Vessel Operations in Right Whale Protection Areas in 2009

Gregory K. Silber and Shannon Bettridge

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA Technical Memorandum NMFS-OPR-44
July 2010

Vessel Operations in Right Whale Protection Areas in 2009

Gregory K. Silber and Shannon Bettridge
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

NOAA Technical Memorandum NMFS-OPR-44
July 2010

U.S. Department of Commerce
Gary Locke, Secretary

National Oceanic and Atmospheric Administration
Jane Lubchenco, Ph.D., Administrator

National Marine Fisheries Service
Eric C. Schwaab, Assistant Administrator for Fisheries

Suggested citation:

Silber, G.K., and S. Bettridge. 2010. Vessel operations in right whale protection areas in 2009. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-44. 44 p.

A copy of this report may be obtained from:

Office of Protected Resources
NOAA, NMFS, F/PR2
1315 East-West Highway
Silver Spring, MD 20910

Or online at:

http://www.nmfs.noaa.gov/pr

Acknowledgements

Mr. Kam Chin and Mr. Dave Phinney of the Department of Transportation's Volpe National Transportation Systems Center have been a pleasure to work with on this project and their technical expertise is formidable. Ms. Carliane Johnson of SeaJay Environmental helped immensely with data processing and in developing procedures for data synthesizing.

Executive Summary

One of the greatest threats to the recovery of the highly depleted North Atlantic right whale (*Eubalaena glacialis*) is collisions with ships (or "ship strikes"). The U.S. National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) has taken a number of steps to reduce the threat, including issuing a final rule (73 Federal Register 60173, October 2008) that requires vessels $\geq$65 feet in length to travel at 10 knots or less in certain times and locations (termed "Seasonal Management Areas", or SMA) of right whale occurrence. NMFS also initiated a program whereby "Dynamic Management Areas" (DMA) are established in areas in which right whales are observed outside SMAs, whereby temporary zones are created and vessels are requested (but, not required) to either navigate around the zone or travel through it at 10 knots or less. This process allows for management measures that are tied directly to the known, but perhaps transitory, presence of right whales, and provides a means to establish areas effecting vessel operations that are smaller (in area) and shorter (in duration) than seasonal management measures. NMFS is monitoring the effectiveness of the restrictions by assessing compliance with the vessel speed limits as well as adherence to associated voluntary measures. Automatic Identification System (AIS) technologies provide a precise and easily accessible means to do so.

Originally conceived as a safety of navigation technology, the AIS uses Global Positioning System (GPS)-linked, very high frequency (VHF) radio signal that provides for ship-to-ship and ship-to-shore information transfer. It transmits the ship's name, call sign, position, dimensions, speed, heading and other information multiple times each minute. The AIS signal provides a suite of information, both dynamic (that is unique to a particular voyage) and static (that is consistent for a given vessel). Dynamic information includes the vessel's position, speed over ground, course over ground, heading, rate of turn, and position accuracy (< or > 10 m) which are determined by continuous GPS-linked updates. Static information includes the vessel's: name, call sign, type, cargo, and its Maritime Mobile Service Identity (MMSI) number. Given the rate at which it provides this information, AIS is a precise means to remotely track vessel speeds and other vessel operations.

Our goal here is to provide (a) a characterization of vessel traffic volume, patterns, and speeds of vessels transiting SMAs, and (b) an initial assessment of vessel adherence to the vessel speed restrictions. This summary is for the period of January 2009 (the rule was enacted December 2008) through December 2009. We also provide an initial characterization of vessel use of DMAs in the same period.

We gathered information on vessel activity in 10 operational SMAs, and in 18 DMAs for the period January to December 2009. As set forth in the rulemaking, the SMAs we analyzed were effective in: Cape Cod Bay (1 January – 15 May); an area Off Race Point, MA (1 March – 30 April); an area in the Great South Channel (1 April – 31 July); an area extending from mid-coastal Georgia to northern Florida (15 November – 15 April); and (1 November – 30 April for each of the following) Block Island Sound, port entrances of New York City and New Jersey, Philadelphia, PA, Norfolk VA, Wilmington, NC, and an area extending from Wilmington, NC to just south of Savannah, GA.

A total of 39,615 vessel transits were recorded in active SMAs in 2009. Of these, 10,982 were not applicable to conditions set forth in the Rule or were deemed inaccurate and were therefore removed from further analysis. Thus, a total of 28,633 transits were analyzed to determine vessel types, vessel speeds, SMA use, and other characteristics of these passages.

The New York-New Jersey port entrance SMA had the greatest number of transits (n = 7,651) followed by the North Carolina-Georgia complex and the Norfolk SMAs (6,502 and 4,790 transits, respectively). Cargo vessels constituted the majority of ship passages in all SMAs, comprising over 50.3 % of all vessel transits, (and excluding the "other" vessel type category) followed by tanker vessels (14.9%), and tug-type vessels (10.2%). Cargo vessels were strongly represented in the New York-New Jersey, Norfolk and North Carolina-Georgia SMAs, with the North Carolina-Georgia complex having the highest number of cargo transits of all SMAs. Considering all transits in all active SMAs the ratio of foreign flagged to domestic vessels was 1.6:1

The most common maximum speed represented was 11 knots; and the majority of all transits were between 11 and 16 knots. A substantial number of transits were at maximum speeds in excess of 16 knots. Aggregate maximum speeds in most SMAs exhibited a "bell-curve" with peaks between 10 and 16 knots; while the most highly represented maximum speed in nearly all SMAs was 11 - 12 knots. Generally, domestic vessels had lower aggregate vessel speeds than did foreign-flagged vessels; foreign-flagged vessels tended to travel at 12 knots or greater. Cargo vessels exhibited the highest aggregate maximum speeds (with the most traveling in the 15-16 knot range), followed by tankers (with peaks in the 11-13 knot range), and aggregate speeds for passenger vessels had peaks around 12 knots. Vessels in the "tug, tow, dredge", and "other" categories exhibited peak aggregate speeds around 10 knots.

In 2009, 18 DMAs were "triggered" by right whale presence, all occurring in waters off New England. A total of 1,406 vessel transits occurred in these active DMAs. The majority were tankers (n = 521), nearly twice as many as any other vessel category. Excluding the "other" category, cargo vessels were the second most common type. The distribution of vessel speeds through DMAs is different than the distribution for vessel speeds utilized in SMAs (it was not a "bell-shape" as in the SMA speed distributions). In DMAs, 11 knots was the most common maximum speed; and there appeared to be a higher proportion of vessels traveling 11 knots or less than those vessels traversing SMAs. A second peak occurred at 14 knots with a large portion traveling at 13 and 14 knots; probably reflecting the number of cargo ships and tankers traversing the zones. Likely, many tug and barges and "big-tows" (vessels typically traveling at speeds under 12 knots) have limited options to route around such areas: being largely coastal and having specific destinations that require routes through DMAs and therefore opt to travel through DMAs; whereas larger, ocean-going vessels on more lengthy routes may have the latitude to avoid a particular area.

It is not clear why "compliance" (defined strictly here as maximum speed $\leq$10 knots) with vessel speed requirements was low. Contributing factors may be a lack of public recognition of the rule, disregard for it, or inadequate early enforcement. There are almost certainly learning and acquisition phases to a requirement that substantially alters standard practices. With regard to “foreign-flagged” vessels and their operators, particularly those making infrequent port calls, language barriers or simple lack of familiarity with domestic requirements may hamper acquisition of the significance and requirements of the rule. Regarding knowledge of the rule, however, NOAA and a suite of partners made a concerted effort to notify the public and maritime community about the requirements both prior to their enactment and during the periods in which SMAs were in effect. Perhaps one significant weakness in efforts to alert mariners is that of NOAA’s printed nautical charts which currently do not depict SMAs. There are lessons to be learned about the importance of an effective enforcement program, and about possible weaknesses in the distribution of various notification outlets, their capacity to reach the targeted audience, or the level of their impact in influencing the behavior of certain maritime operators.

Acronyms and Abbreviations

AIS	Automatic Identification System
BI	Block Island
CCB	Cape Cod Bay
DMA	Dynamic Management Area
GPS	Global Positioning System
GSC	Great South Channel
IMO	International Maritime Organization
ITU	International Telecommunications Union
MID	Maritime Identification Digits
MMSI	Maritime Mobile Service Identity
MOA	Memorandum of Agreement
MOR	Morehead City, South Carolina
NAIS	National Automatic Identification System
NC-GA	Wilmington, North Carolina to Savannah, Georgia
NEUS	Northeast United States
NY-NJ	Port of New York and New Jersey
NOR	Norfolk
ORP	Off Race Point
PHI	Ports of Philadelphia
SEUS	Southeast United States
SMA	Seasonal Management Area
SOG	speed over ground
SOLAS	[International Convention for the] Safety of Life at Sea
USCG	United States Coast Guard
VHF	very high frequency

Vessel Operations in Right Whale Protection Areas in 2009

Introduction

Perhaps the greatest threat to the recovery of the highly depleted North Atlantic right whale (*Eubalaena glacialis*) is collisions with ships (or "ship strikes"). In response to this threat, the U.S. National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) has taken a number of steps to reduce right whale vulnerability to severe ship strikes. One such measure is the Final Rule to Implement Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales (73 Federal Register 60173, October 2008) that requires vessels ≥65 feet in length to travel at 10 knots or less in certain areas during right whale occurrence (NMFS, 2008a). Vessel speed restrictions apply in "Seasonal Management Areas" (SMA): specific locations and times that coincide both with key right whale aggregation and migration areas and with port entrances and other locations where maritime activities are concentrated. In this same rule, NMFS also established "Dynamic Management Areas" (DMA): areas in which right whales are observed outside SMAs whereby temporary zones are established and vessels are requested (but, not required) to either navigate around the zone or travel through it at 10 knots or less. NMFS is monitoring the effectiveness of the regulation by assessing compliance with the vessel speed restrictions as well as adherence to associated voluntary measures. Automatic Identification System (AIS) technologies provide a precise and easily accessible means to do so.

Originally conceived as a safety of navigation technology, the AIS uses Global Positioning System-linked, very high frequency (VHF) radio signal that provides for ship-to-ship and ship-to-shore information transfer. It transmits the ship's name, call sign, position, dimensions, speed, heading and other information multiple times each minute. Given the rate at which it provides this information, AIS is a highly precise, and in a number of ways an ideal means to remotely track vessel speeds and other vessel operations.

AIS transponders are required on certain vessel types that transit U.S. waters. These include: 1) all commercial tugs, barges, tow and similar vessels that are 26 feet in length or greater; 2) all passenger vessels (such as ferries and cruise ships) 150 gross tonnage or more; and 3) any commercial self-propelled vessel that is 65 feet in length or greater, which consists of commercial fishing vessels, tankers, cargo ships, etc. (33 CFR 164.46). United States Coast Guard (USCG) rulemaking proposed in December 2008 would also require AIS on any passenger vessel carrying 50 or more passengers for hire, regardless of length or tonnage; and high speed craft (30 knots or greater) that carry 12 passengers or more, regardless of length or tonnage. The USCG is incrementally establishing a National Automatic Identification System (NAIS) system -- a network of shore-based receivers and relayers that when completed will provide coverage of nearly all U.S. coastal waters.

NMFS Headquarters' Office of Protected Resources has been acquiring AIS data feeds from the USCG NAIS. Data are downloaded and processed, under a Memorandum of Agreement (MOA), by the Department of Transportation's Volpe National Transportation Systems Center (Volpe Center) and provided to NMFS in monthly data summaries. Using those data, we were able to describe vessel traffic volume and operations in the SMAs and describe mariner behavior with regard to adherence with NOAA's vessel speed restrictions.

Our goal here is to provide (a) a characterization of vessel traffic volume, patterns, and speeds of vessels transiting SMAs, and (b) an initial assessment of vessel adherence to the vessel speed restrictions. This summary is for the period of January 2009 (the rule was enacted December 2008) through December 2009. We also provide an initial description of vessel use of DMAs in 2009. We expect to prepare a more comprehensive summary report for a longer time series, likely through late 2010 or early 2011; and we expect to prepare periodic summaries (*e.g.*, monthly or quarterly) during that period.

The Automatic Identification System

The U.S. Coast Guard (USCG) implemented a vessel safety rule in 2003 (Title 33 Code of Federal Regulations 164.46[1]) that requires all vessels of 65 feet (20 meters) or greater and transiting U.S. navigable waters to carry AIS. The rule codified regulations by the International Convention for the Safety of Life at Sea (SOLAS), an international agreement that specifies minimum standards for the construction, equipment and operation of ships (International Maritime Organization, 1974). Flag States are responsible for ensuring that ships operating under their jurisdiction comply with SOLAS requirements. Under the Convention, all ships of 300 gross tonnage and greater engaged in international voyages and cargo ships of 500 gross tonnage and greater not engaged in international voyages and passenger ships irrespective of size are required to have AIS. A large, undetermined number of vessels less than 300 gross tons (and less than 65 feet) also voluntarily carry AIS transmitting capabilities.

The initial intent of AIS was to help ships avoid collisions, as well as assist port authorities to better control sea traffic. The AIS transponder includes a Global Positioning System (GPS) receiver and collects static and dynamic information and transmits this

---

[1] *§ 164.46 Automatic Identification System (AIS).*
(a) The following vessels must have a properly installed, operational, type approved AIS as of the date specified:
(1) Self-propelled vessels of 65 feet or more in length, other than passenger and fishing vessels, in commercial service and on an international voyage, not later than December 31, 2004.
(2) Notwithstanding paragraph (a)(1) of this section, the following, self-propelled vessels, that are on an international voyage must also comply with SOLAS, as amended, Chapter V, regulations 19.2.1.6, 19.2.4, and 19.2.3.5 or 19.2.5.1 as appropriate (Incorporated by reference, see § 164.03):
(i) Passenger vessels, of 150 gross tonnage or more, not later than July 1, 2003;
(ii) Tankers, regardless of tonnage, not later than the first safety survey for safety equipment on or after July 1, 2003;
(iii) Vessels, other than passenger vessels or tankers, of 50,000 gross tonnage or more, not later than July 1, 2004; and
(iv) Vessels, other than passenger vessels or tankers, of 300 gross tonnage or more but less than 50,000 gross tonnage, not later than the first safety survey for safety equipment on or after July 1, 2004, but no later than December 31, 2004.

information on two VHF channels (frequencies 161.975 MHz and 162.025 MHz). Other vessels or base stations are able to receive this information, process it using special software and display the location of vessels on a chart plotter or on a computer. The data are also available in the public domain. One searchable database on the Internet that offers location information of ships is www.marinetracker.com.

