passage information from 2017 is used to convert incidents per year to incidents per passage. Optimally, vessel passages for each of the years from 2001 to 2015, corresponding to the years of the accident data, should have been used. However, in the absence of this information the estimates provide a rough order of magnitude and suggest that the proposed value in AASHTO and other sources (Larsen 1992) seems applicable also within our study area. Overall, the causation probability is not expected to change significantly as a result of the estimated OSW vessel traffic.

The geometric probability of a vessel heading toward an object is not expected to change within the study area. OSW vessel are expected to follow the existing routes and channels and lateral distribution across channels. Drifting allisions will for all vessels be impacted by wind and current direction with no specific impact from OSW vessels.

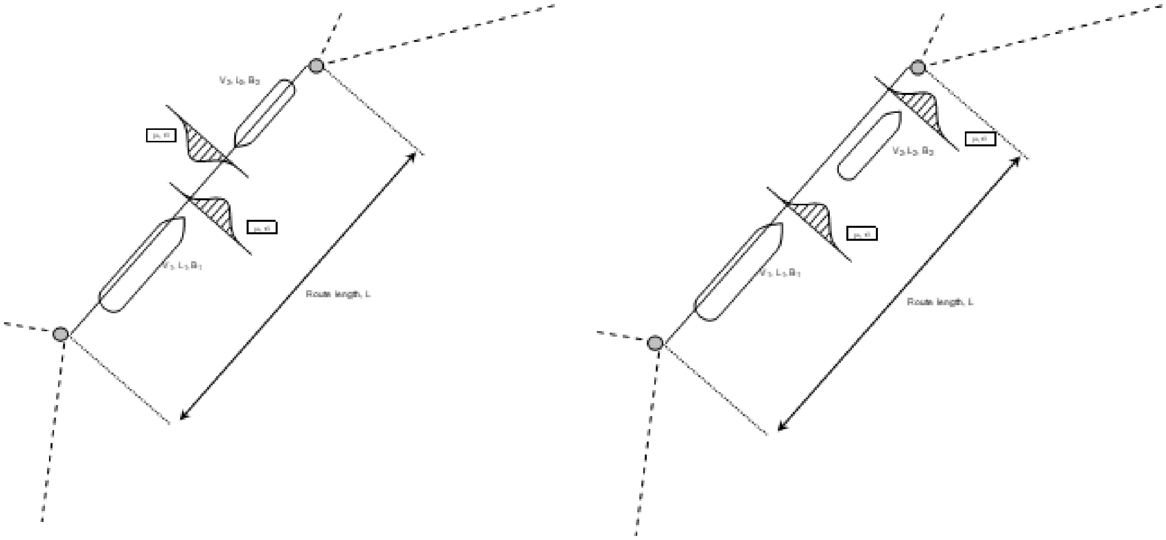
Risk reducing measures may be introduced generally or project specifically by the authorities and/or developers. A cursory review of some potential mitigation measures is found in section 6.

The majority of the input parameters to calculate allision frequency remain more or less unaffected in the future scenario with OSW vessel traffic. The frequency of vessel allisions with fixed objects is expected to increase proportional to the increase in vessel traffic i.e., approximately 1–5% depending on the considered passage line and whether or not only large vessels are considered.

5.3 Ship-to-Ship Collision

Collisions between two ships are generally divided into two types, namely route collision and node collisions. Route collisions arise from vessels navigating in parallel, either in the same direction (overtaking) or opposite direction (head-on) as displayed in Figure 8. Node collisions, arising from bends/crossings in the navigation channel are generally also relevant, but there are no nodes in the vicinity of the passage lines and this scenario is not considered to change appreciably within the study area. It may, however, be relevant when varying out the project specific NSRA where new routes may be introduced.

Figure 8. Principles for Calculation of Ship-to-Ship Collisions



The calculation of collision frequencies of route collisions is based on the same principles as collisions with fixed objects. The key inputs are the length of the route segment, the traffic intensity in each of the two directions, the width and speed of the ships, the deviation of the ships from the route axis and the causation probability of a ship being aberrant or failing to correct to intended course on the navigation route. A detailed description of the model is provided in appendix B.

The meeting frequency of two vessels is one of the key inputs, and this information is obtained by combining every ship with every possible collision partner and hence, the number of meeting situations is proportional to the square of the vessel traffic.

The geometrical collision probability is obtained based on the lateral distribution of vessels across the waterway or channel taking into account the breadth of the ship as well. A normal distribution is assumed for the vessel traffic in each direction. The distribution and geometrical collision probability is not considered to be impacted from the OSW induced vessel traffic.

The causation probability represents the probability that two ships sailing on collision course do not undertake any evasive measures. The impacting factors are similar to those described in the previous section and are not expected to be significantly impacted by the projected OSW vessel traffic.

To provide an idea of the change in collision frequency for this scenario, a number of rough calculations were carried out based on the calculation principles described above and detailed in appendix B. Vessel traffic distributions were established based on available information from Automatic Identification System (AIS) data and the width of the channel. While these calculations cannot be seen as exact results, they provide a reasonable indication of the expected impact. Only the year with maximum added OSW vessel traffic is considered as well as the 2017 baseline year. Overall, the return period for ship-to-ship collisions within the considered area was estimated to be nine years based on 2017 vessel traffic. The increase in collision frequency from future non-OSW vessel traffic increase was generally leading to an increase in ship-to-ship collision of 10–40% depending on the year considered.

The estimated collision frequencies resulting from OSW vessel traffic were found to increase by 1–10% in the year with the largest OSW vessel traffic increase when comparing to the results for that same year without OSW vessel traffic.

5.4 Summary of Findings

In this chapter the identified risks were presented and evaluated. The two considered risks are:

1. Vessel collision with fixed object.
2. Ship-to-ship allision.

The principles for evaluating the above risks have been presented along with a semi-quantitative evaluation based on available vessel traffic information.

The expected increase in vessel allisions with fixed objects is roughly proportional to the increase in vessel traffic which was previously estimated to be 1–5% at the considered passage lines.

In the case of ship-to-ship collisions the number of meeting situations increase with the square of the vessel traffic increase and hence the increase in ship-to-ship collision probability is found to be slightly higher for this scenario and generally between 1–10%. It is observed that the expected increase in risk resulting from assumed development in non-OSW vessel traffic vastly exceeds that associated with OSW vessel traffic.

6 Mitigation Measures

This section covers a cursory review of navigational rules and mitigation measures that may be relevant on a local and regional level to address risks associated with an increase in vessel traffic identified in the previous sections. However, it will always be the developer and regulatory authorities who determine the extent of mitigation measures required to obtain an acceptable risk level for a specific project.

6.1 Navigational Rules

To mitigate potential risks to navigational safety, navigational rules as outlined by governing authorities must be followed. According to USCG Navigation and Vessel Inspection Circular No. 01-19 (United States Coast Guard 2019), navigation safety requires that mariners are able to:

- Determine their position at all times.
- Determine a safe course to steer well in advance of detecting a potential obstacle.
- Be aware of unseen dangers via charts, maps, or signs.
- Determine if risk of collision or allision exists either visually or when using radar systems.
- Take action to avoid collision and allision.

Additionally, vessels, including those with OREI-associated navigational purpose, must adhere to the USCG Navigation Rule and Regulations Handbook (United States Coast Guard 2014). The Handbook consists of the following rules and regulations for operating vessels:

- 77 COLREGS: International Regulations for Preventing Collisions at Sea, 1972.
- 33 CFR 83: Inland Navigation Rules.
- 33 CFR 84-90: Respective technical annexes to the above.
- 33 CFR 80: COLREGS Demarcation Lines.
- 33 CFR 26: Vessel Bridge-to-Bridge Radiotelephone Regulations.
- 33 CFR 161: Vessel Traffic Management Regulations.

Additional pertinent provisions of the U.S. Code and Code of Federal Regulations regarding compliance and penalties associated with the Navigation rules.

Additional local navigational restrictions and regulations may be present and must be adhered to by all vessel traffic.

6.2 Mitigative Measures

Referring to USCG Navigation and Vessel Inspection Circular No. 01-19 (United States Coast Guard 2019), potential mitigations to the possible increase in navigation risk caused by intensified vessel traffic density and/or changes to navigation patterns because of the installation of OREI projects and introduction of new offshore wind vessel types within existing navigation channels are listed below. These measures are generally already adopted and could potentially be expanded or extended to address new risks:

- Aids to navigation (ATON).
- Pilotage in high congestion areas.
- VTS and AIS-based services.
- Precautionary areas and areas to be avoided.
- Anchorage restrictions.
- Limited access areas.
- Advanced notification systems.
- Other routing measures.

Specific examples of risk mitigation strategies provided in NVIC 01-19 (United States Coast Guard 2019) that are applicable to risks studied include:

- Monitor vessel traffic on a regular basis (i.e., monthly) and continuously assess trends. Continuous monitoring may help identify new passage lines or areas of interests that may not have been captured during the permitting stage of OREI projects. If problematic areas are detected, competent jurisdictions may be able to enable information broadcast (live information) to vessels; or work with the USCG and/or NOAA to inform mariners via navigation charts.
- Marine structure upgrades (such as pier extensions, mooring facilities upgrades, or terminal reconfiguration) may cause obstructions to navigation and in turn, increase the risk of collision and allusion. Awareness shall be maintained as port upgrades are performed. Changes to the topography or configuration of constricted channels (particularly further inland) should be communicated to NOAA, USCG, in a timely manner.
- Provision of forecast vessel traffic estimates and coordination with local authorities on management of increased vessel traffic, specifically in the passage lines identified in this study.
- Advertisement of information and warnings of increased vessel traffic as well as vessel types through Local Notices to Mariners and Broadcast Notice to Mariners, as well as other media channels (including mobile and satellite phones, multi-channel very high frequency [VHF]).
- Provision of cautionary notation on nautical charts during execution of the construction and operation phases. The rise of digital NOAA electronic navigation chart products facilitate rapid update cycles.
- Continuous communications watch using multi-channel VHF, including digital selective calling.

Mitigating factors and examples as described above are typically implemented with the intent of lowering risk, including raising situational awareness, increasing local knowledge and expertise, or improving navigation (United States Coast Guard 2019).

The proposed OREI projects are in an early stage, with only a few key parameters known at this time. This limits our ability to describe their impacts on navigation safety in more detail. When the projects have sufficiently advanced to later design stages, we recommend coordination with governing authorities to manage additional potential risks induced by increased traffic density and introduction of new vessel types to the navigation routes as well as increasing awareness of these effects among mariners. We anticipate that a project specific NSRA be produced together with an update of this study to consider the combined effects of increased vessel traffic. Integrating these projects and managing risks will be of utmost importance to ensure safe, continued use of the navigation routes in the study area.

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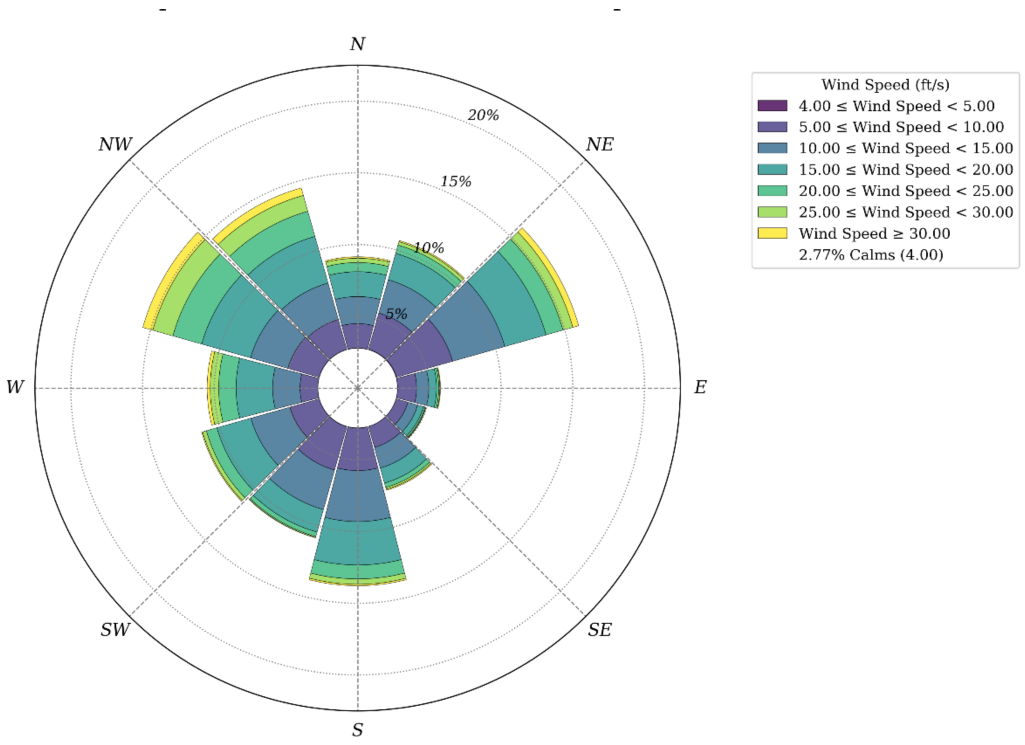
Appendix A. Metocean Conditions

A.1 Wind Data

A wind rose extracted from data from La Guardia Airport (NOAA 2018) is displayed in the figure below.

