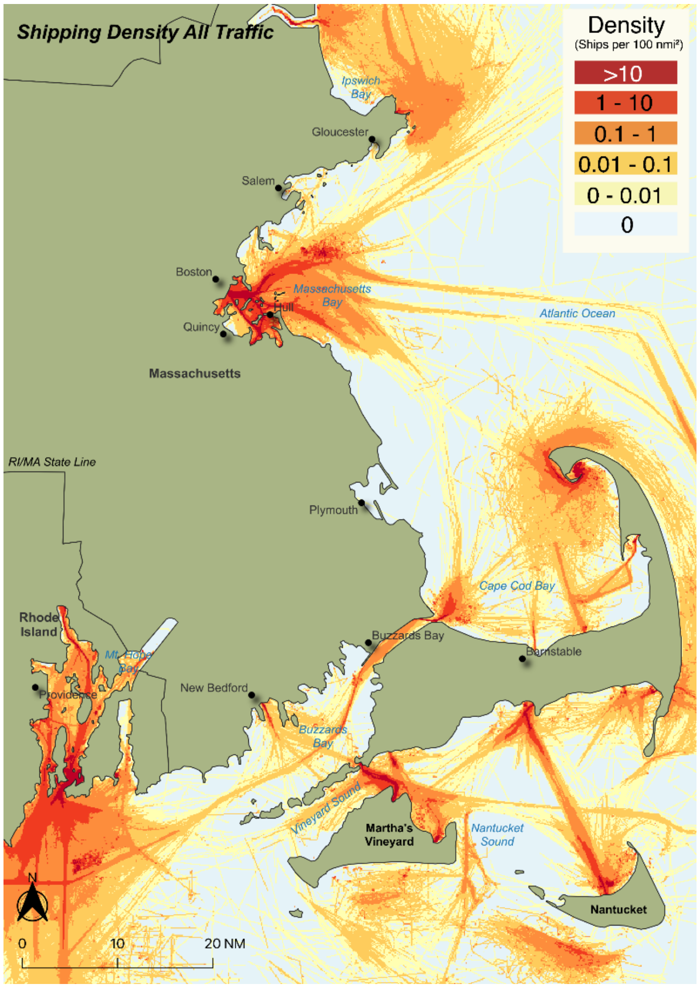
# Marine Oil Spill Threats to Massachusetts Coastal Communities: Updated Assessment





*Left: Vessel traffic density based on 2017-2020 AIS data*
*Top right: Shoreline impacts from 2003 Bouchard B-120 spill in Buzzards Bay*
*Bottom right: First responders from Marion and Mattapoisett participate in boom deployment exercise in 2015*

## Report to
## Massachusetts Department of Environmental Protection
## January 2024

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# Executive Summary

The Massachusetts Oil Spill Prevention and Response Act (MOSPRA) was passed in 2004 to strengthen the statutes governing oil spill prevention and response. As directed by MOSPRA, the Massachusetts Department of Environmental Protection (MassDEP) Marine Oil Spill Prevention and Response Program implements a range of programs and initiatives related to oil spill readiness and risk reduction.

In 2008-2009, MassDEP funded a study to inform MOSPRA program activities by evaluating marine oil spill threats and response capabilities in Massachusetts. The threat assessment was developed with consideration of future updates to evaluate and compare changing threats and to inform long-term strategies for MOSPRA. In the years since that study, the MOSPRA program has grown and expanded, while there have been changes to the factors impacting oil spill risk and response. This report updates the 2009 study by re-evaluating the threat of oil spills by fuel type, source, and location. This report is an interim deliverable to a larger MOSPRA project that considers the intersection between oil spills, climate hazards, and decarbonization.

This report relies on two primary data sources: OR-1 reports and AIS data. OR-1 reports are generated for the Department of Revenue to collect a per-barrel tax on all oil imported through bulk marine terminals. Automated Information System (AIS) data tracks vessel movement and characterizes the types of vessels transiting through Massachusetts ports, harbors, and waterways. A third data source – Notice of Intent to Transit reports documenting tug and oil barge movements through Buzzards Bay and Cape Cod Canal – also provided important information to evaluate the overall risk picture. The combined analysis of bulk oil storage and marine transportation data spanning 2015-2020 provides an updated estimate of marine oil spill threats in the Commonwealth.

The analysis in this report shows a relatively stable threat level when compared to the 2009 study. Apart from 2020, when the global pandemic limited travel and reduced gasoline and aviation fuel consumption, the general trend has been a slight increase in petroleum imports into Massachusetts harbors. When comparing geographic areas of the state, Boston Harbor has the highest threat level, based on both oil storage and vessel traffic. At the harbor level, this report identified three additional harbors with high threats of oil spills: New Bedford, Vineyard Haven, and Nantucket. This information was carried forward to a May 2023 workshop to support discussions about climate change and potential impacts to oil spill risk and response.

# Contents

# 1. Introduction

## 1.1. BACKGROUND

The Massachusetts Oil Spill Prevention and Response Act (MOSPRA) was passed in 2004 in response to the grounding and subsequent oil spill from the B-120 barge in Buzzards Bay. MOSPRA strengthened several statutes that govern Massachusetts' ability to prevent and respond to oil spills in the coastal waters of the Commonwealth. It created M.G.L. Chapter 21M, which contains most of the provisions related to implementation of MOSPRA, including provisions for establishing a Trust Fund financed by a 5-cent per-barrel fee on petroleum products delivered to marine terminals in the state.

In 2008-2009, MassDEP funded a study to inform MOSPRA program activities by evaluating marine oil spill threats and response capabilities in Massachusetts. The threat assessment was developed with consideration of future updates to evaluate and compare changing threats and to inform long-term strategies for MOSPRA.

In the years since that study, the MOSPRA program has grown and expanded considerably. At the same time, there have been changes to the storage and transportation of oil in the Commonwealth, driven by several different factors, including decarbonization strategies that aim to reduce consumption of fossil fuels at the state, national, and international scales and shift towards renewable energy sources. There have also been observable changes to weather patterns and coastlines driven by climate change, and there has been considerable work done by local, state, and federal authorities to consider future implications of climate change and to develop adaptation strategies.

## 1.2. PURPOSE OF THIS REPORT

This report updates the 2009 Threat Assessment to support the MassDEP Study *Evaluating and Adapting Oil Spill Preparedness and Response Capabilities for a Changing Climate* (MAROIL #102039). The climate change study considers how future decarbonization and climate change scenarios may influence MOSPRA's marine oil spill preparedness and response activities, including changing risk profiles. The oil spill threat data presented in this report provides a baseline for consideration of future scenarios.

## 1.3. SCOPE

The 2009 Threat Evaluation provided a relative comparison of oil spill threats at the harbor, municipality, and regional scale based on petroleum exposure from vessels and storage tanks. To evaluate trends and changes to petroleum storage and marine transportation, an updated analysis was conducted based on data from 2017 through 2020 derived from various sources. This section summarized the methods and results of that analysis. The scope of this updated threat assessment focused on vessel movements and bulk oil transfers in Massachusetts coastal waters.

# 2. Historical Oil Spill Threats

## 2.1. OVERVIEW

In 2008-2009, MassDEP conducted a study to evaluate marine oil spill threats (Nuka Research and Planning Group, LLC, 2019) and response capabilities (Nuka Research and Planning Group, LLC, 2009) in Massachusetts. The reports assessed marine oil spill threats from storage and transportation activities and evaluated the baseline for marine spill response equipment across Massachusetts and neighboring states. The results of these studies have been used to inform MOSPRA program activities, including the placement of equipment trailers in coastal communities, the development of Geographic Response Strategies (GRS) for vulnerable coastal sites, and the implementation of oil spill prevention activities such as escort tugs.

## 2.2. 2009 COASTAL OIL SPILL THREAT EVALUATION

### 2.2.1. Overview

To inform the ongoing development of the MOSPRA program, MassDEP conducted a series of studies on oil spill threats and response capabilities, including the 2009 Threat Evaluation. This report was intended for use by MassDEP to support decision-making and allocation of resources within the MOSPRA program.

### 2.2.2. Methods

To assess overall threat levels and compare oil spill threats across Massachusetts coastal areas, the methodology estimated threat exposure at the harbor, community, and regional level based on the following categories and subcategories:

- Vessel movements
    - Tank vessel (tanker or oil barge) activity in ports (e.g., loading/unloading cargo)
    - Tank vessel movements through shipping lanes
    - Non-tank vessel activity in ports
    - Non-tank vessel movements through shipping lanes
- Resident vessel fleets (number of vessels, size range, average size)
    - Recreational and charter vessels
    - Commercial fishing boats
    - Ferries and car-carriers
    - Other vessels (tugs, research vessels, government vessels)
    - Shipyards
- Land-based bulk fuel storage facilities

For each category, threat estimates were developed based on gallons of petroleum exposure (GPE) for harbors and communities. The use of GPE to estimate threat assumed that the volume of petroleum stored and transferred in each area will influence the probability of oil spills. The assessment did not consider the potential consequences of oil spills, which is also an important consideration for understanding risks.

### 2.2.3. Results

The 2009 Threat Evaluation characterized the exposure to potential marine oil spills at the harbor, community, and regional scale. The result of this semi-quantitative assessment was a comparative analysis of exposure at the three geographic scales. The results identified the Boston Harbor region as having the highest relative threat, followed by the Cape and Islands. All other regions were similar. Tank vessel movements created the highest comparative exposure, followed by land-based storage and non-tank vessels.

Figure 2-1 shows the estimated gallons of petroleum exposure (GPE) by port or harbor based on tank vessel activities (in thousands of GPE, based on 2006 data). Figure 2-2 shows the estimated petroleum exposure based on regional vessel transits through shipping lanes. Figure 2-3 shows the petroleum exposure based on shipyard activities.

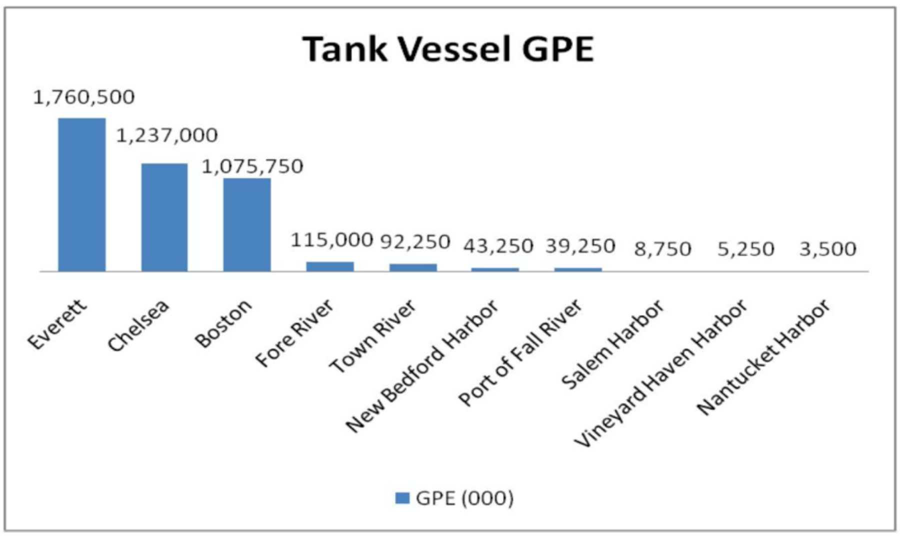


*Figure 2-1: Excerpt from 2009 Massachusetts Coastal Oil Spill Threat Evaluation estimating the gallons of petroleum exposure by port or harbor. Boston Harbor had the highest threat level by an order of magnitude.*

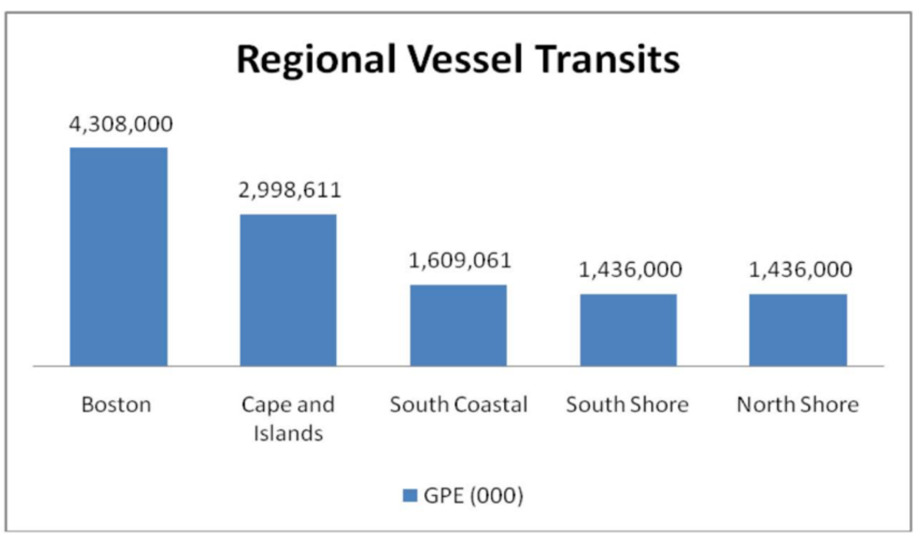


*Figure 2-2: Excerpt from 2009 Massachusetts Coastal Oil Spill Threat Evaluation estimating the gallons of petroleum exposure based on vessel transits through shipping lanes.*

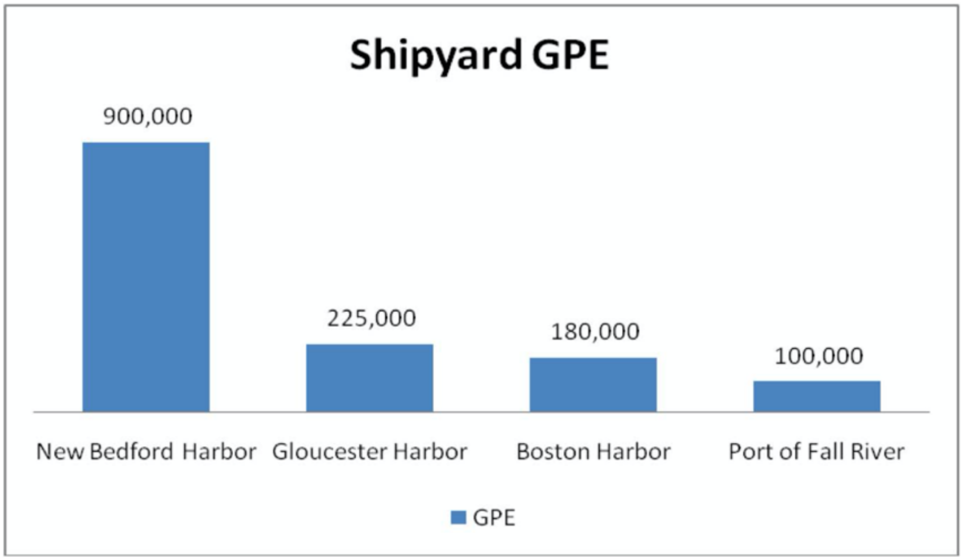


*Figure 2-3: Excerpt from 2009 Massachusetts Coastal Oil Spill Threat Evaluation estimating the gallons of petroleum exposure based on shipyards.*

Figure 2-4 shows two graphs – one showing the petroleum exposure from oil storage at federally regulated facilities (defined in federal regulations as holding 42,000 gallons or more in aboveground storage tanks) and at locally regulated facilities, which have smaller overall capacities. The primary difference between these two types of facilities is the average tank size, which is larger for the federally regulated facilities. However, safety requirements for EPA-regulated tank farms may exceed those for smaller facilities. In considering how climate change hazards and adaptations may impact the threat of spills from facilities, the volume of oil stored is one risk factor, but other variables may also influence overall threat levels.

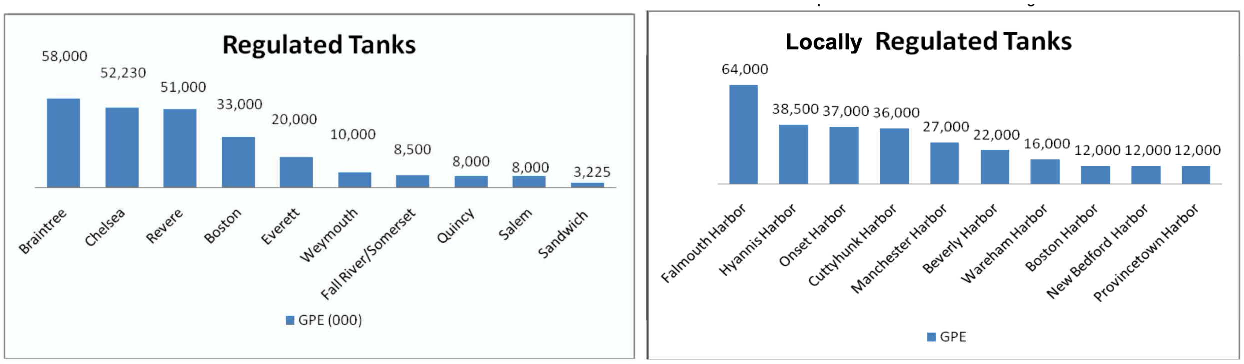


*Figure 2-4: Excerpt from 2009 Massachusetts Coastal Oil Spill Threat Evaluation estimating the gallons of petroleum exposure in federally and locally regulated oil storage tanks*

The 2009 report did not consider how climate change hazards, adaptations, and mitigation (including decarbonization strategies) might interact with different threat levels.

### 2.2.4. Recommendations

The 2009 Threat Assessment recommended several measures for MassDEP to consider in shaping future MOSPRA program activities:

- Tailor prevention activities to areas with the highest exposure through targeted measures such as escort tugs;
- Ensure that geographic response strategies (GRS, also referred to as GRP) are developed for areas with high threat and that adequate equipment is available to rapidly deploy GRS;
- Develop harbor and regional response plans and conduct scenario analyses to better assess preparedness in high-threat areas;
- Diversify state-owned oil spill response equipment stockpiles to enhance response capability: and
- Identify opportunities for outreach and education to encourage awareness of oil spill threats from resident vessel fleets and other "small" threats that may have cumulative impacts.

## 2.3. 2019 OIL AND HAZARDOUS MATERIALS COMMODITY FLOW STUDY

### 2.3.1. Overview

A 2019 report commissioned by MassDEP estimated bulk oil and hazardous materials (OHM) transportation through Massachusetts by analyzing transportation and storage data from 2013-2017. The purpose of that study was to inform local emergency planners and responders about the risks posed to health, safety, and the environment from accidental releases of OHM.

### 2.3.2. Methods

The primary data source for the OHM study was the Massachusetts Emergency Management Agency (MEMA) Tier II database, which includes OHM transportation and storage by all modes, both marine and terrestrial. A key finding of that study was that the Tier II data contained numerous errors and inaccuracies; for that reason, Tier II data was not included in this threat assessment update methodology (Section 4 of this report). The 2019 OHM study also considered data from the Massachusetts Division of Revenue OR-1 reports, which were also a primary data source for this updated threat assessment. The 2019 OHM study relied on Army Corps of Engineers bulk commodity shipping data to estimate OHM flows over marine routes; this study uses Automated Information System (AIS) data instead.

For the 2019 OHM study, several large data sets were assembled and run through a series of validation steps to eliminate duplicate entries and flag potential inaccuracies in the data. Once the data set was assembled, it was analyzed based on two main outputs: (1) the number of facilities that reported OHSM shipments of a given substance and (2) the average annual quantity of OHM transportation and storage by individual substance, Department of Transportation hazard class, and transportation mode. Data was explored for geographic and spatial trends.

### 2.3.3. Results

Flammable liquids were the dominant hazard class based on both the number of facilities and the quantity reported. Based on facility count, the most prevalent substances in the analyzed data were diesel, unspecified oil, and "other" substances. Based on quantity, the most prevalent substances were residual fuel, aviation fuel, and diesel. In general, quantity data was found to contain a high rate of suspect reporting errors; this is likely the reason that residual fuel dominates the quantity data.

Figure 2-5 compares the transportation and storage of all petroleum products by town, based on the number of facilities (left) and quantity of substances transferred (right). These results are consistent with the findings of the 2009 threat assessment, showing Boston Harbor and the Cape and Islands as the regions in Massachusetts with the highest concentration of petroleum storage and transportation. The OHM results also align with the 2009 characterization of threat by harbor, with Boston, New Bedford, Sandwich, Woods Hole, Gloucester, Nantucket, and Plymouth all showing as red in the map to the right in Figure 3-5, indicating the highest comparative quantity of petroleum transfers per year. This suggests some stability to the geographic nature of oil spill threats over time since the Threat Assessment analyzed data from 2002-2006, and the OHM study used data from 2013-2017.

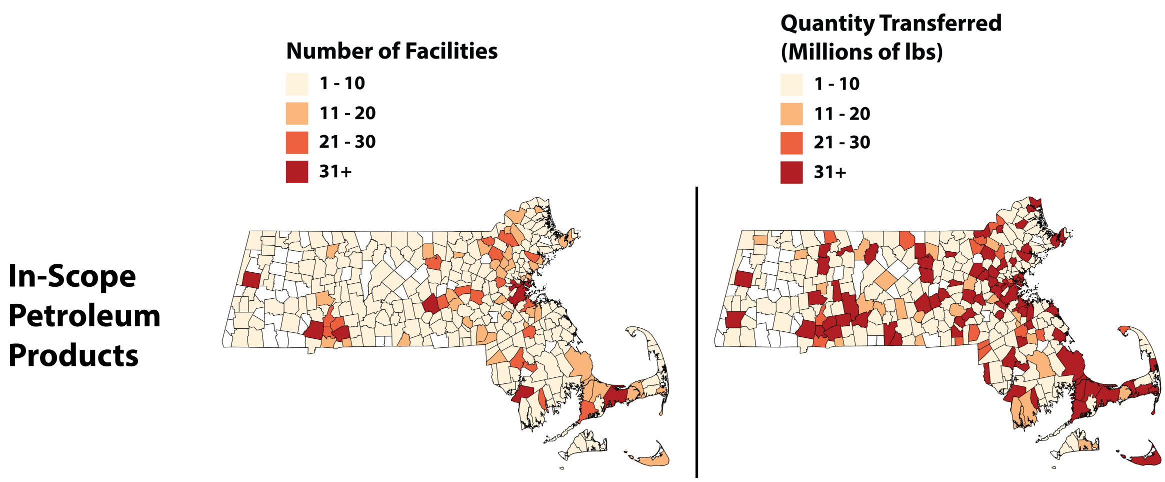


*Figure 2-5: Statewide comparison by town of petroleum product storage and transportation based on number of facilities and quantity transferred (Nuka Research, 2019)*

In comparing Massachusetts towns and cities, flammable liquids and flammable gas were the most prevalent hazard classes. The top substances transported by mode varied significantly. Residual fuel was the top substance by quantity transported by truck, followed by diesel and unspecified oil. Methanol was the top substance transported by rail, followed by propane and diesel. Aviation fuel was the top substance transported by pipeline, dominating the data for this transportation mode. Due to data quality issues, specific transportation routes could not be established for truck or rail transportation.

The OHM report also considered bulk petroleum shipping through Massachusetts waters, showing the major transportation routes and port calls based on 2016 Army Corps of Engineers data. Figure 2-6 shows shipping routes and annual quantities transported for petroleum (blue) and chemicals[1] (purple). The primary route for through vessels (not stopping at Massachusetts

[1] The Army Corps data format makes it difficult to determine specific chemicals, which is why they are grouped together.

ports) going both north and south is Buzzards Bay and the Cape Cod Canal. Over 100,000 pounds of chemicals and between 5-10 million pounds of petroleum products moved along this route in 2016.