The AIS is capable of handling more than 4,500 reports per minute and updating as often as every two seconds. AIS vessel transponders normally work in an autonomous and continuous mode with a typical range of coverage of about 20 nautical miles, but perhaps more in certain circumstances.

A national network of receivers is being established by the USCG; and NOAA, in cooperation with the USCG utilizes data feeds from this system to monitor vessel operations, relative to its vessel speed restrictions and other ship strike reduction measures.

Methods

Timing and Locations of Vessel Speed Restrictions

We gathered information on vessel activity in 10 operational SMAs, and in 18 DMAs for the period January to December 2009. NOAA's vessel speed restrictions went into effect 9 December 2008 establishing SMAs in specific periods and locations corresponding to right whale migration, feeding, and nursery areas, as well as high vessel traffic densities in certain port entrances (Tables 1 & 2; Fig. 1) (73 FR 60173, October 2008) (NMFS, 2008). As set forth in the rulemaking, the SMAs we analyzed were effective:

1 January – 15 May: Cape Cod Bay (CCB);

1 March – 30 April: an area Off Race Point (ORP);

1 April – 31 July: an area in the Great South Channel (GSC);

1 November – 30 April:

- Block Island Sound (BI);
- port entrances of New York City (NY);
- Philadelphia (PHI);
- Norfolk (NOR);
- Wilmington, NC; and
- an area extending from Wilmington, NC to just south of Savannah, GA (NC-GA); and

15 November – 15 April: an area extending from mid-coastal Georgia to northern Florida (SEUS).

Processing Automatic Identification System Data

The monitoring program we developed involves a rather substantive data set. As noted, vessels' AIS transponders send signals multiple times each minute; tens of vessels are moving through active SMAs at any given time, thousands of transits per month. Nonetheless, we wanted to ensure, to the extent possible and despite the volume of data, that results were summarized in ways useful to managers and that we were clear in how these data were processed. Therefore, we provide detail here on data handling and error checking.

Under the conditions of a Memorandum of Agreement (MOA), dated 10 June, 2009, and in cooperation with the USCG, NOAA acquires NAIS data via the Volpe Center (Cambridge, MA). The Volpe Center obtains AIS data directly from the USCG NAIS and archives and houses the entire data set at its Cambridge, MA facility. The Volpe Center provides to NOAA (via a secure web site) monthly spreadsheet summaries of every vessel transit occurring in an active SMA. The Volpe Center utilizes a highly customized software program it developed over a decade ago to handle such data, called Transview 32 (or “TV32”). Under the MOA, the Volpe Center is also providing analysis of the DMA program established in conjunction with the final rule; NOAA-established recommended routes; and an International Maritime Organization (IMO)-approved Area To Be Avoided. The latter two measures will be assessed in subsequent reports.

Having monthly spreadsheet summaries allowed us to organize large amounts of data and to readily analyze them for various features to characterize vessel traffic (*e.g.*, by vessel type, country of origin). Each spreadsheet line entry represents a unique “transit,” that corresponds to a vessel that made a single entry and exit within a management zone during the time the SMA was active. Inbound, outbound, and transiting ships occurring in any active SMA were analyzed. Vessels making multiple transits during the same day, or within more than one SMA, were also designated by a single spreadsheet line.

The AIS signal provides a suite of information, both dynamic (that is unique to a particular voyage) and static (that is consistent for a given vessel). Dynamic information includes the vessel’s position, speed over ground, course over ground, heading, rate of turn, and position accuracy (< or > 10 m) which are determined by continuous GPS-linked updates. Static information includes the vessel’s

- name,
- call sign,
- type,
- cargo, and
- Maritime Mobile Service Identity (MMSI) number.

The MMSI is a unique nine digit number regulated by the International Telecommunications Union (ITU). The MMSI is a unique nine digit number regulated by the International Telecommunications Union (ITU). The MMSI format for a vessel is $M_1I_2D_3X_4X_5X_6X_7X_8X_9$ where the first three digits represent the Maritime Identification Digits (MID) and X is any figure from 0 to 9. The MID denotes the country or geographical area responsible for the identified ship station and ranges from 201 to 775. In general, a MID beginning with 2 denotes Europe; 3 is North America, Central America or the Caribbean; 4 is Asia; 5 is Oceana; 6 is Africa; 7 is South America; and 8 is for regional use.

Data Handling and Screening

We established three initial data screening criteria. We first removed all vessels <20 m (65 ft) as these were not subject to the conditions of the vessel speed restrictions (Table 3). We then removed all records identified as belonging to sovereign vessels, as they are exempt from the speed restrictions (described in more detail below). We also decided, *a priori*, to remove from analysis transits that were represented by <10 AIS position "fixes", reasoning that a small amount of information would likely not provide an adequate characterization speed and other features of these transits.

Identifying and Correcting Errors in the Data

Although we believe the information presented here faithfully characterizes vessel activity in these areas and times, the AIS data are not flawless. This section describes our attempts to locate and address incomplete records, because we want to ensure their accuracy and because these data are an assessment of the regulation and actions of a significant portion of a substantial maritime industry. Nonetheless, we believe the vast majority of records are accurately sent, received, and processed by generally highly reliable electronic technologies and systems.

Consisting of a VHF signal, the range (distance of reception) of AIS transmissions is constrained essentially to "line of sight", or tens (or in some instances perhaps hundreds) of miles, a distance that varies depending on the height of the receiving antenna and other factors. In addition, the signal may be momentarily compromised, or enhanced, by local meteorological conditions (*e.g.*, electrical storms), atmospheric bounce, or other possible interferences (*e.g.*, other radio signals), and therefore, ranges may vary.

It is possible that some data are inaccurate or absent. Conceivably, this could happen as a result of:

a. Malfunction of the AIS transponder of the vessel,

b. Errors of the Global Positioning System (GPS) and,

c. Neglect of the vessel's crew to correctly configure the information transmitted by the AIS transponder such as the vessel's name, type and dimensions.

Of these, we believe "a", above, is unlikely (although it is possible that a vessel failed to carry or use or disabled its transponder or it may have malfunctioned for some reason; however, we have no way of assessing this). Although it is possible a vessel's GPS could generate an erroneous position or speed, we believe the occurrence of "b", above, to be highly unlikely given the reliability of this proven international navigational network. (Below, we provide a description of additional screening to remove possible erroneous position fixes and speeds.)

As to "c", above, some of the AIS system is based solely on information provided to the unit by its operators; therefore, correct configuration of the AIS transponders by the ship's crew is important to the transmission of accurate information. That is, while much information (*i.e.*, position, speed, course over ground) contained in this data packet is highly accurate because it is automatically supplied by ship navigation systems including GPS, user input attributes (*i.e.*, length, draft, vessel type) are subject to misinformation due to user input errors or lack of proper training and standards.

It was clear some of the information received was not accurate. As described in more detail below (in the section on "Vessel Length") this occurred most with regard to information on vessel dimensions. Such records, a relatively small portion of the entire sample, were either removed prior to further analysis, or the correct information was added where possible. In quite a few of these cases, we were able to use the ship's name to locate its length via Internet searches; and as a result were able to re-constitute accurate information in the transit record. Nonetheless, in a number of cases, we were unable to locate such information for the vessel and therefore removed 994 records (2.5% of the total received) from further analysis (Table 3).

In some instances, we observed a particular MMSI number being used by more than one vessel. (For example, sequences such as 123456789 are fairly common.) This may occur for several reasons. An operator may enter the wrong MSSI number, or if an operator enters no MMSI number the AIS transponder may automatically enter a pre-determined default number. In addition, if an AIS transponder is shut down or loses its internal configuration memory, a default number may be entered when the system is re-activated. At least one AIS manufacturer uses this default system as standard practice.

A MMSI number links the vessel's static information (*e.g.*, name, call sign) to its dynamic information (*e.g.*, speed, location). A problem can arise if two vessels being tracked within a SMA, or one occurring outside the SMA, have the identical MMSI numbers. If duplicate MMSI numbers are received by the system, each subsequent signal from the vessel within the SMA will generate a new vessel record and track when only one should have been recorded. Thus, duplicative records and erroneous position locations in one or more records for that vessel will be generated.

To correct this situation, a new geo-feasibility test capability was added to the "Transview" (*i.e.*, TV32) program by personnel at the Volpe Center. This test determines whether it is feasible for a vessel to move from point to point within a reasonable time using a reasonable speed. When the program calculates that a jump is not feasible (*i.e.*, two vessels with the same MMSI number are being considered as one vessel), a side record of the history trail is established. As additional position reports are received, each is compared for validity to the latest position report for each side record. As soon as a set of points is found to be geo-feasible, the new report is associated to that vessel track. This can repeat for any number of separate tracks of vessels transiting through any number of zones. The result, for us, is a drastically reduced set of transit summaries as each ship's track is verified. Even with the correction, there is the possibility that two vessels with the same MMSI could cross paths or be in close enough proximity to cause tracks to swap – a condition that can also confound radar tracking systems.

A second outcome arising from duplicate MMSI numbers is a lack of assurance in assigning a vessel's name (and other static data) to a string of position reports. If the IDs of the AIS base stations receiving reports from the multiple ships is known, then that could help determine an association between messages, however, this is generally not the case. To address this, incoming information was processed to indicate if a given vessel being tracked underwent numerous "name changes" which would indicate a possible duplicate MMSI number in the summary record. This is not the number of unique names seen for the MMSI, but the total number of times the name differs from the previously received static vessel messages. This condition was used as long as the vessel is tracked by the system, regardless of whether the vessel is within the SMA. When the vessel departs the SMA, the name change count is written with the transit record. This count indicates how many name changes had occurred since the acquisition of the tracked vessel. Although the name associated with a transit summary is not guaranteed to be correct, but there is an indication when it may not be. In those cases in which a legitimate record was not certain (here termed "too many name changes") we removed it from further analysis; a total of 213 records (0.5%) were removed by this process (Table 3).

Finally, a small number of records (0.5% of all records analyzed) were removed from further analysis because the static information could not be corrected with a high level of certainty (Table 3). For example, the system may receive positions for a vessel that has not yet transmitted its static information. This occurs when a static vessel's information is transmitted less frequently than its positions. In this case, the MMSI number of the vessel will appear in the "vessel name" column instead of its name. In the January 2009 dataset, this occurred 12 times in more than 6,000 transits in the raw data. This ratio was comparable in the other months analyzed.

Given our detection and removal or correction of erroneous information, and given the high transmission rates (*i.e.*, up to hundreds, and often thousands, of individual data points per transit), we believe most of these potential problems with the data set are overcome by the volume of data and they provide a reasonable representation of vessels transiting SMAs and their operations within SMAs.

Grouping of Vessel Type

Numerous identifiers are used by ships to report the type of vessel.[2] In such databases, ships are categorized and subcategorized to better identify the vessel and also its cargo.

Vessel type categories provided by the operator were grouped to facilitate our summarization of the data. Vessel types coded by the operator as "cargo", "tanker", and "passenger" comprise their own, discrete categories. "Tow" and "big tow" boats reflect the sizes of the towing vessel based on the operator's judgment, and were combined into one group called "tow".

Thus, in a number of the graphics presented here, we used only the general category of "type" to differentiate the vessels moving through the SMAs. They are:

Cargo

Tanker

[2] These codes can be found at http://www.navcen.uscg.gov/enav/ais/AIS_Messages_A_Static.htm

Passenger

Tow

Pilot

Tug

Sovereign[3], and

"Other".

Note that in some graphics that follow, we present summaries in categories that include greater detail within a vessel category (*e.g.*, a stand alone category for fishing vessels, pleasure craft -- otherwise complied in the "other" category). The cargo vessel category consists of any ship or vessel that carries cargo, goods, materials from one port to another, including container ships, bulk carriers, and general cargo ships. The tanker category includes ships carrying oil or other liquid products. Passenger vessels include large cruise ships as well as smaller (often coastal) passenger ferries.

"Other" vessels includes the remaining vessels that were listed as:

> fishing, sailing, pleasure, dredging, diving, anti-pollution, WIG (wing-in-ground), Resol-18 (ITU Radio Regulations Resolution No. 18), HSC (high speed craft), reserved, unknown, and other.

A number of ship types grouped within the "other" category are not well defined in the literature such as "Resol-18" and "WIG" but these comprised only a few entries (*i.e.*, generally fewer than five) in any given month.

On occasion, ship operators miscoded vessel type information. In many of these instances ships that were clearly misidentified were coded as "other", such as the *Cape Fear Pilot 2* that was coded as a "fishing" vessel instead of a pilot vessel. These were not corrected in the data set. In some records, a default is used by one AIS company for their transponders that, if not reset by the operators, results in "Nauticast" inserted as the vessel name. In these cases, the record was removed from the dataset.

In a future iteration of this report, further Internet search queries on the vessel types is planned to correct much of this information and allow for more reliable vessel type assessments to be conducted. Nonetheless, we believe the vast majority is coded correctly, and overall characterizations of vessel types are a true representation of transiting vessel type proportions.

Vessel Length

Vessel dimension (length and beam) is static information transmitted in the AIS signal. We were interested in vessel length as a condition for knowing whether the vessel was required to comply with speed restriction zones, *i.e.*, at a length of 65 feet or greater. As noted, vessels generally less than 65 feet in length are not required to carry AIS but some do so for purposes of enhanced navigational safety. Although these are found in the dataset, they have been

[3] Sovereign vessels was a category of our own creation (inasmuch as they are exempt from the vessel speed restrictions), and included, on occasion, a number of descriptions as entered by the AIS operator, such as tanker, fishing, dredging, and law enforcement vessels. We provide some characterizations of sovereign vessel behavior here, but generally, they were removed from analysis.

taken out in the final analysis presented here. It is also possible that not all sovereign vessels transmit an AIS signal, but those that did were removed from most information presented here (unless otherwise indicated).

In some cases, the vessel dimension information was provided as "zero". Vessels that were listed from one to six meters in length (those above 6 m were generally found to be reliably reported) were independently verified and required correcting in a relatively few cases. For example, some cargo ships were incorrectly coded as being one meter long. Inaccurately entered vessel length information occurred in 1,007 of 6,371 (or 16%) entries in January 2009 representing 103 different vessels. The proportion of cases lacking vessel length information in January 2009 is comparable to the proportion occurring in all months in 2009.

In many cases, we were able to locate vessel dimensions that were incorrect or listed as zero by searching on Internet web sites that provide details on vessels worldwide. This was usually done by searching using a vessel's name, MMSI number, and/or call sign on such websites as the USCG Information Exchange (http://cgmix.uscg.mil/PSIX/PSIXSearch.aspx), the Federal Communication Commission's Universal Licensing System (http://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp), Vessel Tracker (http://www.vesseltracker.com/en/VesselArchive.html), and Digital Seas (http://www.digital-seas.com/vessel_search/vessel_archive.html). In cases in which it was not possible to locate the necessary information for a vessel, the entry was removed to a separate worksheet and not used in analysis.