Figure A-1. La Guardia Airport 1-Hour Wind Speed Rose



A.2 Water Levels

The tides in New York Bight are semi-diurnal with a period of about 12.4 hours. Tidal datum at NOAA Station Sandy Hook, NJ (Station ID 8531680) is provided in Table 11. The mean tidal range at Sandy Hook is 4.7 ft. The highest observed tide at Sandy Hook was 7.27 ft, NAVD88 at 09/12/1960 13:00, while the lowest observed tide there was -7.53 ft, NAVD88 at 02/02/1976 16:00.

Table A-1. Table Tidal Datums at NOAA Station Sandy Hook, NJ, 1983–2001 Epoch

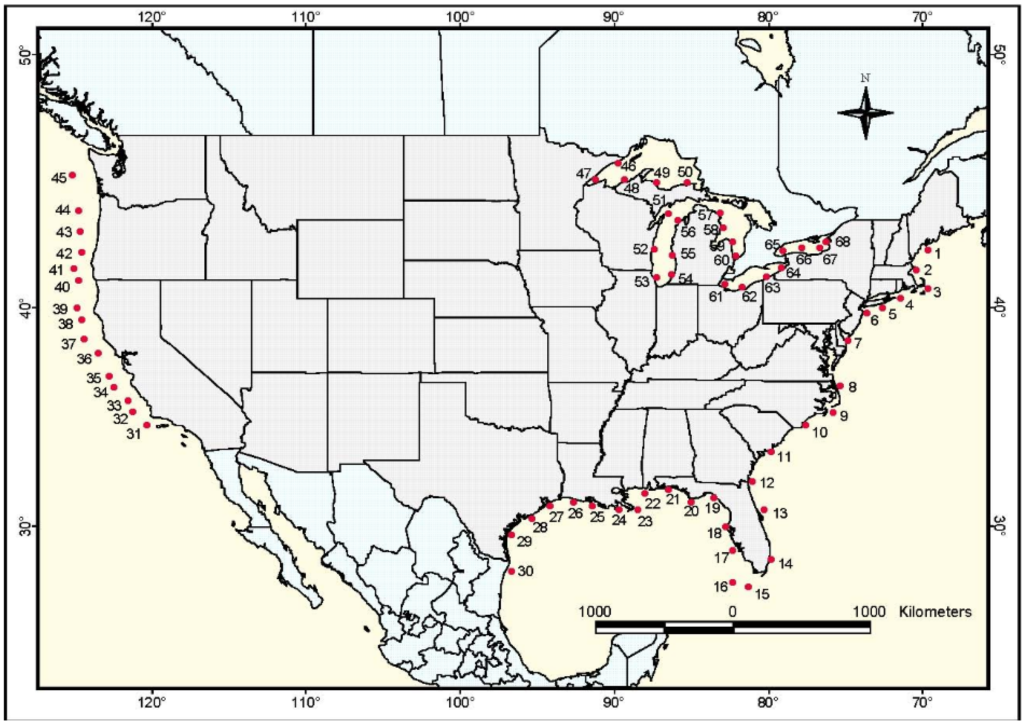
Tidal datum	Value [ft]	Definition
MHHW	5.23	Mean Higher High Water
MHW	4.89	Mean High Water
DTL	2.61	Diurnal Tide Level
MTL	2.54	Mean Tide Level
MSL	2.58	Mean Sea Level
MLW	0.19	Mean Low Water
MLLW	0.000	Mean Lower Low Water
GT	2.71	Great Diurnal Range
MN	2.19	Mean Range of Tide
DHQ	-2.18	Mean Diurnal High Water Inequality
DLQ	-2.32	Mean Diurnal Low Water Inequality
NAVD	2.82	North American Vertical Datum of 1988 (NAVD88)
LWI	19.28	Greenwich Low Water Interval
HWI	-1.57	Greenwich High Water Interval

A.3 Wave Climate

The wave climate at New York Bight comprises of a mixture of swells that propagate from offshore and locally generated wind-waves. The USACE provides representative mean wave statistics at two locations in the vicinity of New York Bight (see Point 5 and Point 6 in Figure 10).

Figure A-3. Map of Locations with Representative Wave Statistics in Atlantic Ocean

Source: USACE Coastal Engineering Manual



A.4 Currents

Tidal currents in New York Harbor and New York Bight are moderate, with ebb currents ranging from -1.1 to -2.1 knots and flood currents ranging from 0.6 to 2.2 knots (USACE 2020). Table 12 shows the ebb and flood currents condition at stations throughout New York Harbor and New York Bight, with the locations of the stations presented in Figure 11.

Table A-4. Ebb and Flood Currents Throughout New York Harbor and New York Bight

Source: (USACE 2020).

Location	Average Ebb (knots)	Average Flood (knots)
Ambrose Channel	-1.68	1.54
Robbins Reef	-1.58	1.28
The Narrows	-2.00	1.31
Bergen Point West	-1.49	1.84

Figure A-4. Locations of the Currents Stations

Source: (USACE 2020).

Appendix B. Probability of Two Ships Being on Collision Course

The geometric probability of two ships being on collision course $P_g(SS)$ is an input parameter to the model describing ship-bridge collision due to ship-ship collision evasion manoeuvres.

There are two types of ship-ship collisions, only route collisions are considered in this analysis:

- Route collisions
- Node collisions

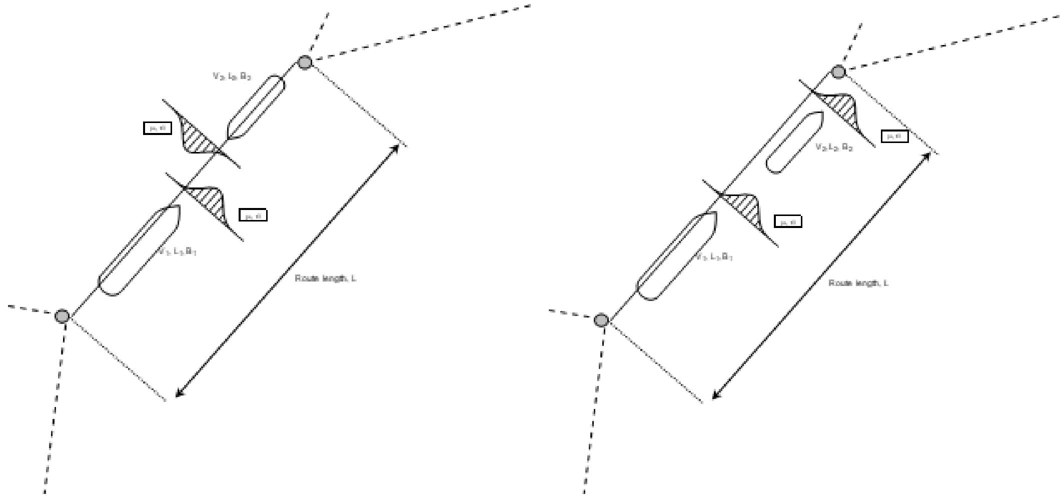
B.1 Route Collisions

When two ships collide while sailing on the same route, this is referred to as route collision. There are two basic cases:

- Head-on collisions between two ships heading in opposed directions.
- Overtaking collisions between two ships heading in the same direction.

These two cases are illustrated in Figure 12.

Figure B-1. Head-On and Overtaking Collisions



For route collisions, $P_g(SS)$ depends on:

- the length of the route segment.
- the traffic intensity in each of the two directions.
- width and speed of the ships.
- the deviation of the ships from the route axis.

In the course of calculation, every ship (ship_1) is combined with every possible collision partner (ship_2). Then, their collision probability is calculated. Both ship_1 and ship_2 have an array of properties such as ship type, speed, size, breadth which are all taken into account.

Two ships sailing along the same route get on collision course with a yearly frequency of:

$$\mathbf{r_x = r_t \cdot P_{g0}}$$

where:

r_t = yearly frequency of meeting within one route segment (a matter of time and route length)

P_{g0} = basic geometrical collision probability (a matter of width)

For ship_1, the probability of getting on collision course with another ship during a given passage is:

$$\mathbf{P_g(SS)=r_x \cdot N_1 \cdot P_g(SS)=r_x \cdot N_1}$$

where: N_1 is the yearly number of ship passages of ship_1.

The partial probabilities are obtained as:

$$r_t = LN_1N_2\left|\frac{V_1 - V_2}{V_1V_2}\right|$$

where:

L = length of route segment

N_1, N_2 = yearly number of passings (ship_1, ship_2)

V_1, V_2 = vessel speed (ship_1, ship_2)

Basic geometrical collision probability:

$$P_{g0} = \Phi\left(\frac{|\mu_1 - \mu_2| + \overline{B}}{\overline{\sigma}}\right) - \Phi\left(\frac{|\mu_1 - \mu_2| - \overline{B}}{\overline{\sigma}}\right)$$

with $\overline{B} = \dfrac{B_1 + B_2}{2}$ and $\overline{\sigma} = \sqrt{\sigma_1^2 + \sigma_2^2}$

where:

m_1, m_2 = mean value of the transversal position of ship_1 and ship_2, respectively, relative to the route axis

s_1, s_2 = standard deviation of the transversal position of ship_1 and ship_2, respectively, relative to the route axis

B_1, B_2 = beam (ship_1, ship_2)

F(…) = Cumulative density function of the standard normal distribution

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Appendix B. AIS Data Processing

This appendix covers technical details related to processing of AIS data obtained from Marine Cadastre. The purpose of this section is to not repeat information given in the report, but to enhance it by providing relevant technical details.

AIS data downloaded from Marine Cadastre was downloaded for year 2017 for UTM zones 18 and 19, with each zone/month combination represented by individual ZIP file. ZIP files were downloaded and a CSV file with actual data was extracted from it and processed. Each CSV file had features shown in Figure B-1, except Transceiver Class which was introduced only for data for years 2018 and forward. Each feature was validated and coerced to a data type as shown in the Marine Cadastre data dictionary.

LON/LAT coordinates were converted from EPSG:4269 to EPSG:4326 coordinate reference system and then filtered using lon/lat box corresponding to the model extents prior to being uploaded to the database.

Time zone was preserved when uploading data to the database. As a result a small portion (5 hours) of data in the Eastern Standard Time (EST) zone at the end of 2016 was "added" and the same amount of data in the EST time zone from the end of 2017 was "missed." This five-hour shift in local time zone does not introduce any significant bias to the analysis and is consistent with methodology employed by Marine Cadastre when performing similar analyses.

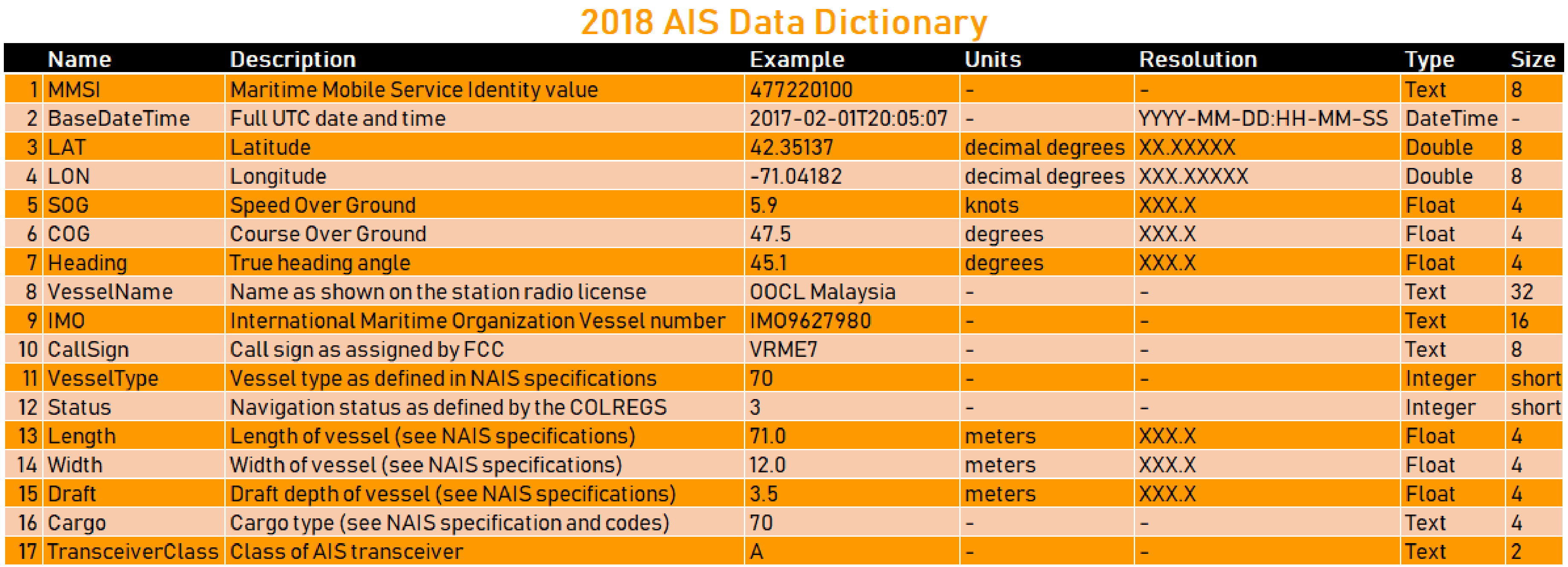
Data in the database was indexed by geometry (lon/lat), datetime, MMSI, and vessel type to significantly improve look up performance when working with the data.