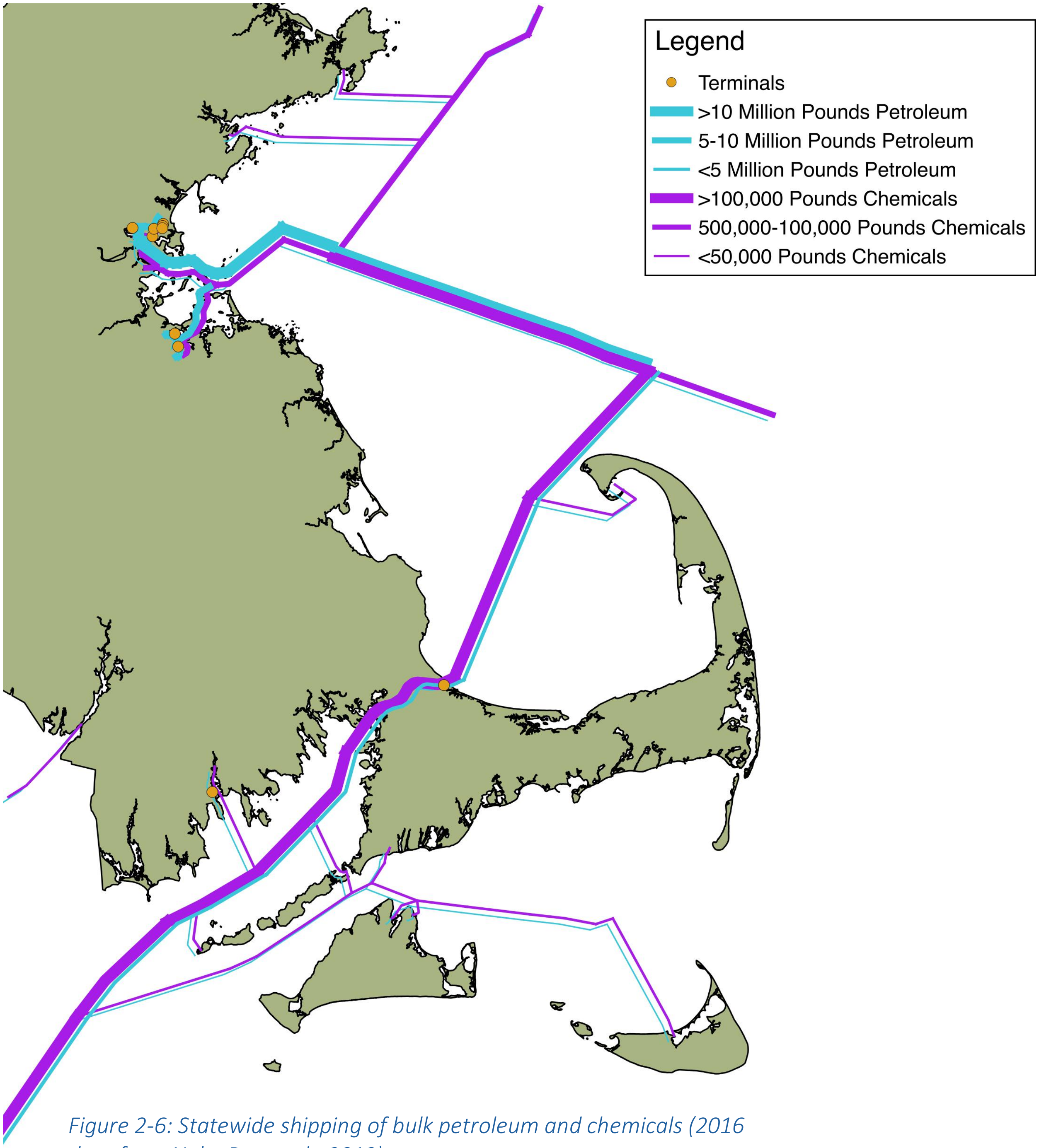


*Figure 2-6: Statewide shipping of bulk petroleum and chemicals (2016 data from Nuka Research, 2019)*

A year-over-year comparison of the Massachusetts data shows a substantial increase in aviation fuel and propane quantities in 2017 compared to previous years. A downward trend in diesel quantities in 2015 and 2016 corresponds to an increase in unspecified oil during those same years, suggesting potential discrepancies in reporting (e.g., diesel reported as unspecified oil for those two years).

To assess the vulnerability of critical infrastructure and sensitive populations, OHM transportation and storage data was overlayed with sensitive receptor data, and a one-half mile buffer was identified around all facilities, major roadways, railroads, and pipeline routes. A series of city- and town-specific summaries were produced that identified the top 5 chemicals by quantity in each Massachusetts municipality, along with summary statistics on hazard class and substances reported. Detailed maps show the overlap between facilities, major transportation corridors, sensitive receptors, and buffers for each city or town.

Figure 2-7 is an example of the sensitive receptors and buffer map for New Bedford, with a half-mile buffer drawn around all major facilities and transportation routes to show the proximity of sensitive receptors to OHM storage and transportation. In New Bedford, as in most Massachusetts municipalities, there are concentrations of sensitive receptors within the half-mile buffer of oil and hazardous materials storage. This has implications to climate change vulnerability since natural hazards like storms, flooding, or erosion could cause OHM spills or leaks in close proximity to critical infrastructure, sensitive populations, and important ecological areas.

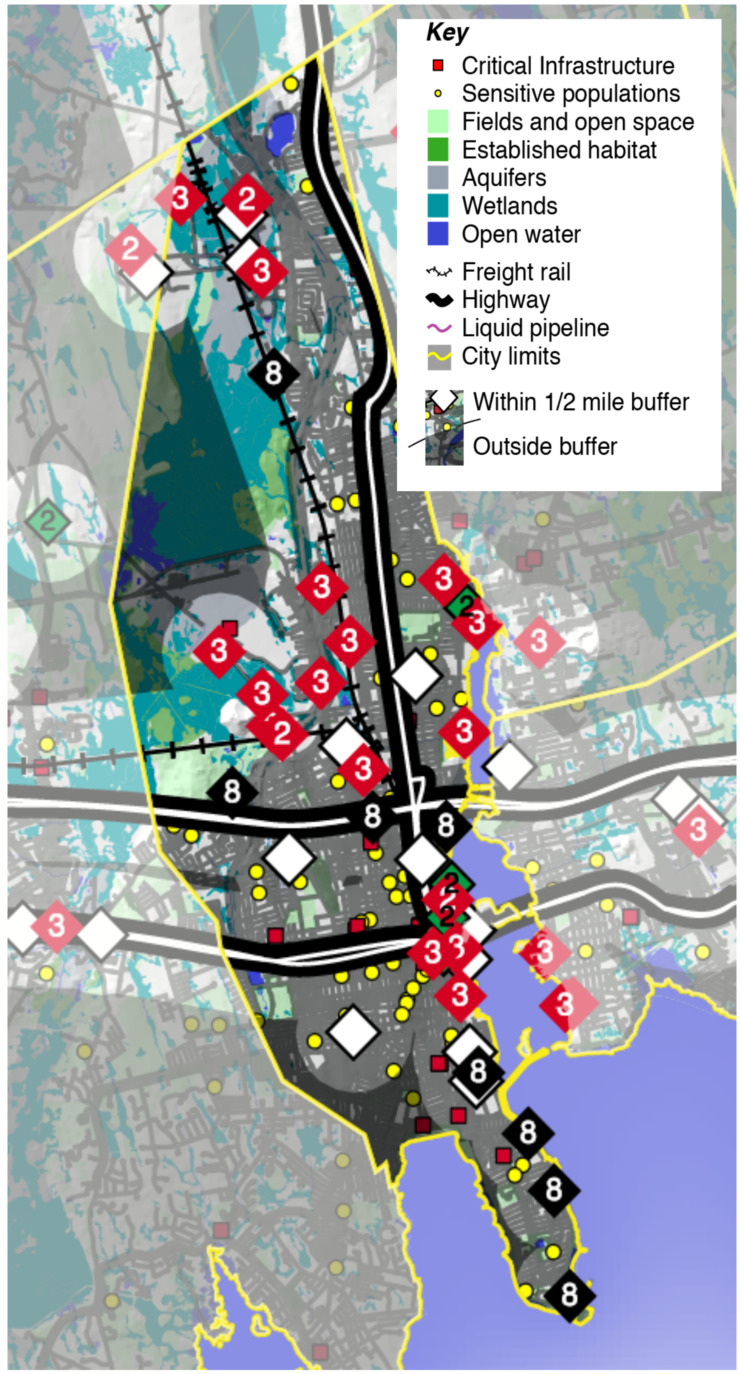


*Figure 2-7: Sensitive receptors, buffers, and OHM facilities in New Bedford (Nuka Research, 2019)*

### 2.3.4. Findings and Recommendations

A key finding of this study was the inconsistency in Tier II data on oil and hazardous materials, and most of the recommendations coming out of the OHM flow study related to data quality and control. The study also recommended that local authorities engage with the outputs, particularly the municipality-specific OHM summaries, to validate the information and help improve future studies. The data quality issues are more significant for non-petroleum products and for road-based transportation. Shipping data and information on bulk petroleum shipments to marine facilities are of higher quality due to the OR-1 reporting.

# 3. Data Sources and Application

Two primary data sources were analyzed to characterize the movement and storage of petroleum: AIS ship tracking data and OR-1 reports on bulk deliveries of petroleum products to marine terminals.

## 3.1. AIS DATA AND ANALYSIS

Automated Information System (AIS) vessel tracking data was compiled for coastal Massachusetts waters for a four-year time period from January 1, 2017, through December 31, 2020.

AIS is an automated tracking system used on ships and by the United States Coast Guard (USCG) Vessel Traffic Services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships and VTS stations. There are two types of AIS transmitters, A and B. Type A AIS vessels report their position every 2-10 seconds depending on the vessel’s speed and/or course changes (every three minutes or less when at anchor or moored) and the vessel’s static and voyage-related information every 6 minutes. Vessels with Class A AIS are also capable of text messaging safety-related information and AIS Application Specific Messages. Type B AIS vessels report every three minutes or less when at anchor or moored, but their position is reported less often and at a lower power. Likewise, they report the vessel’s static data every 6 minutes but not any voyage-related information. They can receive safety-related text and application-specific messages but cannot transmit them (USCG, 2019).

Federal regulations (33 CFR 164.46) and the International Maritime Organization's (IMO) International Convention for the Safety of Life at Sea (SOLAS) require Type A AIS to be fitted aboard vessels weighing 1600 gross tons or more, tank ships carrying dangerous or combustible cargoes, self-propelled vessels of 65 feet or more in length engaged in commercial service, most towing vessels, some dredges, and passenger vessels certificated to carry more than 150 passengers. Type B AIS can be used in lieu of Type A for fishing vessels, small commercial passenger vessels, and some dredging vessels that meet the above size requirements. The USCG has the authority to require AIS systems on other vessels to mitigate safety concerns. (USCG 2019)

For this analysis, vessels were categorized into three broad categories: tugs, tankers, and all other vessels. Other vessels represent a wide range of ships, including large commercial ships, ferries, recreational vessels, tour boats, and fishing boats. A series of passage lines were used to count and characterize vessel movements in and out of various ports and waterways as a basis for comparison. Figure 3-1 shows the study area and passage lines.

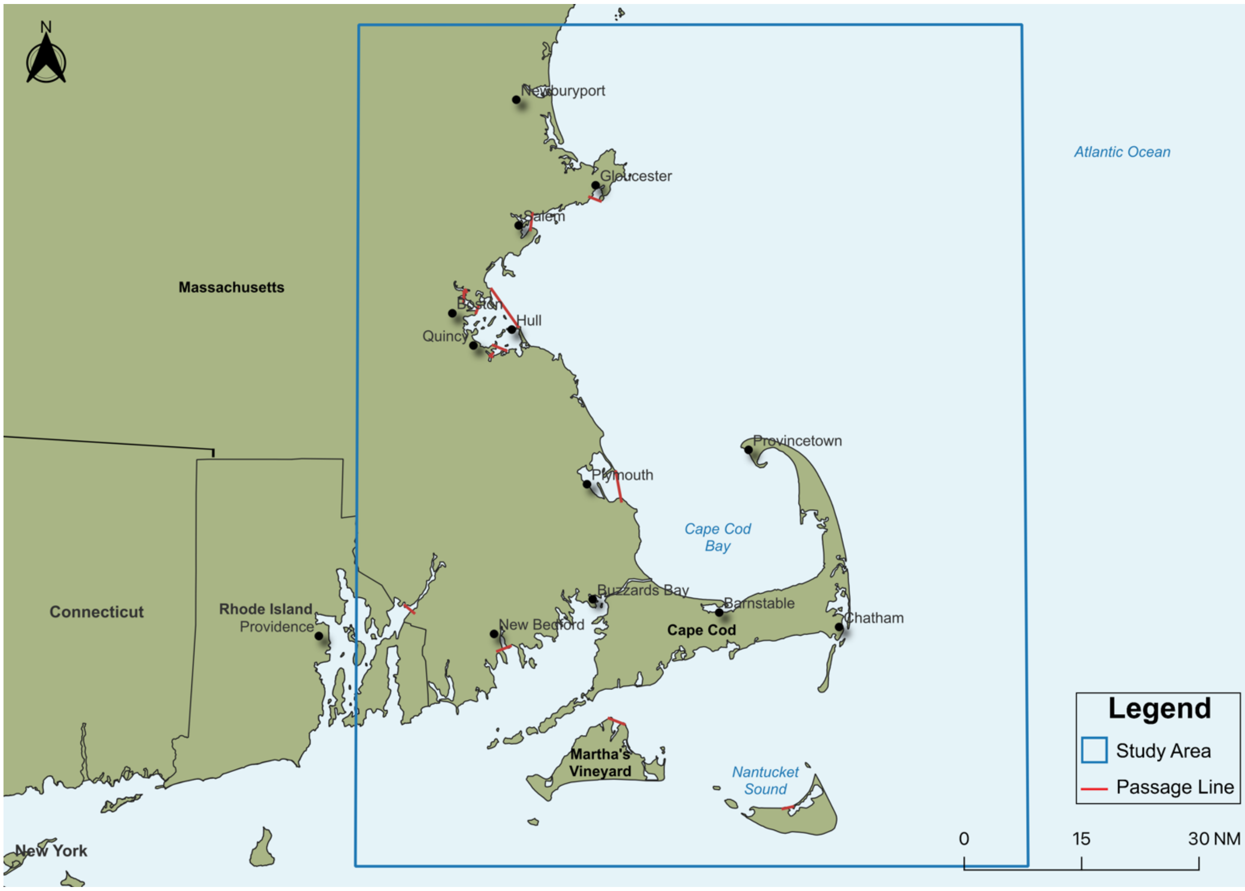


*Figure 3-1: Study area and passage lines for vessel traffic analysis*

AIS stations are not required on barges, only on most of the tugs towing them. As a result, it is not readily apparent from AIS data what barge is paired with any given tug at any given time.

Nuka Research obtained an AIS dataset from Maritime Information Systems, Inc. that included AIS from ground stations and ship signals received within the study area (Massachusetts coastal waters) from 2017-2020. When an AIS signal is transmitted from the vessel to a receiver, a data point is logged identifying the position of the vessel. Each data point includes the vessel's identity, time, date, location, and limited vessel particulars. When the next signal is received, a track of the vessel's movement (track line) can be developed, interpolating location between the data points.

Land-based stations receive signals continuously but have a limited range, and reception can be disrupted by physical obstructions or atmospheric conditions. Therefore, not every signal transmitted by a vessel is recorded. The land-based AIS data set used for this analysis is appropriate to the threat assessment, which focuses on coastal oil spill hazards. The AIS data becomes sparser and less reliable as vessels transit to sea and leave the range of the shore receivers.

The information derived from AIS data included:

- Track lines by vessel category throughout Massachusetts and New England
- Specific events as vessels crossed a particular AIS passage line; these events were sorted and categorized by vessel type and location

## 3.2. OR-1 REPORTS

In the wake of the 2003 *Bouchard B-130* spill, Massachusetts passed the Oil Spill Act, which included a provision requiring marine terminals that receive bulk petroleum deliveries to pay a per-barrel tax on incoming oil (Mass. Gen. Laws. Ch. 251 § (2004). This requirement funds many of the MOSPRA program activities. The tax reporting forms filed monthly by marine oil terminals, called OR-1 forms, also create a record of the quantity and type of oil deliveries over time. To characterize bulk petroleum deliveries, OR-1 reports from 2017 through 2020 were compiled and analyzed.

## 3.3. NOTICE OF INTENT TO TRANSIT REPORTS

The Oil Spill Act also established a requirement that owners/operators of tank barges carrying more than 6,000 barrels of oil as cargo provide a Notice of Intent to Transit through Buzzards Bay and the Cape Cod Canal at least twenty-four hours prior to transit or as soon as operationally feasible. These reports include information such as the name of the vessel owner/operator, the name and type of the vessel, the type and quantity of oil on board, and the vessel's destination.

Notice of Intent to Transit reports are archived and provide a historical record of intended transits of tugs and barges carrying petroleum through Buzzards Bay and the Cape Cod Canal. While this information only applies to a part of state waters, it complements some of the gaps between AIS and OR-1 data. Namely, the AIS data only captures towing vessels since there is no requirement for AIS on barges. The OR-1 data contains sparse and inconsistent information about delivery vessels, making it difficult to associate and AIS track for a specific tug and barge or tanker carrying bulk petroleum with its reported delivery volume and location. The Notice of Intent to Transit Reports includes the destination, which provides insight into whether bulk petroleum shipments are bound for Massachusetts ports or whether it is through traffic transiting Massachusetts waters but not stopping in any ports.

# 4. Analysis of Bulk Transportation and Delivery of Petroleum Products (2015-2020)

OR-1 data forms provide a record of all bulk oil deliveries to marine terminals in Massachusetts. There are nine terminals in Boston Harbor, one in New Bedford, and one on Nantucket. This data was analyzed for special and temporal trends from 2015 through 2020.

## 4.1. ANNUAL SUMMARIES AND TRENDS

Figure 4-1 summarizes the total quantity of oil in barrels that was transported to marine bulk oil facilities from 2015-2020.

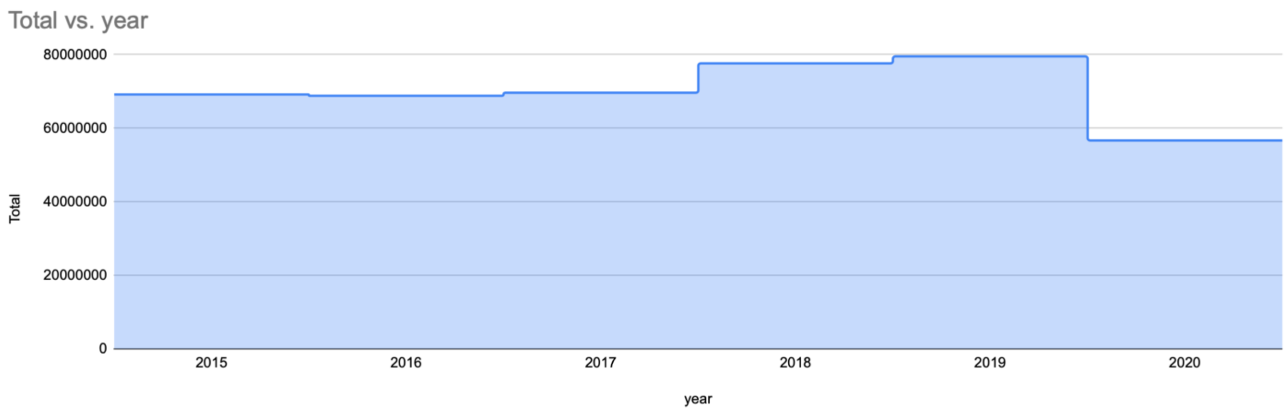


*Figure 4-1: Annual volume of bulk oil transfers to Massachusetts marine storage facilities from 2015-2020*

Figure 4-1 shows a gradual increase in the total volume of bulk oil transfers into Massachusetts through 2019, with a substantial drop-off in 2020 that is attributable to changes in demand while COVID-19 travel restrictions were in place.

Table 4-1 and Figure 4-2 show the annual volumes (in barrels) by fuel type based on OR-1 reports.[2] The top line in Figure 4-2 is gasoline, which is the highest quantity petroleum product transferred in Massachusetts. Figure 4-3 shows the same data with gasoline excluded.

Diesel is the second highest quantity petroleum product imported across all six years. The annual trend lines for most products increase between 2015 and 2019. Gasoline and aviation fuels dropped significantly in 2020 due to COVID-19 travel restrictions. All other petroleum types show a decline from 2019 to 2020. There is a significant increase in "other" petroleum types from 2016 to 2017, which corresponds to a change in the OR-1 reporting system and a complete drop-off in biodiesel and ethanol volumes. This may indicate a reporting bias rather than a trend.

[2] Fuel type is self-reported on OR-1 forms in an open text entry field; therefore, it is possible for data entry errors to compromise data integrity. Part of the data processing for this analysis involved QA/QC of the fuel type data and used basic algorithms to look for and, when possible, correct obvious anomalies based on past delivery history, etc.