After the lengths were obtained for as many ships as possible, the dataset was again sorted and all those found to be 19 meters (62.3 feet) or less were removed and not analyzed further because they are exempt from the rule. Thus, all vessels analyzed in this report were 20 meters (65.6 feet) or greater in length and were presumed to be required to comply with the speed zones in the SMAs.

Determining Country of Origin

AIS data also include country of origin information. We were interested in analyzing this to, in part, assess whether certain segments of the shipping industry should be the focus of subsequent outreach efforts, and, if so, to help direct such efforts. For analytical purposes, we divided all vessels into two broad categories: domestic and foreign. "Domestic" includes vessels registered in the United States, including Puerto Rico and the U.S. Virgin Islands; "Foreign" includes all others.

As indicated above, the MMSI number can be used to determine flag country and we used this to separate foreign-registered vessels from domestic. For the relatively small number that had "unknown" information with regard to flag country, we used MMSI numbers and conducted Internet searches to determine country of registry.

Sovereign Vessels

Nearly all sovereign vessels (*e.g.*, U.S. Navy, USCG, NOAA, etc.) carry AIS transmitting and receiving capabilities; however, for national security reasons they are neither required nor expected to transmit the signal. Thus, many sovereign vessel transits may be absent from the data set. Since sovereign vessels are exempt from the speed restrictions, records identified as belonging to sovereign vessels were removed from further analysis (Table 3). Several sort queries were used on the dataset to identify sovereign vessels; two of the most common methods were by the vessel's name or its type.

Certain known acronyms of governmental entities were used to determine sovereignty: CG, CGC, Coast Guard, COE, USCG, USCGC, USA, USAV, USGOV, USEPA, USNS, USS, US Sub, and Warship. Certain vessel codes, including MILOPS (military operations), SAR (search and rescue), and LAW, were used to determine sovereign status. Some vessels were also coded as "fishing" but were determined to be NOAA ships (such as the *Thomas Jefferson*). Other military vessels were listed as "tankers" but determined to be military based on an Internet search on their names (such as *Big Horn*, *Kanawha*, *Leroy Grumman*, and others).

It is possible that some sovereign vessels were overlooked because they were neither clearly coded as such nor had a vessel name that easily identified them as sovereign. If so, we believe this represents a very small, if any, portion of the dataset.

Vessel Speed

Vessel "Speed Over Ground" (SOG) is the speed metric used explicitly in the vessel speed restriction rule; and here we use SOG interchangeably with the term "speed".

There were some cases in which a vessel's status (as entered by the user) indicated a vessel was "anchored", but we obtained position and speed information, as supplied by the ship's GPS, that indicated the vessel was moving. Therefore, we relied on the more accurate GPS-linked vessel position, speed, and course indicators.

We observed vessel SOG as provided by AIS transmissions to range from 0 to 102 knots. Vessels with speeds greater than 100 knots or that included speeds of "N/A" were removed from the analysis as they clearly are erroneous data for a vessel at sea (although some craft transmitting AIS signals are capable of considerable speeds (*e.g.*, high speed ferries) we believe some of these in excess of 100 knots may be aircraft, some of which also carry AIS capabilities). In most cases, this represented fewer than ten instances in each month's data.

We used "maximum SOG" as a means to characterize vessel transit speeds. As noted elsewhere, there are likely a number of ways to characterize a particular transit. We explore one later in this paper and others are being discussed, but for our purposes – characterizing adherence to the vessel speed restrictions – we regarded this metric suitable for these purposes.

Results and Discussion

A total of 39,615 vessel transits were recorded in active SMAs in 2009 (Table 4). We assume this is a full record of all vessels traveling in active SMAs, but we have no way to determine if all vessels with AIS carriage requirements adhered to those requirements. Given, however, AIS's primary function is that of navigational safety in low light and poor sea conditions it is illogical that vessels would not use the system.

Of these, a total of 10,982 transits were removed from further analysis; including those in which vessels were < 20 meters as the vessel speed restrictions did not apply to vessels of this length (n = 7,020); reports related to sovereign vessels (n = 1,370); those reports that contained < 10 AIS position "fixes" (n = 1,500); records in which multiple vessels had the same MMSI numbers (or, "name changes" here) (n = 213); and those records in which the data appeared erroneous for other reasons (n = 211) (Table 3). As noted above, a number of records did not have vessel lengths as entered by the AIS operator. In many cases, we were able to determine vessel length by making Internet searches; nonetheless, we could not determine vessel length in 994 of the records, and they, too, were removed from further analysis.

Some vessel transits fell into more than one category for exclusion; for example, a vessel could be < 20 meters in length and have fewer than 10 AIS position reports and thus could be flagged for removal more than once. A total of 326 transits were flagged for removal under two or more categories, therefore 10,982 transits were removed from the database (with the removal criteria having been met a total of 11,308 times) (Table 3). Thus, following this review and manually checking virtually each transit, we analyzed a total of 28,633 records of vessels traveling through operational SMAs in 2009 (Table 4).

We therefore regard these numbers as minimum, but reliable counts of the number of vessel transits. By any measure, the number of records removed from analysis notwithstanding, this is a formidable fleet that traverses areas vital to the right whale population's longevity. It appears large vessels are nearly ubiquitous throughout the range of the species, and a given individual may encounter tens of vessels each day, hundreds each year.

Composition of Vessel Traffic within SMAs

Overall, the greatest vessel traffic volumes were in the NY/NJ, NC-GA and NOR SMAs (see Table 1 and the "Acronyms and Abbreviations" appendix for lists of acronyms for each of the SMAs). The NY-NJ SMA had the greatest number of transits (n = 7,651) followed by the NC-GA complex and the NOR SMA (6,502 and 4,790 transits, respectively) (Table 5). The number of ship using the NY-NJ port complex dwarfs the others, despite the fact that the NC-GA SMA encompasses a number of large ports, including Savannah and Charleston; and considering the NOR SMA services Baltimore, Hampton Roads, and other destinations within the Chesapeake Bay. The NOR SMA exhibited a relatively large number of sovereign and "other" vessels due to key military installations being located there. The total number of transits is likely underrepresented at this location based on the assumption that some military vessels likely are not transmitting. Volume in the MOR SMA is, proportionally, much lighter relative to the other ports.; however noted an increase in the total number of vessels transiting the NOR SMA in December 2009. This resulted from dredging activity near or within the SMA, such that the number of dredge vessels went from three in November to 254 December.

Vessel Type

Cargo vessels constituted the overwhelming majority of ship passages in all SMAs, comprising over 50.3 % of all vessel transits, (and not including the "other" category, for the moment, were) followed by tanker vessels (14.9%), and tug-type vessels (10.2%) (Table 5; Fig. 2). Cargo vessels were strongly represented in the NY-NJ, NOR and NC-GA SMAs, with the NC-GA complex having the highest number of cargo transits of all SMAs (Fig. 3). The proportion of cargo vessels is also substantially greater than other vessel types using the SEUS SMA (57.9%). Tanker vessels were higher, proportionally, in northern SMAs than in more southern SMAs. The NC-GA complex encompasses the primary ports supporting movement of goods to the U.S. south, which accounts in part for the volume represented here over single-port entrance SMAs.

Relative to the other SMAs, there were proportionally low numbers of vessels transiting the ORP, GSC, and MOR SMAs. The ORP SMA is active for a relatively short period (Table 2) which likely accounts for this pattern; but, overall, Morehead City appears to be one of the smaller ports, in terms of volume, inside active SMAs. The numbers reflected in the Great South Channel SMA is more difficult to interpret given it is the largest (in area) of all the SMAs and is used by international vessels making port calls in Boston, New York, and elsewhere. The relatively low volume in this area may indicate that (a) mariners are responding to the Area To Be Avoided established in June, 2009 by skirting the area; (b) vessels are (more heavily) utilizing the Traffic Separation Scheme servicing Boston since it lies outside the GSC SMA; or (c) relatively higher vessel volumes in SMAs other than the GSC is indicative of the level of many coast-wide (*e.g.*, port-to-port) transits along the eastern seaboard, as opposed to trans-Atlantic passages. There may be an additional compounding factor in this SMA, and that is the inherent transmission ranges of the AIS signal. Given this SMA extends rather far from shore, perhaps not all transmissions from vessels in the area are being captured. (This will likely be a subject of further study.) Regardless, this is a key feeding aggregation area for right whales, which may involve relatively long residency times for the whales, and it is be fortuitous that the traffic volume may be low in this area.

Tow-type vessels were common in the Cape Cod Bay SMA (Fig. 4) reflecting the tug-and-barge industry utilizing the Cape Cod Canal as well as those vessels providing heating oil and other materials to Cape Cod communities and elsewhere in the northeast. These are typically slow moving vessels, a fact that is partly reflected in slower speeds in this area relative to other SMAs where other vessel types and higher speeds were observed. Also, an intensive outreach effort has been ongoing for years involving a NOAA/U.S. Army Corps of Engineers collaboration whereby vessels using the canal are provided information on minimizing ship strikes from canal vessel traffic officials.

Vessel Lengths

Vessel length is another feature available from AIS (limited to those with AIS carriage requirements and are transmitting the signal) to characterize vessel traffic in SMAs, and therefore a further means to identify industry segment recipients for outreach and education actions. The majority of SMA transits involve large vessels (generally considered to be the tankers and cargo ships) that range from 100 meters (328 feet) to 299 meters (981 feet) in length (Fig 5).

Country of Origin

Considering all transits in all active SMAs the ratio of foreign flagged to domestic vessels was 1.6:1 (Fig. 6). This is generally consistent across all months except July when only the GSC SMA was active in which the ratio was 5:1. The majority of cargo and tanker vessels were foreign-flagged; while all tow and nearly all tug and pilot vessels were domestic (Fig 7). The highest proportion of foreign versus domestic vessels occurred in the GSC SMA, followed by the ORP SMA perhaps reflecting trans-Atlantic passages destined for Boston or New York; and lowest number of foreign flags relative to domestic vessels occurred in the CCB and MOR SMAS (Fig 8). Patterns of domestic versus foreign-flag SMA transits appeared comparable when plotted by month (Fig 9).

Assessment of Vessel Speeds

There are a number of ways to characterize vessel speeds within SMAs. As described above, for this analysis, we chose to use "maximum speed over ground" as one metric of vessel speed. This may not be the most accurate way to depict speeds used in an entire transit, but it was a readily accessible metric, and one measure of each transit. More nuanced characterizations follow, particularly with regard to "compliance" with the speed restrictions, and will be explored in future analysis. Nonetheless, using this metric and for the purposes of this report, we provide distributions of vessel speed in aggregate, by vessel type, and vessel speeds in each of the SMAs. The most common maximum speed represented was 11 knots; and the majority of all transits were between 11 and 16 knots (Fig. 10). A substantial number of transits were at maximum speeds in excess of 16 knots.

We were interested in determining if aggregated maximum vessel speeds diminished with time as awareness of the restrictions increased. However, there were not large differences in vessel speed distributions when compared by months studied (Fig 11). We observed the greatest number of transits with maximum speeds around 10 knots for the months of January, March, April, May, June and July. The greatest number of transits for the months of February, November and December were centered around 11 knots maximum speed. It is unclear why this was observed in February, but the trend in the November and December records may reflect the SMAs once again going into effect.

Cargo vessels exhibited the highest aggregate maximum speeds (with the most traveling in the 15-16 knot range), followed by tankers (with peaks in the 11-13 knot range), and aggregate speeds for passenger vessels had peaks around 12 knots (Fig. 12). Vessels in the "tug, tow, dredge", and "other" categories exhibited peak aggregate speeds around 10 knots. With regard to those in the tug, tow, and dredge categories, such vessels travel around 10-12 knots routinely and regardless of vessel speed restrictions. We observed an interesting bimodal distribution, around 10 and between 20 - 22 knots, for fishing vessels. This may reflect the non-homogenous nature of the vessel category; some fishing vessels, such as charter fishing operations, travel at high speeds to minimize transit time to fishing grounds and maximize fishing time for passengers. Other fishing vessels may not be capable of traveling above certain speeds, or may not find it economical to travel at such speeds. Note, too, that in some cases pilot vessels – that are capable of relatively high speeds – were coded as "fishing" vessels for reasons that are not clear to us.

Generally, domestic vessels had lower aggregate vessel speeds than did foreign-flagged vessels; foreign-flagged vessels tended to travel at 12 knots or greater (Fig. 13).

Aggregate maximum speeds in most SMAs exhibited a "bell-curve" with peaks between 10 and 16 knots; while the most highly represented maximum speed in nearly all SMAs was 11 - 12 knots (Fig. 14). Data expressed as aggregate speeds were quite similar for the GSC, ORP, BI, PHI, NOR, and MOR SMAs, all exhibiting peaks around 10 to 11 knots maximum speed, and a number of these had relatively a large number of vessels with maximum speeds over 16 knots (Figs. 14 & 15). The outliers appear to be the SEUS SMA, exhibiting a peak at 12 knots; and the NC-GA SMA with the most transits with maximum speeds around 14 - 16 knots, with a second set of transits with maximum speeds of 19 - 21 knots. The MOR SMA exhibited a steady increase in the number of compliant vessels for the months of February and March. This is due to the number of fishing and dredging vessels recorded in these months that were not present in similar numbers during the other months. These vessels are typically slower moving than other vessel types also using these waters.

The CCB SMA exhibited the lowest aggregate vessel speeds, with the highest proportion (90%) among the SMAs in which maximum speeds were $\leq$11 knots. This is likely due to the proportion of tug-and-barge type vessels in the region. As noted, these vessels typically travel at slower speeds than ocean-going vessels.

It is not clear why "compliance" (defined strictly here as maximum speed $\leq$10 knots) with these regulations was relatively low. Contributing factors may be a lack of public recognition of the rule, disregard for it, or inadequate early enforcement. There are almost certainly learning and acquisition phases to a requirement that substantially alters standard practices. With regard to "foreign-flagged" vessels and their operators, particularly those making infrequent port calls, language barriers or simple lack of familiarity with domestic requirements may hamper acquisition and understanding of the significance and requirements of the rule.