All processing was performed using software developed by COWI in-house in programming language Python 3.9. Data was stored in the PostgreSQL database with PostGIS extension. Total size of the database table containing 2017 data was 47 GB, of which 21 GB corresponded to data and 26 GB to indexes. Over 150 million entries (pings) were processed and stored.

Figure B-1. Marine Cadastre AIS Data Dictionary

(2017 data has the same schema, but without the Transceiver Class feature)

Source: COWI; Marine Cadastre



2018 AIS Data Dictionary

	Name	Description	Example	Units	Resolution	Type	Size
1	MMSI	Maritime Mobile Service Identity value	477220100	-	-	Text	8
2	BaseDateTime	Full UTC date and time	2017-02-01T20:05:07	-	YYYY-MM-DD:HH-MM-SS	DateTime	-
3	LAT	Latitude	42.35137	decimal degrees	XX.XXXXX	Double	8
4	LON	Longitude	-71.04182	decimal degrees	XXX.XXXXX	Double	8
5	SOG	Speed Over Ground	5.9	knots	XXX.X	Float	4
6	COG	Course Over Ground	47.5	degrees	XXX.X	Float	4
7	Heading	True heading angle	45.1	degrees	XXX.X	Float	4
8	VesselName	Name as shown on the station radio license	OOCL Malaysia	-	-	Text	32
9	IMO	International Maritime Organization Vessel number	IMO9627980	-	-	Text	16
10	CallSign	Call sign as assigned by FCC	VRME7	-	-	Text	8
11	VesselType	Vessel type as defined in NAIS specifications	70	-	-	Integer	short
12	Status	Navigation status as defined by the COLREGS	3	-	-	Integer	short
13	Length	Length of vessel (see NAIS specifications)	71.0	meters	XXX.X	Float	4
14	Width	Width of vessel (see NAIS specifications)	12.0	meters	XXX.X	Float	4
15	Draft	Draft depth of vessel (see NAIS specifications)	3.5	meters	XXX.X	Float	4
16	Cargo	Cargo type (see NAIS specification and codes)	70	-	-	Text	4
17	TransceiverClass	Class of AIS transceiver	A	-	-	Text	2

Appendix C. Transit Count Estimation

A vessel transit, as defined in the report, is a distinct segment of vessel track having its start and end within or at the edge of a cell. Same track can produce multiple transits with a grid cell if it enters and exits it multiple times. Calculating transit counts by clipping each track by a polygon to get segments and then counting them would be an approach faithful to the concept yet prohibitively expensive in terms of processing time. In order to calculate transit counts in reasonable time (~80 hours on a 12-core central processing unit) a simpler approach was used:

- Calculate number of points where track intersects a given polygon.
- Divide this number by two to get number of transits—this is based on idea that each transit involves vessel entering and exiting the cell (thus, 2 points per transit).
- Round up the number to nearest integer to account for cases where vessel track starts or ends inside the cell (odd number of points).
- Perform this for every track and grid cell and aggregate the results to get total transit counts for each of the cells and vessel types.

This approach is demonstrated in Figure C-2. This algorithm gives accurate results with the only scenario resulting in under-counting when a vessel track starts and ends inside the same grid cell—this results in missing one transit for such track because initial exit and final entrance are counted as single transit. These scenarios are exceedingly rare and have negligible effect on the model. This methodology is consistent with analysis methods employed by the joint effort between NOAA & BOEM (Jeremy Fontenault, 2019).

An example where this methodology was applied is shown in Figure C-2 and Figure C-3.

FigureC-1. Transit Count Scenario Diagram

Source: COWI (December 2021)

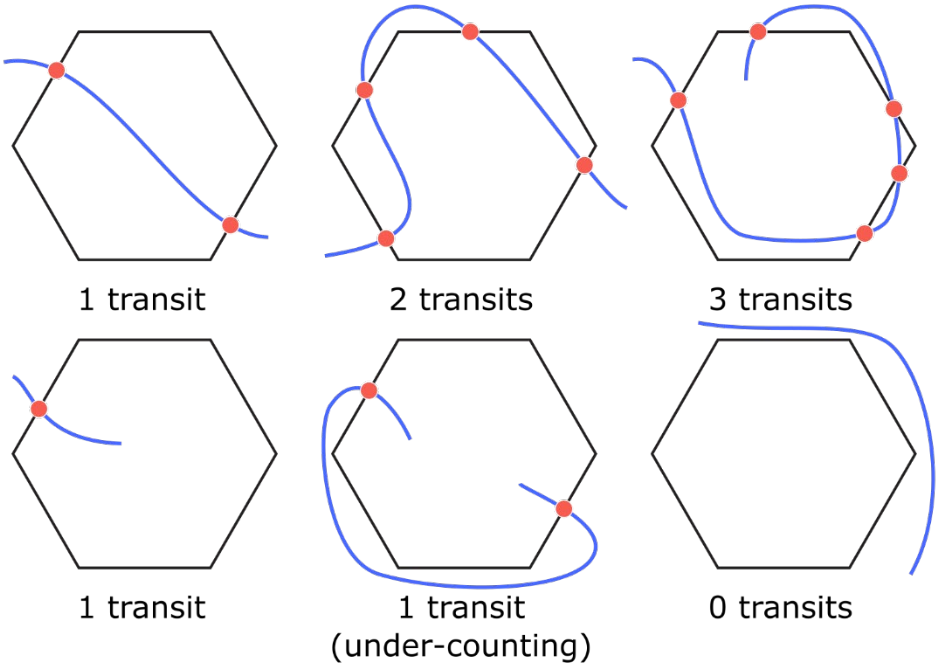


Figure C-2. Transit Counts (One Day of Data)

Source: COWI (December 2021); Google Earth

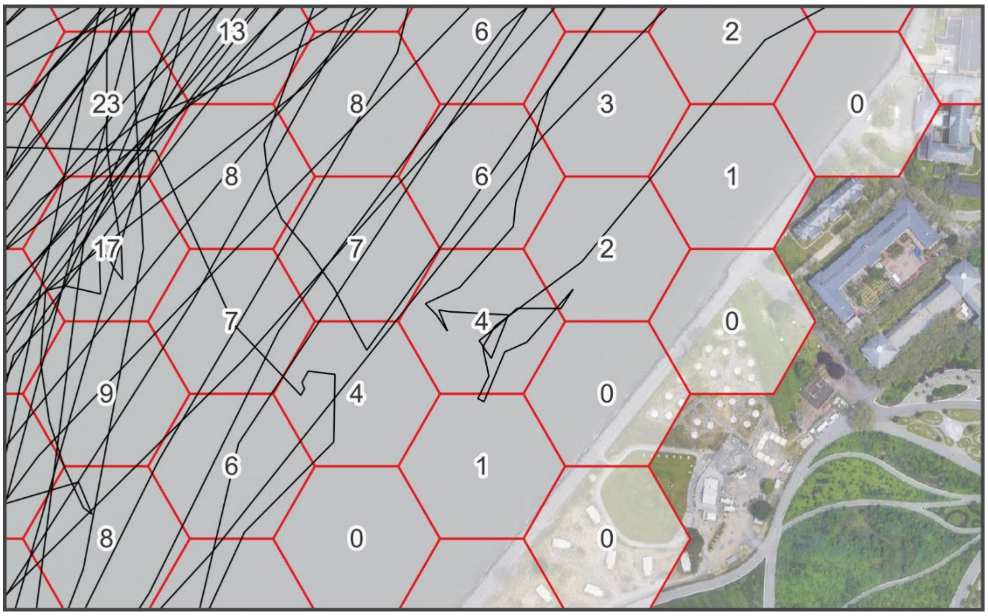
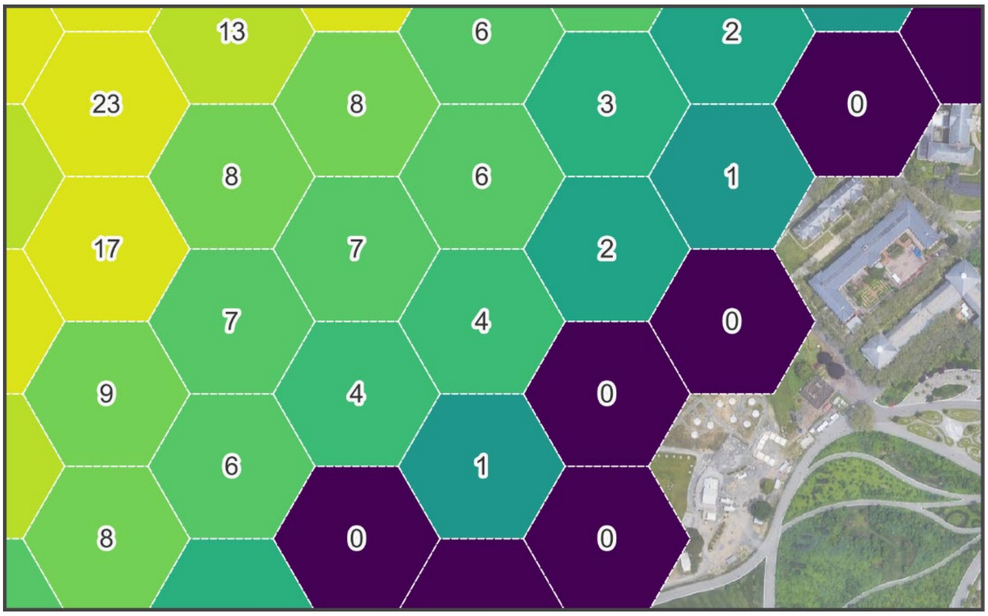


Figure C-3. Transit Counts Color-Coded (One Day of Data)