*Table 4-1: Annual bulk petroleum deliveries to Massachusetts terminals by year and fuel type (2015-2020)*

| Petroleum type | Barrels of Petroleum per Year | | | | | |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| **asphalt** | 832,970 | 676,682 | 574,966 | 0 | 0 | 0 |
| **aviation fuels** | 5,569,427 | 9,911,087 | 11,681,742 | 13,219,837 | 13,880,788 | 5,631,854 |
| **biodiesel** | 340,237 | 52,596 | 19,930 | 0 | 0 | 0 |
| **diesels** | 17,692,199 | 12,307,431 | 10,769,559 | 9,855,085 | 8,660,117 | 7,844,617 |
| **ethanol** | 1,498,292 | 2,021,049 | 1,640,014 | 0 | 0 | 0 |
| **gasoline** | 34,801,888 | 37,076,128 | 37,391,339 | 41,289,451 | 44,281,217 | 33,931,203 |
| **heating oils** | 4,288,722 | 3,450,112 | 2,913,086 | 4,387,781 | 4,943,579 | 4,019,626 |
| **heavy fuel oil** | 3,333,444 | 2,734,383 | 360,847 | 464,873 | 376,629 | 267,199 |
| **kerosene** | 130,690 | 77,207 | 80,905 | 49,356 | 141,371 | 39,829 |
| **other** | 704,900 | 531,806 | 4,234,882 | 8,396,376 | 7,282,314 | 4,953,035 |
| **Total** | 6,919,769 | 68,838,600 | 69,667,388 | 77,662,760 | 79,566,017 | 56,687,363 |

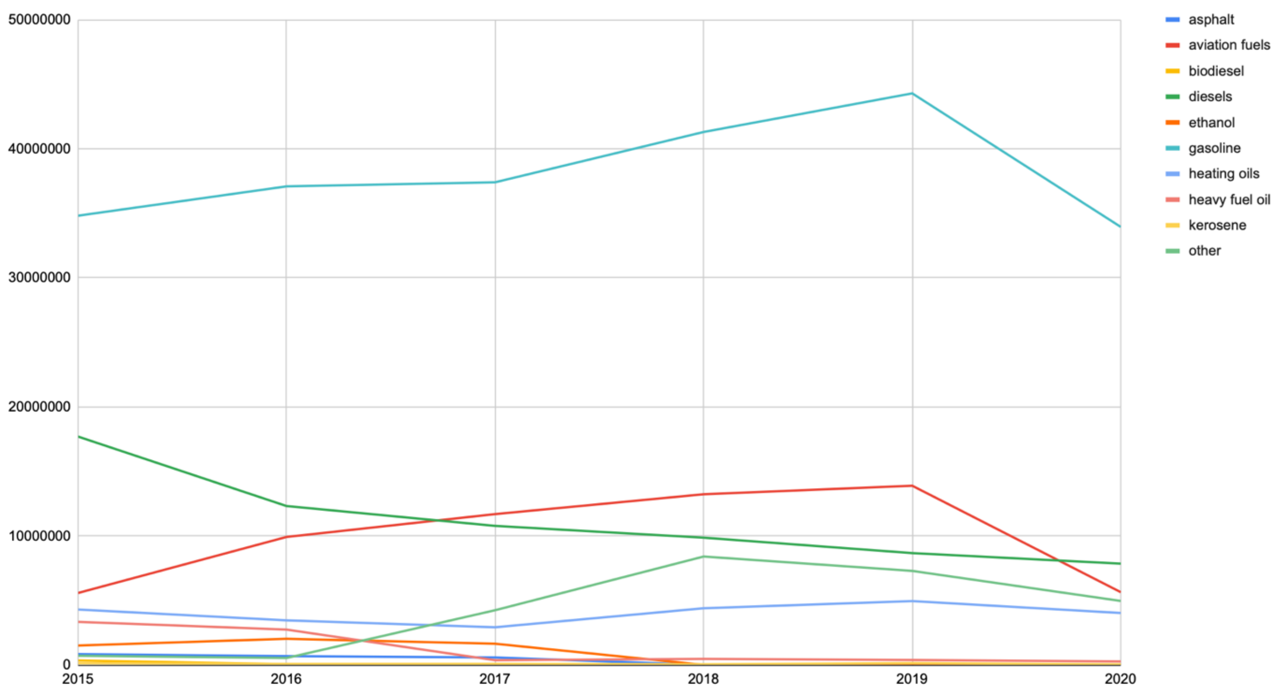


*Figure 4-2: Volume of bulk petroleum imports by year and fuel type (2015-2020)*

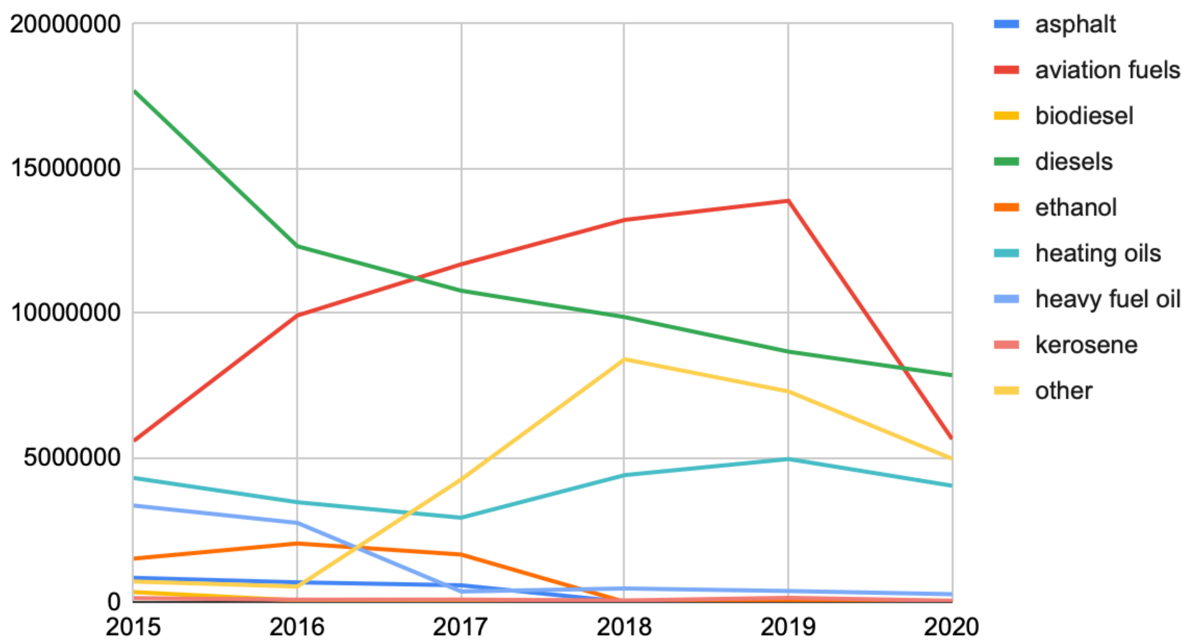


*Figure 4-3: Total volume of bulk petroleum imports by year and fuel type, excluding gasoline (2015-2020)*

## 4.2. MONTHLY SUMMARIES AND TRENDS

OR-1 forms are filed monthly, providing additional detail about trends over time. Data from 2015 and 2016 are excluded from the monthly summaries because of data quality.[3] Figure 4-4 shows the monthly breakdown of gasoline, diesel, heating fuel, aviation fuel, and other fuel deliveries for each month from January 2017 through December 2020. Each bar graph has a different scale, and they are presented from top to bottom based on total delivery amounts.

Monthly gasoline delivery volumes ranged from just under 1 million to just over 5 million barrels per month. Gasoline deliveries peaked in January 2018 at 5.1 million barrels, then stayed relatively consistent through 2018 and 2019. Gasoline delivery volumes decreased notably in May 2020. “Other” fuel deliveries also peaked in January 2018 with 2.97 million barrels. Other fuel deliveries also had relatively high volumes in January 2019 (2.1 million barrels) and May 2019 (1.6 million barrels). Other fuel delivery volumes across the four years ranged from under 40,000 barrels to nearly 3 million barrels per month.

Monthly diesel deliveries ranged from just under 200,000 barrels to 1.5 million barrels per month. Diesel deliveries were highest in February and March of 2018 (each month just over 1.5 million barrels), with volumes over 1 million barrels reported for five months in 2017, four months in 2018 (inclusive of February and March), one month (March) in 2019 and one month (April) in 2020.

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[3] Prior to 2016, OR-1 forms were filed manually, and data was extracted from PDF files using an automation function. From 2017 on, OR-1 data was collected electronically.

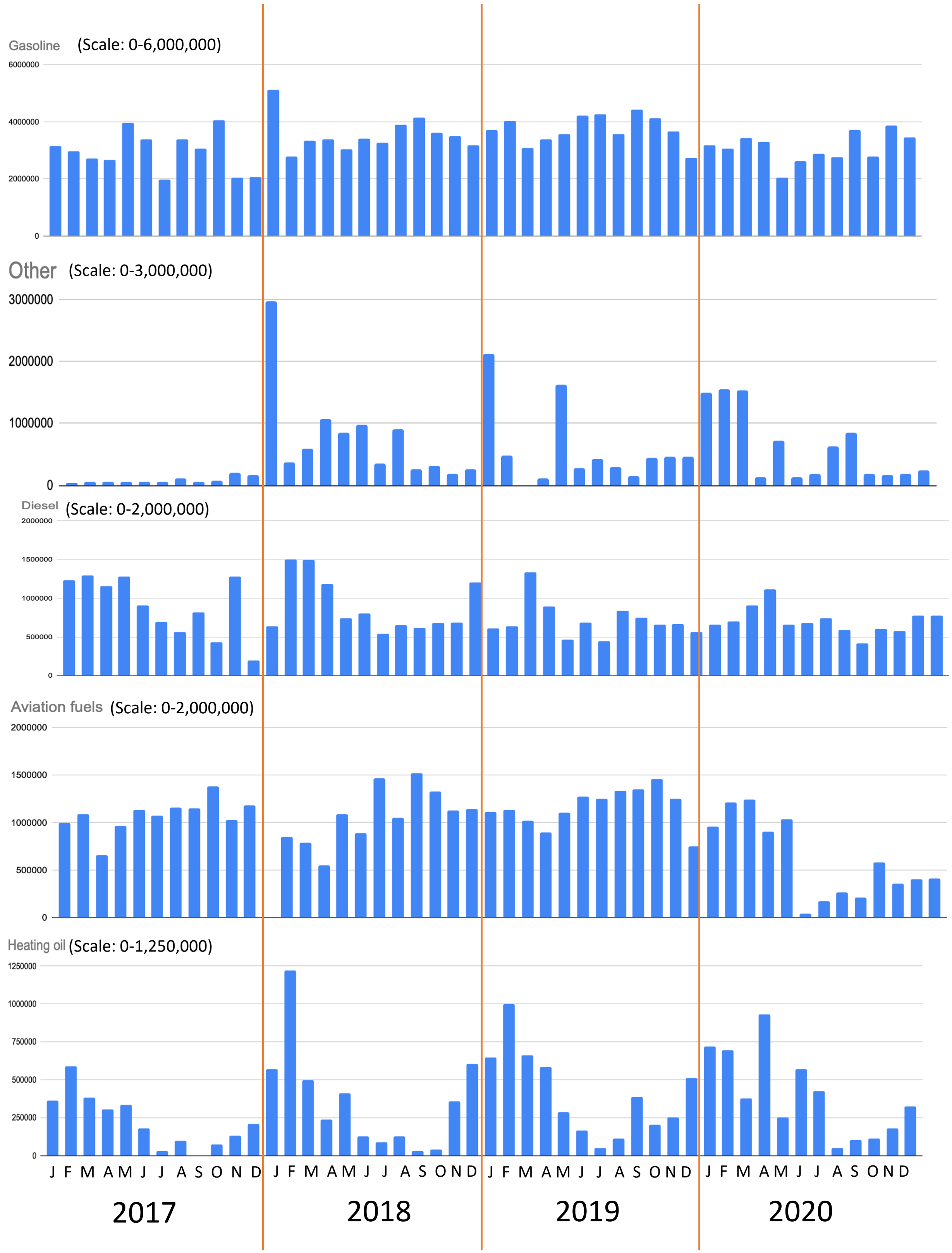


*Figure 4-4: Monthly petroleum deliveries by product to Massachusetts bulk oil terminals (2017-2020)*

Apart from December 2017, for which zero barrels of aviation fuel deliveries were reported (likely a reporting or data error), monthly volumes ranged from 40,000 to 1.52 million. The highest reported delivery months were September 2018 (1.53 million barrels), July 2018 (1.47 million barrels), and October 2019 (1.46 million barrels). Aviation fuel volumes, which averaged 1.24 million barrels per month across the four-year data set, dropped to just over 40,000 barrels in May 2020, clearly tied to pandemic travel restrictions. From May through December 2020, aviation fuel deliveries averaged 305,000 barrels per month.

Home heating oil follows a seasonal trend for each of the four years analyzed, with delivery volumes peaking in January and February during 2017-2019 and in April 2020. Home heating oil deliveries drop off during July and August. There was one month (September 2017) with zero barrels reported. Otherwise, monthly delivery volumes ranged from 30,000 (September 2018) to 1.2 million barrels (February 2018).

## 4.3. FUEL DELIVERIES BY PORT AND HARBOR

Figure 4-5 shows the location of marine terminals that received bulk petroleum shipments based on OR-1 reports from 2017-2020. Nine terminals are in Boston Harbor; seven are behind the Boston Harbor Passage line, and two are behind the Braintree/Weymouth line. There are individual terminals in New Bedford, Nantucket, and Sandwich.

OR-1 reports identify the receiving terminal by company name but not always by location. 2017 reports identify deliveries to terminals in Sandwich and New Bedford, while reports from 2018-2020 do not include any deliveries. Notice of Intent to Transit reports indicate that these terminals continued to receive deliveries; therefore, this is probably a reporting issue. Rather than apply assumptions, deliveries where the terminal is not identified in OR-1 data are presented as such.[4]

Table 4-2 shows the total volume of petroleum deliveries reported through the OR-1 reports for the nine terminals in Boston Harbor, individual terminals in New Bedford, Sandwich, and Nantucket, and unspecified terminals. Based on the data, 85% of oil deliveries go to terminals in Boston Harbor. This number may be higher if any of the unspecified deliveries go to Boston Harbor. Deliveries to Nantucket are less than 1% of the total volume. Data is insufficient for New Bedford and Sandwich.

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[4] Two sets of OR-1 reports specified the terminal by company name but not location. The two companies are Global, which has terminals in Chelsea, Revere, and Sandwich, and Sprague, which has terminals in Everett, Quincy, and New Bedford. During data exploration, we attempted to link OR-1 and Notice of Intent to Transit data however data fidelity was inadequate to link the two with any confidence.


*Figure 4-5: Marine terminals that received bulk oil deliveries (2017-2020)*

*Table 4-2: Bulk petroleum deliveries to marine terminals by harbor based on OR-1 reports from 2017-2020*

| Terminal locations | Barrels of petroleum delivered by year | | | | Total |
|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2020 | |
| Boston Harbor | 66,808,868 | 67,586,535 | 69,840,550 | 49,792,951 | **254,028,904** |
| New Bedford | 165,451 | | | | **165,451** |
| Nantucket | 142,019 | 153,479 | 159,217 | 238 | **454,953** |
| Sandwich | 44,527 | | | | **44,527** |
| Terminal unspecified | 1,904,626 | 9,977,799 | 9,260,821 | 7,031,083 | **28,174,330** |
| **Total** | **69,065,491** | **77,717,813** | **79,260,589** | **56,824,272** | **282,868,165** |

Figure 4-6 shows the oil delivery trends by year. Consistent with other data sets, there is a gradual year-over-year increase from 2017-2020, followed by a decline in 2020.

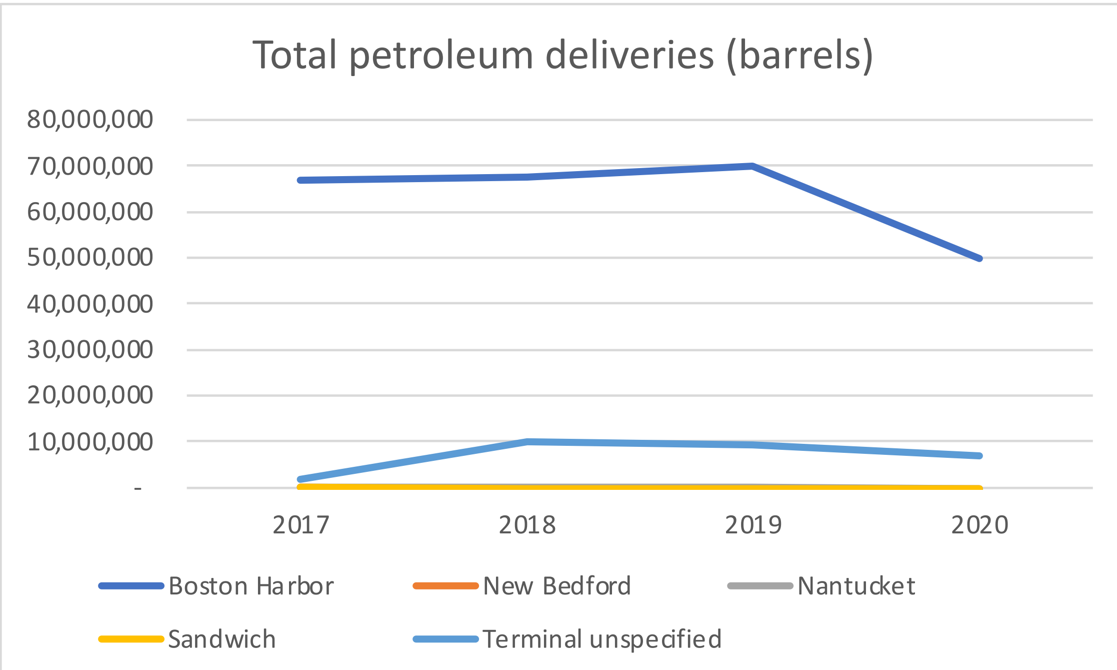


*Figure 4-6: Summary of petroleum deliveries reported on OR-1 forms (2017-2020)*

Table 4-3 shows the oil deliveries by type and harbor based on combined OR-1 data for 2017-2020. Traffic into Boston Harbor is split by Boston Harbor (Chelsea, Everett, Revere, East Boston) and Braintree/Weymouth (Quincy and Weymouth) to highlight the differences in oil types as traffic splits from north to south upon entrance to Boston Harbor. Diesel is the only fuel type reported at all terminals in the state.

*Table 4-3: Total volume of oil deliveries by harbor and type (2017-2020 combined)*

| Terminal Locations | Total volume of oil delivered in barrels (2017-2020 combined) | | | | | TOTALS |
|---|---|---|---|---|---|---|
| | Other | Heating oil | Gasoline | Diesels | Aviation | |
| Boston Harbor | 7059468 | 7607146 | 127331410 | 22581082 | 44285797 | 208864903 |

| Terminal Locations | Total volume of oil delivered in barrels (2017-2020 combined) | | | | | TOTALS |
|---|---|---|---|---|---|---|
| | Other | Heating oil | Gasoline | Diesels | Aviation | |
| Braintree/Weymouth | 1669237 | 5583311 | 31733898 | 6898843 | 1075019 | **46960308** |
| New Bedford | 0 | 109094 | 0 | 75614 | 0 | **184708** |
| Nantucket | 0 | 171855 | 258554 | 37407 | 1369 | **469185** |
| Sandwich | 0 | 0 | 0 | 44527 | 0 | **44527** |
| Terminal Unspecified | 16177521 | 3115238 | 727299 | 9285189 | 95421 | **29400668** |
| Totals | **24906226** | **16586644** | **160051161** | **38922662** | **45457606** | 285924299 |

Figure 4-7 shows the breakdown of oil deliveries by type and harbor for the three highest totals: Boston Harbor, Braintree/Weymouth, and Terminal Unspecified. Boston Harbor receives most of the aviation fuel at a single facility. Most of the gasoline is delivered to Boston Harbor and Braintree/Weymouth. All five types of oil deliveries are associated with an unidentified terminal location.

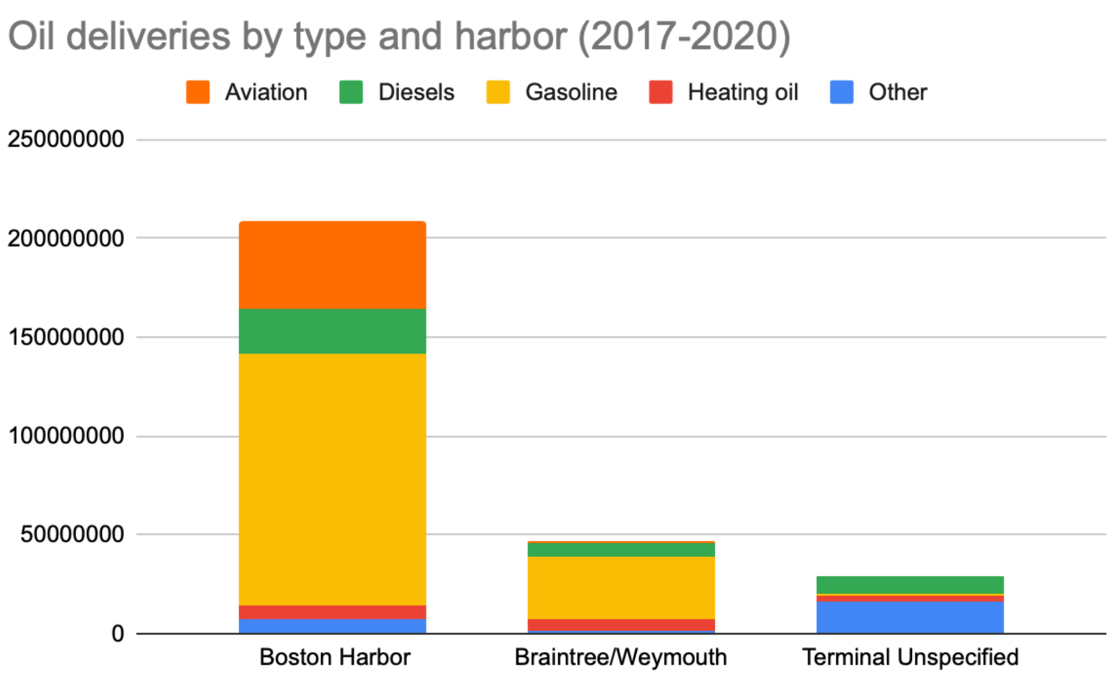


*Figure 4-7: Breakdown of oil deliveries by type for Boston Harbor, Braintree/Weymouth, and Unspecified deliveries (2017-2020 combined)*

# 5. Analysis of Vessel Traffic Patterns

## 5.1. DENSITY MAPS AND PASSAGE LINES

Vessel traffic density is presented here through a combination of AIS density maps and statistical analysis of vessel movements.

AIS data for ship traffic from 2017-2020 was analyzed to produce density maps, which show the relative density of ship movements in coastal Massachusetts waters over this four-year period. The density scale is logarithmic, which means that the progression from the lowest density (light yellow) to the highest density (dark red) represents an order of magnitude increase in the number of ships that transited a given grid cell (0.2 $km^2$). The density measurement reflects the likelihood that a vessel will be present in a given grid cell based on the average of all vessel tracks from 2017-2020.

While the density maps provide a visual comparison of historic vessel tracks, they represent average traffic over time. Another way to compare vessel traffic is by counting actual transits of various vessel types using a passage line approach. Figure 3-1 shows a series of passage lines that were used to count vessel transits into various harbors and waterways. Inbound transits were counted based on the ship's heading to avoid double-counting ships that enter and then exit. The entire 4-year data set was analyzed using this approach to quantify the passage of ships.

## 5.2. REGIONAL

Figure 5-1 shows regional traffic patterns for all vessels. It shows a partial picture of regional traffic because of the limits of AIS shore-receiver data. It shows the relative vessel traffic in ports and waterways within Massachusetts in the context of other regional ports and waterways from Maine to New York.

Figure 5-2 shows the regional heat maps for tugs and tankers. The traffic density is consistent with data from the OR-1 and Notice of Intent to Travel forms, which show that tug and barges traveling through Buzzards Bay and the Cape Cod Canal travel from south to north, originating most often in New York and New Jersey, and less frequently from Connecticut, Delaware, or Pennsylvania. Tugs and barges either deliver fuel to Massachusetts ports, with most deliveries to the Boston Harbor terminals and occasional deliveries to New Bedford. Tugs and barges also transit through Massachusetts waters from these same ports to deliver to ports in Maine.

Tanker transits are less frequent than tugs and barges, and there are some differences in their traffic patterns. Most notably, tankers are transiting the shipping lines outside Cape Cod, while tug and barges are transiting the Cape Cod Canal. The gaps in the tanker transits leaving New York and traveling north in the outside shipping lanes are caused by limitations of AIS shore-based data. The two distinct traffic lanes visible running west-east from New York and southeast-northwest outside Cape Cod most likely connect southeast of Nantucket as large commercial vessels follow the shipping lanes.