With regard to knowledge of the rule, however, NOAA and a suite of partners made a concerted effort to notify the public and maritime community about the requirements both prior to their enactment and during the periods in which SMAs were in effect. Such notifications appeared in various navigational aids, such as the U.S. Coast Pilots, Sailing Directions, USCG Local and Broadcast Notices to Mariners; via periodic NOAA Weather Radio announcements; distribution of laminated "compliance guides" and free interactive CDs through USCG personnel, port captains, and marine exchanges; National Weather Buoy and other web sites; NOAA shipping industry liaisons and NOAA's Nav Managers; e-mail distribution lists; press releases; notifications provided directly to their members by maritime associations (*e.g.*, World Shipping Council, the U.S. Chamber of Shipping, the Passenger Vessel Association); announcements and articles in trade journals and periodicals (see, for example, Silber and Bettridge, 2009); distributions by agencies such as the Department of Transportation's Maritime Administration (literally thousands of vessels or owners were contacted directly); outgoing messages of the U.S. east coast right whale Mandatory Ship Reporting systems, and other means (Bettridge and Silber, 2008).

Perhaps one significant weakness in efforts to alert mariners is that of NOAA's nautical charts themselves. Nautical charts are a key, perhaps the most important, navigational aid used routinely by every mariner. However, at this time, SMAs do not appear on NOAA paper charts because the areas are not permanent (*i.e.*, seasonal, and set to expire in 2013) and due to issues of "chart clutter".

This study may provide feedback about the importance, and components, of an effective enforcement program. Lessons can be learned, too, about the use of various outlets to notify maritime interests and whether distribution of such notifications is possibly incomplete, their capacity to reach the targeted audience, or their level of impact in influencing the behavior of certain maritime operators.

Characterization of Vessel Tracks

One of the principal reasons for our interest in acquiring and analyzing AIS data was to monitor "compliance" with the vessel speed regulations. Using these data we could determine if, for example, compliance changed through time; as a result of a particular enforcement action; or whether outreach or enforcement actions needed to be targeted for a particular port or region, or segment of the industry.

Questions remain as to the most desirable way to represent speeds used in a vessel's transit. Characterization may be complex and imperfect because, for example, a vessel may employ a number of speeds on any given transit as a result of slowing after entering the SMA, slowing to board a pilot, or finding the need to increase speed in adverse weather conditions. Because a ship may use a number of speeds in the course (or even a portion) of a given transit, providing an "average" speed for the duration of the trip may be misleading. Use of "maximum speed", or any of a variety of other metrics, may have similar pitfalls.

Ultimately, the means used to characterize a voyage will depend on one's objectives. As a first assessment of "compliance", we choose maximum speed as the metric reasoning that, strictly speaking, any speed (by any measure) over 10 knots is a violation of the vessel speed restrictions (although perhaps not reasonable to enforce at this threshold). However, maximum speed may represent only a fraction of the entire transit, so this measure may overestimate the overall speed of a given transit and bias upward summaries of speeds in all transits.

Therefore, to further characterize mariner behavior within SMAs we examined the *portion* of each transit for which speeds were above 10 knots and above 12 knots. This approach provides a means for examining the "egregiousness" of violations of the speed restrictions (*i.e.*, was the violator exceeding the speed limit for the majority of the trip or only a small portion?). We assessed the "percent of the transit (distance) >10 knots" and "percent of the transit (distance) >12 knots" of each transit. We then determined, for each transit, whether most of the trip (<50% or >50%) was below or above these two speed thresholds. Thus, as general measures of "compliance", we provide the distribution of vessels traveling (a) slower than 10 knots/12 knots for the entire transit, (b) those traveling at and above 10 knots/12 knots for up to half of the transit, and (c) those traveling more than half of the transit distance above 10 knots/12 knots (Fig. 17).

A preliminary (but, not statistical) comparison of speed distributions between "maximum" speeds and those with a large percentage over particular thresholds (Fig. 17) suggest that either metric may be a reasonable representation of speeds utilized, particularly given the goals of this study and overall monitoring program are (a) determination of number and which vessels are in violation of the regulation (*e.g.*, over 10 knots at any point of the passage), and (b) general characterization of speeds to determine if compliance improves through time. Nonetheless, we anticipate further examination and comparison of these metrics to identify one or more that best represents mariner behavior in SMAs.

Only 5,584 (or 20% of over 28,000) records exhibited maximum speeds at or below 10 knots for the entire transit; 13,800 (49%) were at or under 12 knots for the duration of the transit (Fig. 17). A total of 18,415 (or 64% of all records) exhibited maximum speeds over 10 or 12 knots for the entire transit. However, to the extent that enforcement actions, or monitoring efforts for that matter, rely on any excessive speed above, say, 12 or 13 knots as an indicator of "non-compliance", maximum speed still serves as a measure of relative adherence to the restrictions.

Dynamic Management Areas

Designating Dynamic Management Areas (DMA) is a process of restricting vessels' activities in areas where right whales occur outside the SMAs or in areas encompassed by SMA but when they are not in effect. DMAs could effectively occur anywhere throughout out the range of the species.

The use of dynamically managed areas allows for substantially smaller (in area) and shorter (in duration) seasonal management measures. It also allows for management measures that are tied directly to the known, but perhaps transitory, presence of right whales. When a specific aggregation of right whales is sighted, a temporary zone around the aggregation is established in which speed restrictions applies for 15 days. However, mariner action is voluntary: they are expected, but not required, to either avoid the area or travel through it at 10 knots or less. Zones are in effect for 15 days and automatically expire at the end of that period. If the whale aggregation persists the period may be extended for an additional 15 days.

In 2009, 18 such areas were "triggered" by right whale presence (Table 6), all occurring in waters off New England. We quantified the (a) number of vessels, (b) vessel types, and (c) speeds of vessels passing through each of the DMAs (Table 6; Fig 18). In subsequent analysis, we plan to assess whether mariners were inclined to avoid the areas as opposed to traveling through them.

A total of 1,406 vessels passed through the 18 active DMAs. The majority were tankers (n = 521), nearly twice as many as any other vessel category. Excluding the "other" category, cargo vessels were the second most common type (Table 6). The distribution of vessel speeds through DMAs (Fig. 18) is different than the distribution for vessels traversing SMAs (it was not a "bell-shape" as in the SMA speed distributions). In DMAs, 11 knots was the most common maximum speed; and there appeared to be a higher proportion of vessels traveling 11 knots or less than those vessels traversing SMAs. A second peak occurred at 14 knots with a large portion traveling at 13 and 14 knots; probably reflecting the number of cargo ships and tankers traversing the zones. Many tug and barges and "big-tows" may have limited options in routing around such areas, engaging in largely coastal passages and having specific destinations that require routes through DMAs; whereas larger vessels on more lengthy routes may have the latitude to route around a particular area.

Literature Cited

Bettridge, S., and G.K. Silber. 2008. Update on the Untied States' actions to reduce the threat of ship strikes to large whales. Paper provided to the International Whaling Commission's Working Group on Ship Strikes and Presented at the International Whaling Commission's Conservation Committee, Santiago, Chile, 16 June 2008. 11 pages. Available at: www.nmfs.noaa.gov/pr/shipstrike/.

International Maritime Organization. 1974. International Convention for the Safety of Life at Sea (SOLAS). Adopted 1 November 1974. Available at: http://www.imo.org/Conventions/contents.asp?topic_id=257&doc_id=647.

National Marine Fisheries Service. 2008. Final rule to implement speed restrictions to reduce the threat of ship collisions with North Atlantic right whales. 73 FR 60173; 10 October 2008. Available at: http://www.nmfs.noaa.gov/pr/pdfs/fr/fr73-60173.pdf.

Silber, G.K., and S. Bettridge. 2009. New vessel speed regulations for U.S. east coast ports. Mariners Weather Log 53 (1):8-9. April 2009.

Tables and Figures

Table 1. Dates of active SMAs, number of days analyzed in each, and number of transits analyzed in each in 2009.

Region	Acronym	Times "Active"	Number of SMA days	Number of SMA transits analyzed
Cape Cod Bay	CCB	1 January – 15 May	135	718
Off Race Point	ORP	1 March – 30 April	61	217
Great South Channel	GSC	1 April – 31 July	122	410
Block Island	BI	1 November –30 April	181	1,240
New York	NY	1 November – 30 April	181	7,651
Philadelphia	PHI	1 November – 30 April	181	3,857
Norfolk	NOR	1 November – 30 April	181	4,790
Morehead City	MOR	1 November – 30 April	181	475
North Carolina to Georgia	NC-GA	1 November – 30 April	181	6,502
Southeast U.S.	SEUS	15 November – 15 April	152	2,773
TOTAL			**5,636**	**28,633**

Table 2. Dates of active SMAs. Shaded cells represent SMA in effect.

	CCB	ORP	GSC	BI	NY/NJ	PHI	NOR	MOR	NC-GA	SEUS
Jan										
Feb										
Mar										
Apr										
May										
Jun										
Jul										
Aug										
Sept										
Oct										
Nov										
Dec										

Table 3. Records flagged for removal from analysis and the reason for removal.

Month 2009	**Vessels <20 m**	**Sovereign Vessels**	**Too Few Total Reports**	**No Vessel Length Found**	**"Name Changes"**	**Misc. Corrupted Data**	**Total**
January	1,070	153	199	143	17	18	1,600
February	879	159	193	113	36	24	1404
March	1,354	460	188	337	40	27	2,406
April	995	161	593	20	29	27	1825
May	13	8	4	2	0	2	29
June	2	9	7	1	1	2	22
July	4	7	23	0	0	5	39
November	1,285	202	174	236	50	58	2,005
December	1,418	211	119	142	40	48	1,978
Total	**7,020**	**1,370**	**1,500**	**994**	**213**	**211**	**11,308**

Table 4. Number of records received, removed, and analyzed in 2009.

Month 2009	Total Records Received	Total Records Removed	Total Transits Analyzed
January	6,371	1,554	4,817
February	5,718	1,361	4,357
March	7,532	2,354	5,178
April	6,369	1,785	4,584
May	202	29	173
June	129	20	109
July	174	39	135
November	6,279	1,912	4,367
December	6,841	1,928	4,913
TOTAL	**39,615**	**10,982**	**28,633**

Table 5. Number of transits analyzed, by vessel type, in each of the SMAs in 2009.

SMA	Cargo	Tanker	Passenger	Tow	Tug	Pilot	Other	Total
CCB	22	65	1	205	380	0	45	**718**
ORP	87	71	0	25	23	0	11	**217**
GSC	165	132	35	5	0	0	73	**410**
BI	400	309	8	118	194	0	211	**1,240**
NY-NJ	3,200	1,562	151	896	1,001	127	714	**7,651**
PHI	1,385	779	138	598	517	21	419	**3,857**
NOR	3,382	285	47	181	224	2	669	**4,790**
Morehead	51	30	3	26	25	0	340	**475**
NC-GA	4,116	811	65	176	454	59	821	**6,502**
SEUS	1,606	212	251	278	113	0	313	**2,773**
Total	**14,414**	**4,256**	**699**	**2,508**	**2,931**	**209**	**3,616**	**28,633**

Table 6. Dates, locations and vessels transiting active Dynamic Management Areas.

Event Number	Date of Implementation	#RWs	General Location	Boundaries	Total Area (nm^2)	Days in Effect	Cargo	Tanker	Tow/Big Tow	Tug	Other	Total
E04	1-Jan	7	Jeffreys Ledge	43 24 N 42 40 N 069 44 W 070 46 W	1994.1	29	16	46	42	76	15	195
E05	16-Jan	3	Race Point	42 26 N 41 46 N 069 41 W 070 35 W	1602.7	13	26	44	37	59	36	202
E06	11-Feb	6	Northern Jeffreys Ledge	43 18 N 42 40 N 069 45 W 070 37 W	1445.5	14	7	15	7	9	7	45
E07		5	Southern Jeffreys Ledge	42 56 N 42 18 N 069 32 N 070 24 W	1454.1	14	20	41	2	7	6	76
E08		12	Great South Channel	42 04 N 41 15 N 069 04 W 070 10 W	2416.2	14	18	17	0	1	5	41
E09	17-Mar	3	Georges Shoal	41 45 N 41 05 N 066 50 W 067 43 W	1589.8	11	0	0	0	0	0	0

Event Number	Date of Implementation	#RWs	General Location	Boundaries	Total Area (nm^2)	Days in Effect	Cargo	Tanker	Tow/Big Tow	Tug	Other	Total
E10	13-Apr	5	Georges Shoal	41 51 N 41 09 N 067 05 W 068 01 W	1761.5	12	1	0	0	0	0	1
E11	12-May	15	Cashes Ledge	43 08 N 42 30 N 068 26 W 069 35 W	1923.3	15	6	13	0	0	8	27
E12	13-May	3	Jordan Basin	43 42 N 43 02 N 068 14 W 069 09 W	1599.3	14	15	33	0	1	11	60
E13	2-Jun	37	Cashes Ledge	43 06 N 42 07 N 068 15 W 069 56 W		27	34	49	3	0	30	116
E14	9-Jul	3	Cashes Ledge	43 06 N 42 07 N 068 15 W 069 56 W		13	21	23	0	0	36	80
E15	2-Sep	5	Fippenies Ledge	43 11N 42 31N 068 48W 069 44W		14	3	7	2	0	21	33
E16	15-Oct	11	Jeffreys Ledge	43 21N 42 35N 069 45W 070 48W		27	9	23	28	27	47	134

Event Number	Date of Implementation	#RWs	General Location	Boundaries	Total Area (nm^2)	Days in Effect	Cargo	Tanker	Tow/Big Tow	Tug	Other	Total
E17	22-Oct	7	Jordan Basin	43 50N 43 06N 068 02W 069 02W		41	27	52	8	0	3	90
E18	27-Oct	16	Cashes Ledge	43 24N 42 35N 068 28W 069 36W	2437.1	15	4	11	2	0	3	20
E19	10-Nov	30	Jeffreys Ledge	43 33N 42 32N 069 27W 070 49W		40	18	117	23	34	56	248
E20	10-Nov	47	Cashes Ledge	43 22N 42 21N 068 26W 069 42W		14	7	22	1	0	0	30
E21	4-Dec	27	Jordan Basin	43 47N 42 47N 067 47W 069 23W		15	0	8	0	0	0	8
						Total	**232**	**521**	**155**	**214**	**284**	**1406**

