An Assessment of the Final Rule to Implement Vessel Speed Restrictions to Reduce the Threat of Vessel Collisions with North Atlantic Right Whales

Gregory K. Silber and Shannon Bettridge

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
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Gregory K. Silber and Shannon Bettridge
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

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John E. Bryson, Secretary

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

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Samuel D. Rauch, Acting Assistant Administrator for Fisheries

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Silver Spring, MD 20910

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EXECUTIVE SUMMARY

On 10 October 2008 the U.S. National Marine Fisheries Service (NMFS) published a "Final rule to implement speed restrictions to reduce the threat of ship collisions with North Atlantic right whales" (73 FR 60173). The rule requires that vessels 65 feet and greater in length travel at 10 knots or less near key port entrances and in certain areas of right whale aggregation along the U.S. eastern seaboard, known as "Seasonal Management Areas". Text in the preamble of the rule indicated NMFS's intention to also develop a "Dynamic Management Area" program to protect unpredictably occurring aggregations of right whales whereby mariners would be requested, but not required, to avoid temporarily established areas or travel through them at 10 knots or less. This "ship strike" reduction rule is set to expire five years from its effective date on 9 December 2013, before which NMFS was expected to develop ways to monitor and assess the rule's effectiveness at reducing ship strikes of right whales.

To this end, NMFS convened a workshop in November 2008 to determine ways to measure the rule's effectiveness. Among other things, the workshop concluded that regardless of the metrics developed to assess effectiveness, detecting meaningful biological effects of the restrictions would be difficult prior to the five-year expiration. This conclusion, notwithstanding, the workshop developed four metrics, that when combined, might provide a characterization of a possible reduction in ship strike deaths, as well as mariner response to, and economic impacts of, the vessel speed restrictions. The workshop also indicated that given the time needed for the agency to consider actions prior to the expiration of the rule, a report assessing the effectiveness of the regulations should be developed for NOAA leadership by December 2011. This is that report.

The four areas of assessment identified in the 2008 workshop report, and discussed in this report are (1) possible changes in ship strike death rates (*i.e.*, biological effectiveness); (2) changes in vessel operations in response to the regulations (*i.e.*, mariner response); (3) a quantification of mariner outreach and education efforts, and (4) economic impacts resulting from the rule. Results of a separate study on voluntary mariner response to Dynamic Management Areas are also discussed.

Results herein are based on statistical analyses of the occurrence of 55 large whale (all species of large whale) ship strike deaths or serious injuries over the course of 10 years. We also analyzed literally hundreds of millions of remotely-sensed vessel Automatic Identification System data points used to characterize vessel operations and to assess the economic impacts represented in over one hundred thousand passages made by over 6,000 individual vessels within both Seasonal and Dynamic Management Areas. We also evaluated maritime community awareness-raising efforts that were coordinated by a number of NMFS personnel and mediated through hundreds of contacts using various print and broadcast media.

Summary of conclusions:

- Although these data sets (including both vessel operations and biological data) were substantial and the analyses thorough, our findings are inconclusive regarding the biological effectiveness of the rule in achieving its objectives, because the time allotted (based on a sampling period of only two years given the timing of the expiration of the rule and to allow sufficient time to develop this report) to determine its biological effectiveness was simply too brief.
- A statistical assessment of the time needed to detect a change in the rate of ship strikes indicated that two years was an insufficient period to make a meaningful determination regarding a reduction in ship strikes. However, based on three separate statistical analyses, there may be "a meager amount of evidence" in support of a reduction in ship strike deaths and serious injuries of large whales; and at least five years are needed to detect substantial biological effects.
- Mariner compliance with the requirements of the rule was relatively low in 2009 and 2010, but it exhibited a marked improvement in 2011. Compliance was consistently low in "foreign-flagged" vessels.
- The outreach program used to inform the maritime community about vessel speed restrictions appeared to "blanket" the affected communities rather well. Although it was extensive in scope and a variety of communications outlets were employed, improvements in the program, particularly with regard to "non-domestic" vessel operators, appears warranted.
- The maximum estimated total (*i.e.*, direct and indirect) economic impacts resulting from the vessel speed restrictions were $52.4M and $79.0M using 2009 and 2012 bunker fuel prices, respectively. These are revisions to the 2008 projected economic impact of $137.3M. The new estimates assumed 100% compliance with the provisions of the rule and as such represent maximum economic impacts.
- Mariner adherence to voluntary speed restrictions within or avoidance of Dynamic Management Areas was minimal.
- The justification and reasoning for initially establishing vessel speed restrictions still stand. In addition, independent studies conducted since the rule was enacted indicate that the probability of a struck whale being killed or seriously injured is reduced as vessel speed diminishes and further that NMFS' vessel speed restrictions, in particular, are reducing the risk of fatal ship strikes or right whales. Therefore, the reasons for establishing speed limits and these more recent findings strongly suggest that the use of vessel speed restrictions should continue.
- Last, we provide suggestions about steps to improve the vessel-strike reduction program, including possible modifications to the provisions of the rule itself and various related aspects of the program that will enhance their value to right whale conservation.