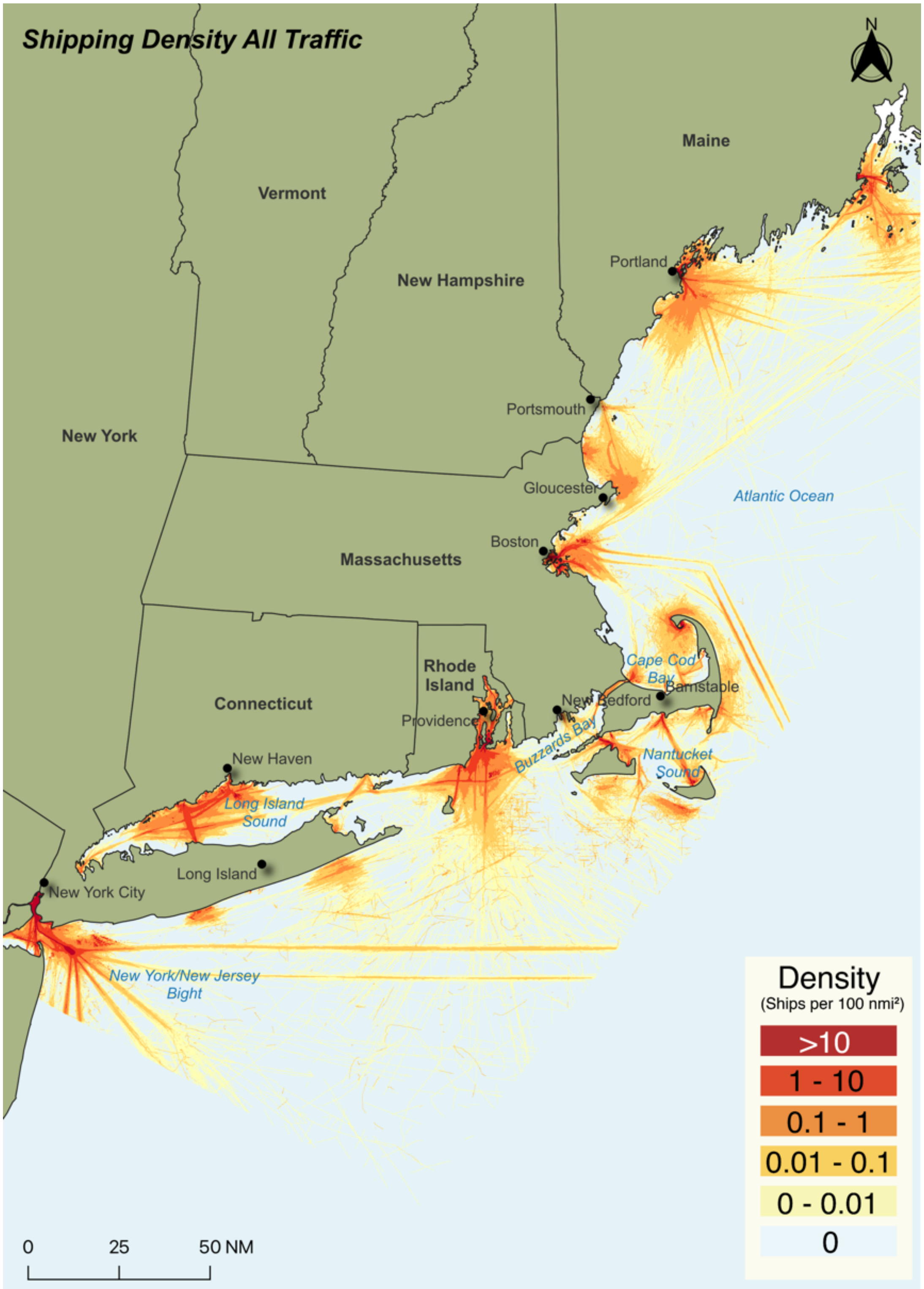


*Figure 5-1: Regional vessel traffic density based on 2017-2020 shore-based AIS data*

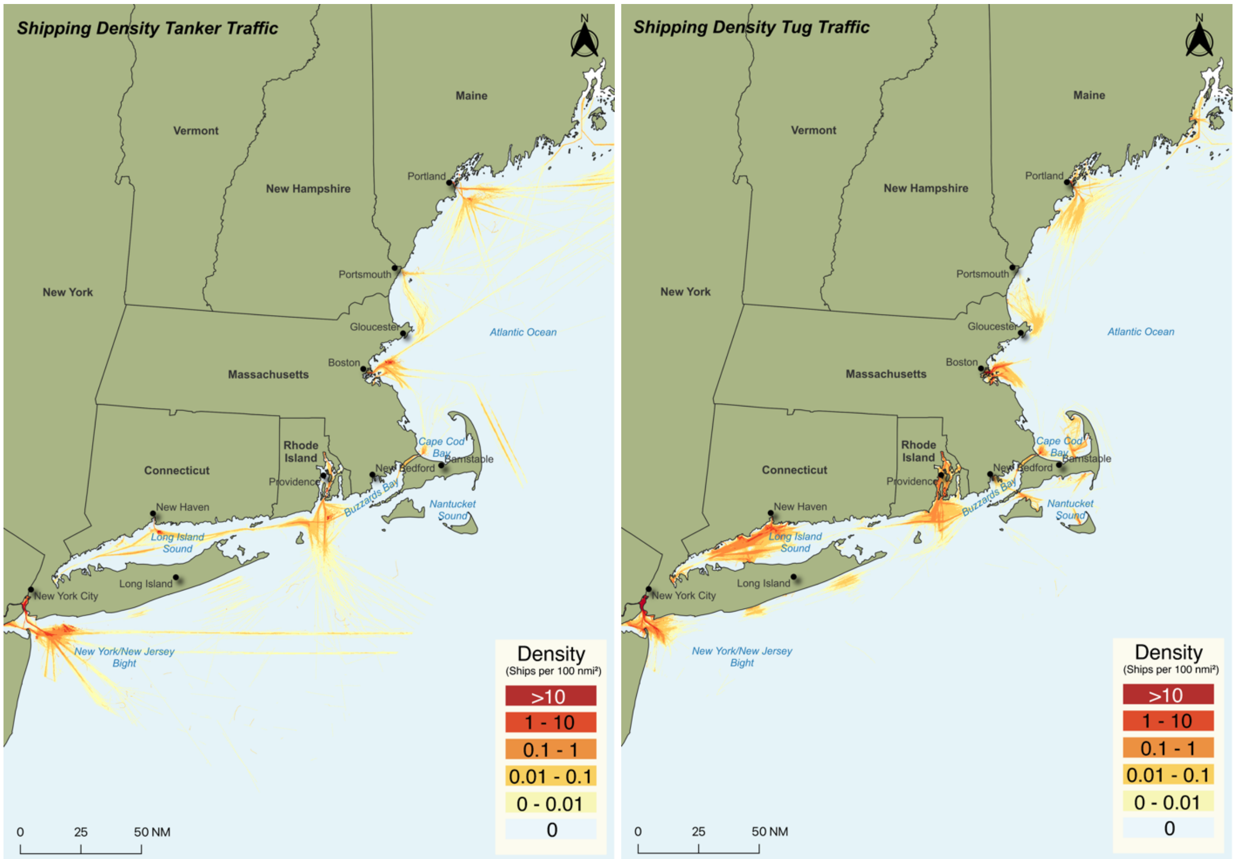


*Figure 5-2: Regional vessel traffic density for tankers (left) and tugs (right) from 2017-2020 shore-based AIS data*

## 5.3. STATEWIDE

Figure 5-3 shows the vessel traffic density map for all vessel types statewide. Harbors with the highest density of vessel activity statewide are Boston, Provincetown, Hyannis, New Bedford, Woods Hole, Nantucket, Vineyard Haven, and Oak Bluffs. Other harbors with comparatively higher vessel traffic density include Rockport, Gloucester, Wellfleet, Brewster, Barnstable, Chatham, and Somerset.

Because the AIS data analyzed here is skewed toward larger commercial vessels in coastal areas, it does not give the full picture of shipping routes and activities in Massachusetts. Figure 5-4 was developed by a working group as part of the 2014 Massachusetts Ocean Management Plan Update to show overall vessel traffic schemes, shipping lanes, ferry routes, separation areas, anchorage areas, and pilot boarding stations (EOEA, 2014).

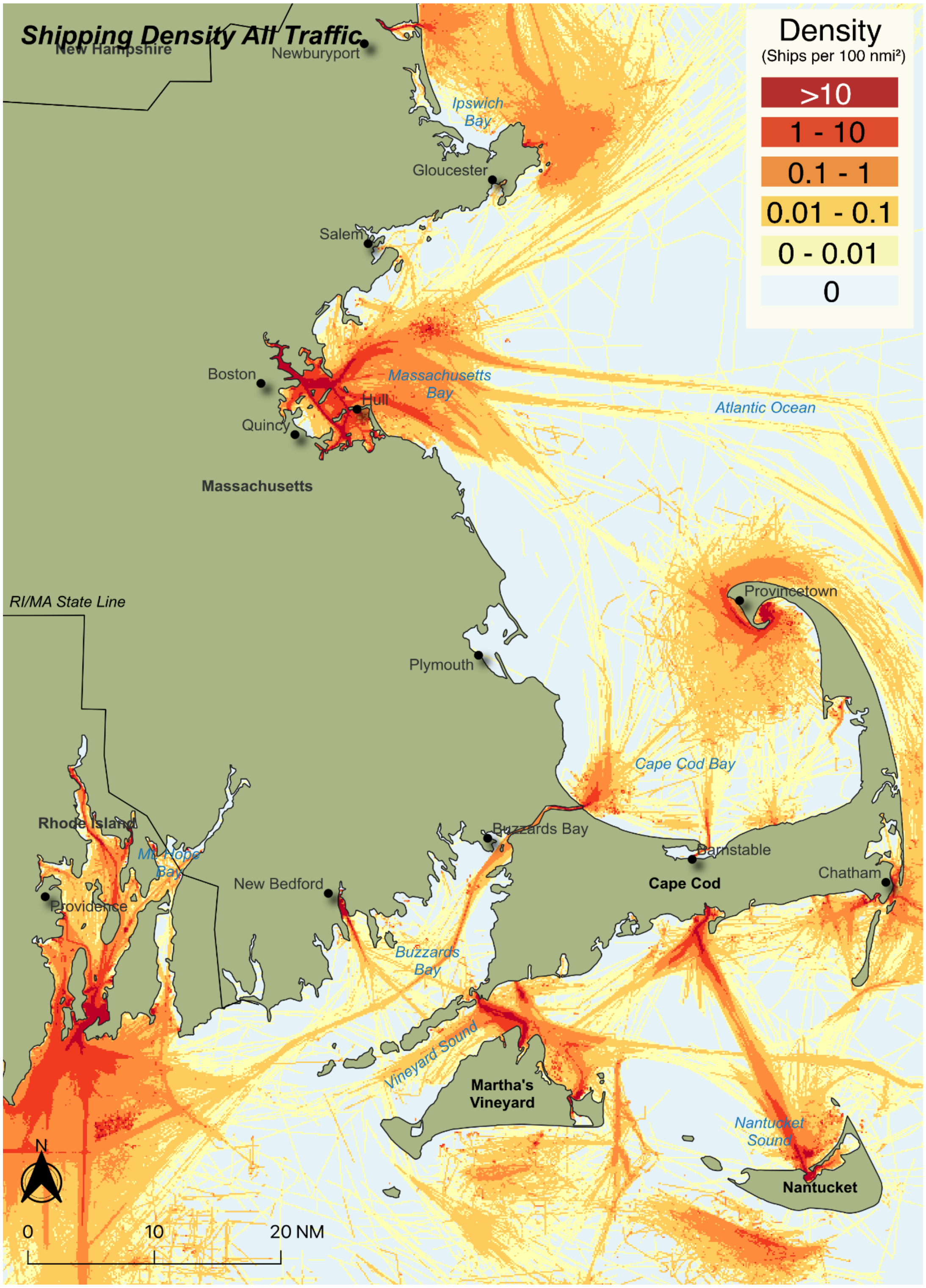


*Figure 5-3: Statewide vessel traffic density for all vessels based on shore AIS data from 2017-2020*

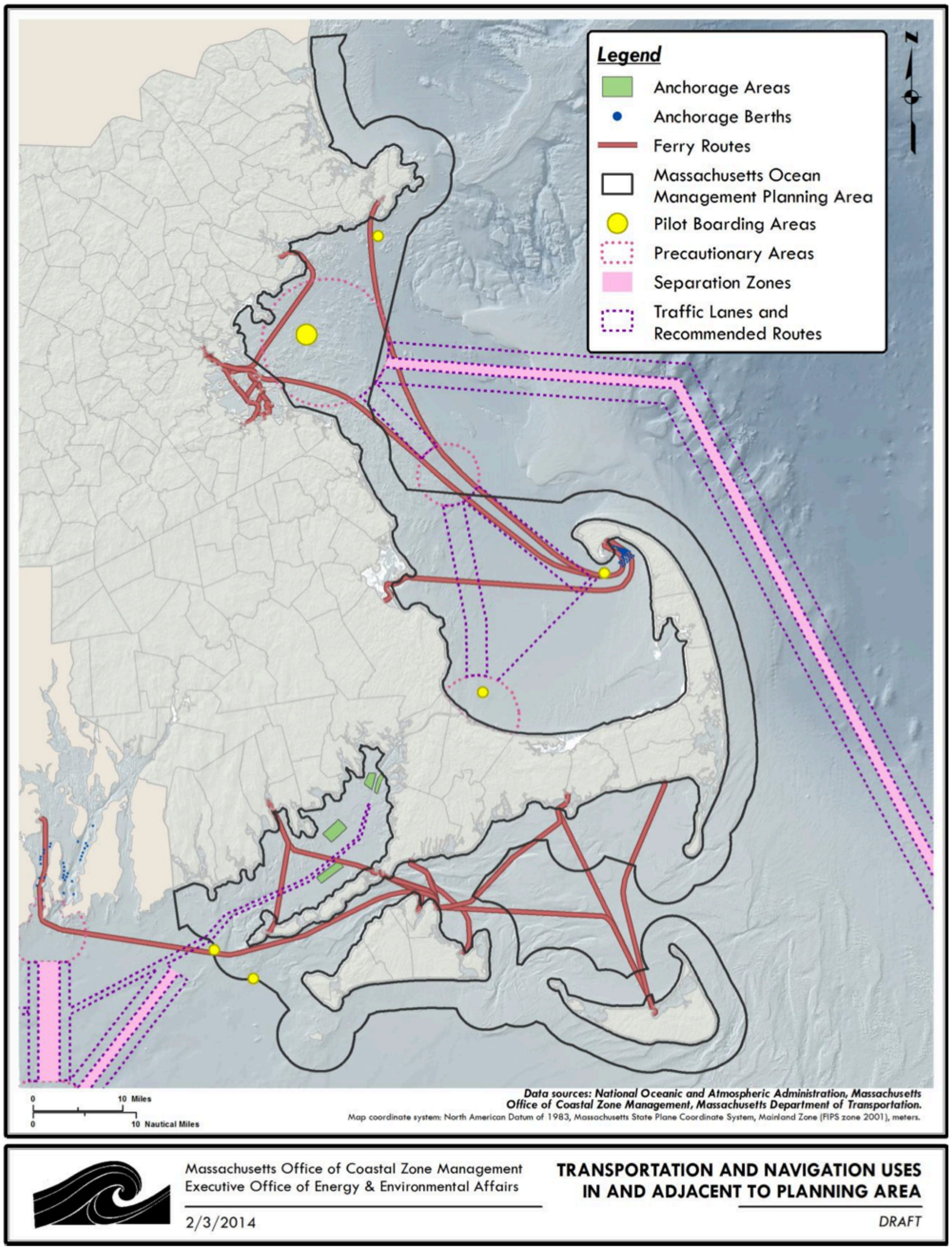


*Figure 5-4: Transportation routes and navigation uses in Massachusetts waters*

Figure 5-5 splits out the statewide vessel traffic data by tug and tanker. The remainder of the traffic shown in the All Traffic Heat Map is categorized for this study as “other,” representing a mix of other vessels that do not transport bulk petroleum, such as ferries, recreational vessels, fishing vessels, cargo ships, and other commercial carriers. It is included in the All Traffic map but not displayed separately.

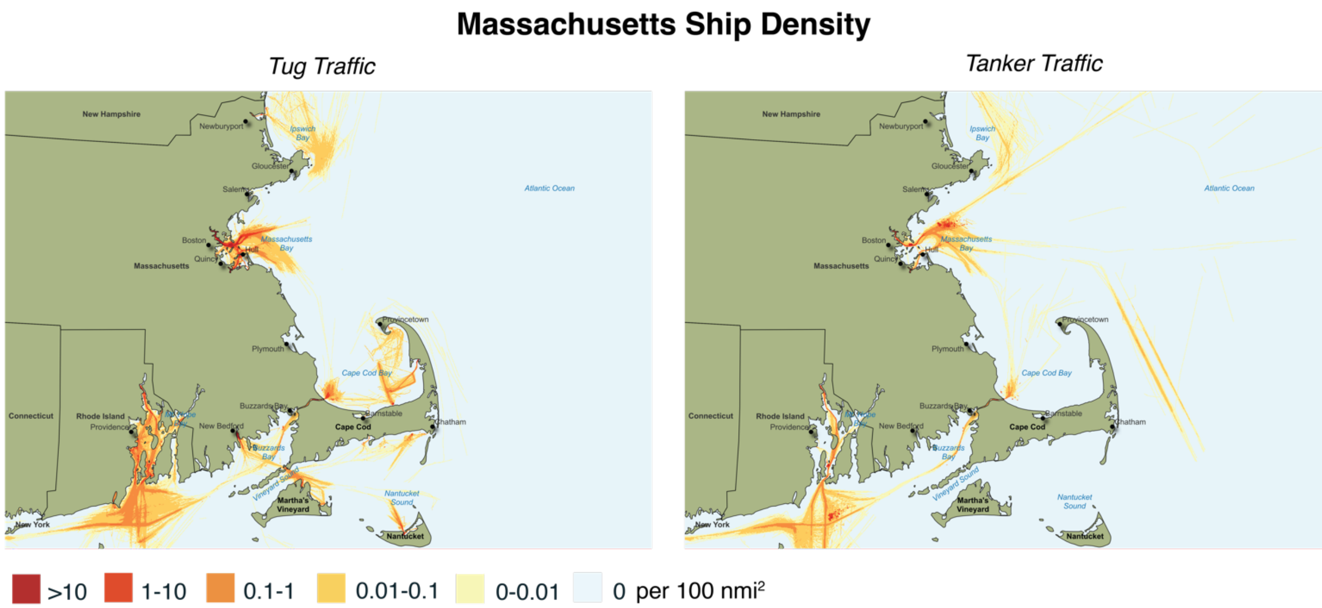


*Figure 5-5: Statewide vessel traffic density for tugs (left) and tankers (right)*

The statewide density maps also show high-density vessel traffic routes. In addition to traffic in and out of the busier harbors, there are also several high-traffic routes, including Buzzards Bay and the Cape Cod Canal, traffic between New Bedford and the islands, Woods Hole and the islands, and Hyannis and the islands. The traffic from New Bedford is primarily fuel deliveries by tug and barge, while the traffic from Woods Hole and Hyannis is primarily passenger vessels. The AIS data does not fully represent these transits, as many of the signals disappear mid-transit. For example, the traffic transiting Buzzards Bay, both east-west and north-south, seems to fade away and pick back up; in reality, the red densities shown at the east end of the Cape Cod Canal and leaving New Bedford Harbor are a more accurate portrayal.

Figure 5-6 shows a series of tiles to represent annual vessel traffic density for all traffic, tug traffic, and tanker traffic statewide. It shows the highest density across those four years in 2019, with a reduced density in 2020. The annual tug traffic shows consistent transit patterns through the Cape Cod Canal, with reduced traffic in 2020. They also show spikes in tug movements to and from Barnstable Harbor in 2018 and Provincetown in 2020. These are likely attributable to dredging or construction projects. Tanker traffic patterns are also consistent, with a reduced density in 2020.

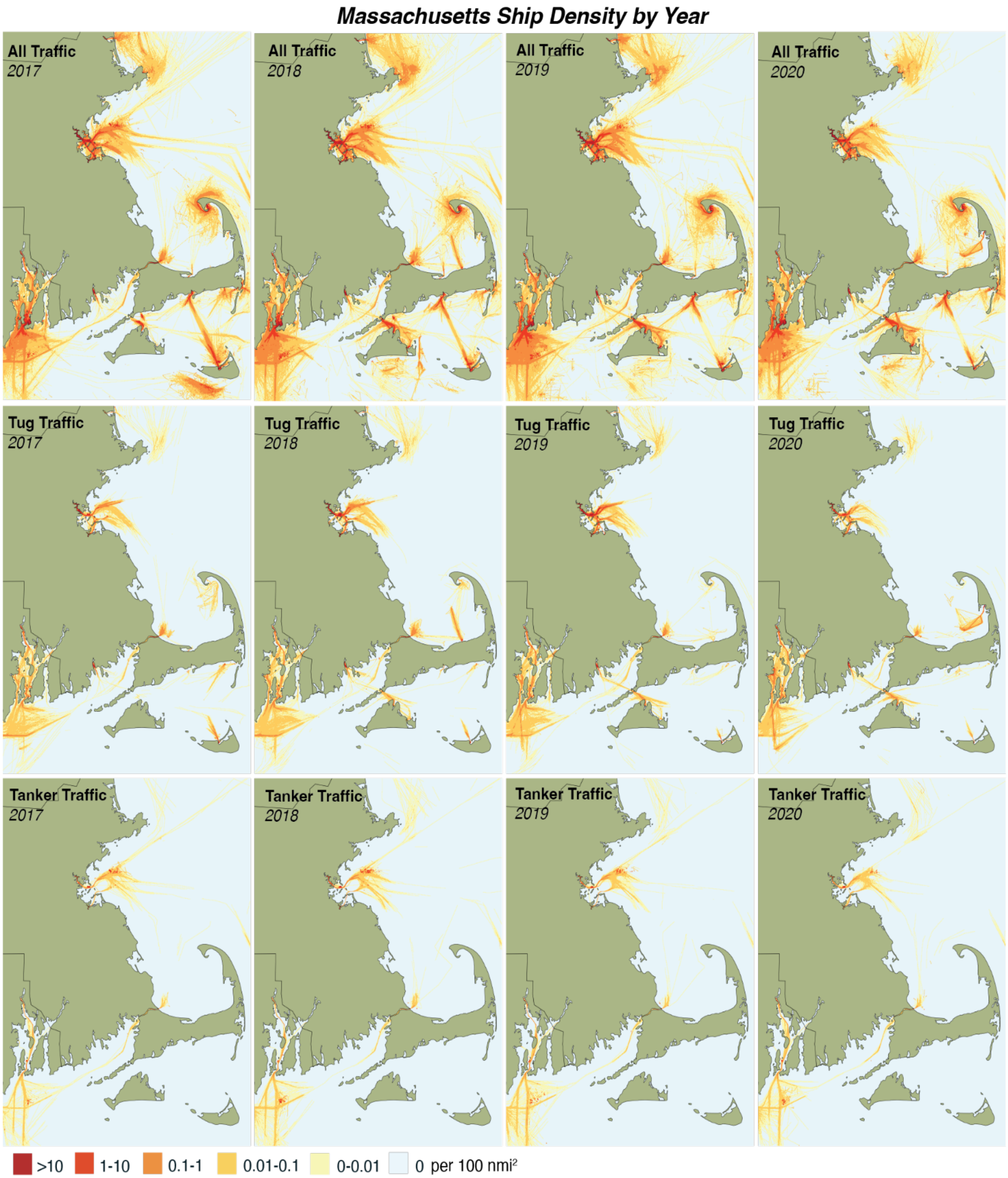


*Figure 5-6: Annual comparison of vessel traffic by type statewide*

Figure 5-7 summarizes the passage line crossings for vessels crossing inbound over the passage lines shown in Figure 3-1 as a percentage of the total passages for all vessel types. Boston Harbor accounts for 62% of the harbor entrances from 2017-2020, while Nantucket Harbor accounts for 22%, New Bedford/Fairhaven accounts for 9%, and Vineyard Haven accounts for 7%.

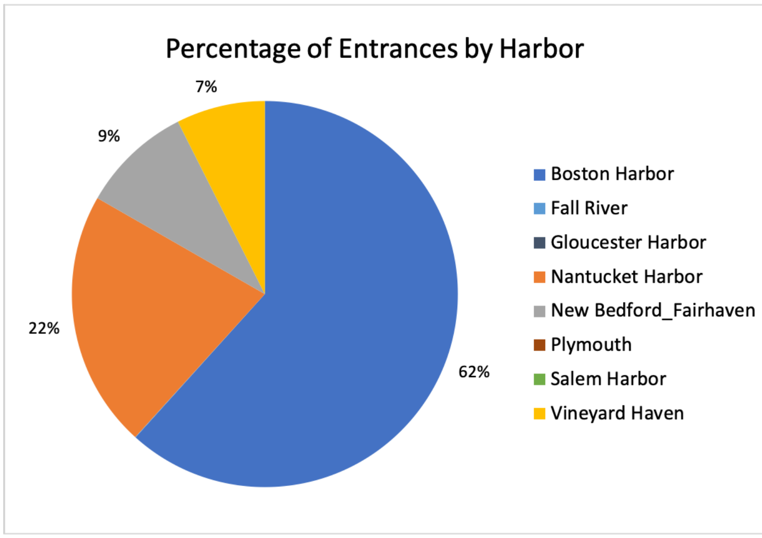


*Figure 5-7: Comparison of inbound vessel traffic into Massachusetts harbors based on AIS data from 2017-2020*

Table 5-1 shows the breakdown of vessel types by entrance for all of the major harbor passage lines. Other vessels dominate the data for all ports. The low number of other vessels in harbors like Gloucester and Plymouth is most likely a reporting bias because smaller fishing boats and recreational boats do not necessarily have AIS transponders. Figure 5-8 compares other vessels by year across the four busiest harbors (for AIS-equipped vessels), and Figure 5-9 shows the passage data for tugs and tankers.