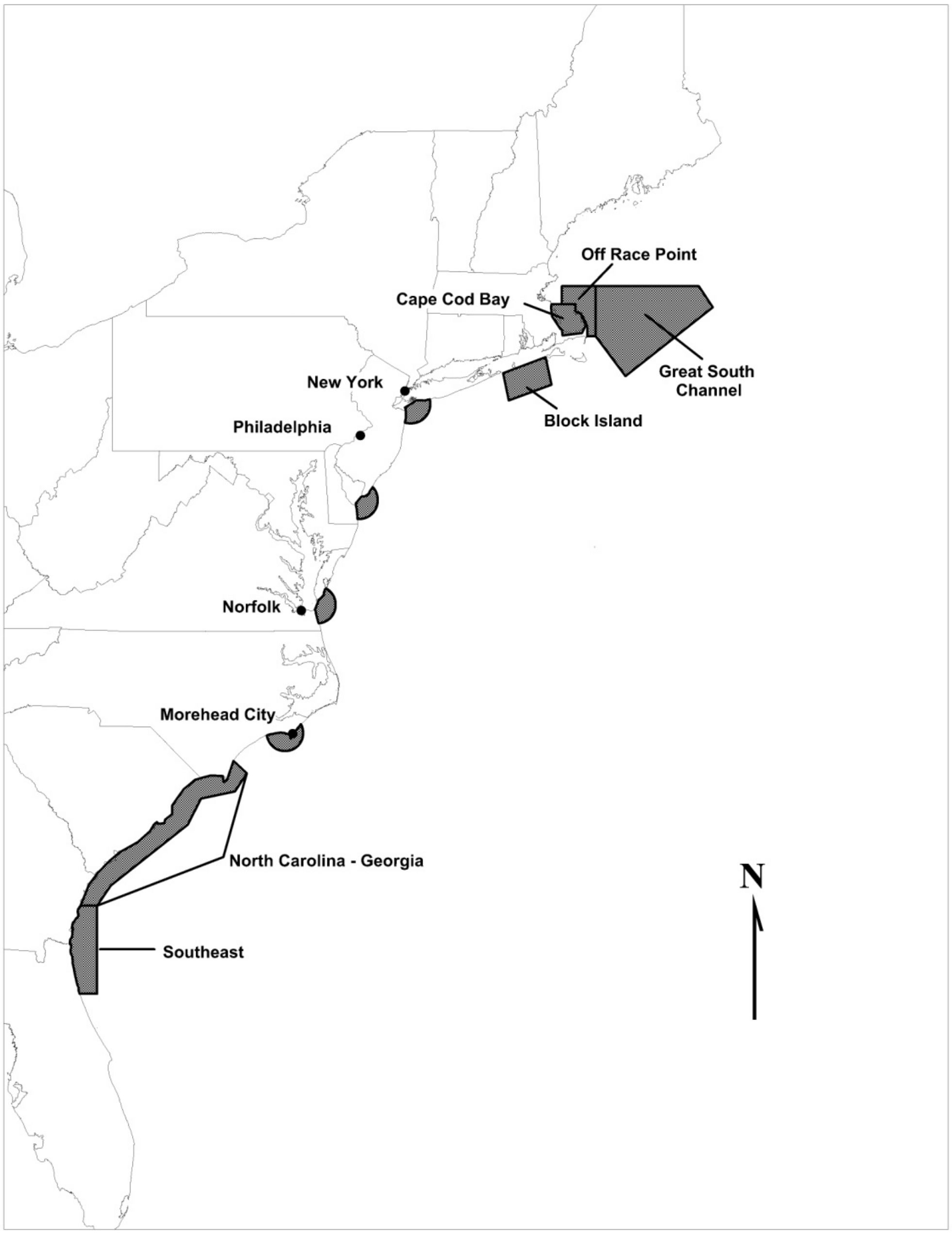

Figure 1. Locations of vessel speed reduction Seasonal Management Areas.

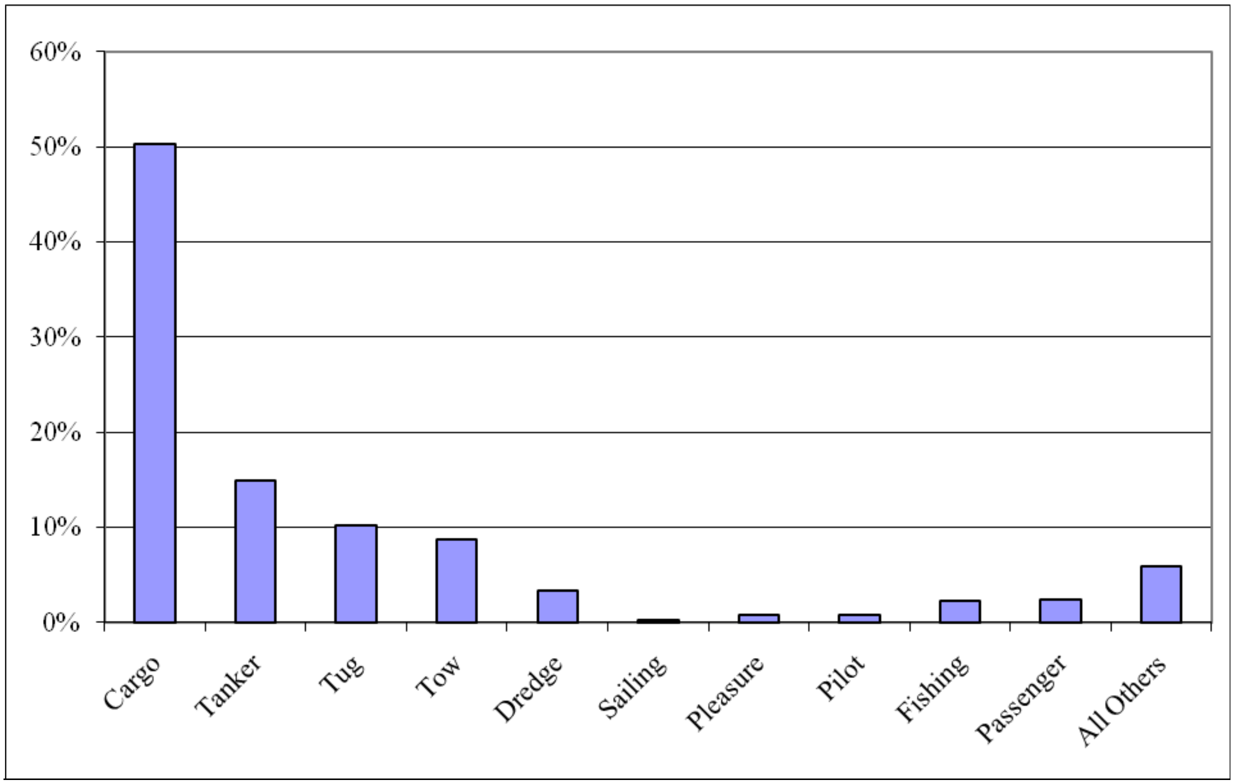

Figure 2. Distribution of vessel types transiting all SMAs in 2009.

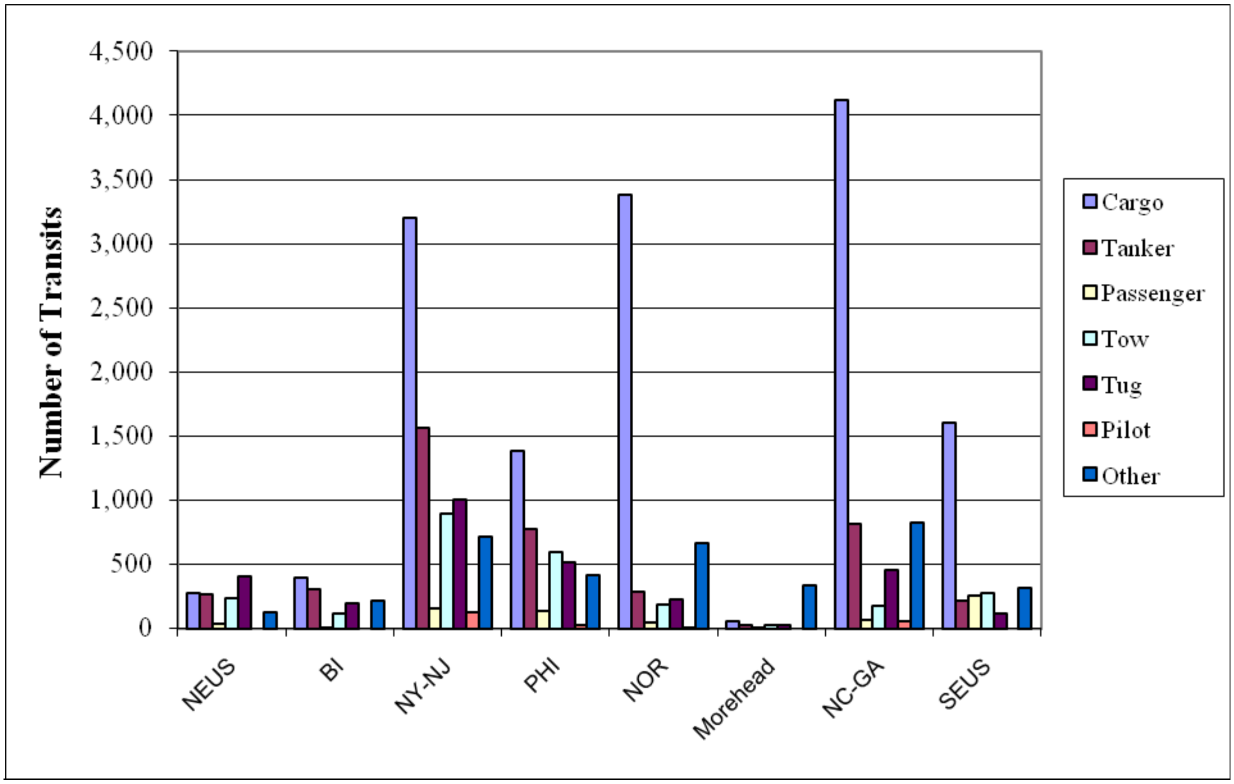

Figure 3. Number of transits in each SMA by vessel type. (Note: CCB, GSC and ORP SMAs were collapsed into "NEUS" category for this figure because the numbers of transits in each of these SMAs were too small to register on this graph.)

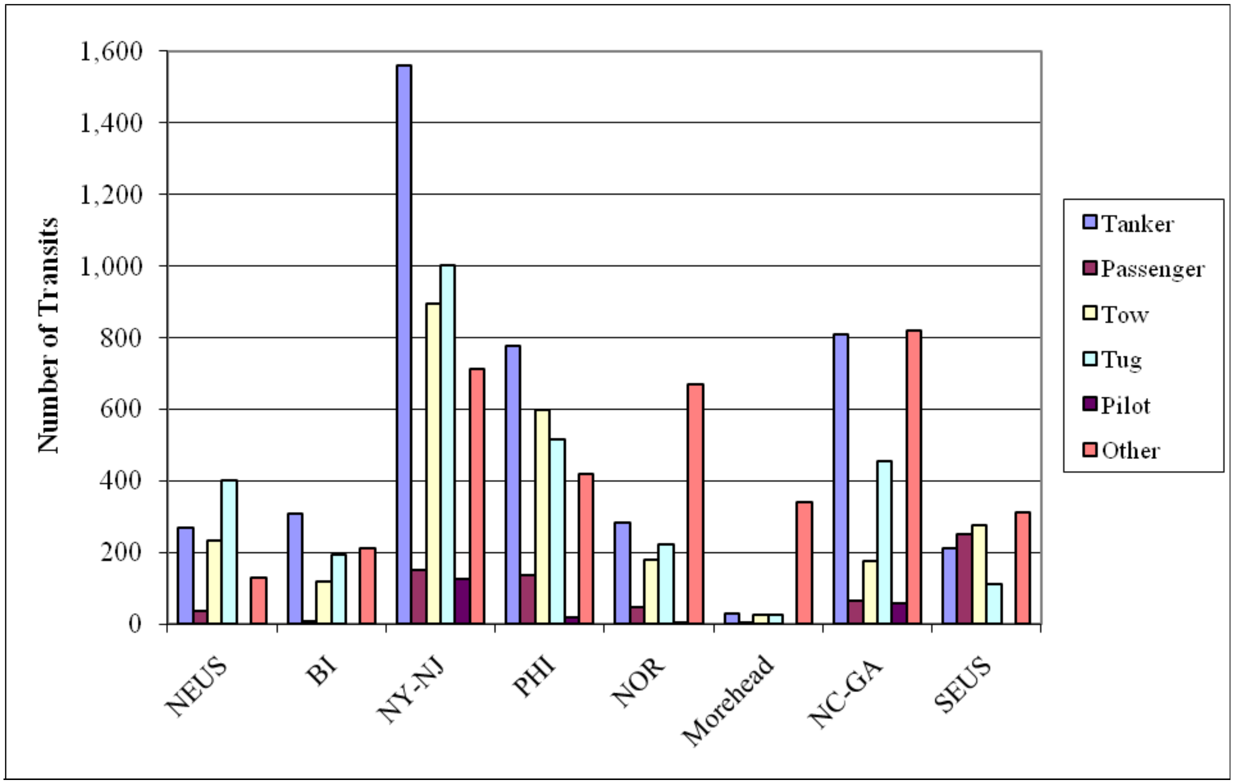

Figure 4. Number of transits in each SMA by vessel type with cargo vessels removed to provide finer detail on other vessel types. (Note: CCB, GSC and ORP SMAs were collapsed into "NEUS" category for this figure because the numbers of transits in each of these SMAs were too small to register on this graph.)

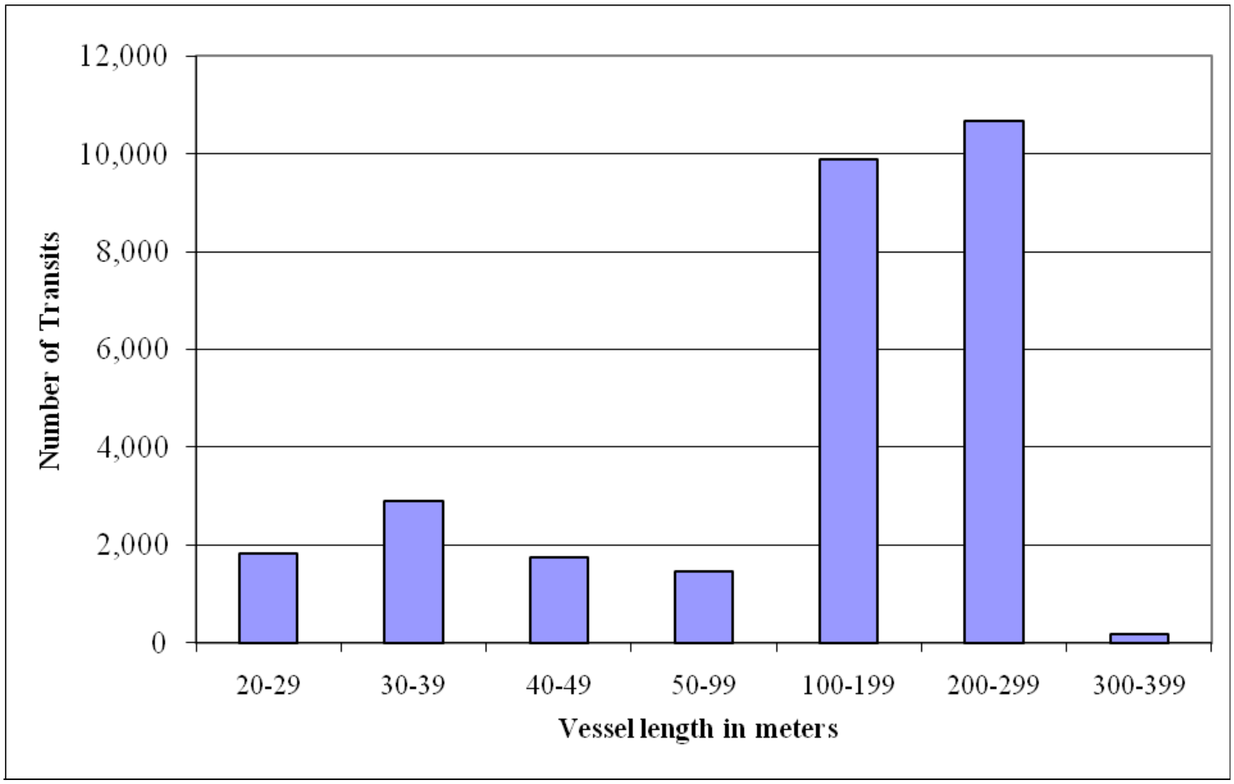

Figure 5. Distribution of vessel lengths transiting all SMAs in 2009.