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We thank a number of contributors and our counterparts in NMFS who helped make this report possible. These include Jeff Adams, Michael Asaro, Cheryl Bonnes, Kam Chin (Volpe Transportation Center), Tim Cole, David Cottingham, Laura Engleby, David Gouveia, Carliane Johnson (SeeJay Environmental), Kristin Koyama, Richard Merrick, David Phinney (Volpe Transportation Center), Barb Zoodsma, and the participants of the 2008 workshop on assessing the effectiveness of the rule. The USCG's National Automatic Identification System program provides a wealth of information on vessel operations and has allowed us to make a number of conclusions contained herein.

TERM AND ACRONYM LIST

ACOE	United States Army Corps of Engineers
AIS	Automatic Identification System
BI	Block Island
CCB	Cape Cod Bay
COPPS	Community Oriented Policing and Problem Solving Letters
CSA	Chamber of Shipping of America
DMA	Dynamic Management Area
GPS	Global Positioning System
GSC	Great South Channel
IMO	International Maritime Organization
ITU	International Telecommunications Union
MMSI	Maritime Mobile Service Identity
MOA	Memorandum of Agreement
MOR	Morehead City, South Carolina
MSR	Mandatory Ship Reporting
NAIS	National Automatic Identification System
NMFS	National Marine Fisheries Service
NC-GA	Wilmington, North Carolina to Savannah, Georgia

NEUS	Northeast United States
NOAA	National Oceanic and Atmospheric Administration
NOAA OLE	NOAA Office of Law Enforcement
NOR	Norfolk
NOVA	Notices of Violation
NY-NJ	Port of New York and New Jersey
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
USN	United States Navy
VHF	very high frequency
WSC	World Shipping Council

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INTRODUCTION

The greatest known anthropogenic threat to the recovery of the highly depleted North Atlantic right whale (*Eubalaena glacialis*) is at-sea collisions with vessels (for the purposes of the report, also called "ship strikes") (Clapham *et al*., 1999; Kraus *et al*., 2005, NMFS, 2005; Knowlton and Brown, 2007). In a population believed to be comprised of 350-550 individuals, any mortality caused by human activity is cause for concern, especially if these threats are preventing the population from recovering from potential extinction. Over the 20-year period from 1986-2005, 50 documented right whale deaths occurred, 19 of which were attributed to vessel strikes (the cause of death could not be determined in the majority of the other of the cases) (Knowlton and Kraus, 2001; Kraus *et al*., 2005; Glass *et al*., 2010). These are likely minimum counts because not all dead whales are detected particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass *et al*., 2010).

There is no evidence that the number of human-caused right whale deaths has diminished in recent years. An average of about two known North Atlantic right whale deaths and serious injuries from vessel strikes occurred annually in 2004 through 2008 (2008 being the most recent years for which peer-reviewed mortality counts are available) (Glass *et al*., 2010; Waring *et al*., 2010).

Right whales are more likely, per capita, to suffer a vessel strike than any other large whale species (Vanderlaan and Taggart, 2007). The factors contributing to their vulnerability to vessel strikes, although not fully clear, most likely relate to the species' coastal distribution that exposes them to high density vessel traffic, their tendency to spend considerable amounts of time at the surface, and that they tend to exhibit little or no vessel avoidance behavior (Terhune and Verboom, 1999; Nowacek *et al*., 2004). Avoiding an advancing ship, even if it was perceived as a threat (and there is no evidence for this), is not likely an inherent behavioral response for right whales (Ford and Reeves, 2008).