Source: COWI (December 2021); Google Earth



Appendix D. Transit Count Maps

Figure D-1. Passage Line Locations: Overview

Source: COWI (July 2022); ESRI Ocean

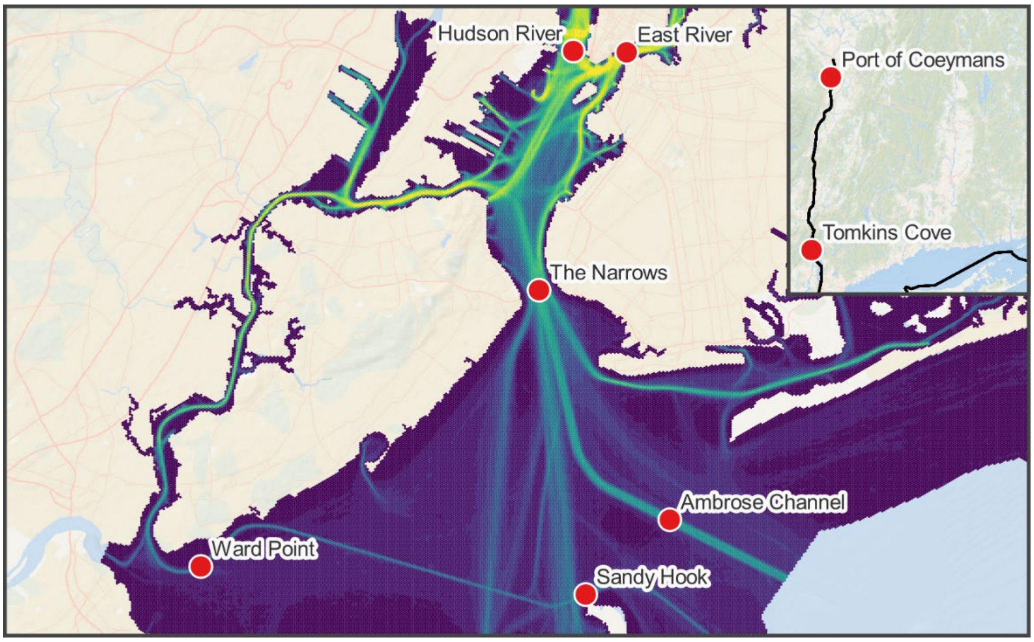


Figure D-2. Passage Line Locations: Ambrose Channel and Sandy Hook

Source: COWI (July 2022); ESRI Ocean

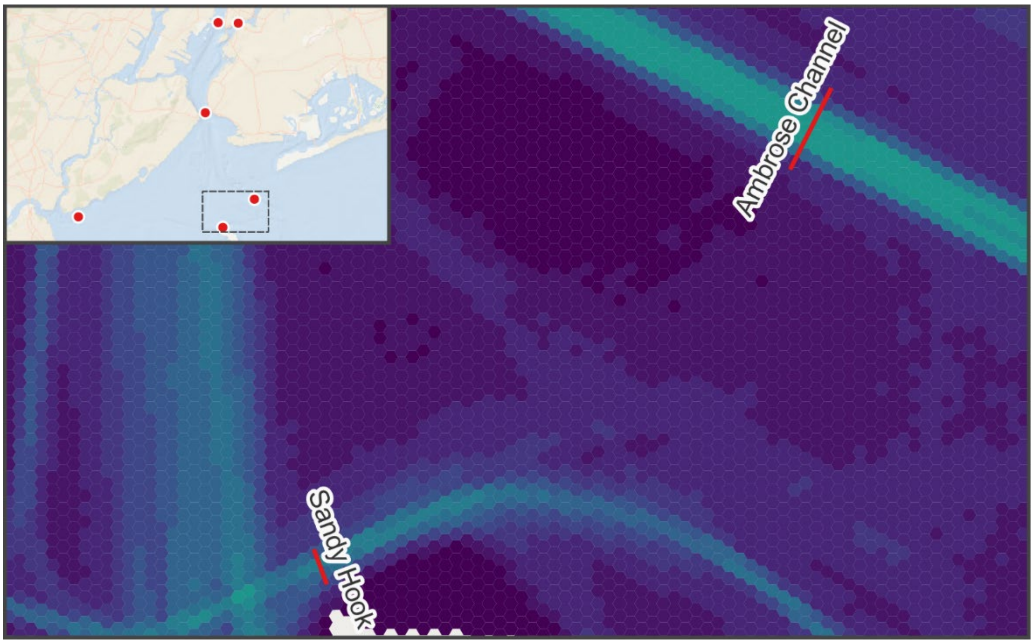


Figure D-3. Passage Line Locations: Ward Point

Source: COWI (July 2022); ESRI Ocean

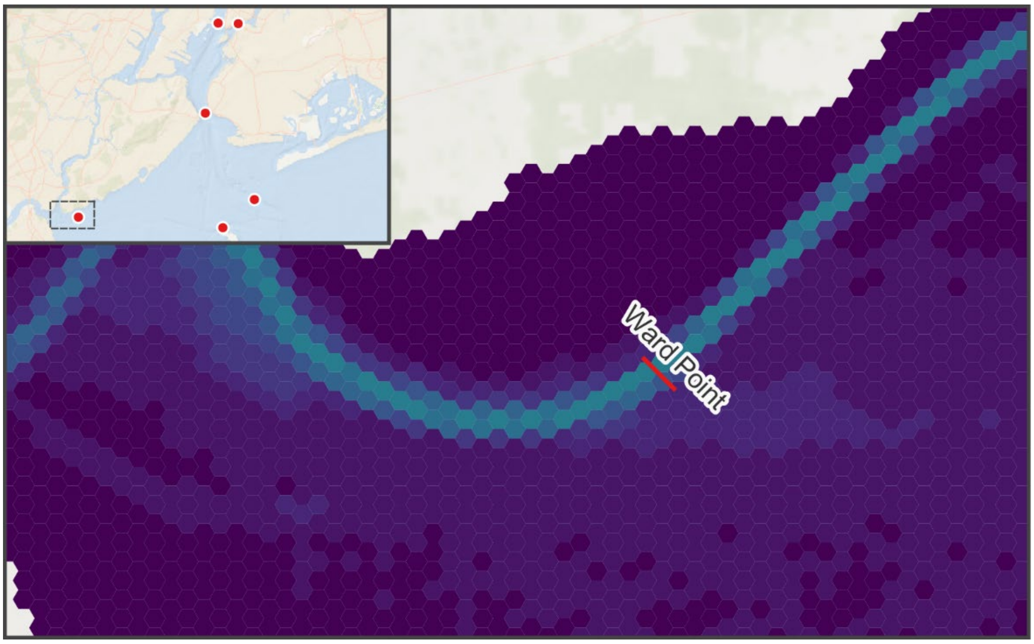


Figure D-4. Passage Line Locations: Hudson River and East River

Source: COWI (July 2022); ESRI Ocean

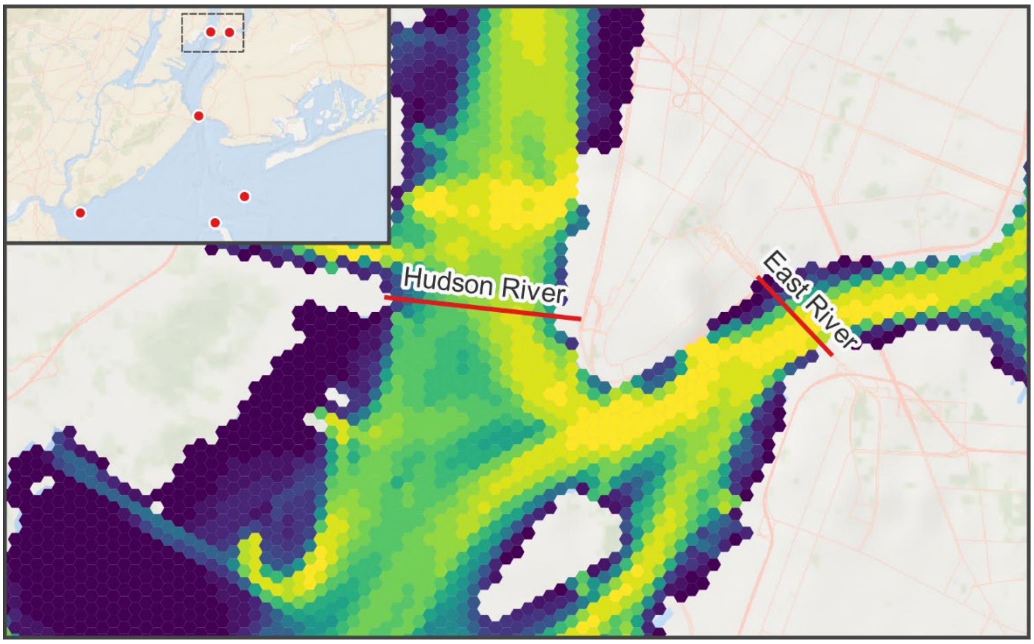


Figure D-5. Passage Line Locations: The Narrows

Source: COWI (July 2022); ESRI Ocean

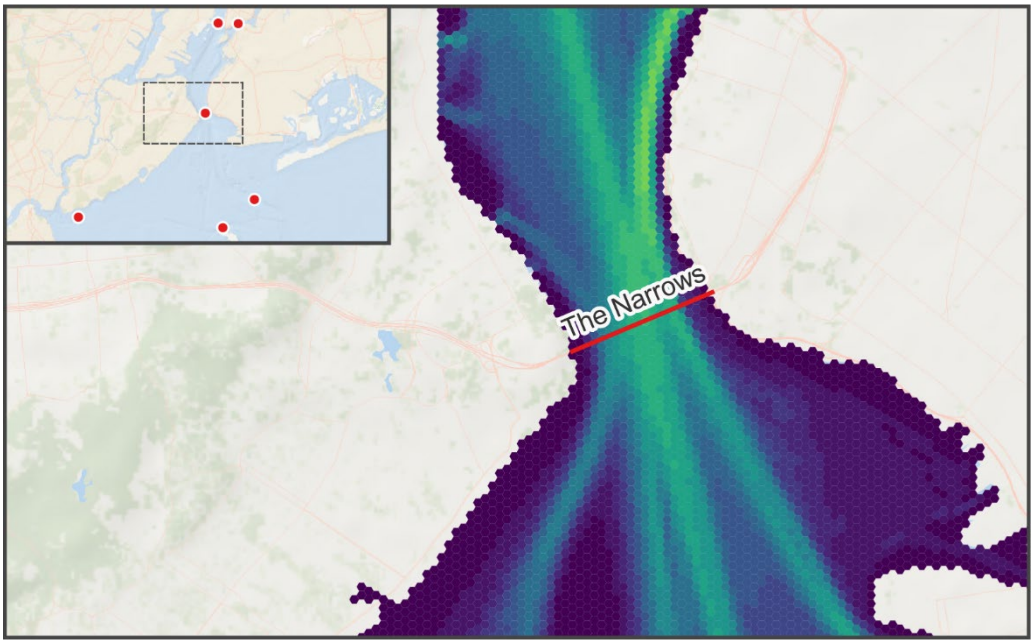


Figure D-6. Passage Line Locations: Tomkins Cove

Source: COWI (July 2022); ESRI Ocean; Google Maps

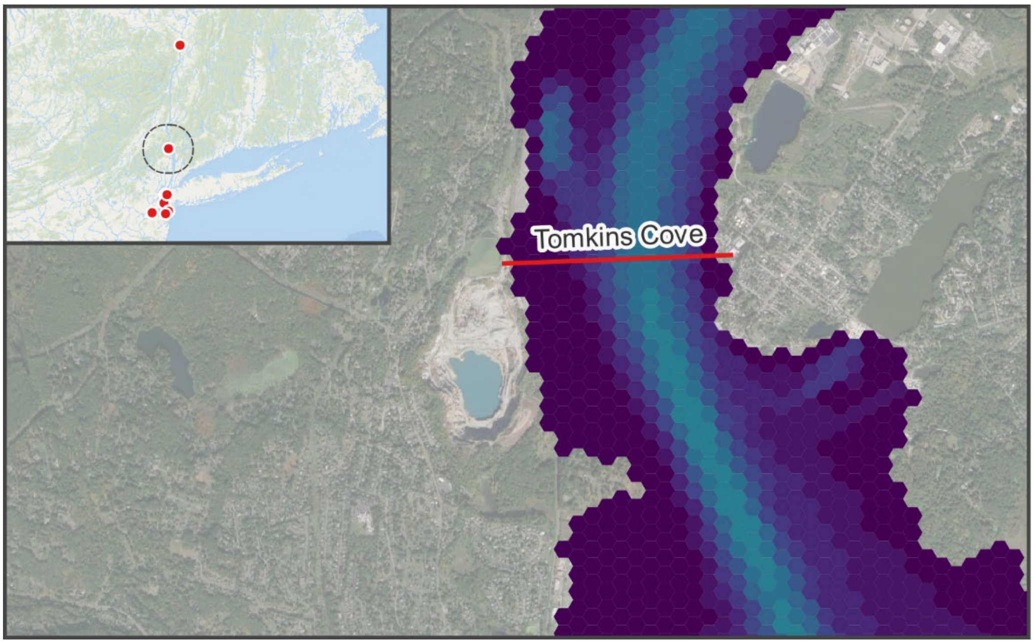
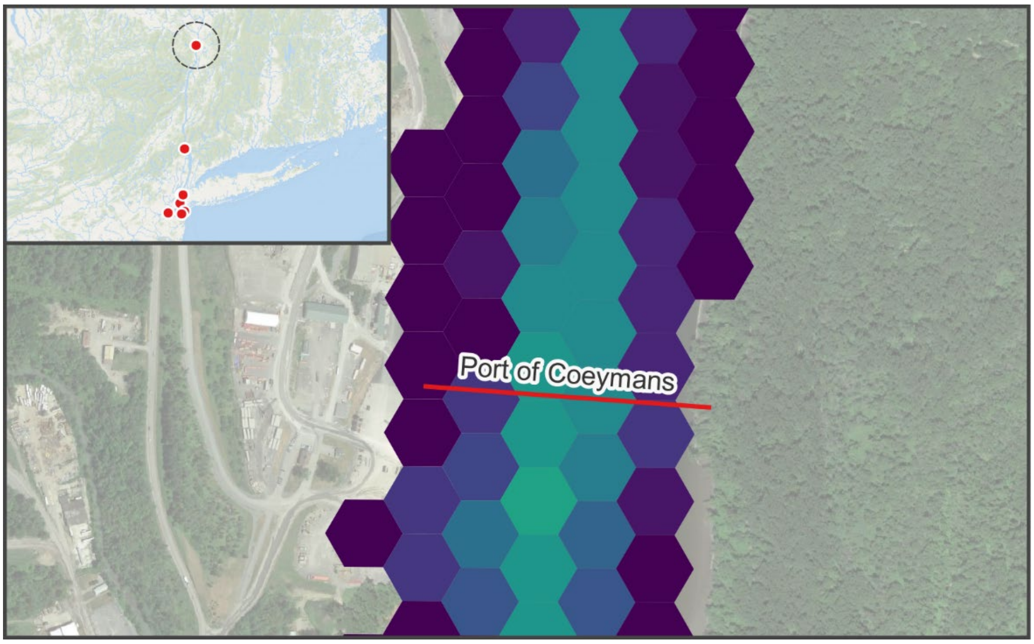


Figure D-7. Passage Line Locations: Port of Coeymans

Source: COWI (July 2022); ESRI Ocean; Google Maps



Appendix E. Detailed Data for Individual Passage Lines

Additional insights can be gained by drilling down into the data structure for a specific passage line.

E.1 Length Distribution for all Passage Lines

Table E-1. Baseline Non-OSW Vessel Length Distribution for Each of the Passage Lines

(Shown as Counts) For year 2017

Length [m]	Hudson River	The Narrows	Ambrose Channel	East River	Sandy Hook	Ward Point	Tomkins Cove	Port of Coeymans
no data	12,083	13,097	826	36,085	786	238	806	218
(0.0, 20.0]	31,705	4,743	396	5,739	1,099	127	1,166	808
(20.0, 40.0]	81,380	16,665	2,352	53,488	954	1,025	3,268	2,975
(40.0, 60.0]	10,953	7,326	510	13,413	46	51	284	70
(60.0, 80.0]	285	65	37	295	22	54	25	21
(80.0, 100.0]	286	130	50	871	17	12	0	0
(100.0, 120.0]	474	190	184	475	0	0	24	24
(120.0, 140.0]	66	161	134	90	7	17	47	50
(140.0, 160.0]	30	218	210	1	29	35	26	31
(160.0, 180.0]	45	569	551	34	51	67	37	36
(180.0, 200.0]	98	2,062	1,975	45	394	488	67	70
(200.0, 220.0]	14	290	280	0	33	26	0	0
(220.0, 240.0]	8	487	480	0	86	93	0	0
(240.0, 260.0]	20	419	416	0	121	121	0	0
(260.0, 280.0]	37	598	599	0	3	3	0	0
(280.0, 300.0]	113	1,110	1,107	0	0	0	0	0
(300.0, 320.0]	4	351	343	0	0	0	0	0
(320.0, 340.0]	96	1,103	1,096	0	0	0	0	0
(340.0, 360.0]	0	252	253	0	0	0	0	0
(360.0, inf]	0	23	22	0	0	0	0	0
Total	137,697	49,859	11,821	110,536	3,648	2,357	5,750	4,303

E.2 Hudson River

Results similar to the Narrows are presented in this section for Hudson River.