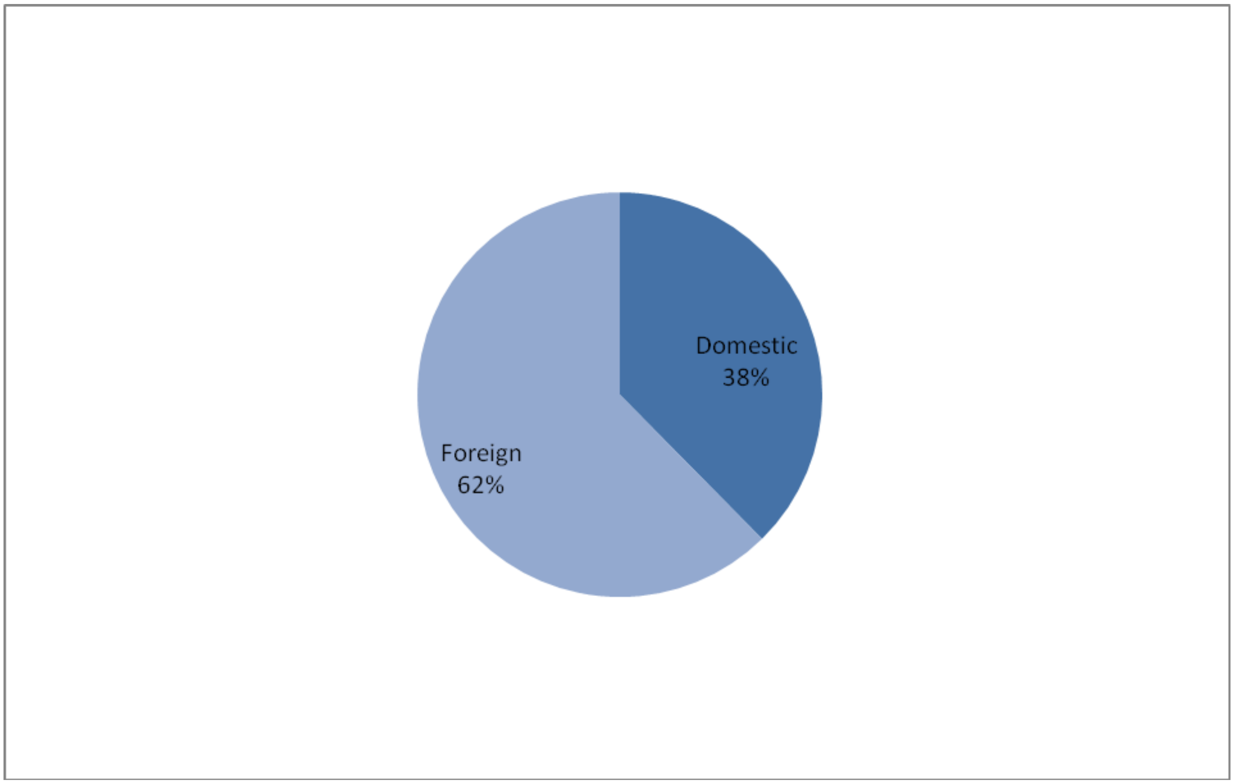

Figure 6. Proportion of domestic and foreign flag vessels transiting all SMAs in 2009.

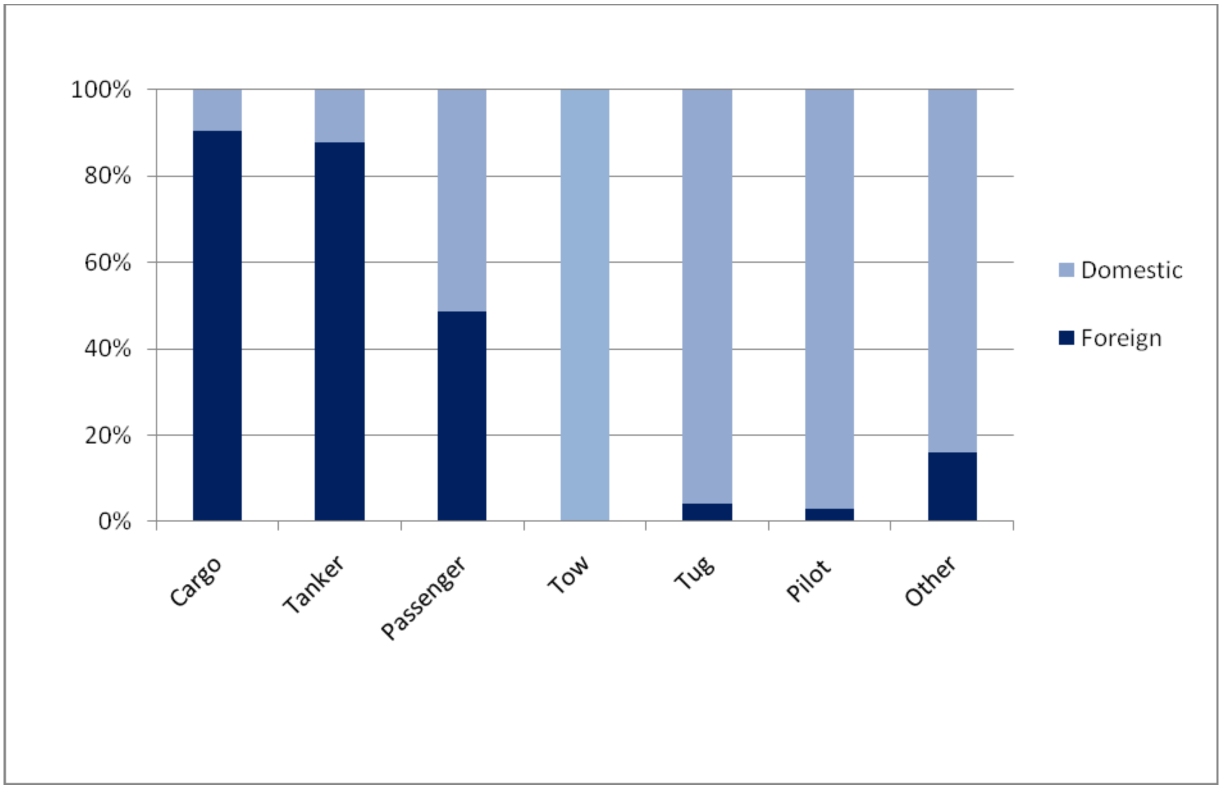

Figure 7. Country of origin by vessel type.

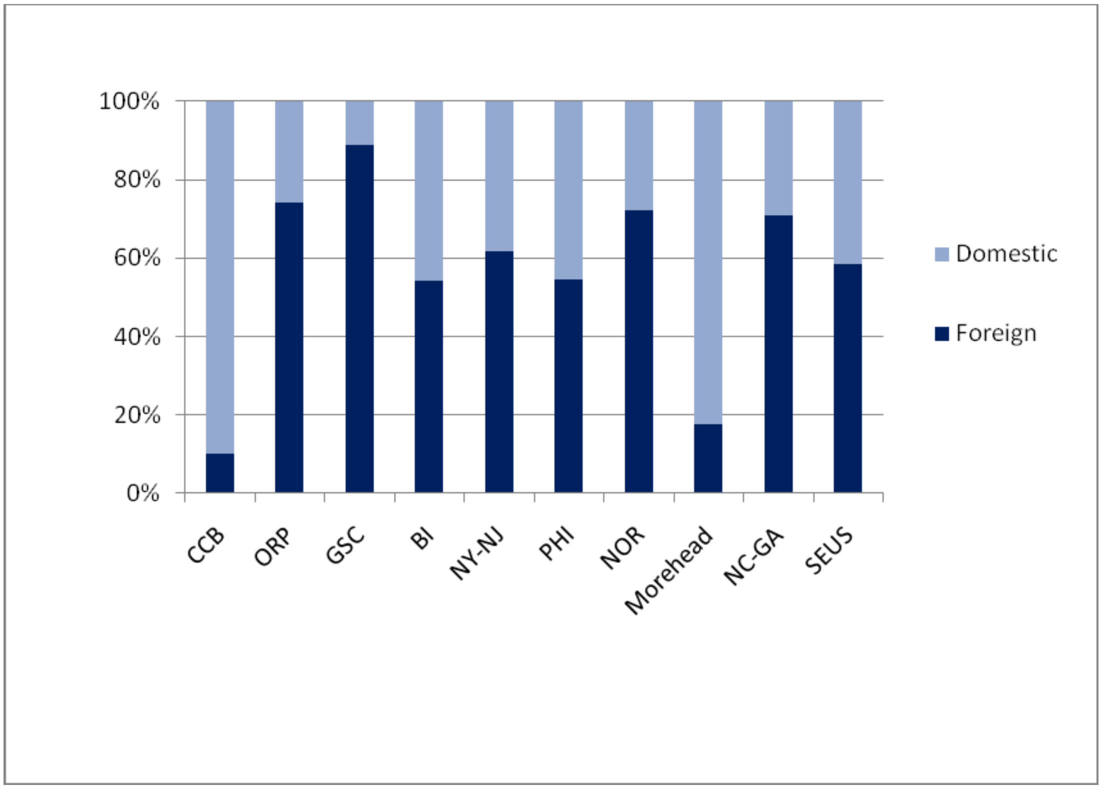

Figure 8. Proportion of use of each SMA by domestic and foreign flag vessels, 2009.

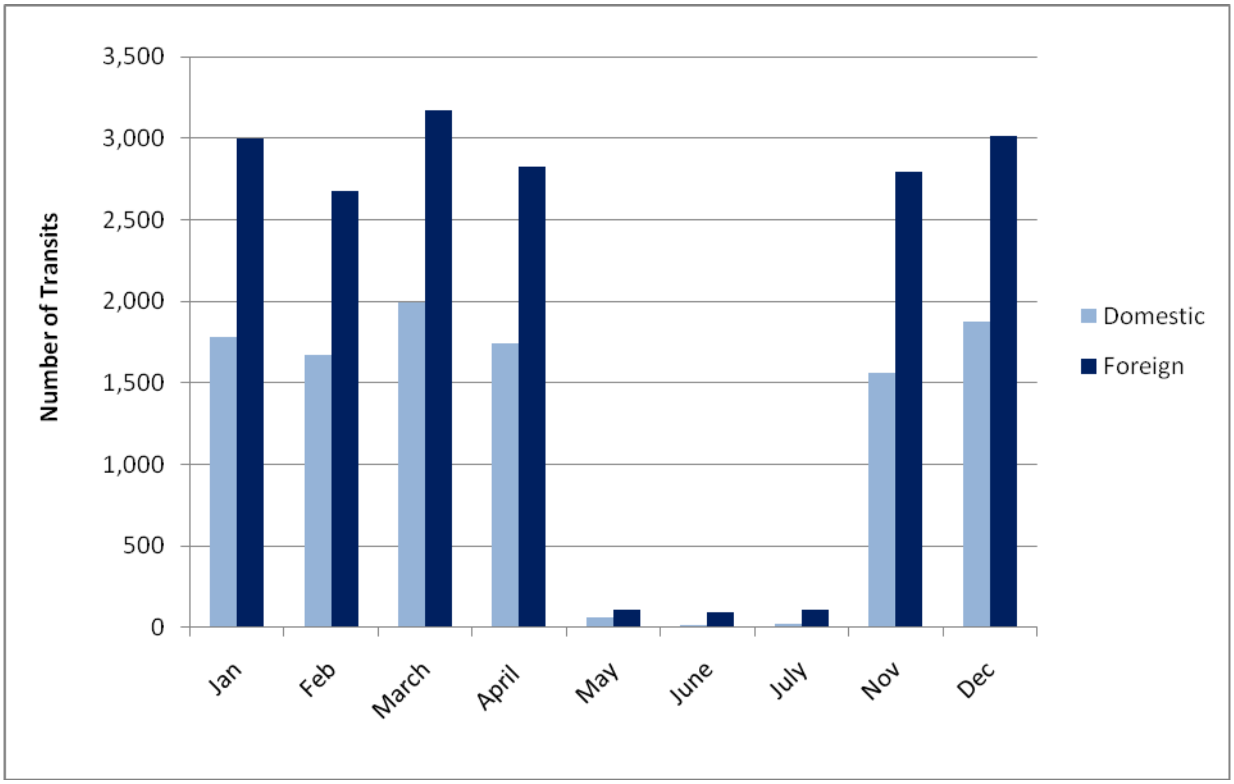

Figure 9. Monthly distributions of domestic and foreign vessels, 2009.