*Table 5-1: Inbound vessel traffic into Massachusetts harbors by vessel type based on AIS data from 2017-2020*

| | Sum of Entrances by Vessel Type (2017-2020 combined) | | | |
|---|---|---|---|---|
| Harbor | Other | Tanker | Tug | Total |
| Boston Harbor | 65936 | 728 | 4833 | 71497 |
| Fall River | 24 | 7 | 12 | 43 |
| Gloucester Harbor | 7 | | | 7 |
| Nantucket Harbor | 24496 | | 495 | 24991 |
| New Bedford/Fairhaven | 9337 | | 1406 | 10743 |
| Plymouth Bay | 1 | | | 1 |
| Salem Harbor | 14 | | 2 | 16 |
| Vineyard Haven | 8362 | | 255 | 8617 |
| **Total** | **108,177** | **735** | **7,003** | **115,915** |

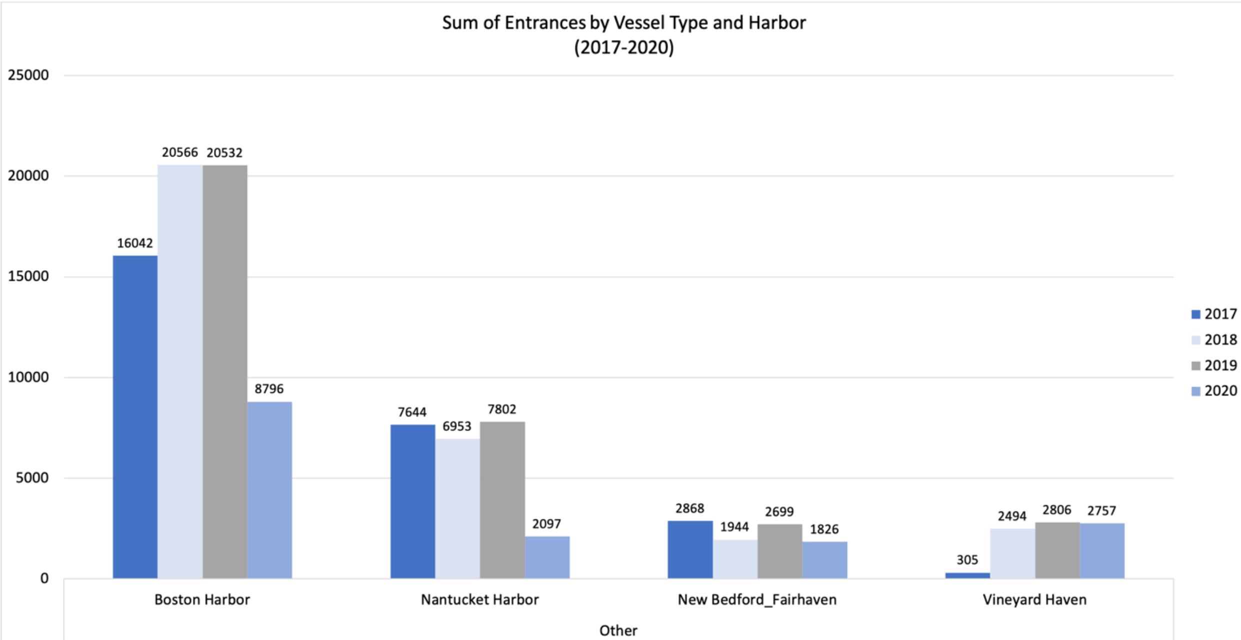


*Figure 5-8: Comparison of inbound "other vessel" (not tug or tanker) into four busiest Massachusetts harbors based on AIS data from 2017-2020*

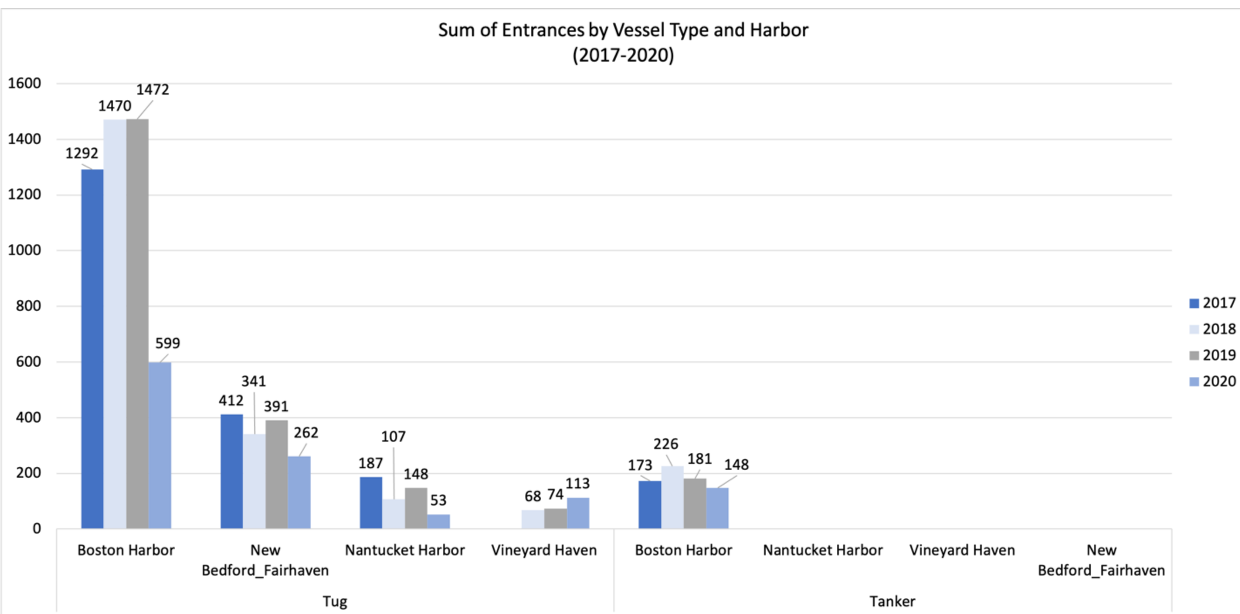


*Figure 5-9: Comparison of inbound tug and tanker traffic into four Massachusetts harbors based on AIS data from 2017-2020*

## BOSTON HARBOR REGION

The Boston Harbor region encompasses several busy ports and waterways, including Chelsea, Everett, Boston Inner Harbor, and the Fore and Town Rivers. Figure 5-10 shows vessel traffic density in Boston Harbor for all ships from 2017-2020.

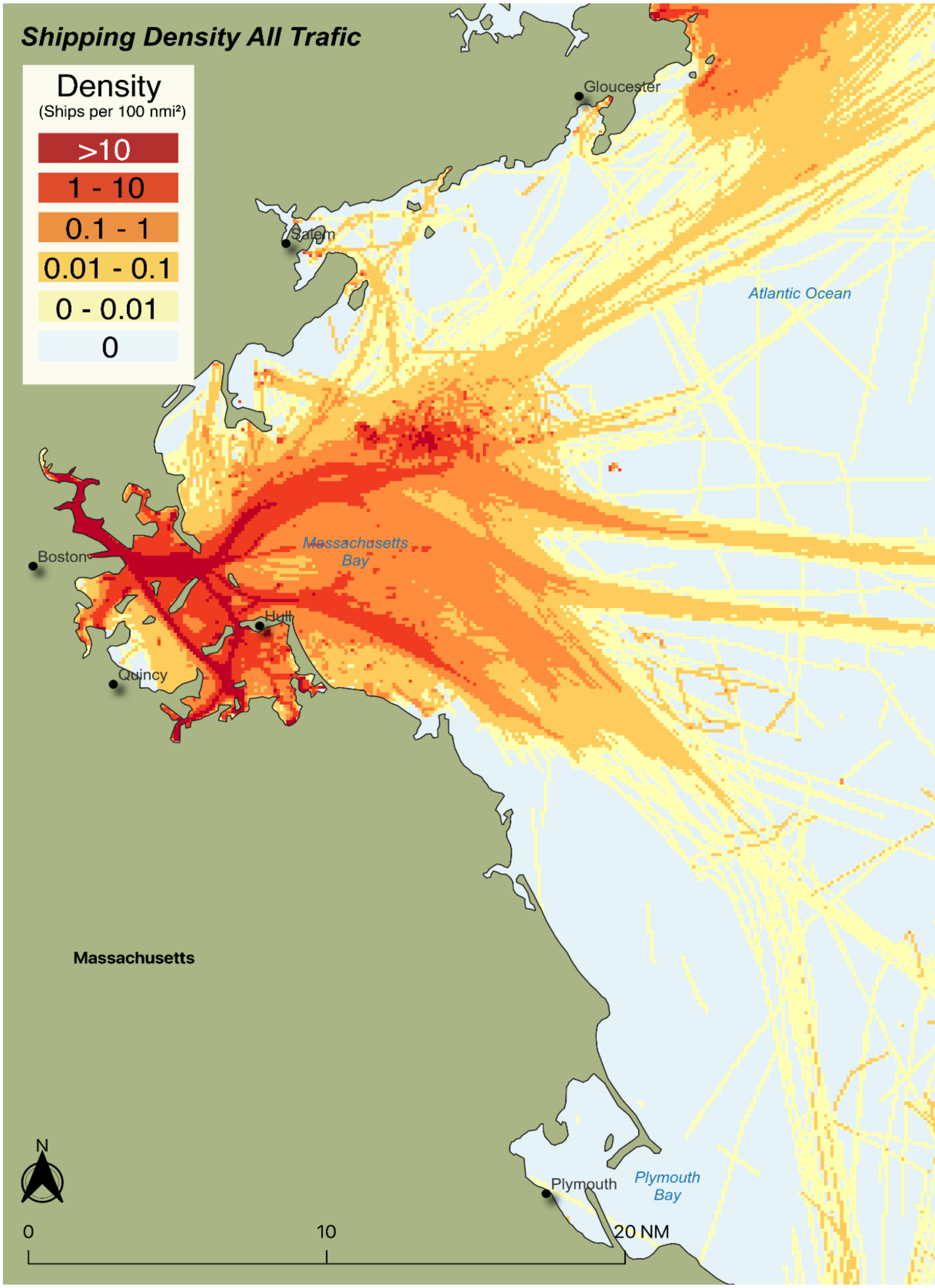


*Figure 5-10: Boston Harbor vessel traffic density for all vessels based on shore AIS data from 2017-2020*

Figure 5-11 shows the tug traffic (left) and tanker traffic (right). The maps showing all traffic and tug traffic show the highest density routes in and out of and within Boston Harbor. Tug traffic includes both tugs with fuel barges and other types of tugs like LNG tanker escorts or harbor assist tugs. Tanker traffic is concentrated on terminals in Chelsea, Everett, and Quincy. The tanker map also shows a series of red dots concentrated in the pilot boarding area, as shown in Figure 5-4.

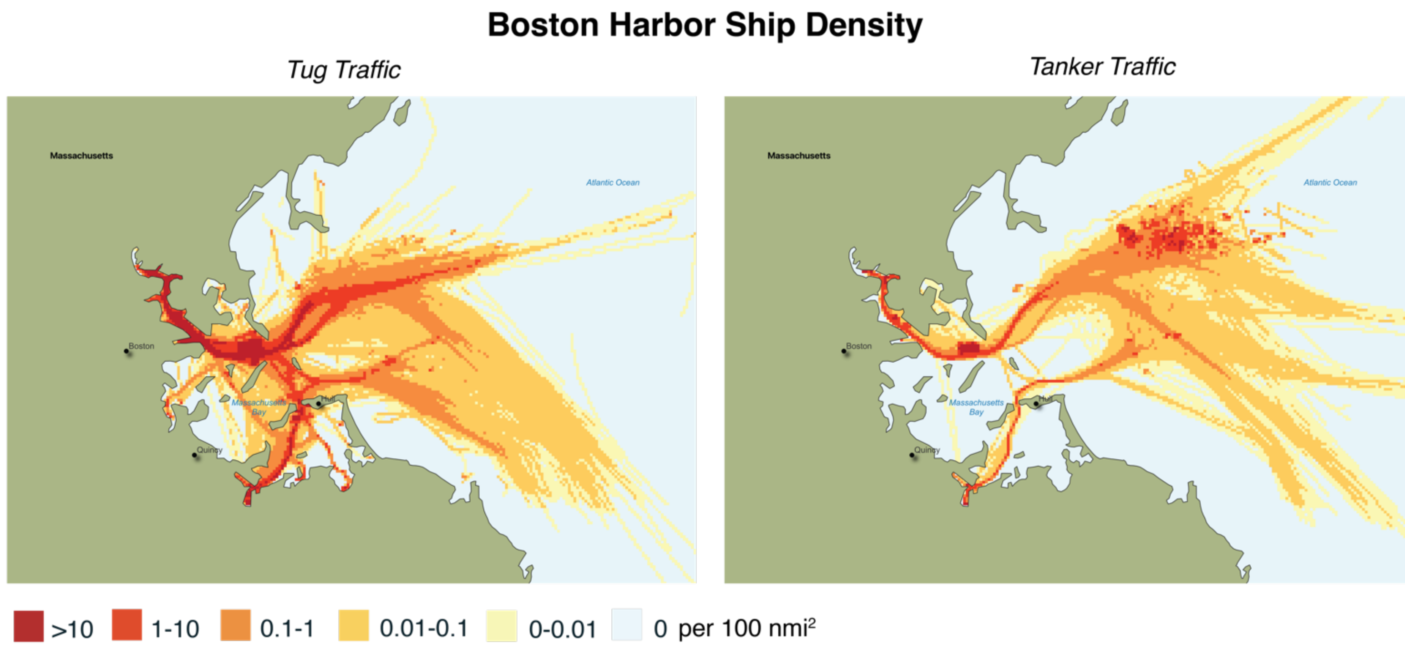


*Figure 5-11: Boston Harbor vessel traffic density for tugs (left) and tankers (right)*

Vessel traffic data was also explored based on a series of passage lines drawn across the map to count the number of vessels that enter a given harbor or waterbody. Several passage lines were established for Boston Harbor, shown in Figure 5-12. Some lines extend over land to account for occasional errors in AIS data.

The passage line for Boston Harbor Entrance counts vessel crossings in one direction for each year in the dataset. The passage lines that are inside the Boston Harbor Entrance line show how traffic splits out as it enters the harbor. The main split is north/south, with vessels entering Boston Harbor and then either traveling towards the Boston Waterfront, the Chelsea River, or the Mystic River. To the south of Boston Harbor, vessels pass the Braintree and Weymouth line, and some continue to the Fore River or the Town River.

Figure 5-13 shows the total entrances into Boston Harbor, with other vessels dominating the data. Figure 5-14 shows the vessel counts for Tankers and Tugs, showing the total count for all of the inner Boston Harbor (Boston Harbor passage line) first and then breaking these down further to show where the vessels are transiting within Boston Harbor. The data is broken out by vessel type and by data years, showing several trends. Other vessels dominate harbor entrances for all passage lines.

Tanker transits peaked in 2018, with 226 tankers crossing the Boston Harbor passage line. The AIS tracks show that more of those tankers traveled north, calling mostly on terminals in the Mystic and Chelsea Rivers. Tug traffic was also highest in 2018, with the majority of tugs transiting Chelsea River, Braintree/Weymouth, and the Mystic River. Across all data sets, there is a steep drop-off in vessel activities in 2020 due to the pandemic.

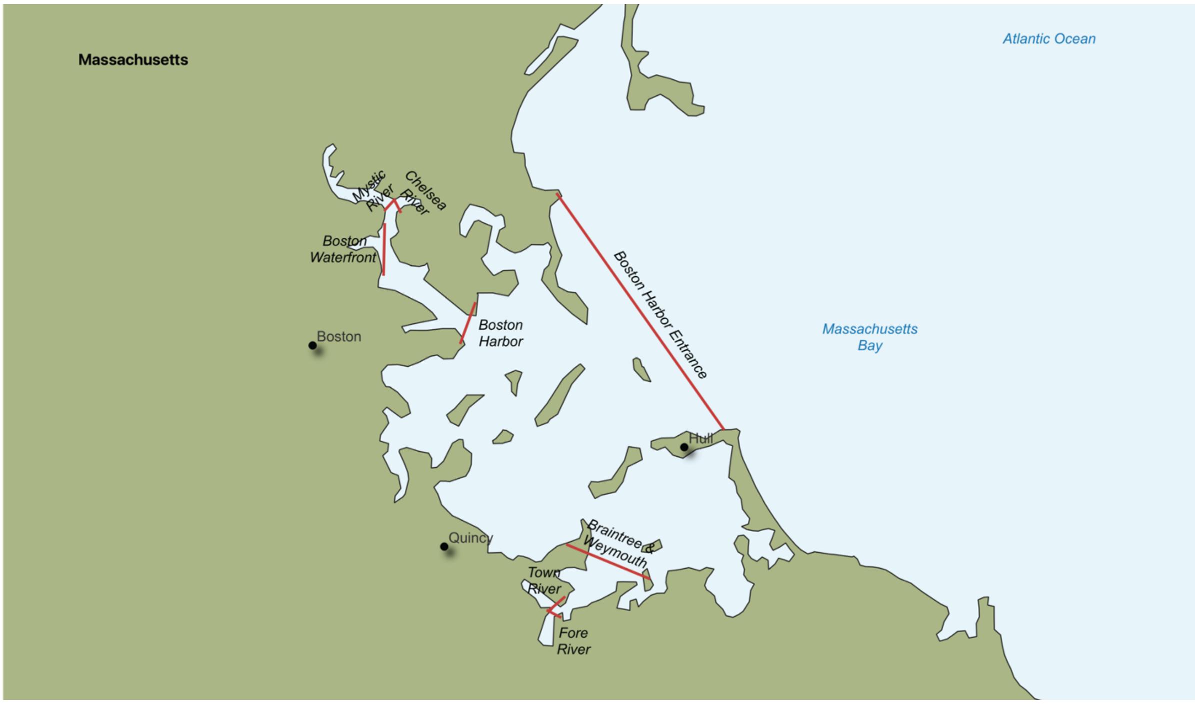


*Figure 5-12: Boston Harbor passage lines used for vessel counts*

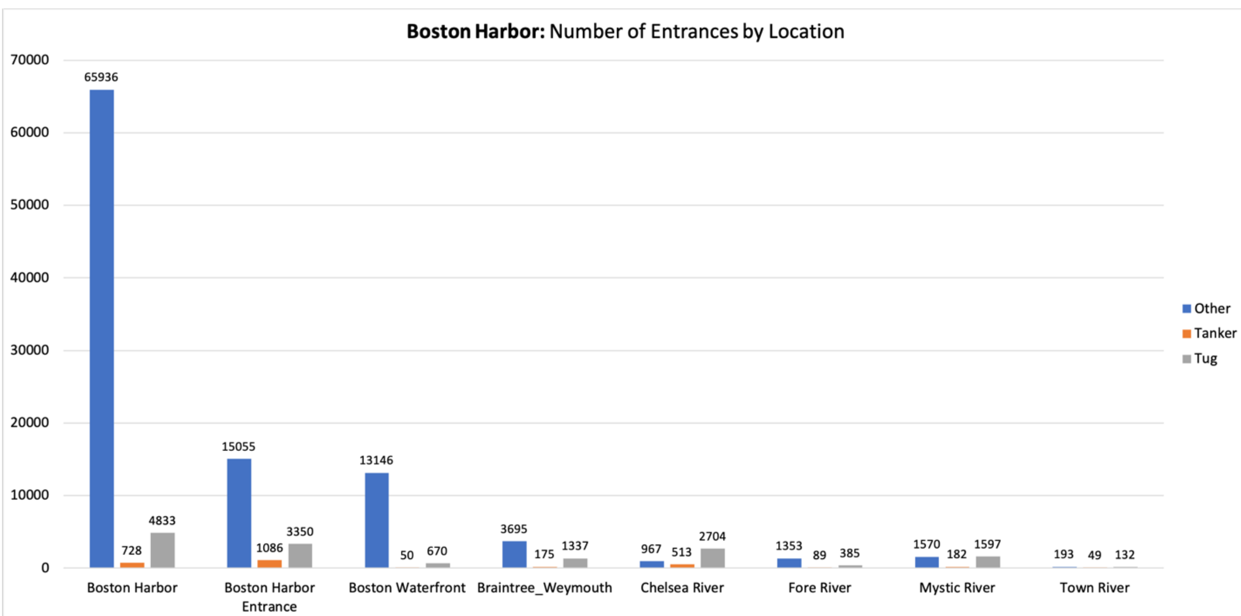


*Figure 5-13: Summary of Boston Harbor entrances based on passage line analysis (all vessels)*

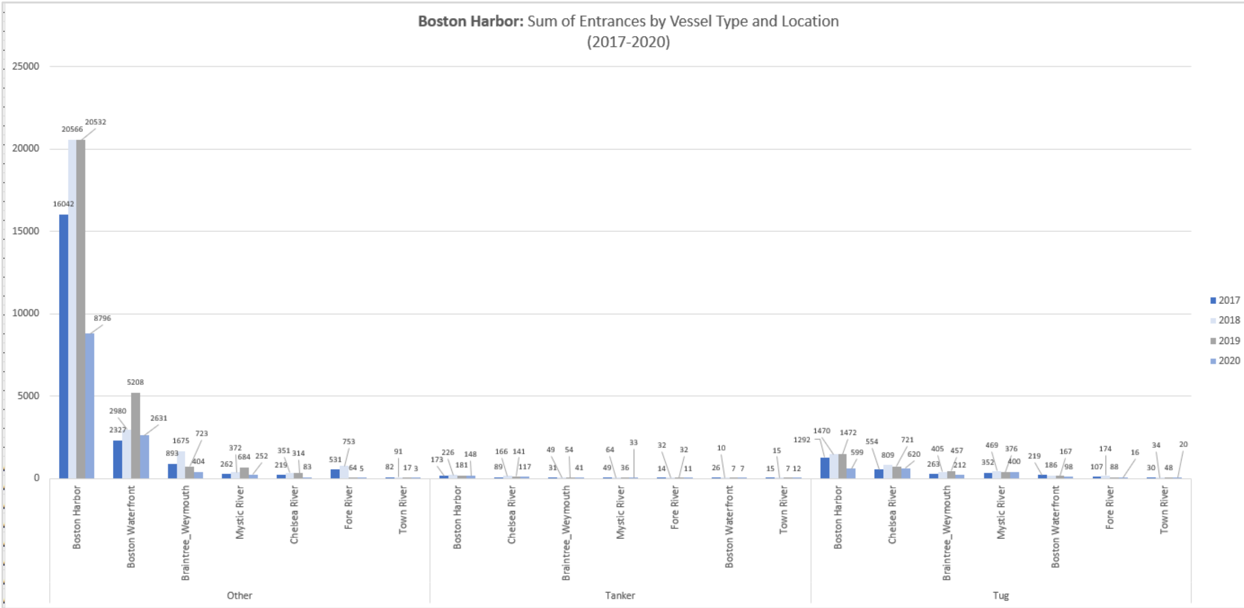


*Figure 5-14: Tanker (left) and tug (right) vessel entrances into Boston Harbor based on passage line analysis*

Figure 5-15 compares heat maps for Boston Harbor for all vessels, tankers, and tugs by year. The relative increase in all traffic in 2019 is followed by a decrease in 2020. Tug and tanker traffic follows a similar pattern. This is consistent with monthly and annual fuel deliveries summarized in Section 4.3.