Table E-2. Hudson River: Future Non-OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	111024	16442	9059	785	381	6	137697
2020	113710	16840	9278	804	390	6	141028
2025	118332	17524	9655	837	406	6	146760
2030	123141	18237	10048	871	423	7	152727
2035	128146	18978	10456	906	440	7	158933
2040	133355	19749	10881	943	458	7	165393

Table E-3. Hudson River: Future OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017		0		0			0
2020		0		0			0
2025		166		22			188
2030		102		40			142
2035		0		0			0
2040		0		0			0

Table E-4. Hudson River: Future OSW Vessel Traffic Relative Increase

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017		0.00%		0.00%			0.00%
2020		0.00%		0.00%			0.00%
2025		0.95%		2.63%			0.13%
2030		0.56%		4.59%			0.09%
2035		0.00%		0.00%			0.00%
2040		0.00%		0.00%			0.00%

Figure E-5. Hudson River

Source: COWI (December 2021)

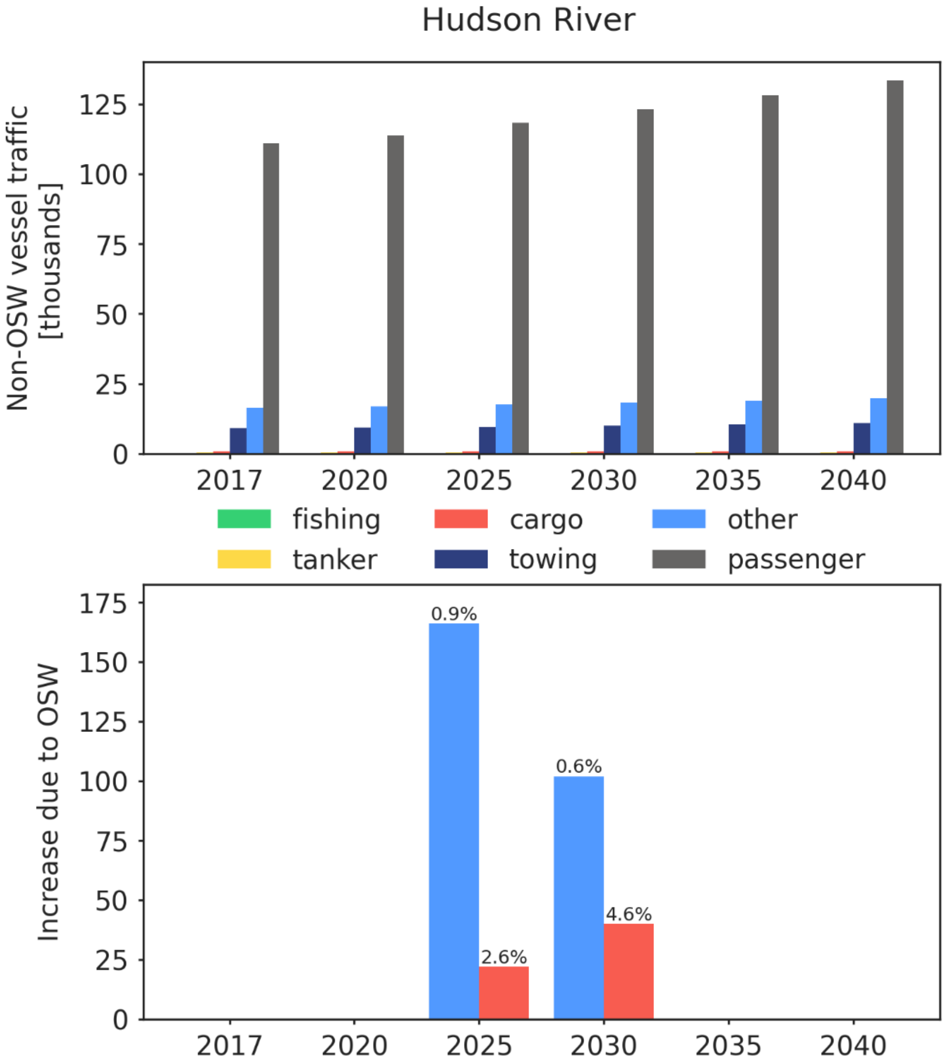
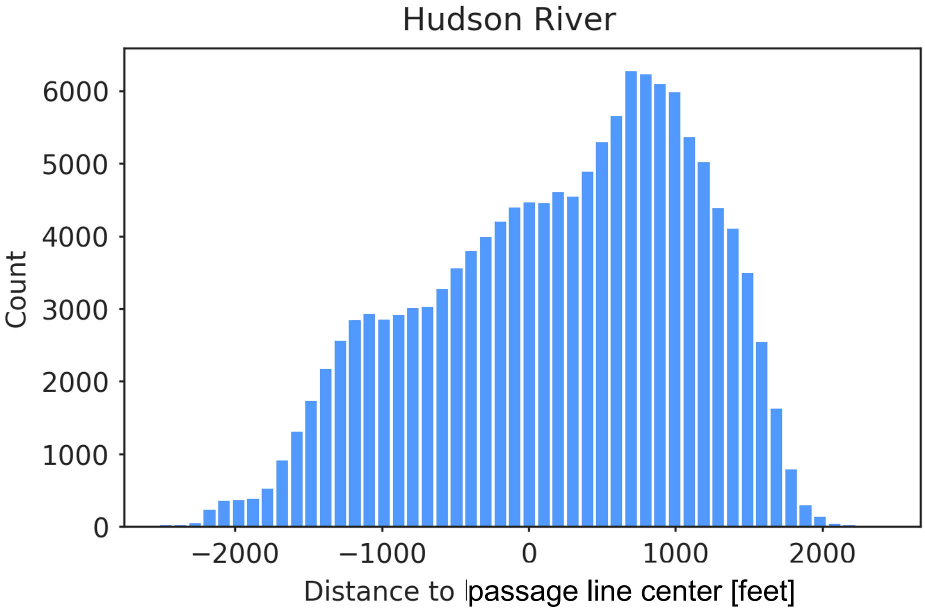


Figure E-6. Distribution of Existing Non-OSW Vessel Traffic across the Hudson River Passage Line

Source: COWI (December 2021)



E.3 The Narrows

In this particular example, traffic counts at The Narrows are shown. At that location, vessel traffic is largely dominated by the passenger vessel type. A cross-sectional view of The Narrows shows a two-peak distribution spanning over approximately 4000 ft (see Figure E-7).

The findings of section 5 were incorporated into the model and compiled in (non-OSW) and (OSW). According to the OSW vessel forecast (section 5), all incurred traffic will only consist of "cargo" and "other" vessel types. Resulting relative transit increase caused by OSW traffic is shown in Table E-8.

The remaining data and figures for the analyzed passage lines are given in the next section. The result of the analysis show that at The Narrows, the maximum fraction of OSW-incurred traffic, as a percentage of the total vessel traffic, will be about 0.5% by 2030. This means that the traffic incurred by OSW projects will not represent a significant fraction of the overall traffic expected at that time horizon. A visual representation of the same data is shown in Figure E-8.

Figure E-7. Distribution of Existing Non-OSW Vessel Traffic across The Narrows Passage Line

Source: COWI (December 2021)

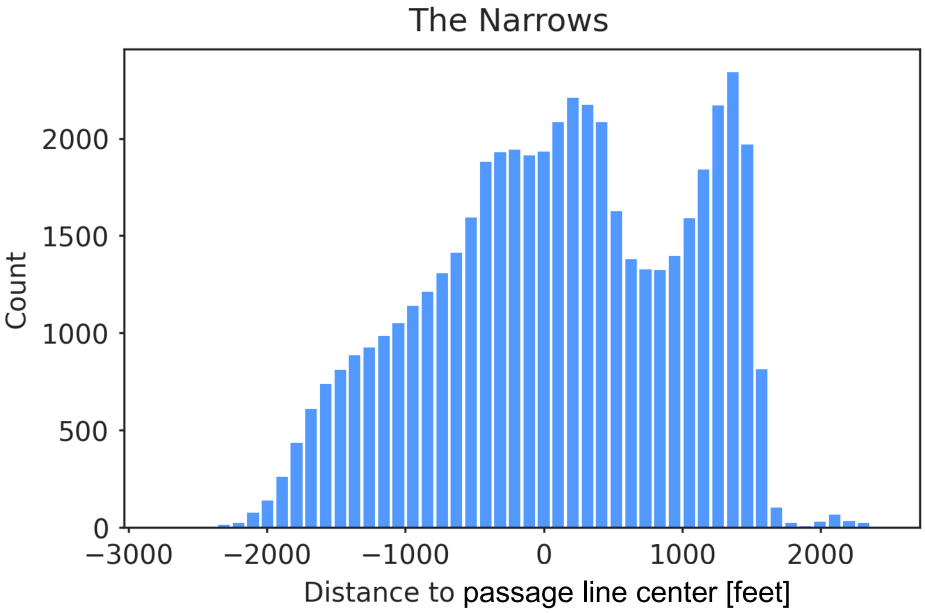


Table E-5. Projected Non-OSW Traffic for The Narrows Passage Line

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	20790	13445	8224	5309	2064	27	49859
2020	21293	13770	8423	5437	2114	28	51065
2025	22158	14330	8765	5658	2200	29	53140
2030	23059	14912	9122	5888	2289	30	55300
2035	23996	15519	9492	6128	2382	31	57548
2040	24972	16149	9878	6377	2479	32	59887

Table E-6. Baseline Non-OSW Vessel Length Distribution for The Narrows Passage Line
(Shown as Counts) For year 2017

Length [m]	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
no data	6,570	6,059	363	41	59	5	13,097
(0.0, 20.0]	441	3,888	397	0	0	17	4,743
(20.0, 40.0]	8,493	967	7,168	4	28	5	16,665
(40.0, 60.0]	4,761	2,266	296	0	3	0	7,326
(60.0, 80.0]	5	60	0	0	0	0	65
(80.0, 100.0]	5	114	0	11	0	0	130
(100.0, 120.0]	2	9	0	172	7	0	190
(120.0, 140.0]	0	52	0	67	42	0	161
(140.0, 160.0]	2	3	0	76	137	0	218
(160.0, 180.0]	5	8	0	355	201	0	569
(180.0, 200.0]	31	0	0	1,006	1,025	0	2,062
(200.0, 220.0]	11	0	0	221	58	0	290
(220.0, 240.0]	10	0	0	215	262	0	487
(240.0, 260.0]	22	0	0	172	225	0	419
(260.0, 280.0]	44	0	0	537	17	0	598
(280.0, 300.0]	157	4	0	949	0	0	1,110
(300.0, 320.0]	4	0	0	347	0	0	351
(320.0, 340.0]	106	13	0	984	0	0	1,103
(340.0, 360.0]	121	0	0	131	0	0	252
(360.0, inf]	0	2	0	21	0	0	23
Total	**20,790**	**13,445**	**8,224**	**5,309**	**2,064**	**27**	**49,859**

Table E-8. Projected OSW Traffic for The Narrows Passage Line

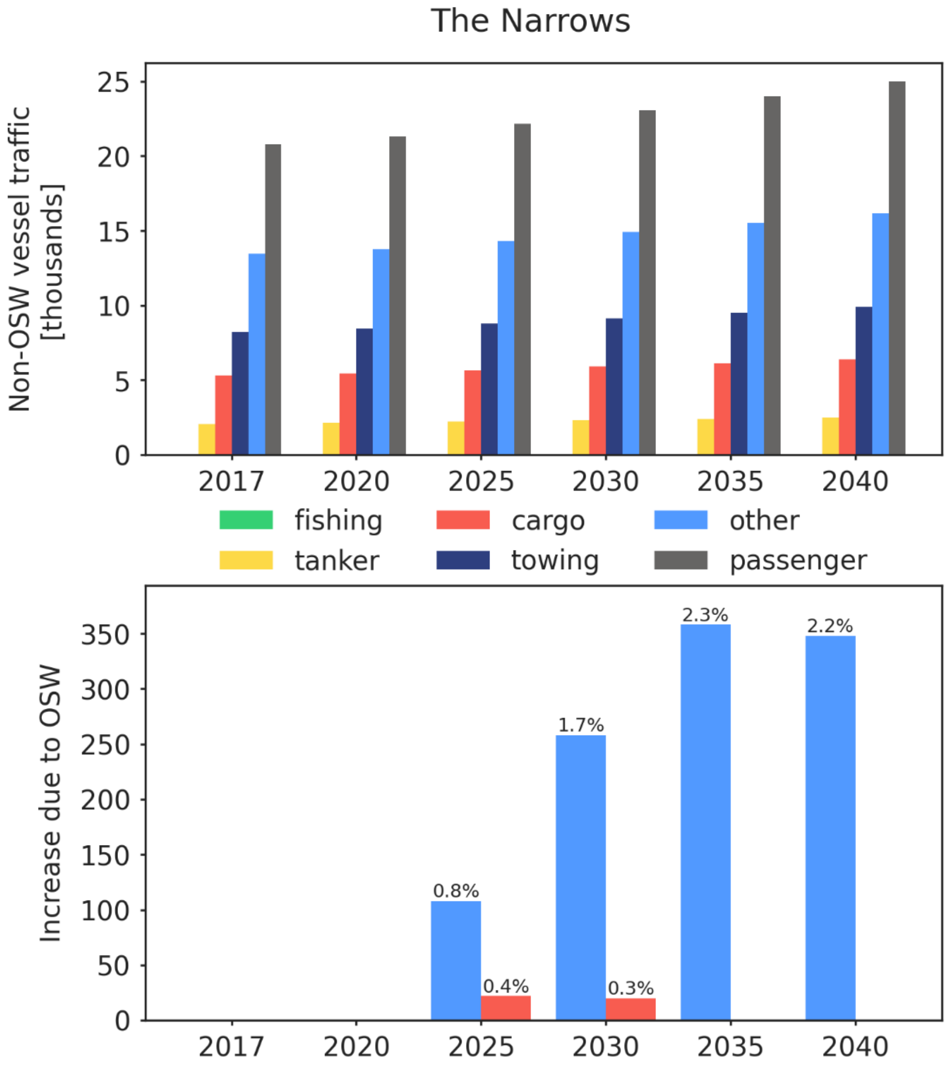
Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017		0		0			0
2020		0		0			0
2025		108		22			130
2030		258		20			278
2035		358		0			358
2040		348		0			348