The endangered status of the right whale and the magnitude of vessel-strike threat to the species in the Northwest Atlantic Ocean has prompted the National Oceanic and Atmospheric Administration (NOAA) to develop and implement a number of management actions to reduce this threat (Bettridge and Silber, 2008; Silber *et al*., submitted). Among these actions were mandatory or recommended changes in vessel-routing practices (Silber *et al*., submitted), and mandatory or recommended vessel speed restrictions (NMFS, 2004; NMFS, 2008). In particular, NOAA instituted regulations that restrict vessel speeds in certain areas and at certain times along the U.S eastern seaboard where right whales feed, migrate, socialize, and rear their young (NMFS, 2008).

The U.S. National Marine Fisheries Service's (NMFS) Final Rule to reduce the severity and likelihood of vessel strikes to North Atlantic right whales went into effect on 9 December 2008 (73 FR 60173; 10 October 2008). The stated goal of the rule was "*to reduce or eliminate the threat of ship strikes [of North Atlantic right whales] - the primary source of mortality in the endangered population*." It requires that vessels 65 feet and greater in length travel at speeds of

10 knots or less near several key port entrances and in certain areas of right whale aggregation and along the U.S. eastern seaboard, known as "Seasonal Management Areas" (SMA) (Fig. 1). These SMAs are in effect during certain times of the year that correspond to right whale seasonal movement and aggregation patterns (Fig. 2). NMFS's Office of Law Enforcement (OLE) is responsible for enforcing the provisions of the vessel speed restriction rule. The U.S. Coast Guard (USCG) and others have taken a number of steps to assist in these efforts.

As indicated in the preamble to the rule, a program of "Dynamic Management Areas" (DMA) was also established whereby temporary zones (15 days in duration, generally) are created around aggregations of right whales occurring outside of SMAs. Mariners are asked, but not required, to either avoid established DMAs altogether or travel through them at speeds of 10 knots or less. This approach provides NMFS with complimentary measures aimed at protecting both predictable and recurring seasonal right whale presence as well as the option to react quickly to the occurrence of unexpected aggregations. The latter may be linked, for example, to shifting presence of right whale prey.

Vessel speed has been implicated as a principal causal factor in both the occurrence and severity of vessel-whale collisions, and therefore formed the basis for NMFS's ship strike reduction measures. Studies indicate that vessel speed restrictions can reduce the probability of serious injury or death resulting from a vessel strike (Pace and Silber, 2005; Vanderlaan and Taggart, 2007). Recent studies also indicate that the likelihood of occurrence of a strike is also lowered by reduced vessel speed (Gende *et al*., 2011); and that the size of the area around a ship's hull in which a whale is drawn to the vessel (thereby increasing the exposure to a strike) and the magnitude of the impact involved in a whale-vessel collision is diminished by reduced vessel speed (Campbell-Malone, *et al*., 2008; Silber *et al*., 2010). Studies conducted since establishment of the vessel speed rule have contributed to a growing body of literature on this subject (Vanderlaan *et al*., 2009; Vanderlaan and Taggart, 2009; Gende *et al*., 2011; Lagueux *et al*., 2011; Wiley *et al*., 2011) indicating that lowered vessel speeds reduce the risk of fatal whale strikes. Of these, Lagueux *et al*. (2011) and Wiley *et al*. (2011) concluded that NMFS's 2008 10-knot vessel speed restrictions, in particular, reduced the risk of lethal strikes of right whale by 38.5% and 56.7% in waters off the southeast U.S. coast and New England, respectively. Therefore, the arguments used to establish vessel speed restrictions to reduce fatal strikes of right whales – and as backed by more recent studies – still support continued use of the restrictions.

The rule is set to expire five years from the date of its publication. NMFS indicated that it would develop ways to monitor the effectiveness of the rule. Therefore, NMFS committed to (a) developing means to monitor the rule's effectiveness, (b) assessing its overall effectiveness, and (c) preparing a report of the findings, which have been compiled as this report This is that report.