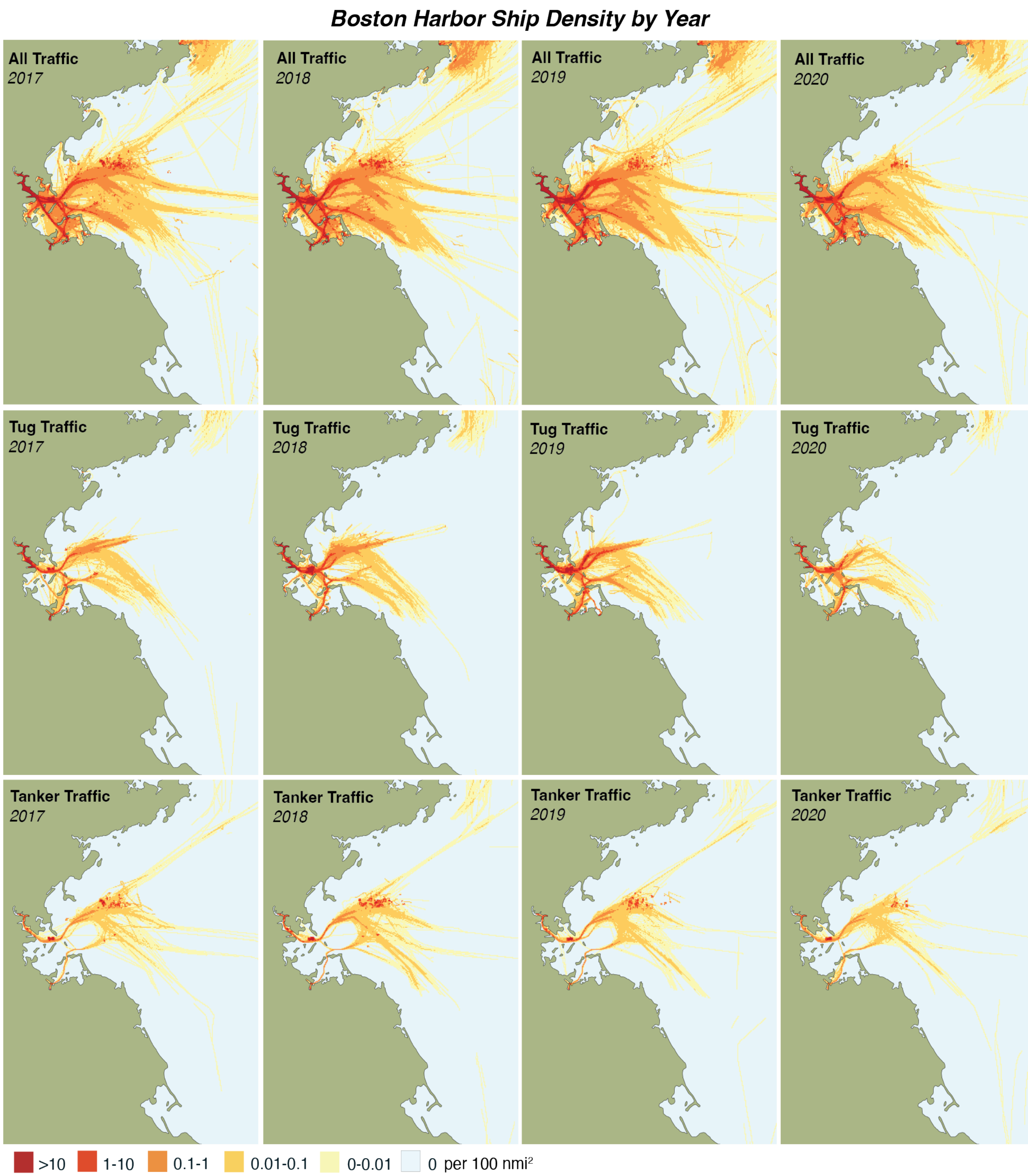


*Figure 5-15: Comparison of Boston Harbor vessel traffic density by type (all, tanker, and tug) and year (2017-2020)*

## 5.4. BUZZARDS BAY AND CAPE COD CANAL

Figure 5-16 shows vessel traffic density in Buzzards Bay and Cape Cod Canal for all ships from 2017-2020.

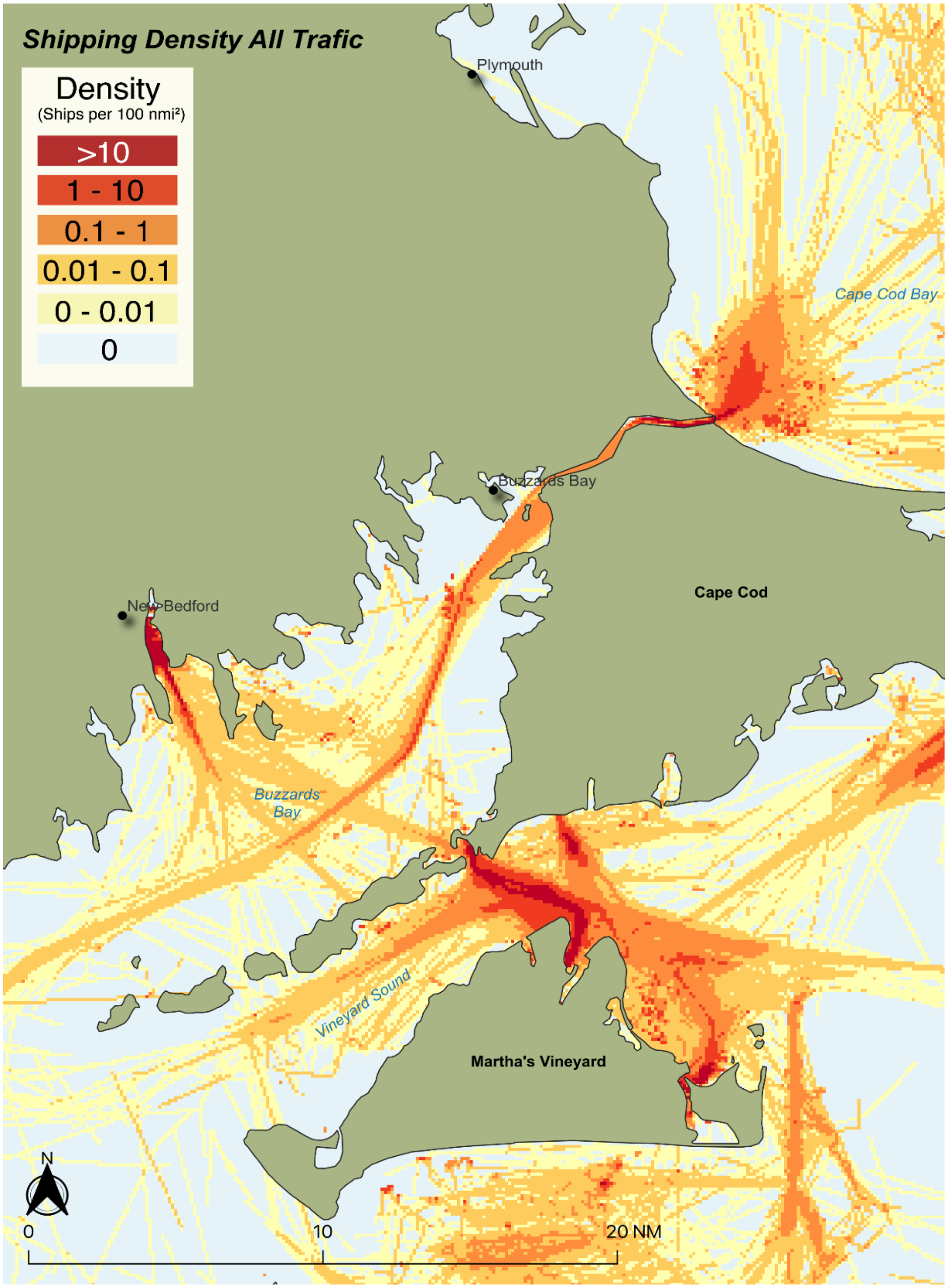


*Figure 5-16: Buzzards Bay and Cape Cod Canal vessel traffic density for all vessels based on shore AIS data from 2017-2020*

Figure 5-17 shows the tug traffic (left) and tanker traffic (right). The maps showing all traffic and tug traffic show the highest density routes through Buzzards Bay and Cape Cod Canal, inclusive of the cross-Buzzards Bay traffic that includes tugs and fuel barges (tug map) as well as other vessels like ferries, fishing, and recreational vessels (all traffic). The tanker map shows tanker traffic transiting from south to north. These tankers either deliver petroleum products to Boston Harbor facilities or continue north to ports in Maine.

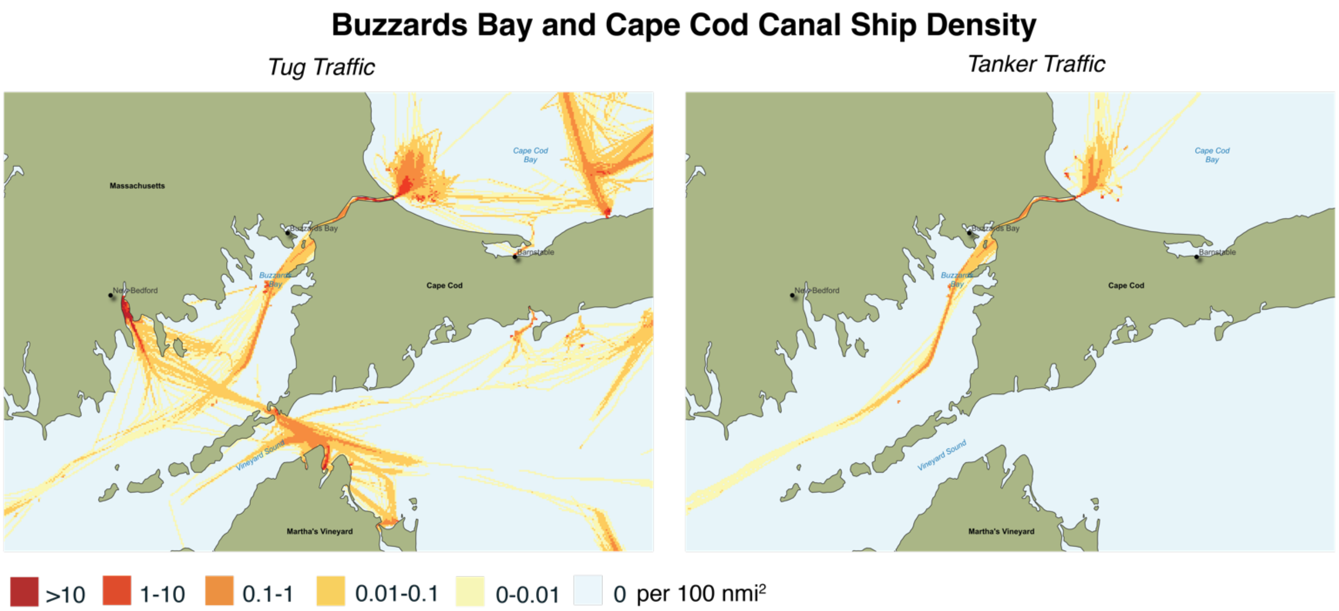


*Figure 5-17: Buzzards Bay and Cape Cod canal vessel traffic density for tugs (left) and tankers (right)*

Vessel traffic data in New Bedford/Fairhaven was explored using a passage line to count vessels entering the harbor (Figure 5-18). The passage line extends onto land to account for errors in AIS data.


*Figure 5-18: New Bedford Harbor passage line used for vessel counts*

Table 5-2 counts the number of vessel transits into New Bedford/Fairhaven by year and vessel type. Other vessels dominate the vessel count, reflecting the fact that New Bedford is an active fishing port. Other vessel counts were highest in 2017 and 2019 and lowest in 2020. Tug transits were highest in 2019. There were no tanker transits during the four years.

*Table 5-2: Vessel transits across New Bedford/Fairhaven passage line by year and vessel type*

| Sum of Entrances | Other | Tanker | Tug | Grand Total |
|---|---|---|---|---|
| 2017 | 2868 | | 412 | 3280 |
| 2018 | 1944 | | 341 | 2285 |
| 2019 | 2699 | | 391 | 3090 |
| 2020 | 1826 | | 262 | 2088 |
| **Grand Total** | **9337** | | **1406** | **10743** |

Notice of Intent to Transit data was used in addition to AIS/passage line data to characterize vessels that are transporting bulk petroleum through Buzzards Bay and the Cape Cod Canal. Figure 5-19 summarizes the number of transits for tugs and tankers through Buzzards Bay and the Cape Cod Canal by month and year.

Analysis of Bulk Transportation and Delivery of Petroleum Products explores this data further to estimate fuel quantities transported. Data from 2017-2019 shows seasonal trends towards higher frequency transits during the winter months, corresponding to home heating oil deliveries. 2020 is an anomaly year, with substantially fewer tug and tanker transits.

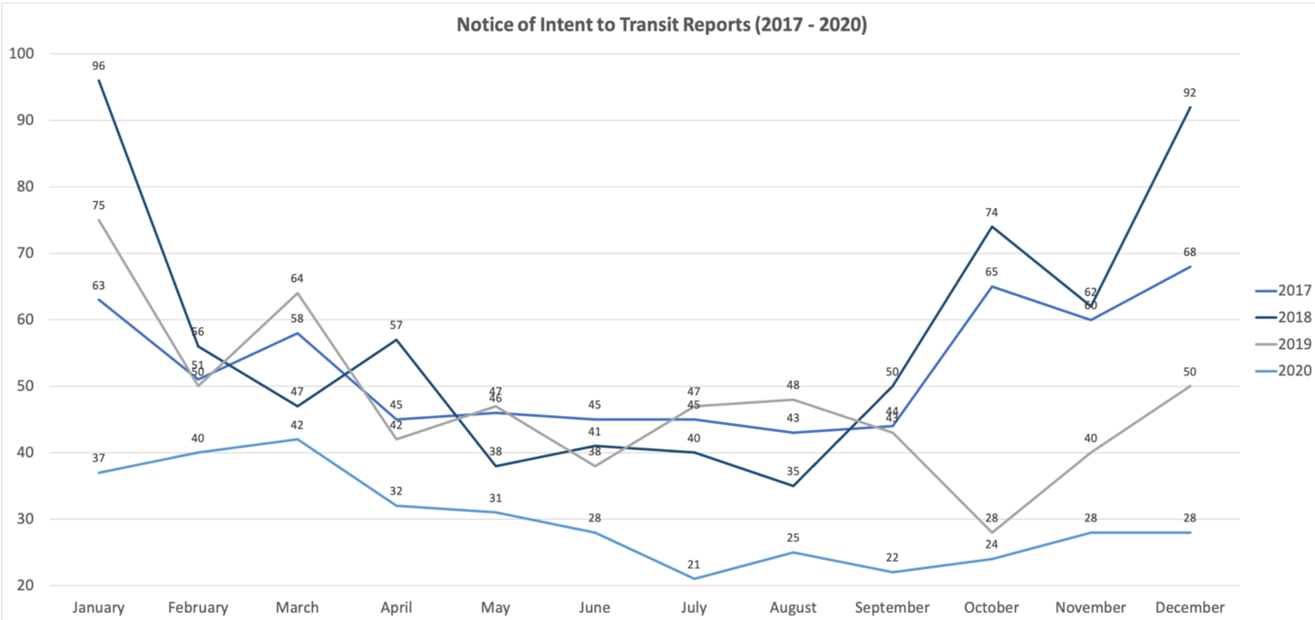


*Figure 5-19: Bulk oil transportation transits by tug/barge and tanker through Buzzards Bay and Cape Cod Canal by month and year based on Notice of Intent to Transit data*

Figure 5-20 compares heat maps for Buzzard Bay and Cape Cod Canal for all vessels, tankers, and tugs by year. The relative increase in all traffic in 2019 is followed by a slight decrease in 2020. Tug and tanker traffic follows a similar pattern. The decline in traffic through Buzzards Bay and Cape Cod Canal during 2020 is somewhat lower than in other regions of the state. Annual and monthly fuel deliveries are explored in Section 5.3.

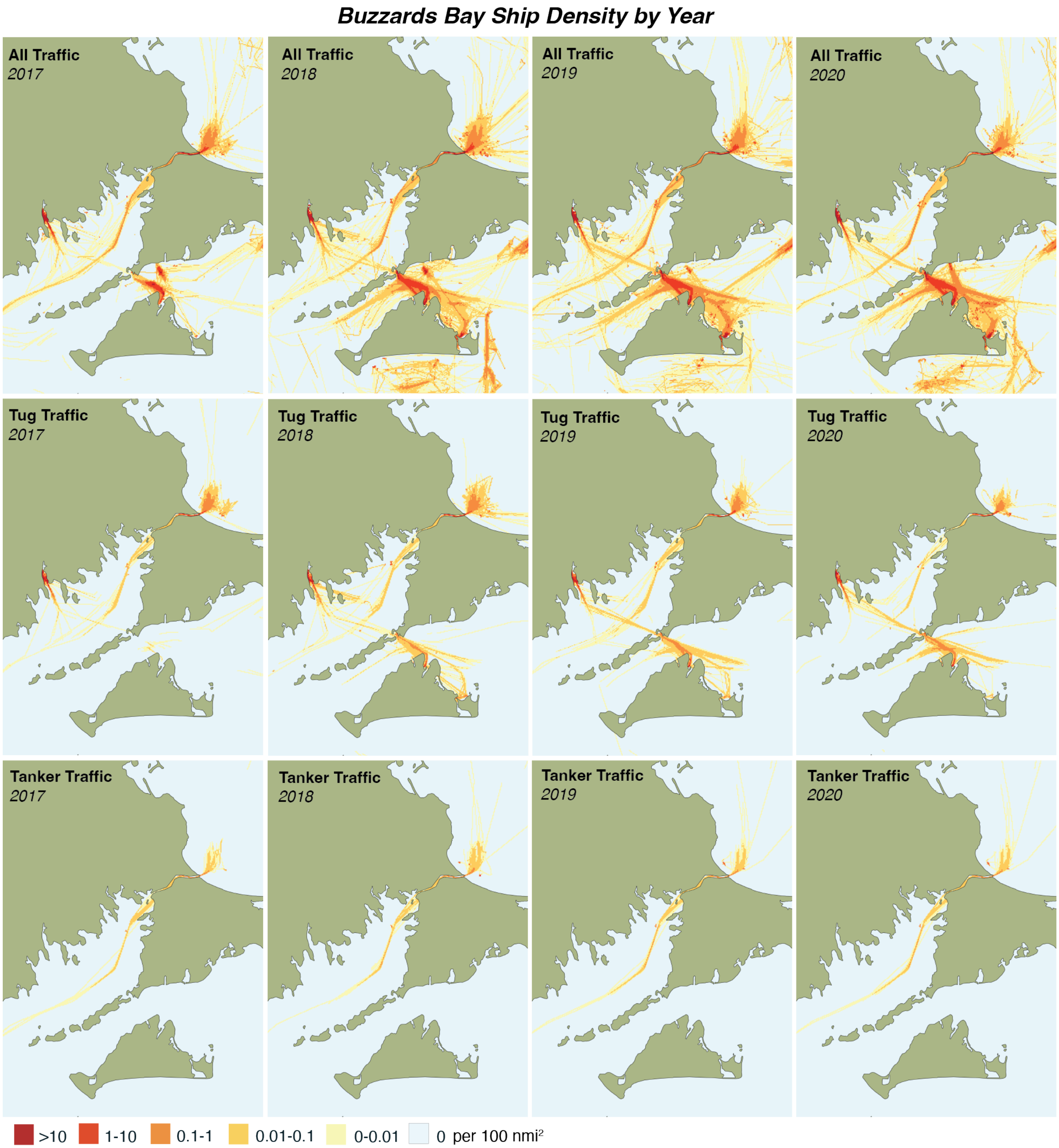


*Figure 5-20: Comparison of Buzzards Bay & Cape Cod traffic density by type (all, tanker, and tug) and year (2017-2020)*

## 5.5. NORTH SHORE

Figure 5-21 shows vessel traffic density along the North Shore for all ships from 2017-2020.

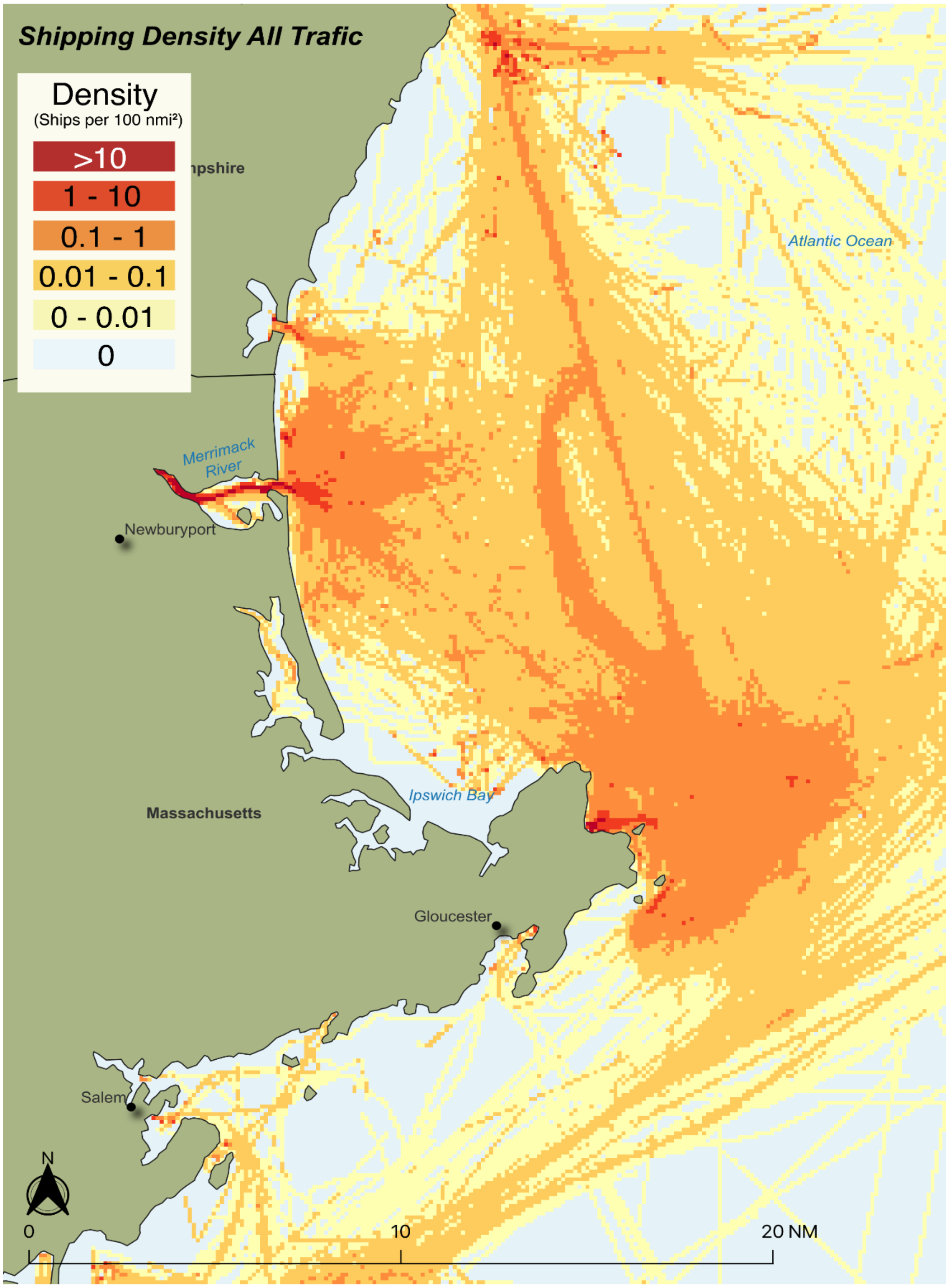


*Figure 5-21: North Shore vessel traffic density for all vessels based on shore AIS data from 2017-2020*

Figure 5-22 shows the tug traffic (left) and tanker traffic (right). Vessel traffic data was also explored through passage lines for Gloucester and Salem Harbor.

The map of all traffic shows the highest density in and out of Newburyport, on the Merrimack River and Gloucester, through the Annisquam River and Gloucester Harbor. Vessel traffic density is lower for Salem Harbor in comparison to Cape Ann and Gloucester. There is some tug traffic near the Merrimack River, Salem Harbor, and around Cape Ann. Tankers transit by this area but do not enter any harbors along the North Shore. Passage line analysis shows just two tug crossings but no tanker crossings in Salem Harbor and no tug or tanker crossings into Gloucester Harbor, with a vast majority of the overall harbor traffic being other vessels.