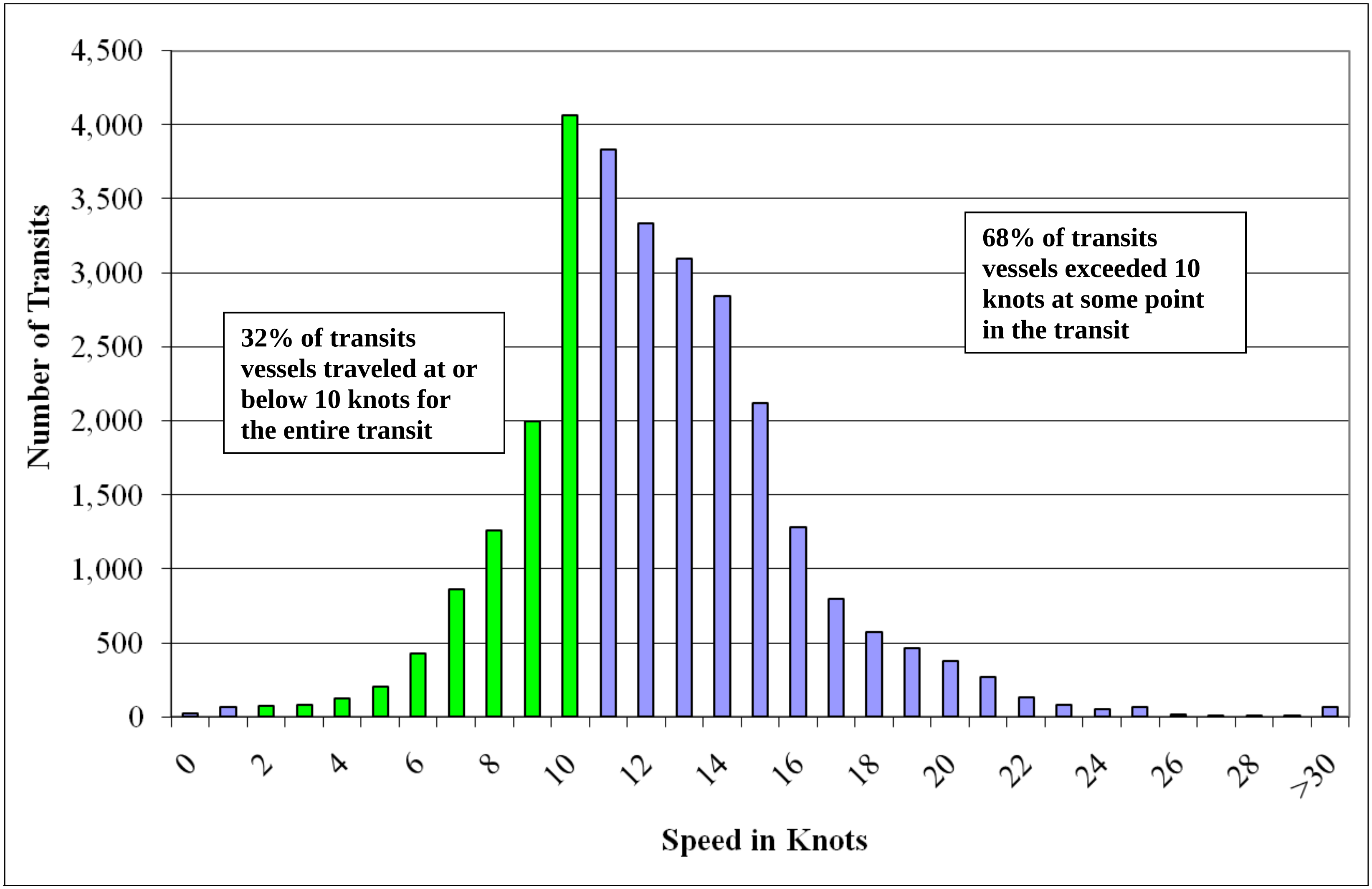

Figure 10. Distribution of vessel speeds, as described by "maximum speed over ground", used in all SMA transits in 2009.

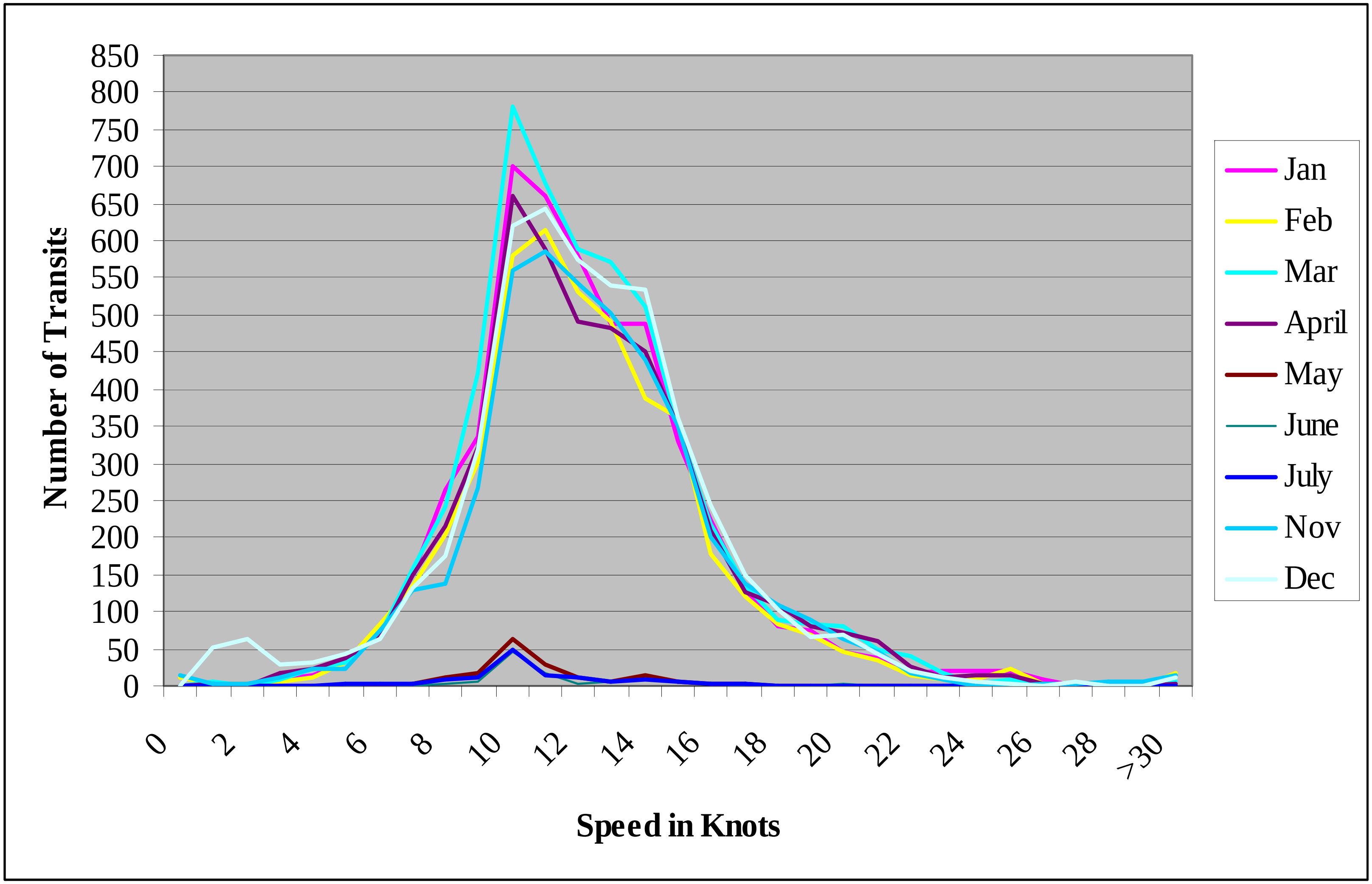

Figure 11. Distribution of vessel speeds, as described by “maximum speed over ground”, used in all SMA transits in 2009 by month.

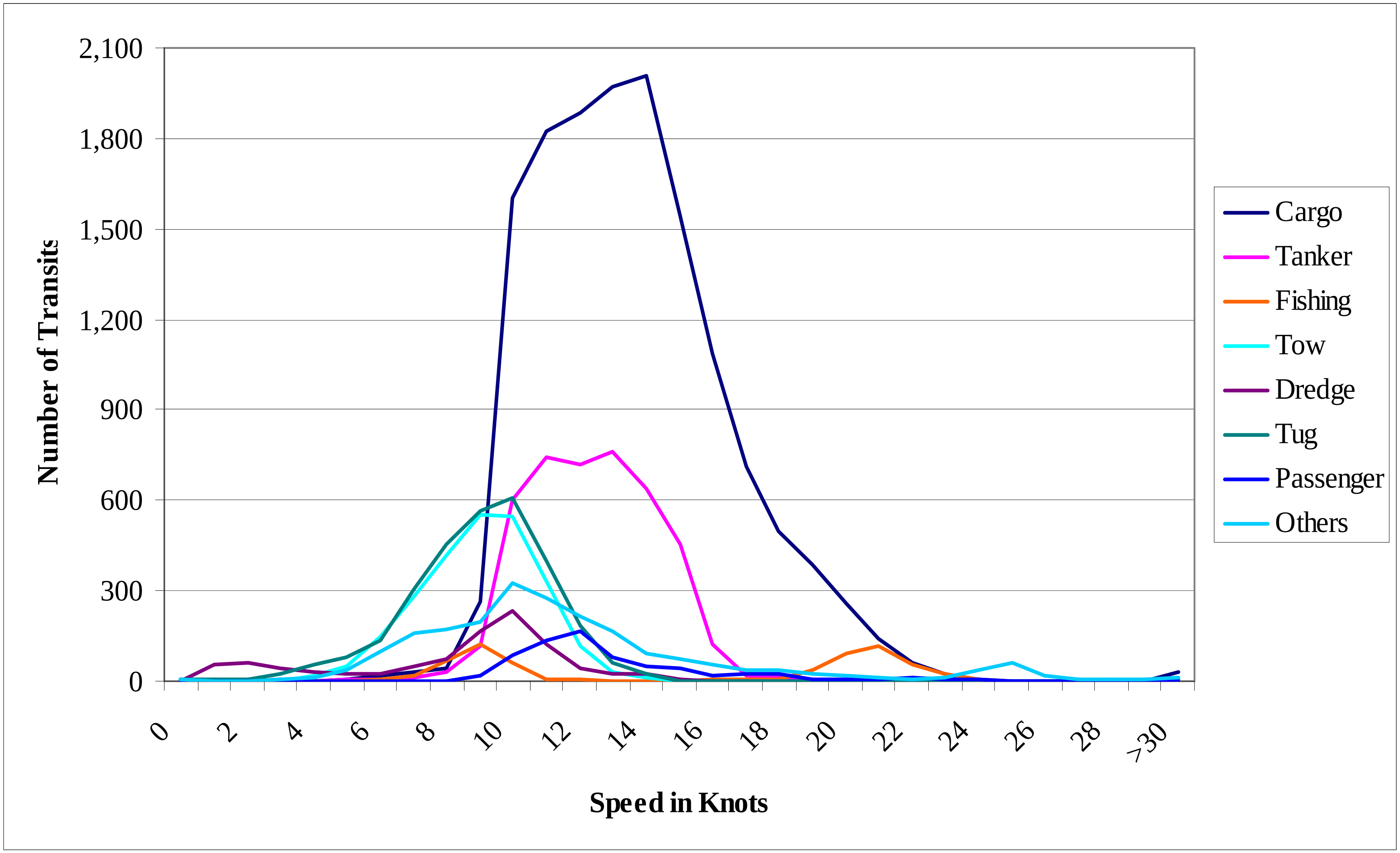

Figure 12. Distribution of vessel speeds, as described by “maximum speed over ground”, used in all SMA transits in 2009 by each vessel type.

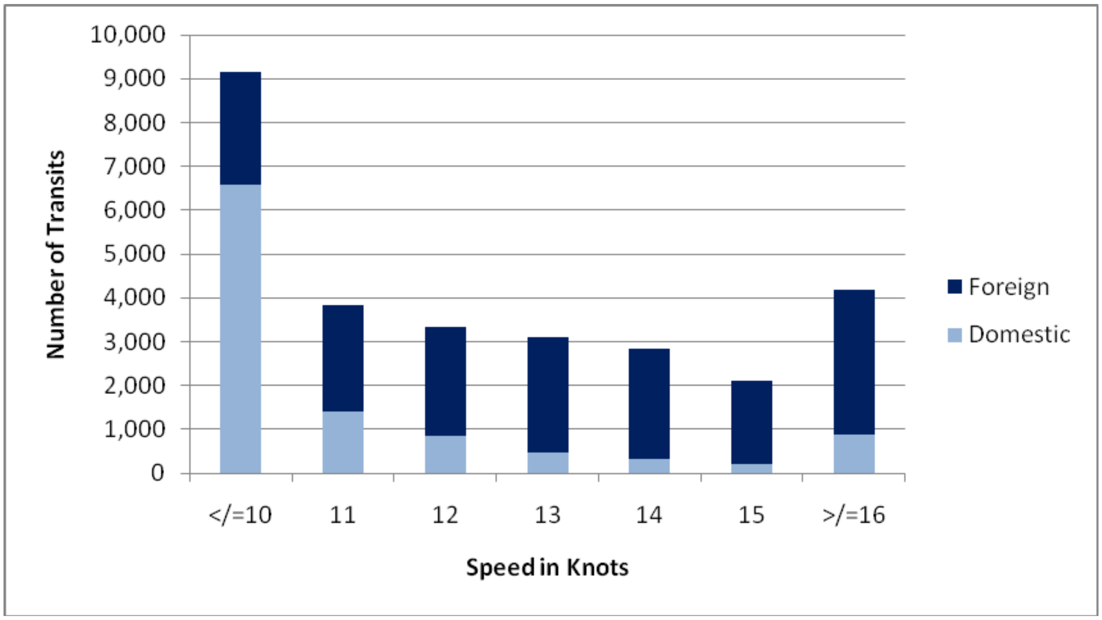

Figure 13. Vessel speed as a function of country of origin.