Workshop to Assess the Effectiveness of the Final Rule

Given the need to monitor the relative success of the rule, NMFS's Office of Protected Resources convened a workshop in November 2008 to determine ways to assess the effectiveness of the vessel speed restrictions in achieving their goals (Silber and Bettridge, 2009;

excerpts of this report (*i.e*., the Executive Summary, only, for the sake of brevity) are provided in Appendix A). The goal of the workshop was to:

> "*develop a strategy, involving multiple components, to monitor and assess whether vessel speed regulations are achieving the rule's intent of reducing the occurrence of ship strikes in right whales (i.e., whether the rule is "effective")*."

Among other things, the workshop concluded that:

> "*The final rule contains a provision that the regulations would expire five years after implementation. With regard to the expiration, the workshop concluded that at that time, NMFS would (a) re-issue the regulations, (b) modify the regulations, or (c) allow them to expire. Therefore, if the regulations are to be modified or re-issued by the December 2013 expiration date through the rulemaking process, it will be necessary to have conclusions regarding effectiveness in hand for National Oceanic and Atmospheric Administration (NOAA) leadership by December 2011. As a result, data collection should start immediately and summaries and reports regarding the rule's effectiveness should be available by December 2011."*
>
> *"Workshop participants agreed that the timeframe for implementing adequate and rigorous metrics is quite short. In fact, given the suite of variables contributing to ship strikes, detecting meaningful biological effects of the regulations would be difficult. Variables complicating a rigorous assessment of effectiveness include maritime commerce, oceanographic features contributing to shifts in whale distribution, and the rarity of a ship strike event. Much longer time series are typically needed to detect statistically meaningful effects. Nonetheless, within these rather arbitrary time constraints, workshop participants understood the charge to develop metrics, as possible."*
>
> *"Workshop participants agreed that NOAA will use four basic parameters to monitor effectiveness*."

These parameters are:

- ***Biological studies*** -- Assess the rate (using the time elapsed between) of known large whale ship strike deaths;
- ***Human behavior*** -- Quantify human response to provisions of the Rule using Automatic Identification System (ideally, relying on a centralized network) to monitor vessel operations;
- ***Mariner awareness*** -- Enhance and quantify mariner awareness-raising efforts through education and outreach programs; and
- ***Economics*** – To the extent possible, quantify economic impacts resulting from the conditions of the Rule.

Following the workshop, NMFS established programs to gather and analyze information in these areas. Results of these analyses are presented here.

The goals of this report are to present the results of assessment studies conducted in the years since implementation of the Rule (December 2008 – 2011); to present summary conclusions from the studies; and to provide recommendations for possible future action with regard to ship strike reduction.

Content and Organization of the Report

Here, we present the results of five independent, but interrelated, studies. Findings are provided in four sections corresponding to the assessment tools identified by the 2008 workshop, and in one additional area: a characterization and assessment of industry response to the establishment of 66 DMAs. While the results of each of these studies have, or may also be, presented elsewhere by various authors as stand-alone papers, reports, or conference presentations, overview summaries of each are presented here. Each summary "chapter" is intended as a self-contained analysis with various contributing authors that correspond to their particular expertise or their having conducted or contributed to a specific type of analysis.

We also include a "Conclusions and Recommendations" section that provides a discussion, in general terms, of ways to improve seasonal and dynamic vessel speed restriction management areas as conservation measures as well as recommendations about ways to improve aspects of the program such as monitoring and compliance, raising the awareness of maritime communities, and data collection. Taken collectively, this is an attempt to assess NMFS's vessel speed restrictions, and the results may be applicable to other settings in which vessel strike reduction of whales is sought or related living marine resource conservation measures.

Specifically, this report contains the following summary papers:

I. Biological Metric
"*Assessment of the frequency of whale and vessel collisions on the U.S. eastern seaboard in the two years following implementation of the ship strike reduction rule*"

II. Human Behavior: Automatic Identification System Monitoring of Vessel Compliance
"*Characterization of vessel operations in, and compliance with, vessel speed restriction Seasonal Management Areas in 2009 and 2010*"

III. Mariner Awareness: Education and Outreach
"*Summary of actions to notify maritime communities about the vessel speed restriction rule*"

IV. Economic Impacts
"Initial estimate of economic impact of the right whale ship strike reduction vessel speed restrictions"

V. Dynamic Management Areas
"*Vessel operations in and around Dynamic Management Areas*"

VI. Conclusions and Recommendations

"*Recommendations and considerations for reducing vessel strikes of right whales through a vessel speed restriction program*."