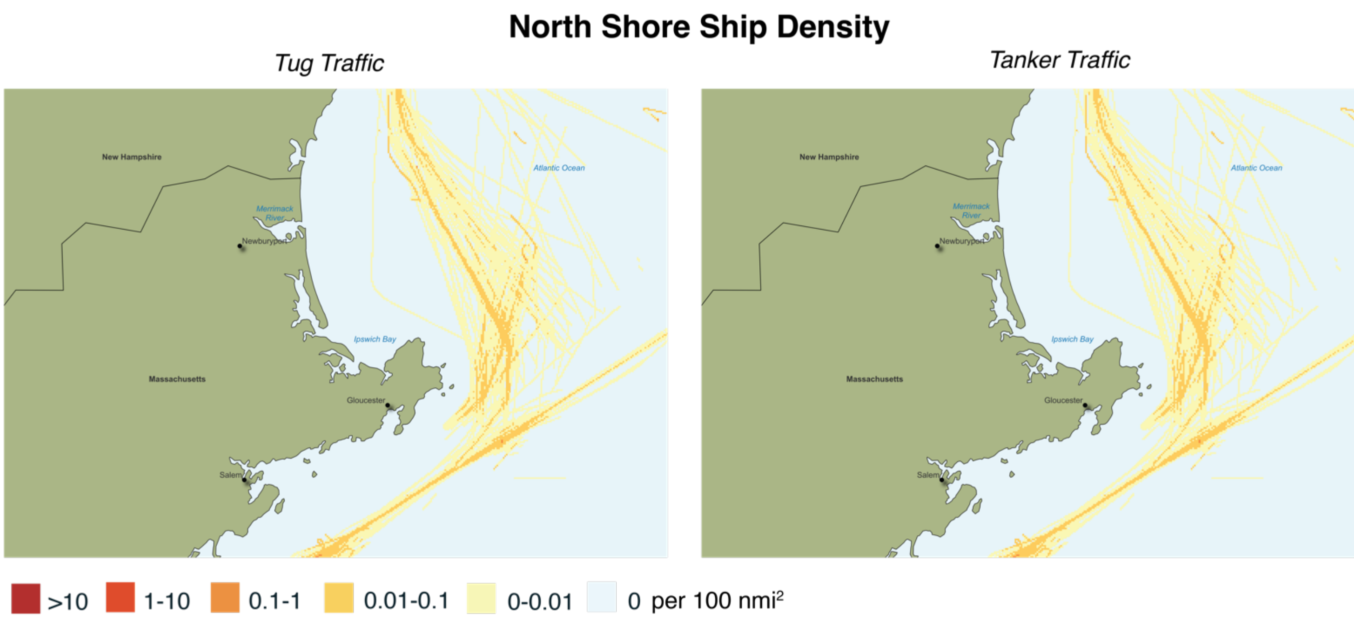


*Figure 5-22: North Shore vessel traffic density for tugs (left) and tankers (right) based on shore AIS data from 2017-2020*

Figure 5-23 shows the location of passage lines, and Figure 5-24 shows the vessel counts. There were minimal passage line crossings in this region, representing mostly other vessels.


*Figure 5-23: North Shore passage lines used for vessel counts in Salem and Gloucester Harbors*

AIS data shows no tanker crossings into either Gloucester or Salem Harbor from 2017-2020. Other vessel data shows very low numbers, which are not necessarily representative of the volume of traffic in and out of these North Shore harbors; this is more likely a reporting bias since these harbors have fewer large commercial vessels mandated to carry AIS and more fishing and recreational vessels for whom AIS is optional.

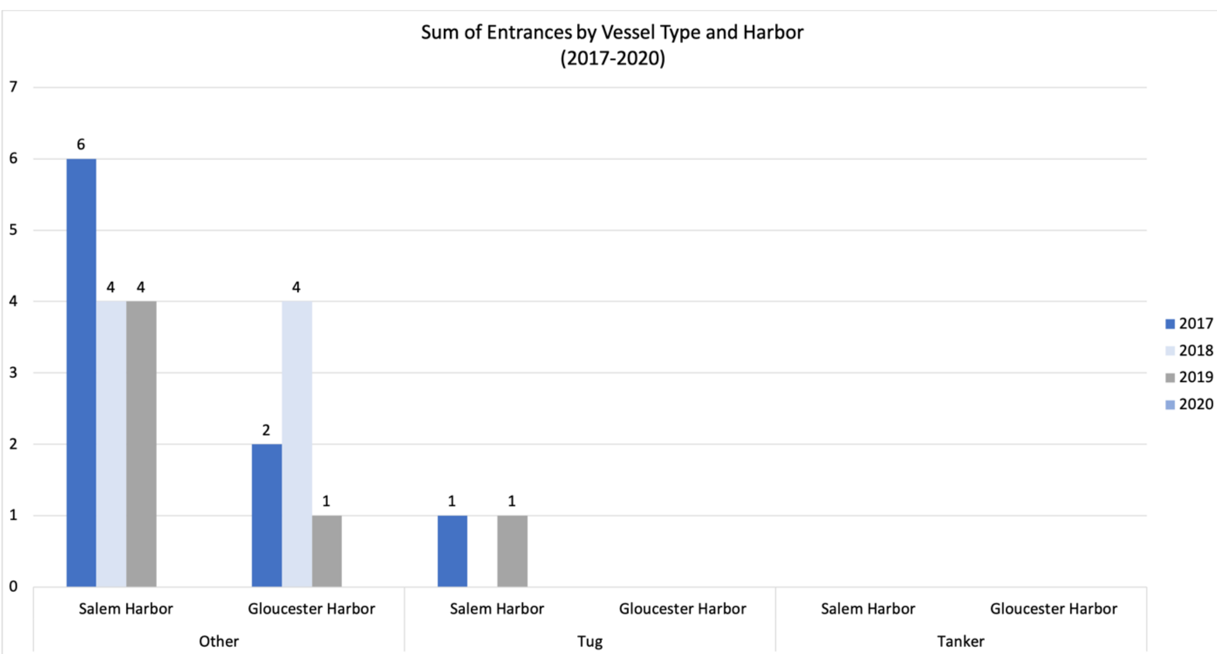


*Figure 5-24: Other vessel (not tanker or barge) entrances into Gloucester and Salem Harbors based on AIS data from 2017-2020*

Figure 5-25 compares vessel traffic by year and type in the North Shore Region. Annual patterns are similar to other regions, with a notable reduction in density in 2020 for all traffic, tugs, and barges.

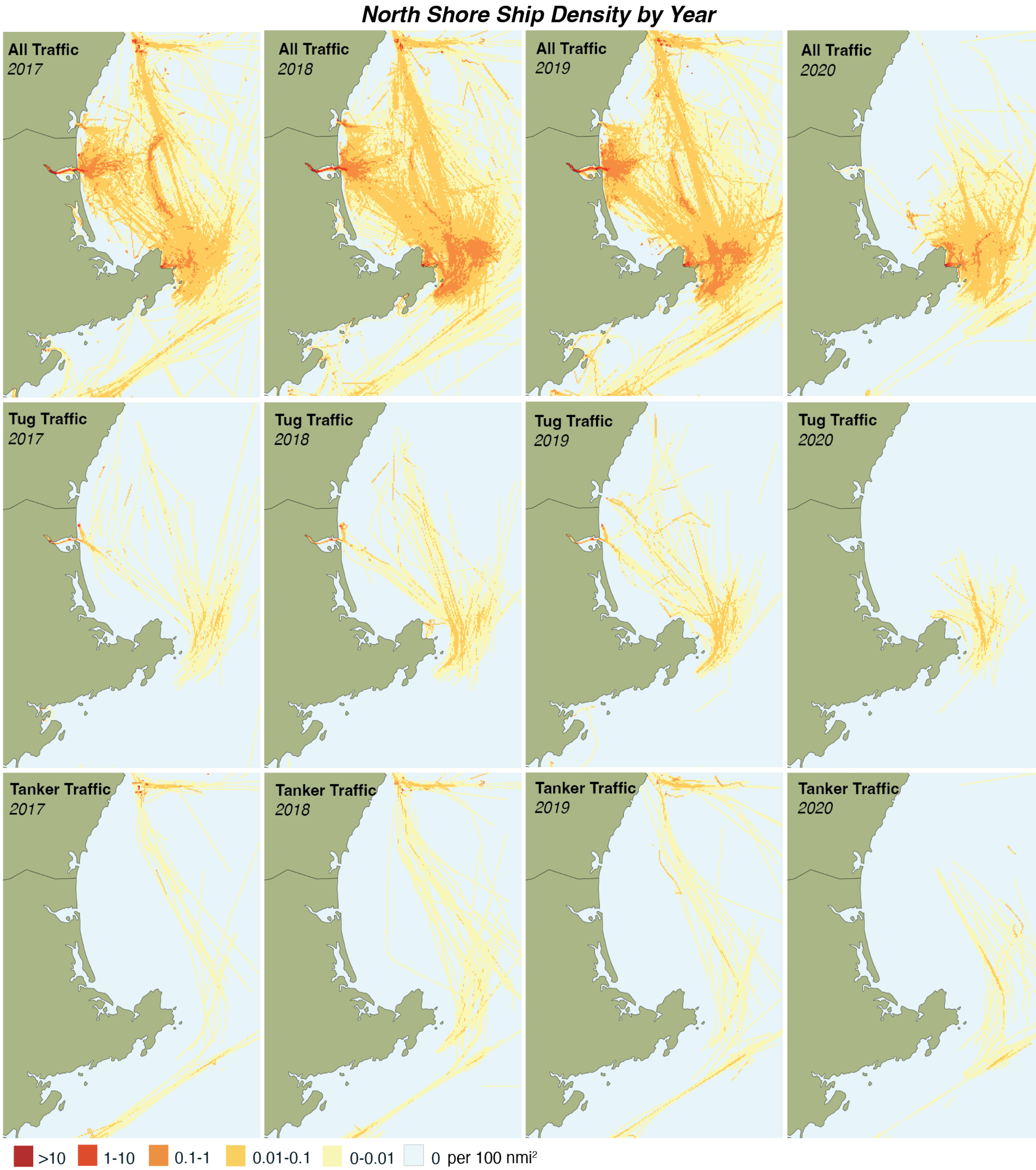


*Figure 5-25: Comparison of North Shore traffic density by type and year for Salem and Gloucester Harbors*

## 5.6. CAPE AND ISLANDS

Figure 5-26 and Figure 5-27 show vessel traffic density in the Cape and Islands for Cape Cod Bay and Provincetown, and for Vineyard and Nantucket Sounds.

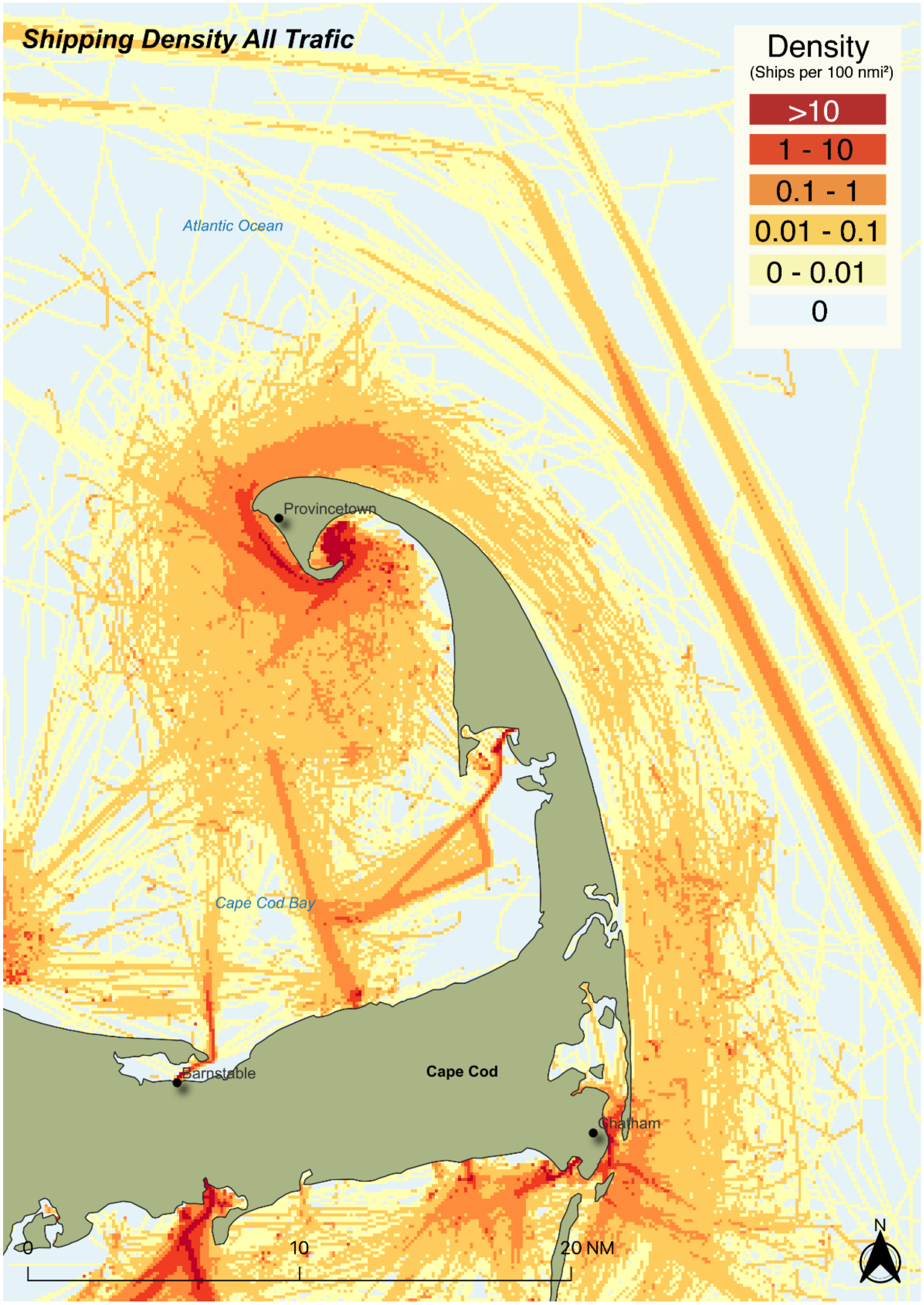


*Figure 5-26: Vessel traffic density for all vessels for Cape Cod Bay and Provincetown based on shore AIS data from 2017-2020*

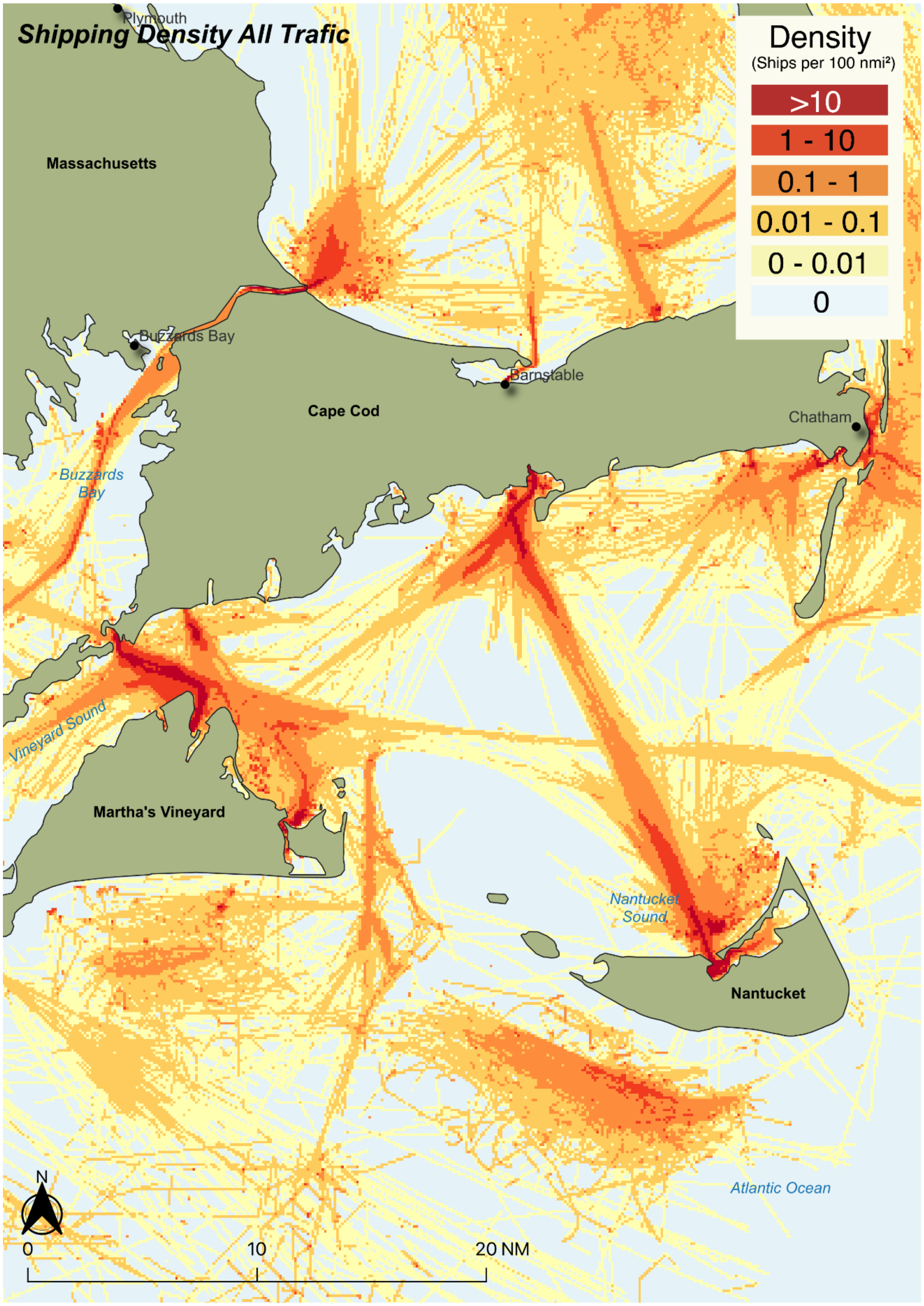


*Figure 5-27: Vessel traffic density for all vessels for Vineyard Sound and Nantucket Sound based on shore AIS data from 2017-2020*

Figure 5-28 and Figure 5-29 show the tug traffic (left) and tanker traffic (right).

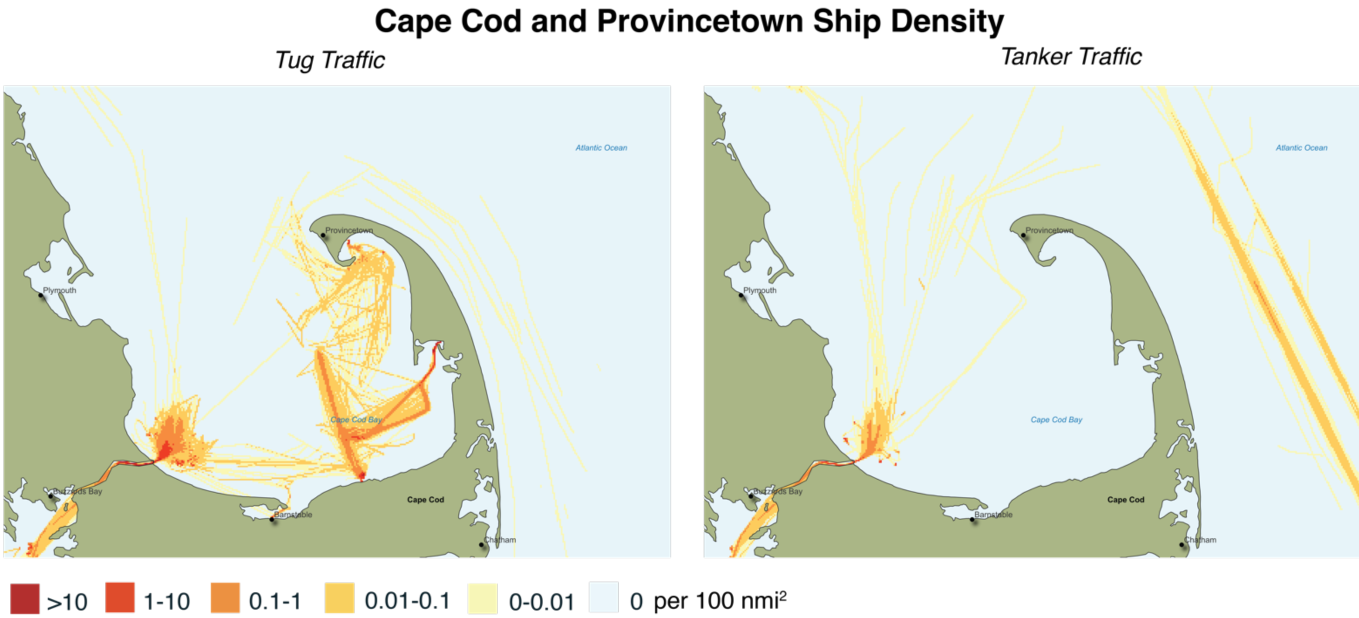


*Figure 5-28: Vessel traffic density in Cape Cod Bay and Provincetown for tugs (left) and tankers (right) based on AIS shore data from 2017-2020*

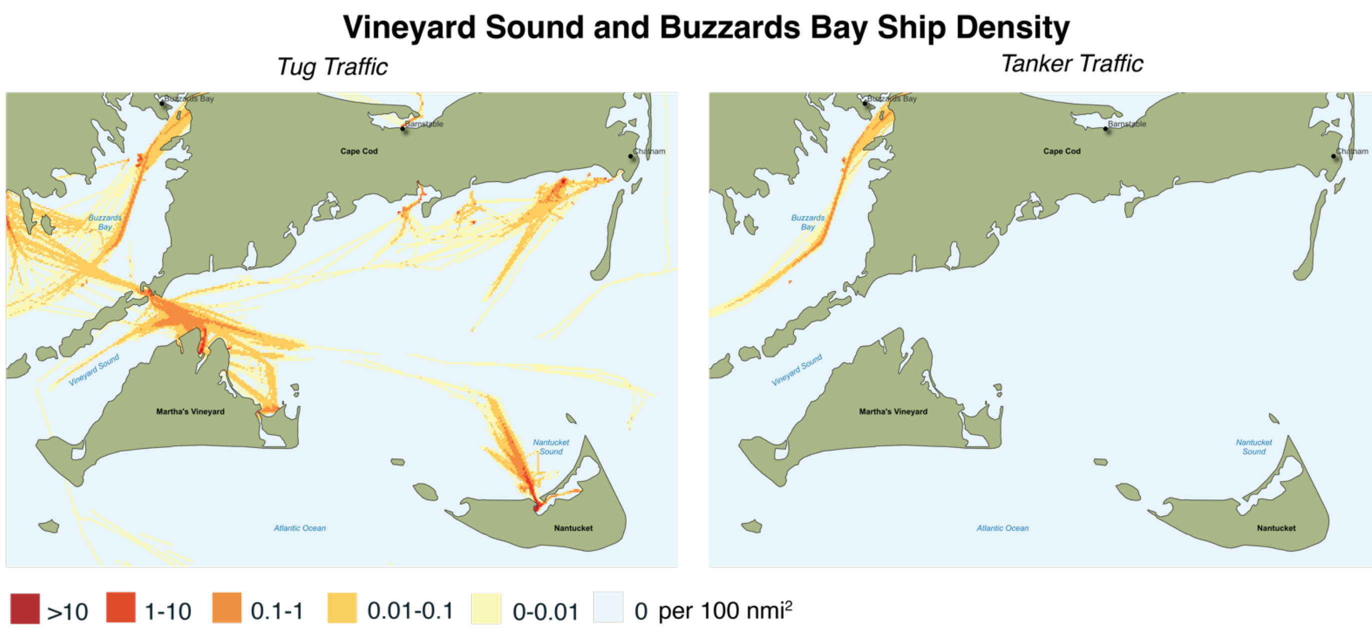


*Figure 5-29: Vessel traffic density for tugs (left) and tankers (right) in Vineyard and Nantucket Sound based on AIS data from 2017-2020*

The Cape and Islands region has several high-density vessel traffic routes. These include harbor traffic in and out of Provincetown, Barnstable, Hyannis, Woods Hole, Falmouth, Chatham, Vineyard Haven, Edgartown, and Nantucket Harbor. The map of all traffic in Figure 5-4 shows the ferry routes between harbors Cape Cod and harbors in Nantucket and Martha's Vineyard.