Table E-9. Relative Transit Count Increase due to OSW Traffic for The Narrows Passage Line

Year		Other		Cargo			Total
2017		0.00%		0.00%			0.00%
2020		0.00%		0.00%			0.00%
2025		0.75%		0.39%			0.24%
2030		1.73%		0.34%			0.50%
2035		2.31%		0.00%			0.62%
2040		2.15%		0.00%			0.58%

Figure E-8. Summary of Non-OSW and OSW Projected Vessel Traffic for The Narrows Passage Line

Source: COWI (December 2021)



E.4 Ambrose Channel

Results similar to The Narrows are presented in this section for Ambrose Channel.

Table E-10. Ambrose Channel: Future Non-OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	679	1576	2374	5262	1921	9	11821
2020	695	1614	2431	5389	1967	9	12105
2025	724	1680	2530	5608	2047	10	12599
2030	753	1748	2633	5836	2131	10	13111
2035	784	1819	2740	6074	2217	10	13644
2040	816	1893	2851	6320	2307	11	14198

Table E-11. Ambrose Channel: Future OSW Vessel Traffic

Year		Other		Cargo			Total
2017		0		0			0
2020		0		0			0
2025		108		22			130
2030		246		0			246
2035		358		0			358
2040		348		0			348

Table E-12. Ambrose Channel: Future OSW Vessel Traffic Relative Increase

Year		Other		Cargo			Total
2017		0.00%		0.00%			0.00%
2020		0.00%		0.00%			0.00%
2025		6.43%		0.39%			1.03%
2030		14.07%		0.00%			1.88%
2035		19.68%		0.00%			2.62%
2040		18.38%		0.00%			2.45%

Figure E-9. Ambrose Channel

Source: COWI (December 2021)

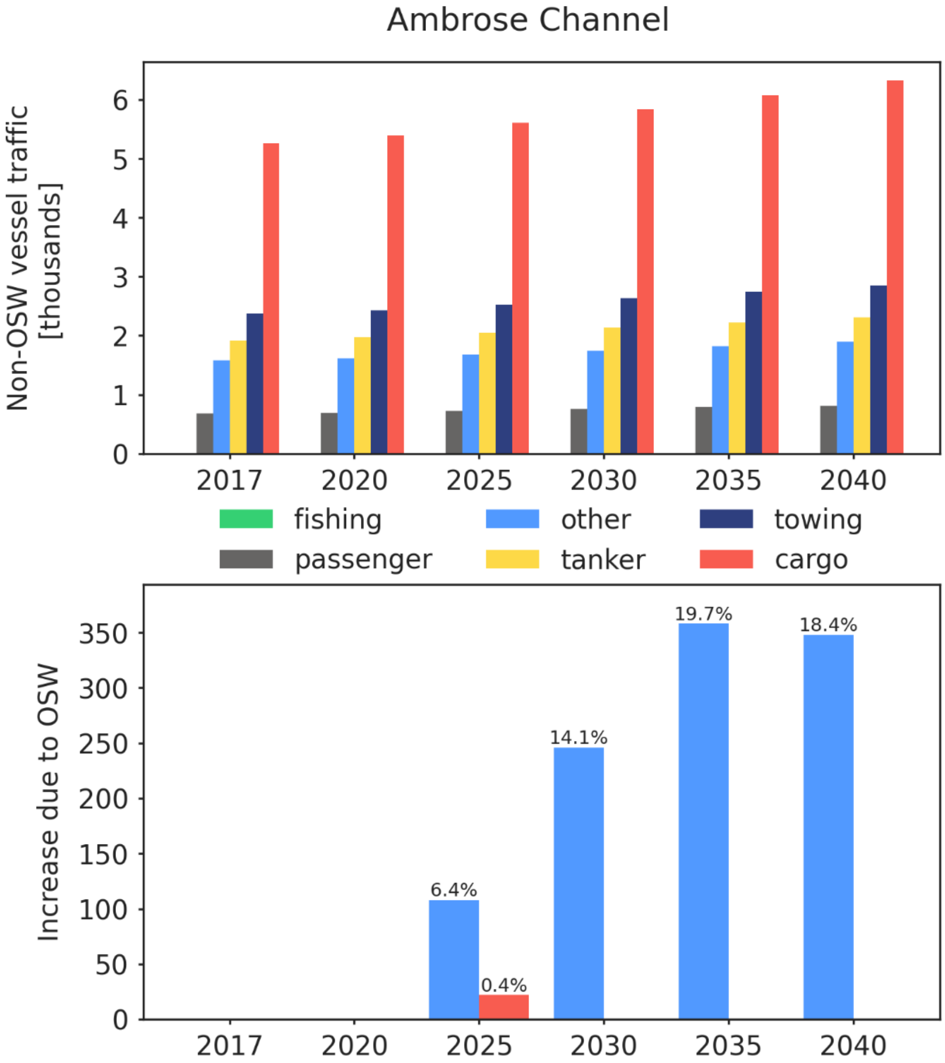
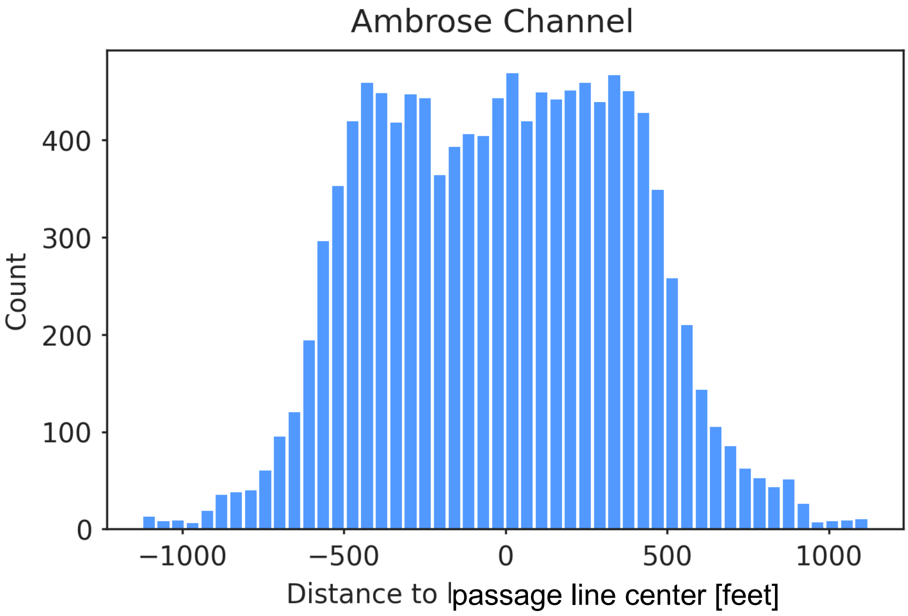


Figure E-10. Distribution of Existing Non-OSW Vessel Traffic across Ambrose Channel Passage Line

Source: COWI (December 2021)



E.5 East River

Results similar to The Narrows are presented in this section for East River.

Table E-13. East River: Future Non-OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	78565	17019	14169	707	68	8	110536
2020	80466	17431	14512	724	70	8	113211
2025	83736	18139	15102	754	72	9	117812
2030	87140	18876	15715	784	75	9	122599
2035	90681	19644	16354	816	78	9	127582
2040	94367	20442	17019	849	82	10	132769

Table E-14. East River: Future OSW Vessel Traffic

Year		Other		Cargo			Total
2017		0		0			0
2020		0		0			0
2025		0		0			0
2030		0		0			0
2035		48		0			48
2040		48		0			48

Table E-15. East River: Future OSW Vessel Traffic Relative Increase

Year		Other		Cargo			Total
2017		0.00%		0.00%			0.00%
2020		0.00%		0.00%			0.00%
2025		0.00%		0.00%			0.00%
2030		0.00%		0.00%			0.00%
2035		0.24%		0.00%			0.04%
2040		0.23%		0.00%			0.04%

Figure E-11. East River Traffic Analysis

Source: COWI (December 2021)

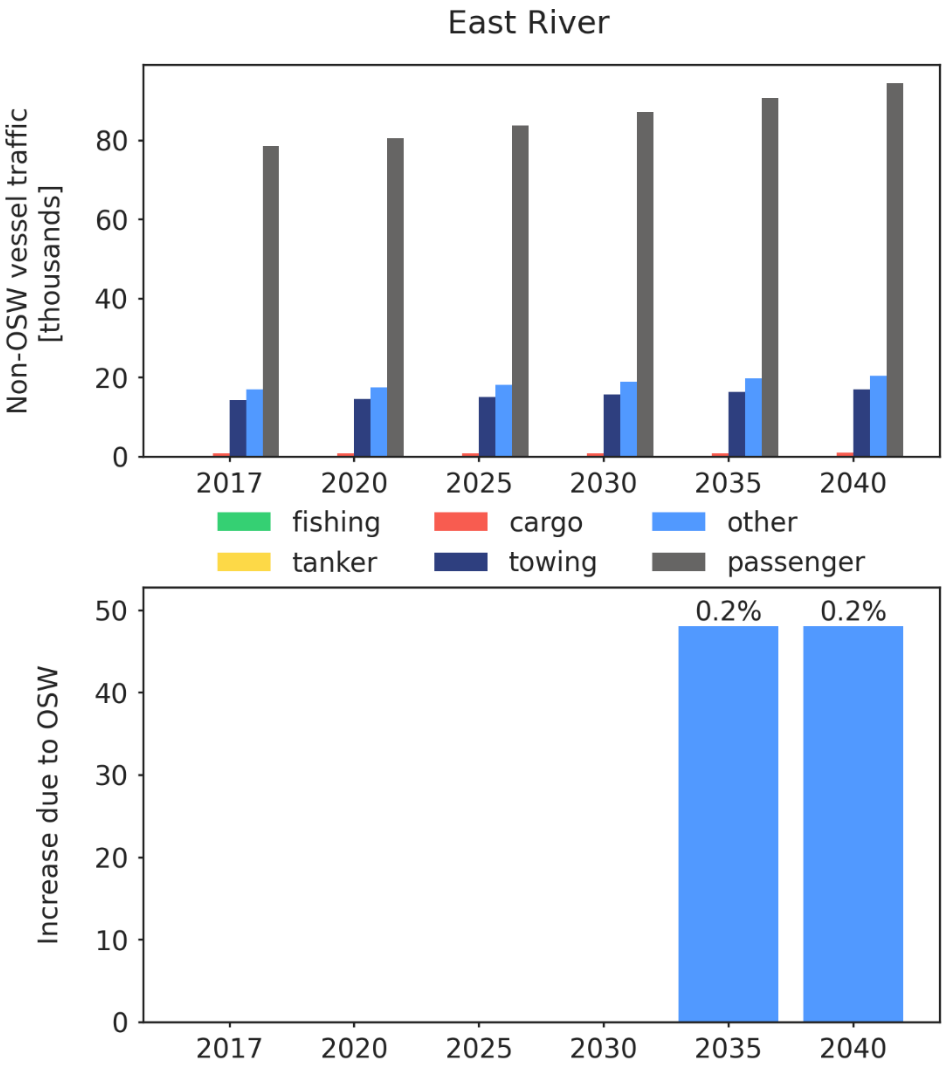
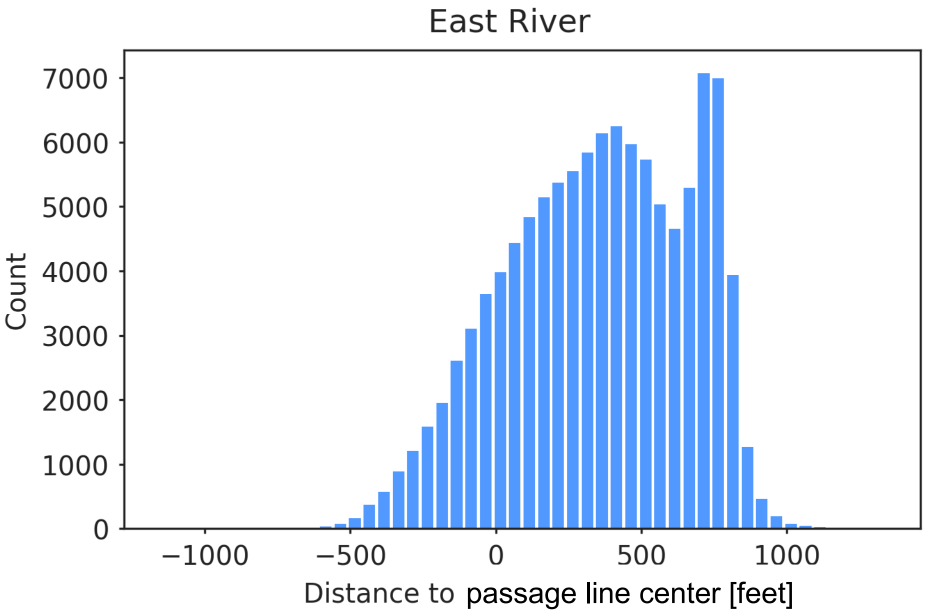


Figure E-12. Distribution of Existing Non-OSW Vessel Traffic across the East River Passage Line

Source: COWI (December 2021)



E.6 Sandy Hook

Results similar to The Narrows are presented in this section for Sandy Hook.