Literature Cited

Figures, Tables, and Appendices

I. Biological Studies: Assessment of the frequency of whale and vessel collisions on the U.S. eastern seaboard in the two years following implementation of the ship strike reduction rule

Gregory K. Silber and Richard M. Pace, III

The ultimate goal of the vessel speed restriction action is to enable population recovery by reducing deaths and serious injuries of whales resulting from vessel strikes. And, the goal of any assessment is to directly quantify a reduction – ideally, determined by direct counts – in actual or averted deaths from ship strikes. However, as noted above and elsewhere (*e.g*., Silber and Bettridge, 2009), quantification of trends in the occurrence of anthropogenic whale deaths using direct counts can be difficult if not impossible particularly when constrained by short sampling periods.

A number of alternative means conceivably may be used to assess a reduction in ship strike deaths. One is quantifying visual observations of imminent collisions that are somehow averted. However, recording such incidents will be few and would not be systematic because it involves observers being located near the interaction at the time it occurs. A second means would be to directly quantify known whale ship strike death rates both before and after a measure is implemented. However, this, too, is difficult to measure directly because other unrelated and difficult to quantify processes may be at play (*e.g.*, shifts in whale distribution, changes in numbers or locations of vessel transits) that may affect the number and rate of known ship strike-related deaths (Silber *et al*., submitted).

Although ship strikes are a significant fraction of the total number of annual large whale deaths and are a legitimate threat to the North Atlantic right whale population, they are actually relatively rare events and, therefore, sample sizes will always be small. This is compounded by an inability to reliably detect and ascertain the cause of *all* ship strike-related deaths. Therefore, long time series' are needed to identify any trends in the occurrence of ship strike deaths. And, even if changes in the rate of ship strike deaths are detected, it may be difficult to attribute that outcome to a specific ship strike reduction action. Several studies have assessed the effectiveness of various ship strike reduction measures by evaluating likely correlates to risk, risk of lethality, and in determining probabilities associated with collisions and steps taken to reduce collisions (Vanderlaan and Taggart, 2007; Vanderlaan *et al*., 2009; Wiley *et al*., 2011), and whereas the studies are highly useful particularly in the absence of direct counts, they remain indirect assessments.

The limitations identified above notwithstanding, NOAA recognized the need to assess the biological affect of the vessel speed restrictions (NMFS, 2008; Silber and Bettridge, 2009). The 2008 workshop participants concluded that assessing the effectiveness of the rule was not possible in a relatively short period if it were based solely on detecting changes in the number of annual right whale deaths, so other means were sought. An alternative metric was developed and presented to the 2008 workshop, namely:

(a) Comparing periods both before and after the rule's implementation by using a 100% sample of known ship strike deaths of *all baleen whale species* (*i.e*., not only right whales to which the rule was targeted) occurring along the U.S. east coast (*i.e*., not only those geographic areas within the rule's SMAs); and

(b) Conducting a statistical analysis of *time elapsed* between subsequent ship strike mortality events.

Known ship strike deaths of all baleen whale species occurring in all areas (not only within SMAs) were to be examined to increase the overall sample size, accompanied by the reasoning that some species might, to some degree, also benefit from U.S. east coast ship strike reduction measures.

The workshop participants agreed that the proposed metric should be used, noting that this approach would to some extent avoid the pitfalls identified above (*e.g*., brief sampling period, relatively infrequent occurrence of actual ship strike events). However, this metric has limitations of its own. As noted in a report of the results (Pace, 2011; Appendix B), a statistical assessment of this approach was undertaken and the conclusion was that the two-year post-rule sampling period was simply too brief to detect a significant change in large whale ship strike deaths. The limited sampling period resulted primarily from the five-year "sunset" of the rule, and the need to generate this report.

Nonetheless, given that the rule went into effect in December 2008, the analysis described here included only U.S. east coast large whale ship strike deaths and serious injuries from 1 January 2000 through 31 December 2010 (n = 58). The results of the analysis are provided in Appendix B; we provide a summary here.