Tug traffic in this region includes shipping traffic from the Cape Cod Canal, fuel deliveries between New Bedford and the islands, and local tug activity in Cape Cod Bay. Tanker traffic in the region is limited to Cape Cod Canal transits and offshore tanker routes outside of the National Seashore.

Vessel traffic data was also explored through passage lines for Vineyard Haven and Nantucket Harbor (Figure 5-30). Figure 5-31 shows the total passages into each harbor by year. There is no tanker traffic in either harbor. Other vessels account for most entries in both harbors.

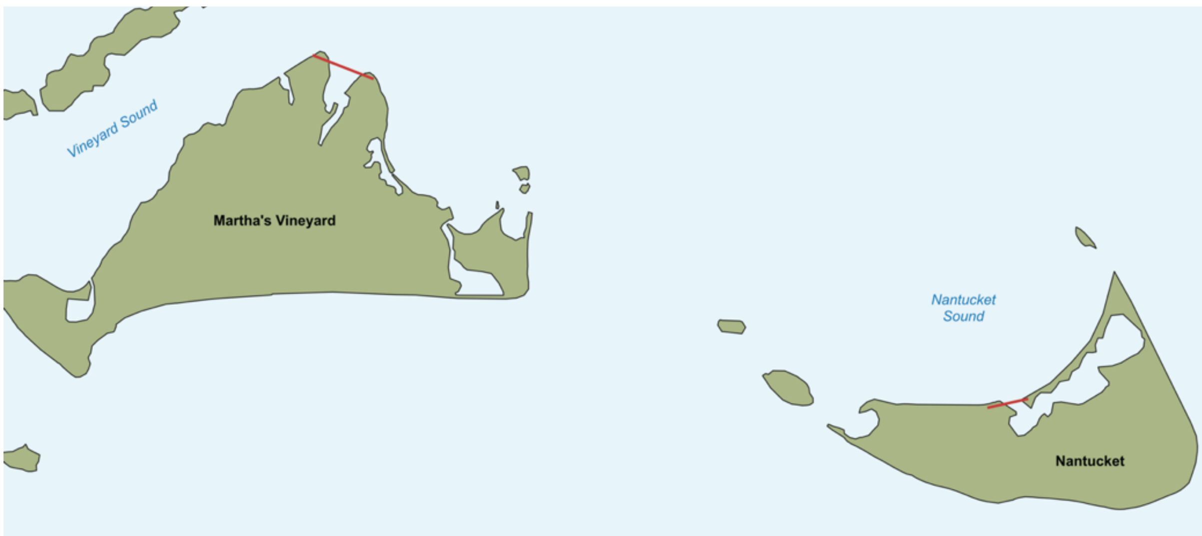


*Figure 5-30: Passage lines used to count vessel entrances to Vineyard Haven and Nantucket Harbor*

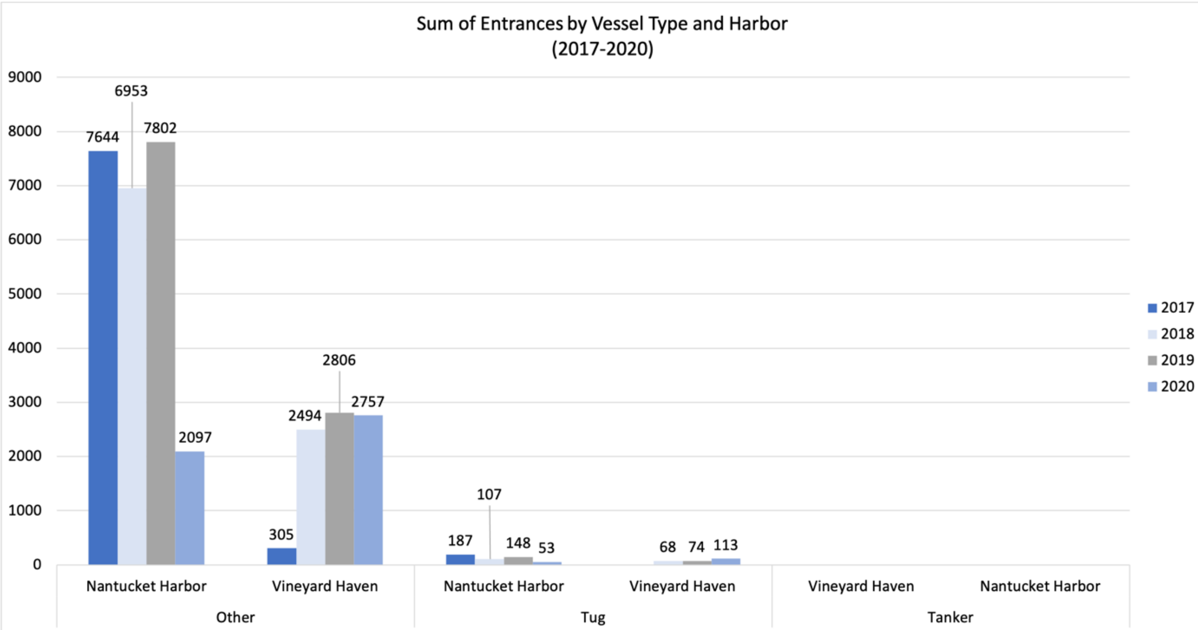


*Figure 5-31: Sum of entrances by vessel type for Nantucket and Vineyard Haven Harbors (2017-2020)*

Figure 5-32 and Figure 5-33 compare traffic by type across years for Cape Cod Bay and the Sounds. All traffic and tanker traffic remain fairly consistent, with slightly lower density in 2020. Tug traffic shows annual variability that is likely due to specific dredging or construction projects.

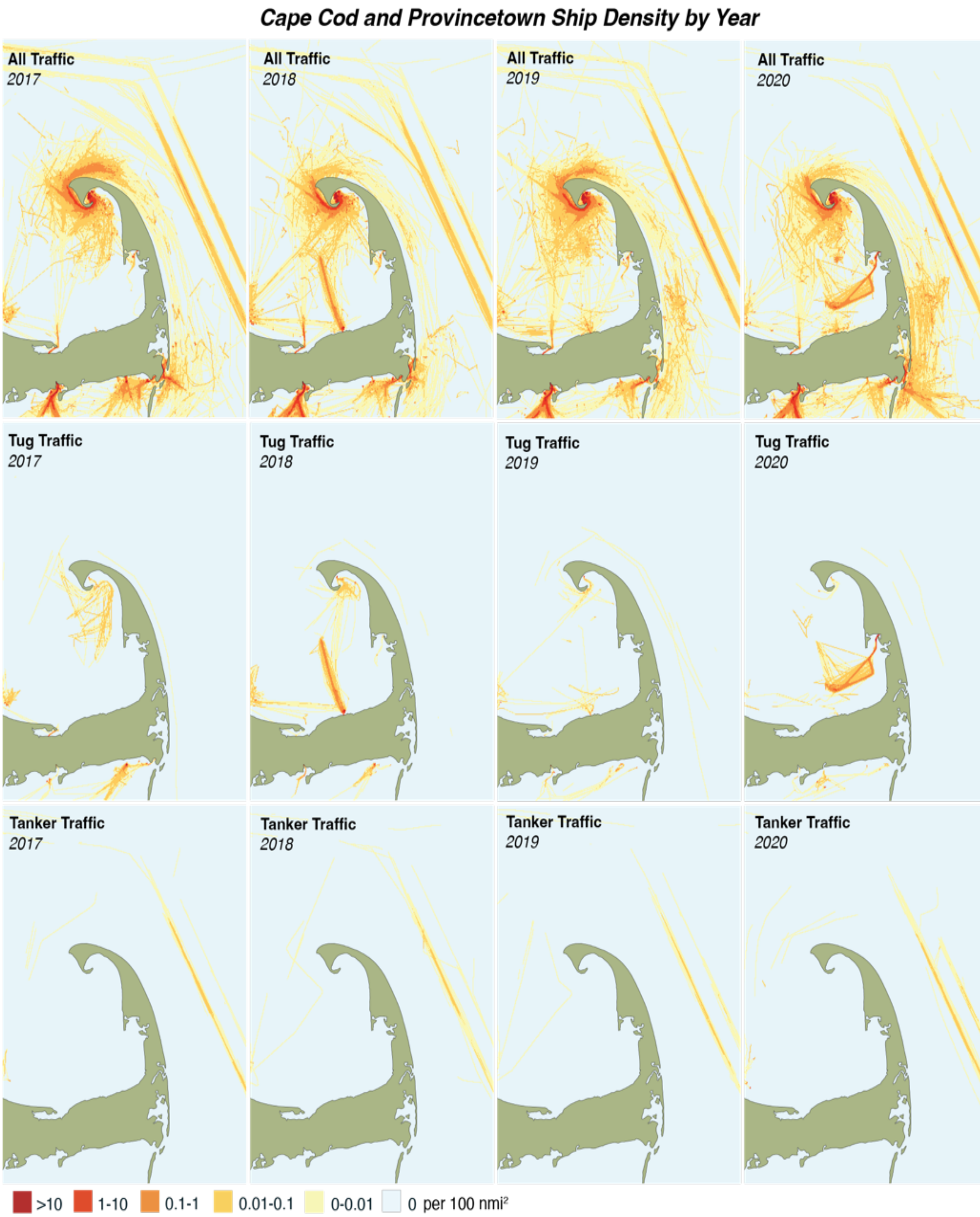


*Figure 5-32: Comparison of Cape Cod Bay and Provincetown traffic density by type and year*

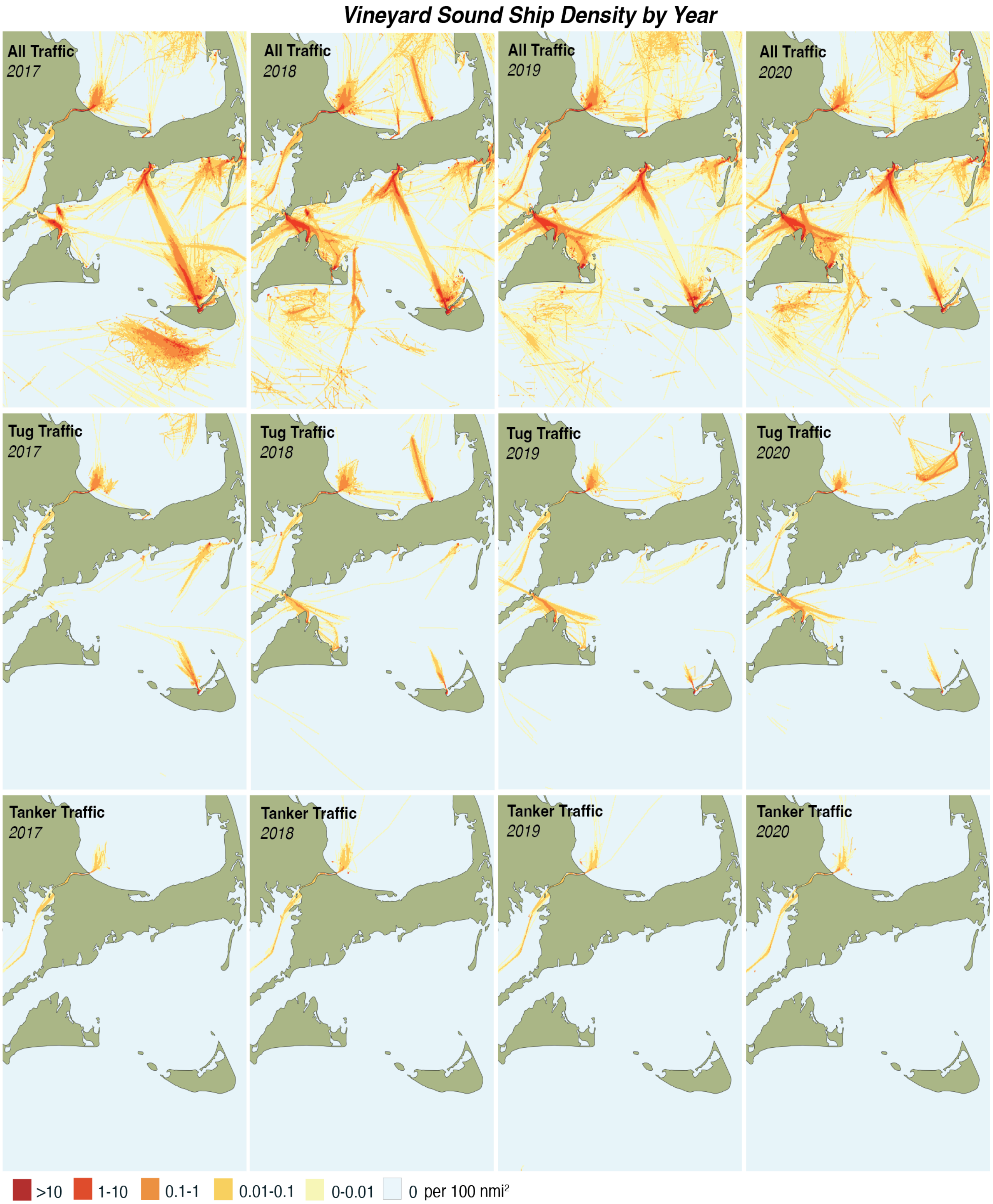


*Figure 5-33: Comparison of Vineyard and Nantucket Sound traffic density by type and year*

## 5.7. MT. HOPE BAY

Figure 5-34 shows the shipping density for all traffic into Mt. Hope Bay. The map also captures traffic in Narragansett Bay and Rhode Island. Figure 5-35 shows traffic by vessel type and year. Mt. Hope Bay has comparatively lower traffic density than other regions of the state. Most of the traffic is commercial, associated with Fall River and Somerset.

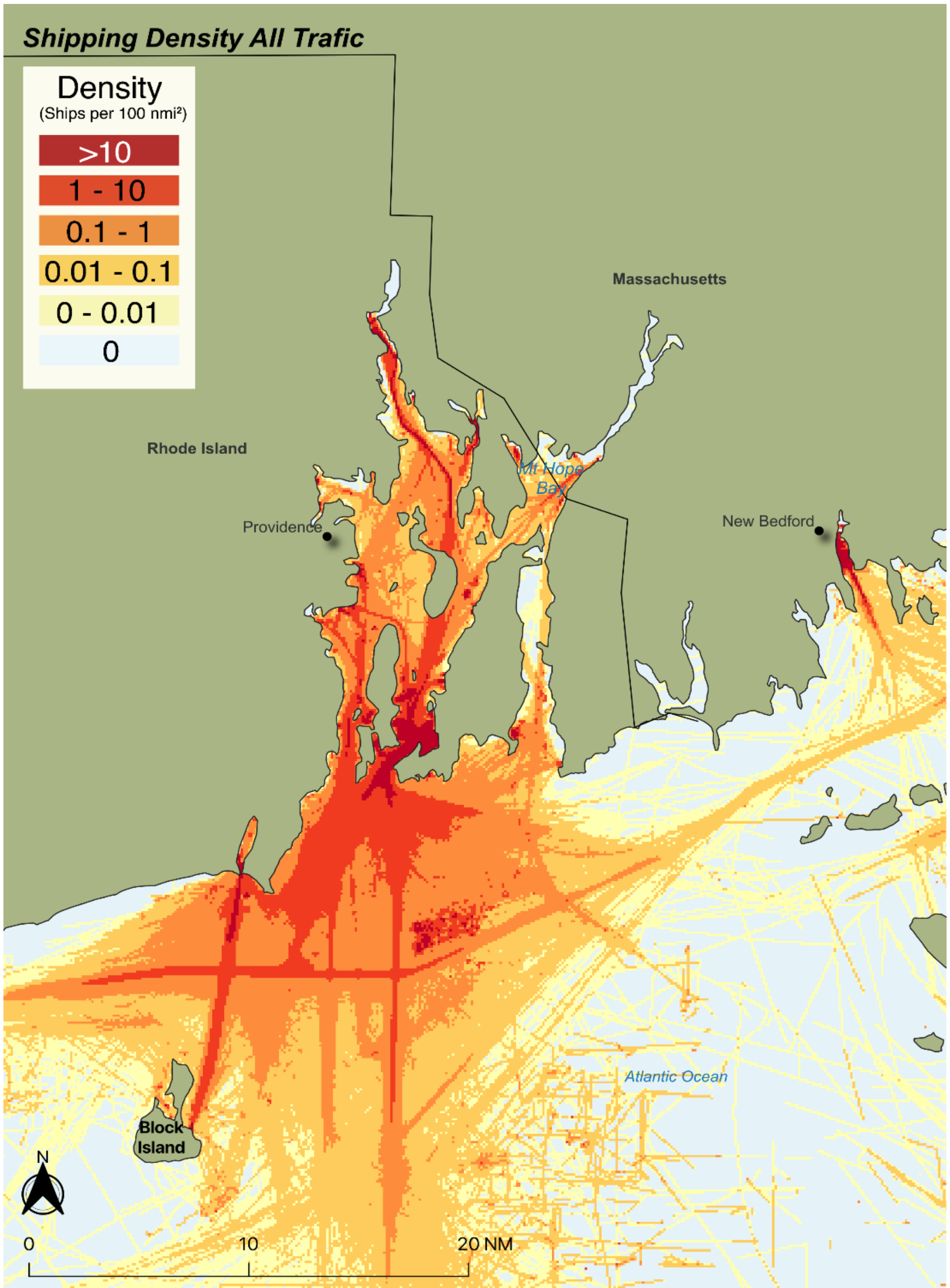


*Figure 5-34: Vessel traffic density in Mount Hope Bay based on shore AIS data from 2017-2020*

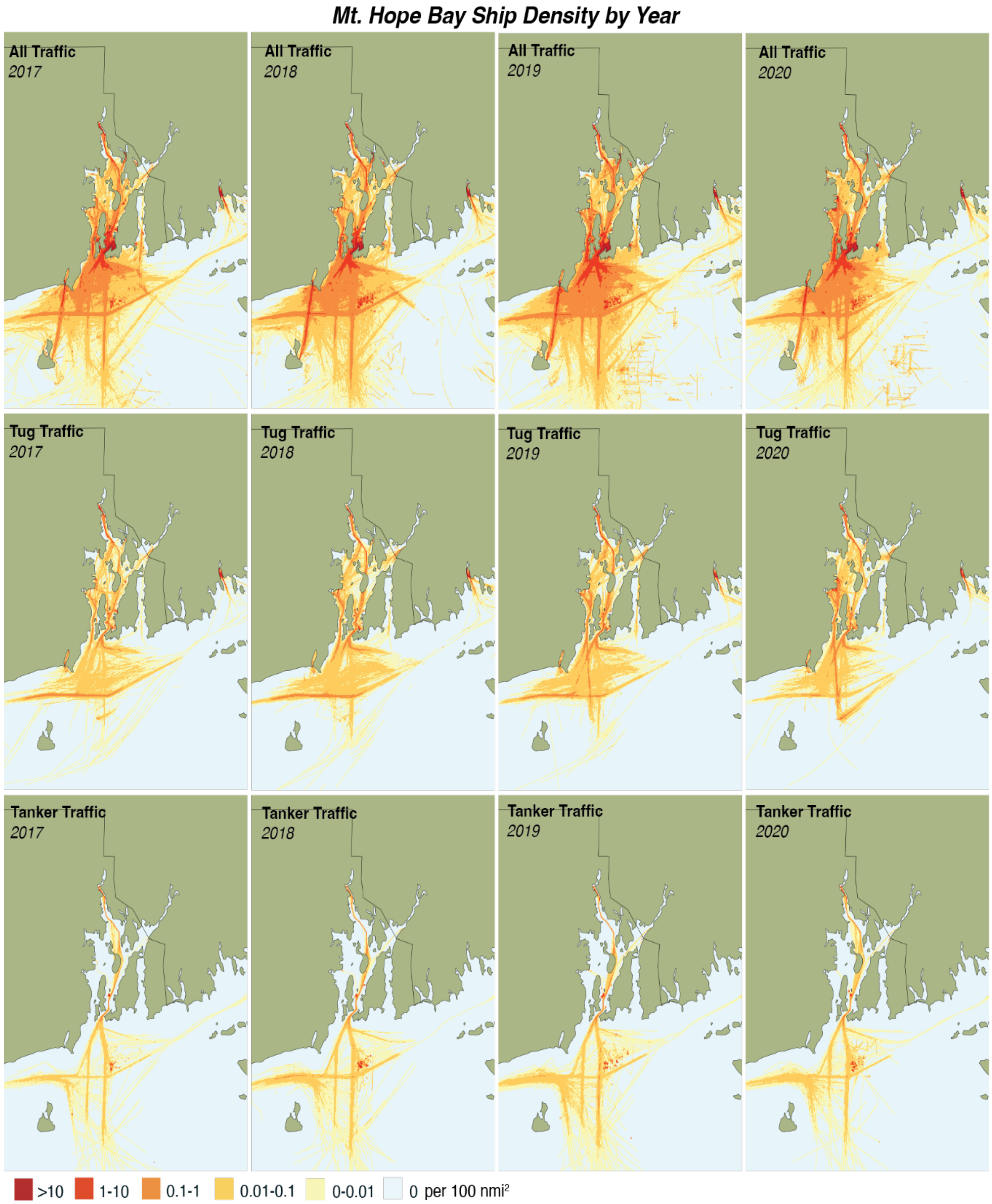


*Figure 5-35: Vessel traffic density in Mt. Hope Bay by vessel type and year*

# 6. Discussion

## 6.1. OVERALL TRENDS AND COMPARISONS

The updated threat assessment presented in this report shows a relatively stable threat level when compared to the 2009 study. The transportation and storage of bulk petroleum in Massachusetts follows predictable patterns based on the location of ports and infrastructure and seasonal demand. There is some variability to vessel traffic, such as tug activity associated with marine construction or tug and tanker movements during the pandemic, but overall, the past has served as a predictor for the future. Prior to the drop in petroleum imports during pandemic travel restrictions, the year-over-year trend shows a slight increase in fuel deliveries to Massachusetts ports.

The findings of this study and the 2009 study also align in terms of relative threat by source and location. Tank vessels (tankers and barges) and bulk storage terminals are the two most concentrated oil spill threats. Regionally, the highest threat is in Boston Harbor, which is the largest port in Massachusetts. The Cape and Islands have the next highest threat level, with the remaining regions (North Shore, South Shore, Mt. Hope Bay) fairly similar. At the port/harbor level, both studies found Boston Harbor to have the highest threat level. In 2009, Sandwich Boat Basin, New Bedford, and Woods Hole were also found to have high threat levels. In this study, the highest threat harbors after Boston are New Bedford, Vineyard Haven, and Nantucket.

## 6.2. GEOGRAPHIC FOCUS AREAS

The analysis of AIS data, which was not performed in the 2009 study, helps to visualize vessel traffic density by port and waterway. Figure 5-7 shows that vessel entries into Boston Harbor account for 62% of the statewide traffic for the data years analyzed (2017-2020). Tanker traffic is concentrated in Boston Harbor, except for occasional visits to Fall River (7 tankers over five years).

The highest levels of tug traffic, including but not limited to tugs towing oil-laden barges, are Boston, New Bedford/Fairhaven, Nantucket, and Vineyard Haven. Overall traffic is also highest in Boston, followed by Nantucket, New Bedford/Fairhaven, and Vineyard Haven.

Bulk petroleum import data, as captured through OR-1 reporting, is highest by an order of magnitude in Boston Harbor, inclusive of Braintree and Weymouth. The next highest volume is transferred to unspecified terminals. After that, the ports with the highest volume of bulk oil transfers are Nantucket and New Bedford, respectively.

## 6.3. NEXT STEPS

This report is provided as an update to the original 2009 study, with the intent to inform MassDEP oil spill preparedness and response program activities. The information and analysis in this report also provided the basis for scenario-based discussions during a May 2023 Climate-Ready Oil Spill Preparedness and Response workshop, where various climate change scenarios were overlain with the baseline threat data from this report.

# 7. References


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