Table E-16. Sandy Hook: Future Non-OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	616	1321	802	4	721	184	3648
2020	631	1353	821	4	738	188	3735
2025	657	1408	855	4	768	196	3888
2030	683	1465	890	4	800	204	4046
2035	711	1525	926	5	832	212	4211
2040	740	1587	963	5	866	221	4382

Table E-17. Sandy Hook: Future OSW Vessel Traffic

Year		Other		Cargo			Total
2017		0		0			0
2020		0		0			0
2025		0		0			0
2030		16		0			16
2035		16		0			16
2040		0		0			0

Table E-18. Sandy Hook: Future OSW Vessel Traffic Relative Increase

Year		Other		Cargo			Total
2017		0.00%		0.00%			0.00%
2020		0.00%		0.00%			0.00%
2025		0.00%		0.00%			0.00%
2030		1.09%		0.00%			0.40%
2035		1.05%		0.00%			0.38%
2040		0.00%		0.00%			0.00%

Figure E-13. Sandy Hook Traffic Analysis

Source: COWI (December 2021)

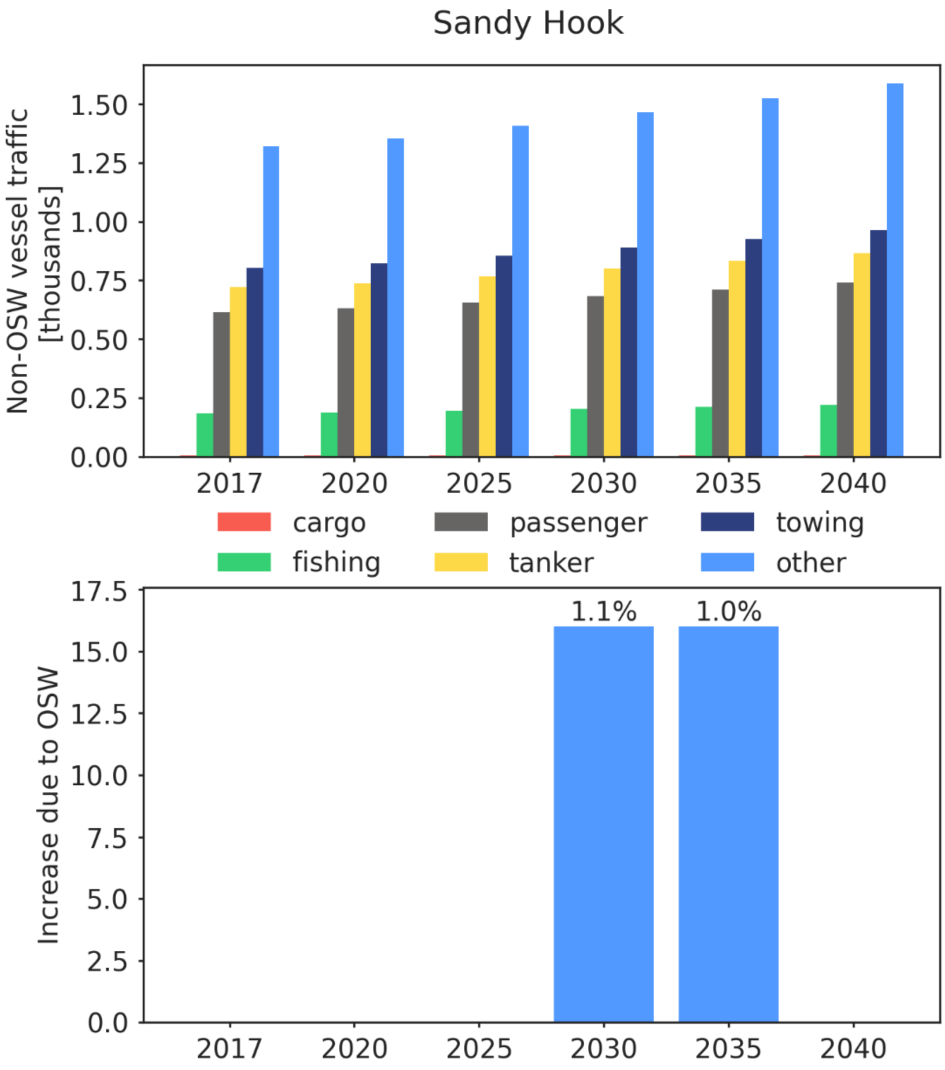
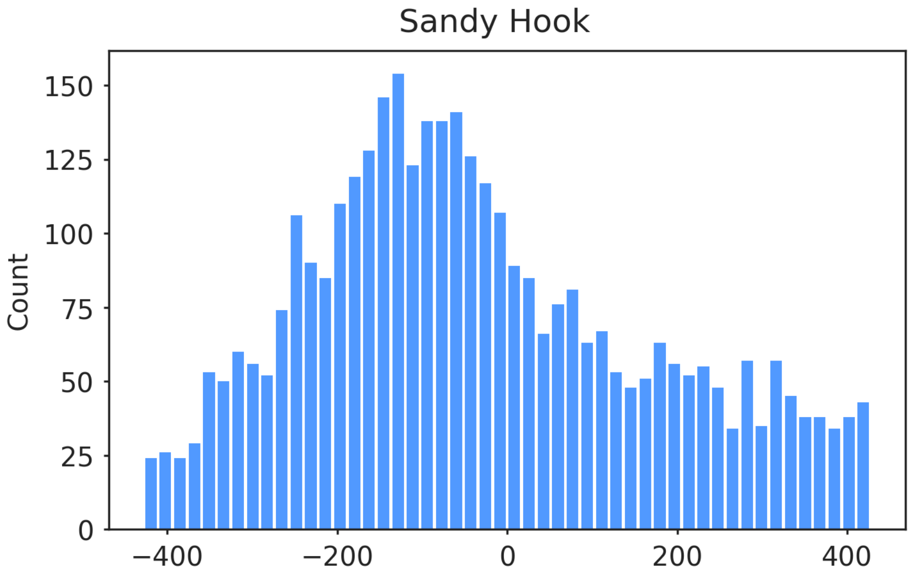


Figure E-14. Distribution of Existing Non-OSW Vessel Traffic across the Sandy Hook Passage Line

The figure shows a histogram portraying the distribution of existing non-offshore wind vessel traffic across Hudson River passage line. Vessel count is on the Y-axis, and distance to passage line center (in feet) is on the X-axis.

Source: COWI (December 2021)



E.7 Ward Point

Results similar to The Narrows are presented in this section for Ward Point.

Table E-19. Ward Point: Future Non-OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	89	412	966	0	862	28	2357
2020	91	422	989	0	883	29	2414
2025	95	439	1030	0	919	30	2513
2030	99	457	1071	0	956	31	2614
2035	103	476	1115	0	995	32	2721
2040	107	495	1160	0	1035	34	2831

Table E-20. Ward Point: Future OSW Vessel Traffic

Year		Other		Cargo			Total
2017		0		0			0
2020		0		0			0
2025		0		0			0
2030		28		20			48
2035		16		0			16
2040		0		0			0

Table E-21. Ward Point: Future OSW Vessel Traffic Relative Increase

Year		Other		Cargo			Total
2017		0.00%		0.0%			0.00%
2020		0.00%		0.0%			0.00%
2025		0.00%		0.0%			0.00%
2030		6.13%		N/A[a]			1.84%
2035		3.36%		0.0%			0.59%
2040		0.00%		0.0%			0.00%

[a] N/A since the relative increase of cargo in 2030 is calculated from zero.

Figure E-15. Ward Point Traffic Analysis

Source: COWI (December 2021)

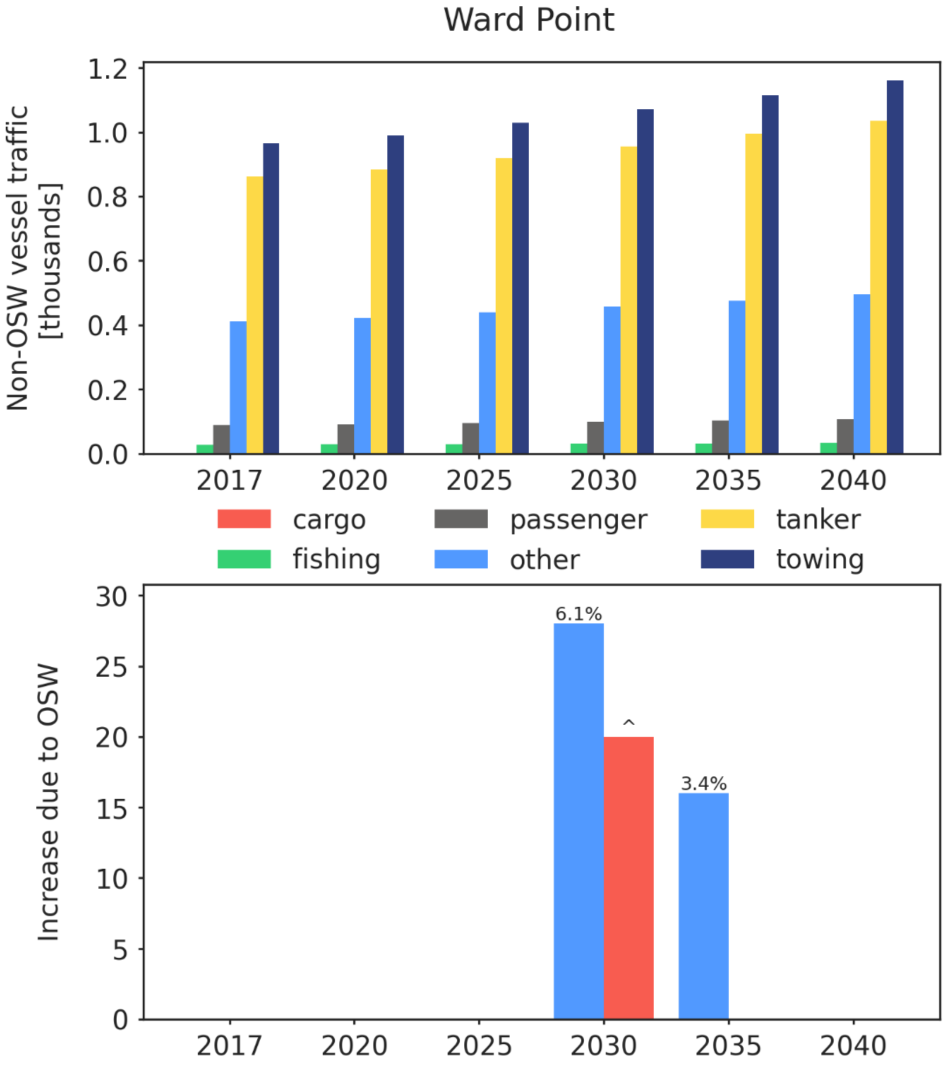
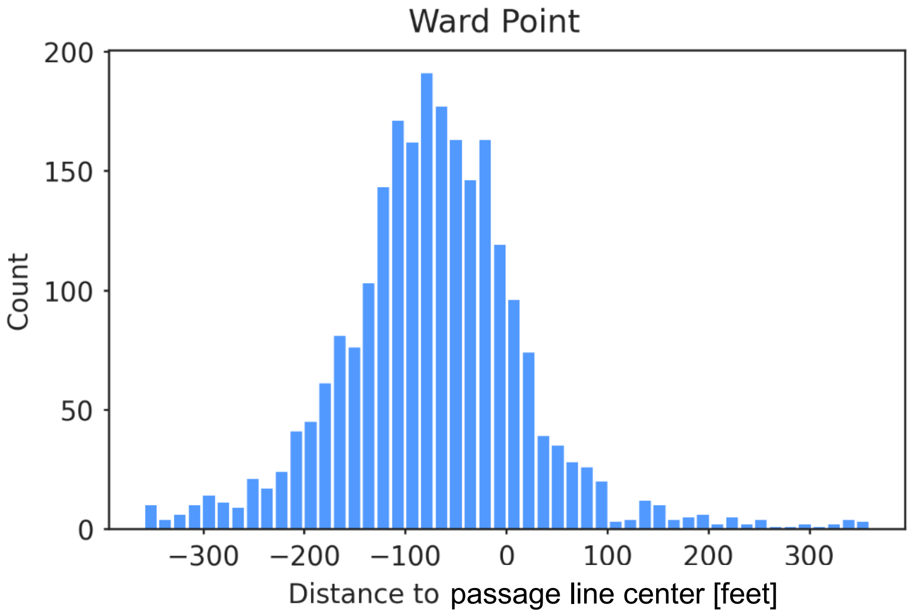


Figure E-16. Distribution of Existing Non-OSW Vessel Traffic across the Ward Point Passage Line

Source: COWI (December 2021)



E.8 Tomkins Cove

Results similar to The Narrows are presented in this section for Tomkins Cove.