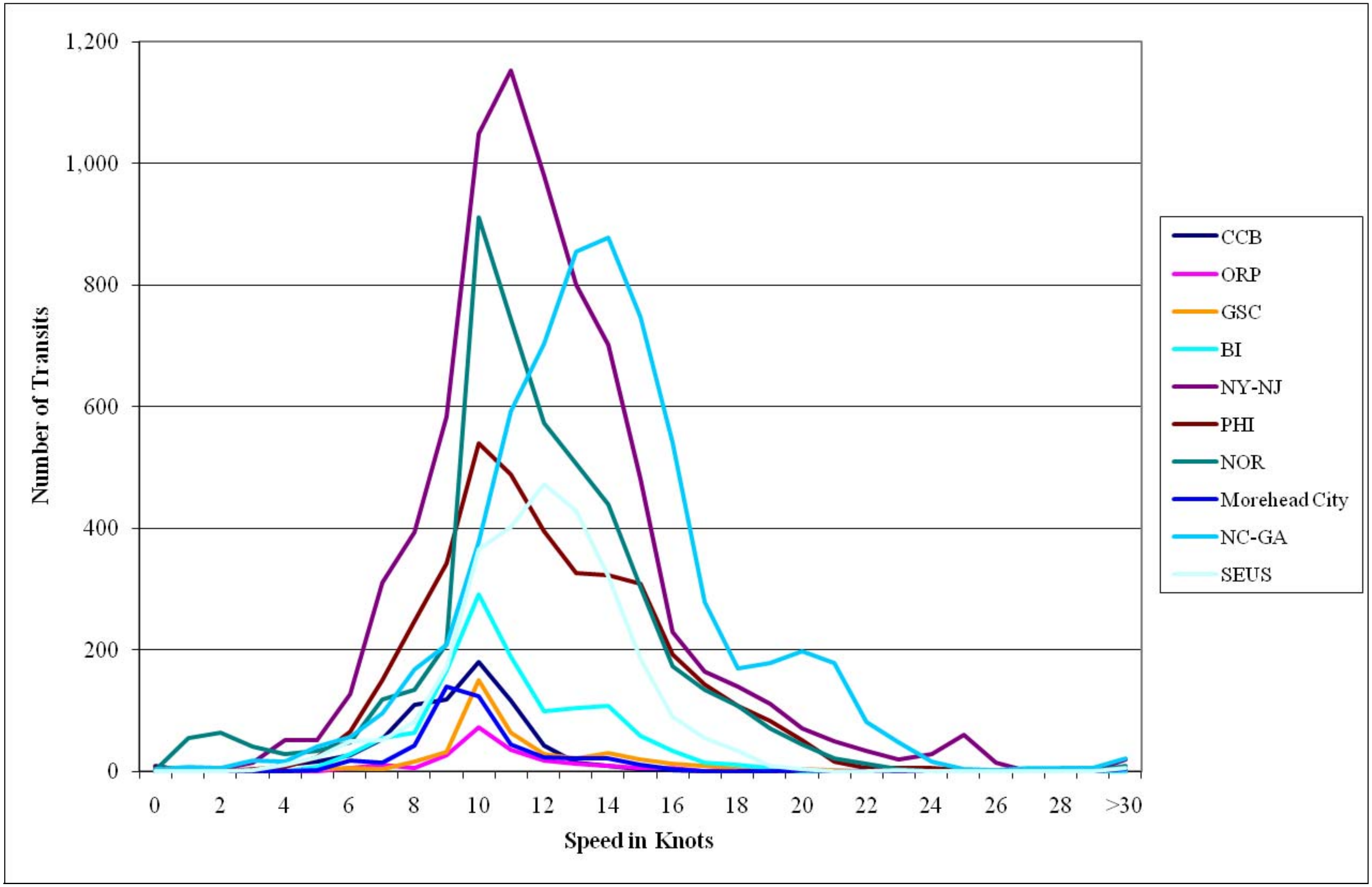

Figure 14. Distribution of vessel speeds, as a function of “maximum speed over ground” used in each of the SMAs.

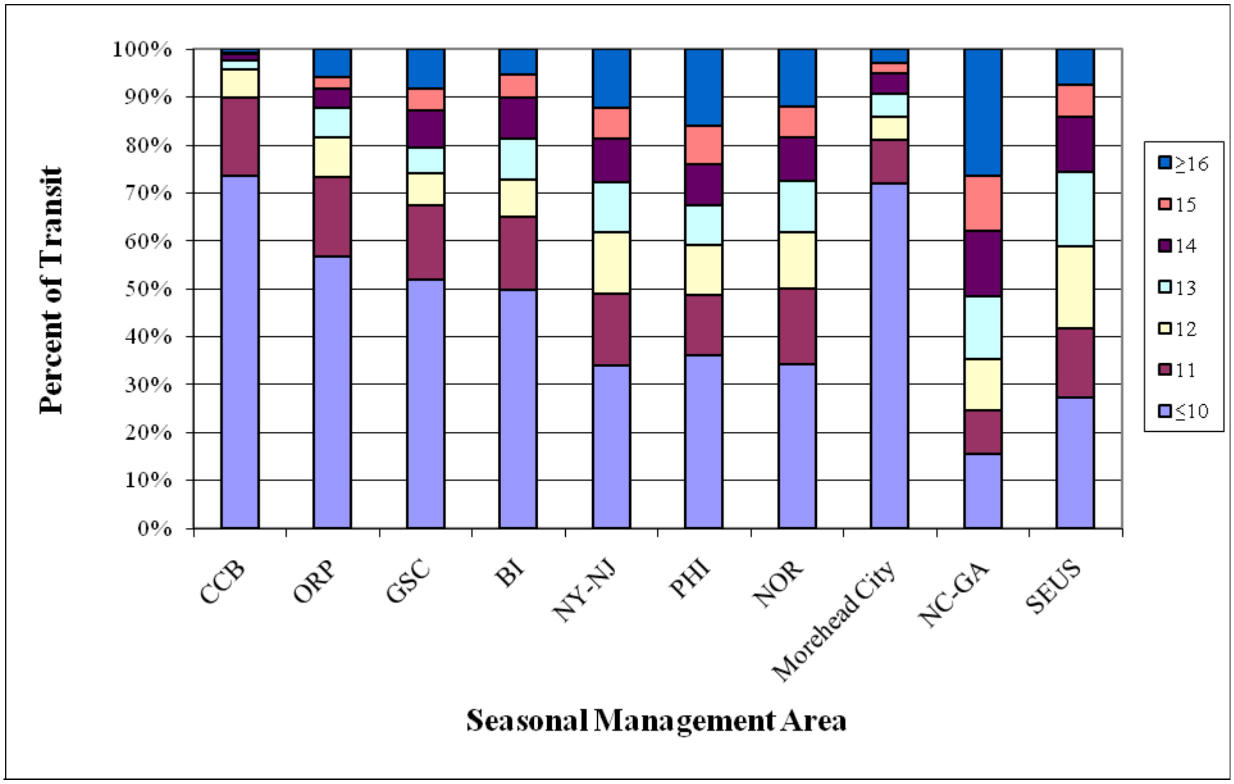

Figure 15. Distribution of vessel speeds, displayed as a percent of the total transit, as a function of “maximum speed over ground” used in each of the SMAs.

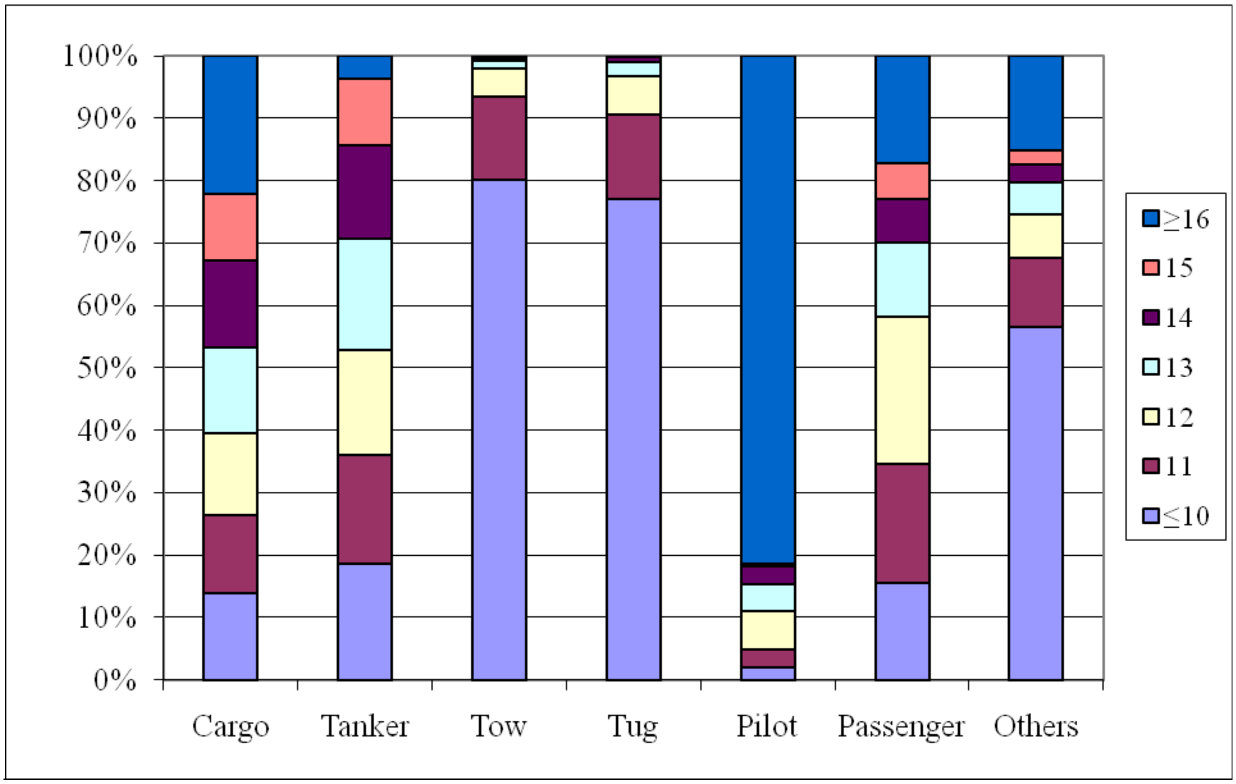

Figure 16. Distribution of vessel speeds, displayed as a percent of the total transit, as a function of “maximum speed over ground” by vessel type.

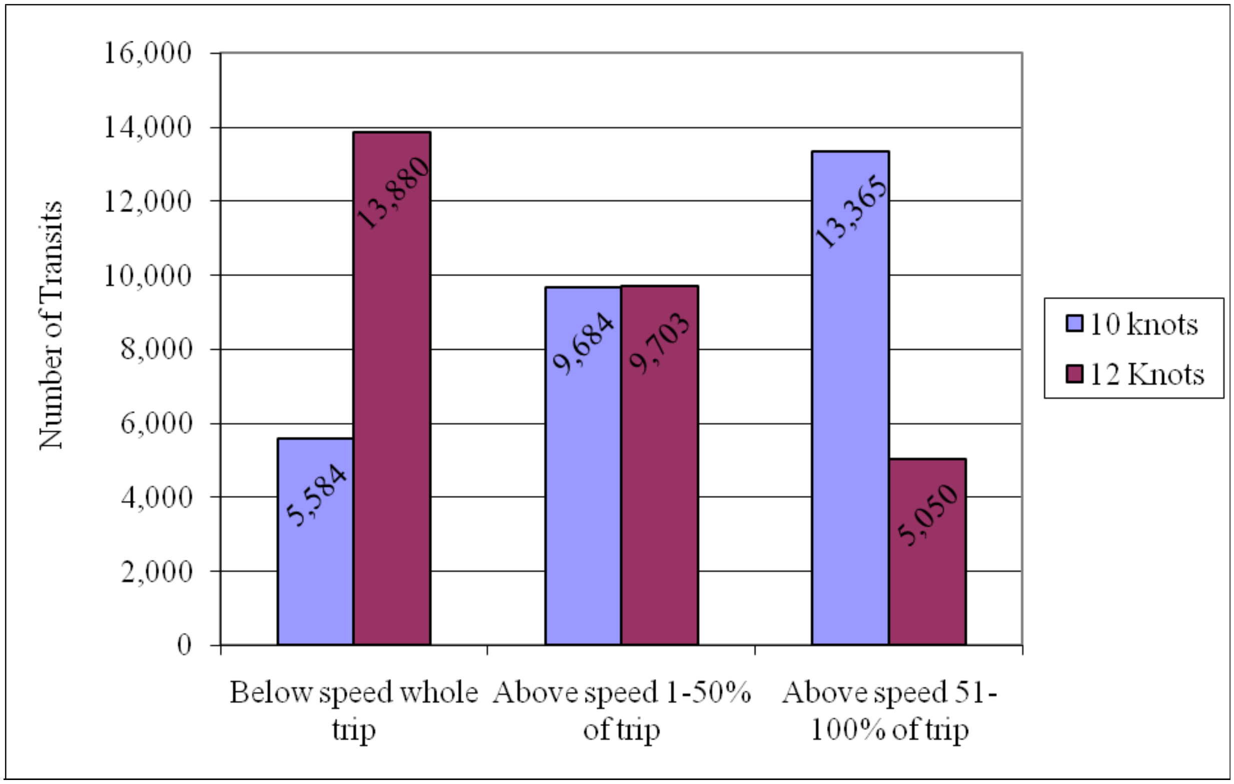

Figure 17. Number of transits in which vessel speed was a) below 10 or 12 knots for the entire distance; b) above 10 or 12 knots for 1-50% of the distance; or c) above 10 or 12 knots for 51-100% of the distance, for all SMAs in 2009.

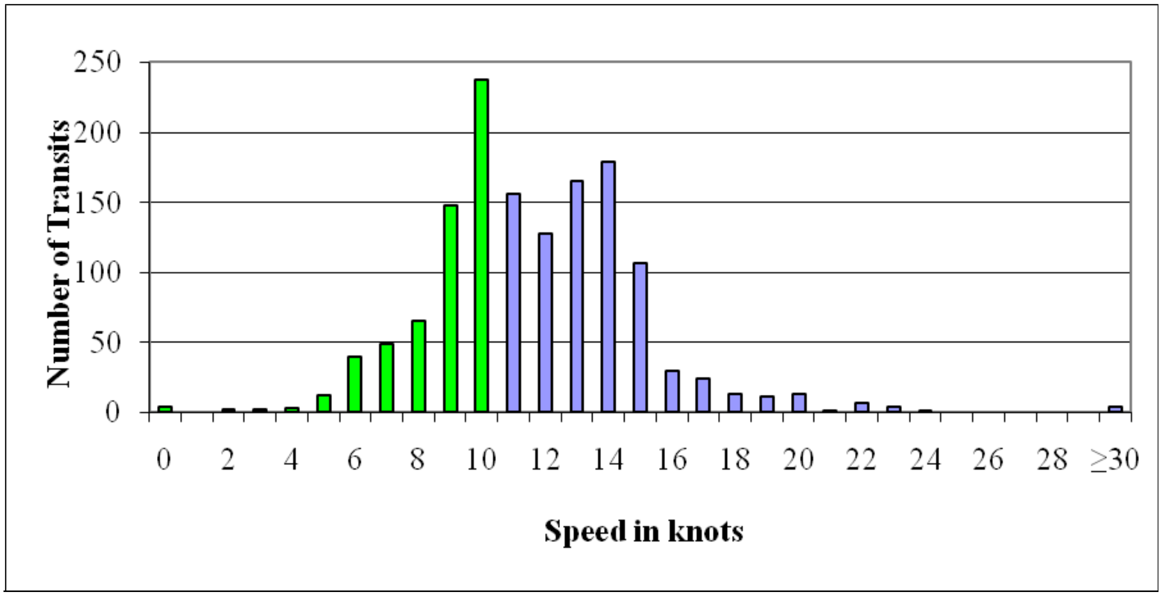

Figure 18. Distribution of speeds of vessels traveling through Dynamic Management Areas.