Table E-22. Tomkins Cove: Future Non-OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	210	1,246	4,095	175	24	0	5,750
2020	215	1,276	4,194	179	25	0	5,889
2025	224	1,328	4,365	187	26	0	6,130
2030	233	1,382	4,542	194	27	0	6,378
2035	242	1,438	4,727	202	28	0	6,637
2040	252	1,497	4,919	210	29	0	6,907

Table E-23. Tomkins Cove: Future OSW Vessel Traffic

Year		Other		Cargo			Total
2017		0		0			0
2020		0		0			0
2025		166		22			188
2030		102		40			142
2035		0		0			0
2040		0		0			0

Table E-24. Tomkins Cove: Future OSW Vessel Traffic Relative Increase

Year		Other		Cargo			Total
2017		0.00%		0.00%			0.00%
2020		0.00%		0.00%			0.00%
2025		12.50%		11.76%			3.07%
2030		7.38%		20.62%			2.23%
2035		0.00%		0.00%			0.00%
2040		0.00%		0.00%			0.00%

Figure E-17. Tomkins Cove Traffic Analysis

Source: COWI (December 2021)

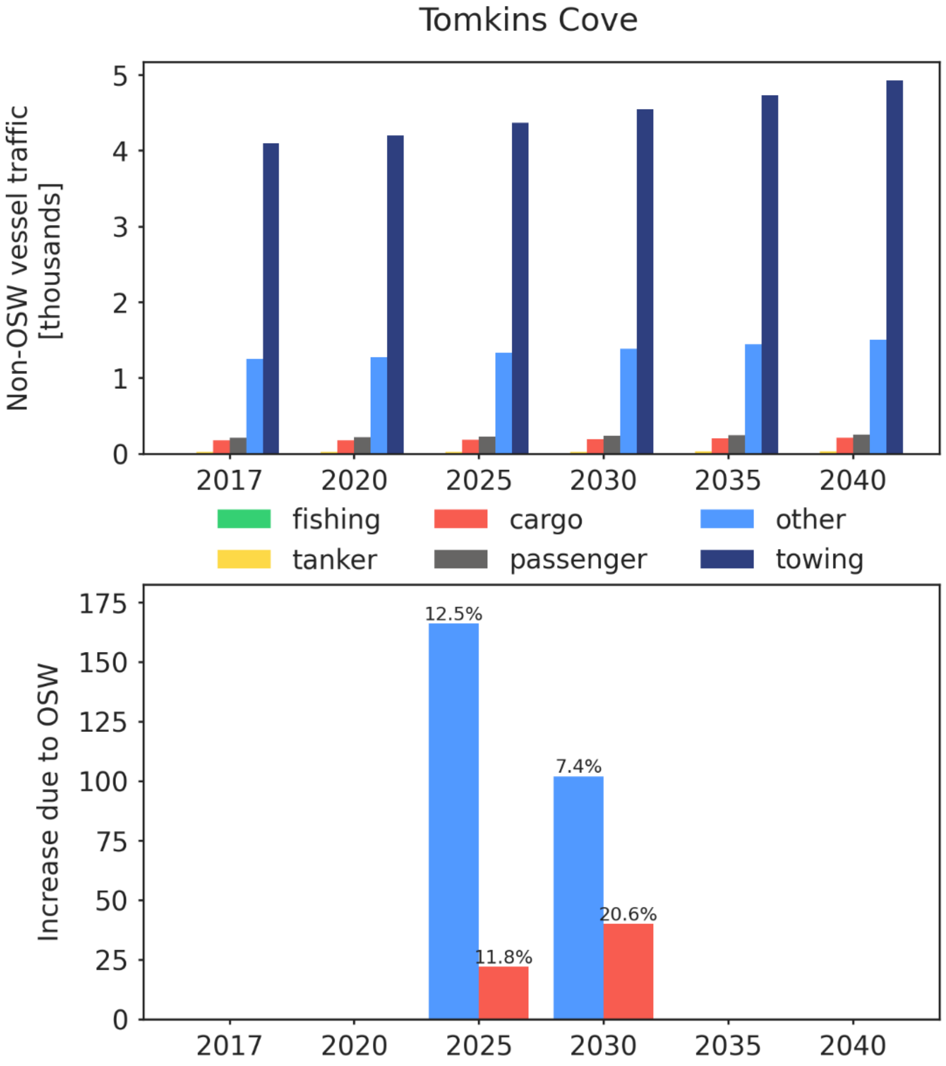
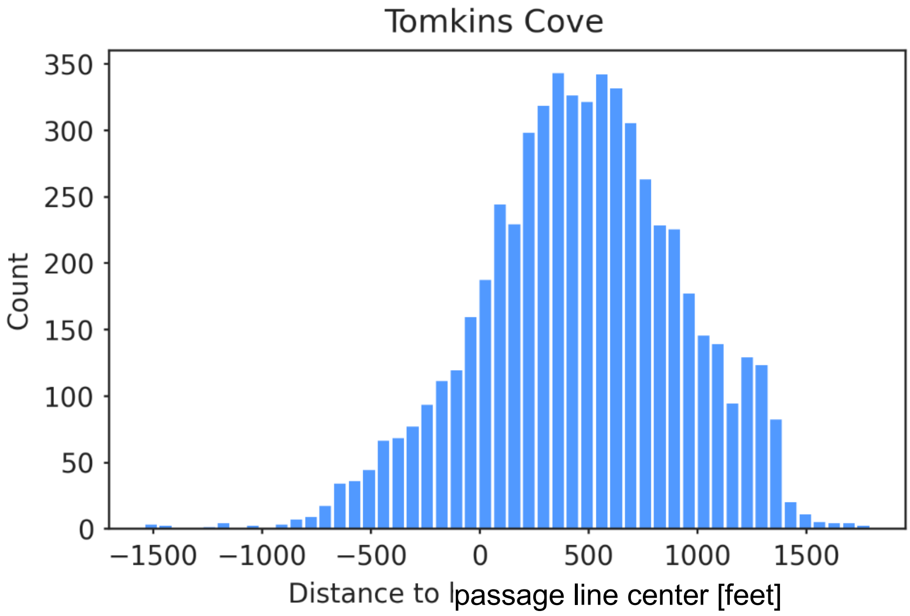


Figure E-18. Distribution of Existing Non-OSW Vessel Traffic across the Tomkins Cove Passage Line

Source: COWI (December 2021)



E.9 Port of Coeymans

Results similar to The Narrows are presented in this section for Port of Coeymans.

Table E-25. Port of Coeymans: Future Non-OSW Vessel Traffic

Year	Pass.	Other	Towing	Cargo	Tanker	Fishing	Total
2017	61	484	3,553	181	24	0	4,303
2020	62	496	3,639	185	25	0	4,407
2025	65	516	3,787	193	26	0	4,587
2030	68	537	3,941	201	27	0	4,774
2035	70	559	4,101	209	28	0	4,967
2040	73	581	4,268	217	29	0	5,168

Table E-26. Port of Coeymans: Future OSW Vessel Traffic

Year		Other		Cargo			Total
2017		0		0			0
2020		0		0			0
2025		158		22			180
2030		94		20			114
2035		0		0			0
2040		0		0			0

Table E-27. Port of Coeymans: Future OSW Vessel Traffic Relative Increase

Year		Other		Cargo			Total
2017		0.00%		0.00%			0.00%
2020		0.00%		0.00%			0.00%
2025		30.62%		11.40%			3.92%
2030		17.50%		9.95%			2.39%
2035		0.00%		0.00%			0.00%
2040		0.00%		0.00%			0.00%

Figure E-19. Port of Coeymans Traffic Analysis

Source: COWI (December 2021)

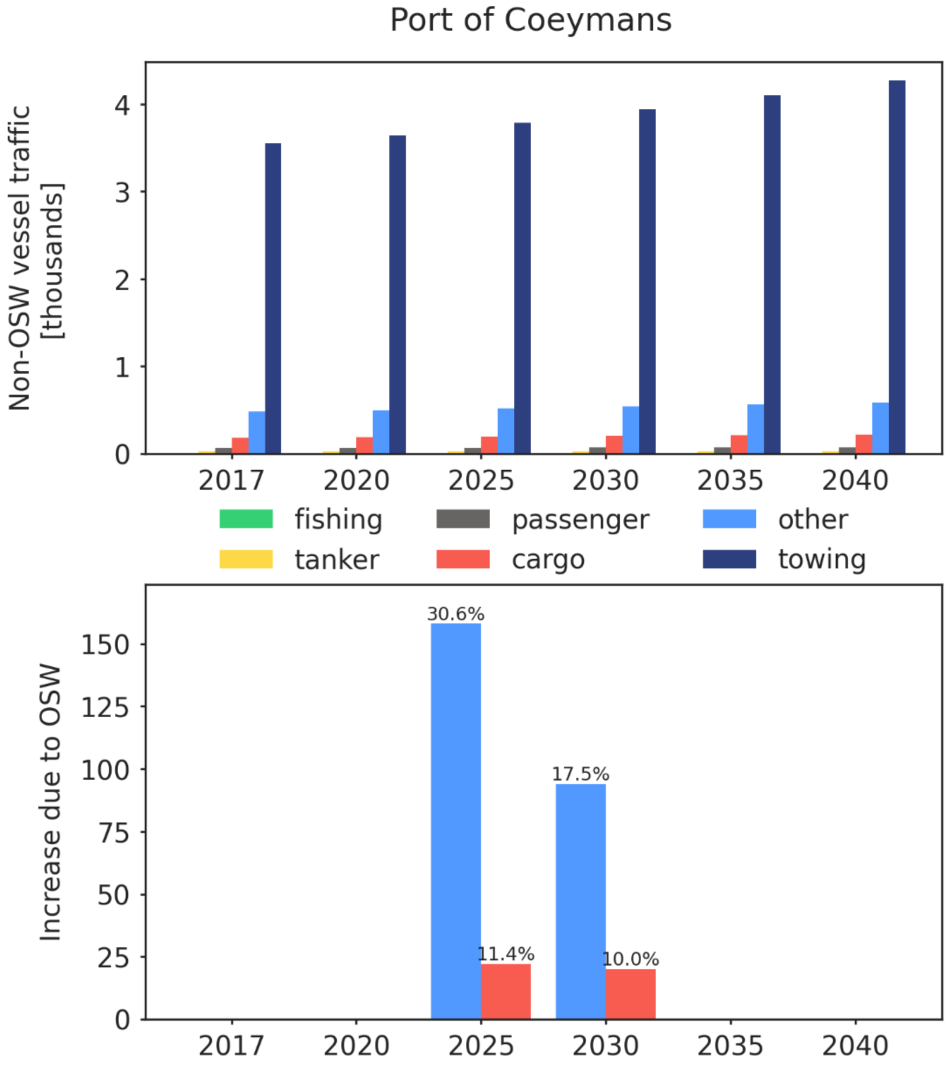
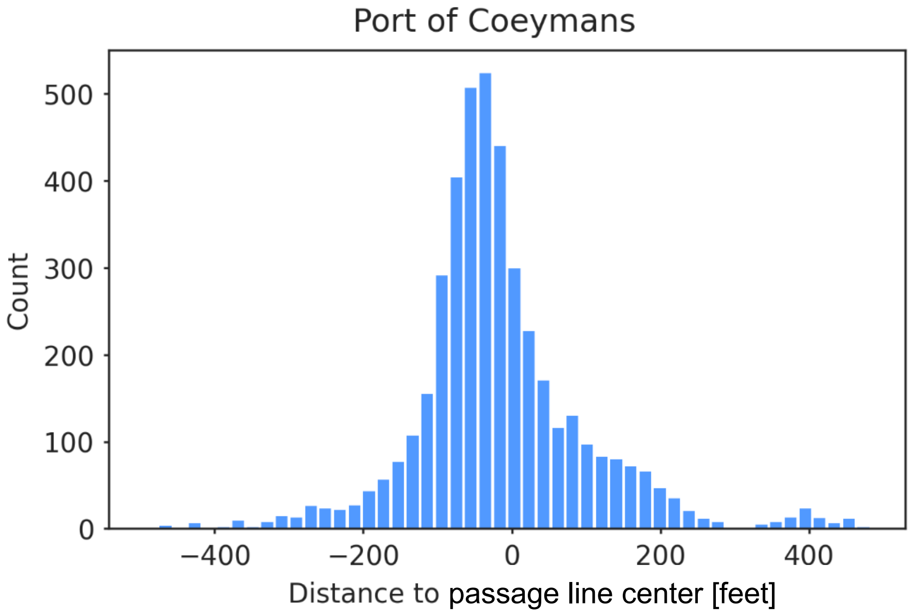


Figure E-20. Distribution of Existing Non-OSW Vessel Traffic across the Port of Coeymans Passage Line

Source: COWI (December 2021)



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