Some central conclusions from a "Frequency of whale and vessel collisions on the US eastern seaboard two years post ship strike rule" (Pace, 2011) are:

- With regard to assessing overall effectiveness of the rule, the results are inconclusive. The time series is too brief;
- A standard classical statistical assessment of the time needed to detect a change in the rate of ships strikes indicates that two years (the selected sampling period given the timing of the expiration of the Rule) was an insufficient period to detect a change. For example,
    - There is a 2.5% probability of detecting a 50% change in ship strike rates after two years (6.1% chance of detecting a 66% change);
    - After 5 years, there is an 80% probability of detecting a 50% change (93% of detecting a 50% reduction after 7 years);
- These critical limitations notwithstanding, statistical testing was done using three separate tests. The results were:
    - Largely inconclusive;
    - A simple plot of the data indicates that 2005 was a very bad year for ship strikes, but statistical analysis do not support this; and

- In considering three separate analytical approaches, there is "a meager amount of evidence for an increase in the time between events post rule implementation."

As for right whale deaths since the rule went into force, no right whale deaths or serious injuries are known to have occurred in times and locations in which SMAs were in effect or by vessels subject to the rule. Some, and as yet not peer-reviewed, observations indicate that one suspected ship strike-related right whale death occurred in the northern Gulf of Maine when SMAs were not in effect; another was struck and likely seriously injured by a sovereign vessel which was not subject to the rule.

II. Human Behavior: Characterization of vessel operations in, and compliance with, vessel speed restriction Seasonal Management Areas in 2009, 2010, and 2011

Shannon Bettridge and Gregory K. Silber

Introduction

This section provides a description of vessel operation patterns in Seasonal Management Areas (SMA). We collected and analyzed data on vessel types, speeds, number of trips and other features obtained from the USCG's National Automatic Identification System (AIS) network – a system of shore-based receivers and relayers that provide information on vessel operations in nearly all U.S. coastal waters.

This serves as a partial update and expansion of a 2010 report on the same subject (Silber and Bettridge, (2010); accessible at: http://www.nmfs.noaa.gov/pr/pdfs/fr/fr73-60173.pdf), in this case evaluating vessel operations in 2009, 2010, and 2011. A number of the findings (*e.g.*, number of vessel transits, proportions of trips by vessel type and flag state) and conclusions presented here are similar to the ones in the Silber and Bettridge (2010) report, notably, that adherence to the vessel speed restriction by maritime communities was not as strong as what might be expected in 2009 and 2010, although compliance appears to have markedly improved in 2011. The reasons for the early low compliance levels are not readily apparent and we only briefly address them here, leaving treatment of this to a later time and/or to be presented in subsequent publications. Instead, our goal here is to characterize vessel operations in SMAs. Except where otherwise indicated, all the AIS data acquisition, storing, parsing, and analyzing used in this study are the same as previously described in the 2010 report (Silber and Bettridge, 2010). The reader is referred to that report for descriptions of data acquisition and analytical methods used.

Automatic Identification System (AIS): Its Purpose and Our Data Analysis

Originally conceived as a safety of navigation technology, the AIS sends Global Positioning System (GPS)-linked signals that provide for ship-to-ship and ship-to-shore information transfer. A ship's name, call sign, position, dimensions, speed, heading and other information are transmitted multiple times each minute via very high frequency (VHF) radio signals. The AIS network that we utilized works in an autonomous and continuous mode and is capable of handling more than 4,500 reports per minute and updating as often as every two seconds. The rate at which it provides this information (*e.g.*, multiple location fixes and speed indications each minute) makes the AIS networks and its components a highly precise and cost effective means to track vessel speeds and other vessel operations and to remotely sense activities of various maritime communities.

A suite of information, both dynamic (unique to a particular voyage) and static (constant for a given vessel), is embedded in the AIS signal. Dynamic information includes the vessel's position, speed over ground, heading, and position accuracy, 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 (a unique number assigned to each

vessel for safety at sea purposes). This information is entered by the operator upon initializing the system.

NMFS Headquarters' Office of Protected Resources has been acquiring AIS data feeds from the USCG National AIS. 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 as raw data and in summaries.

While providing a wealth of information about vessel operations, the system is not without limitations. For example, the range is limited. AIS vessel transponders typically operate with a range of coverage of about 20-40 nautical miles, but perhaps more in certain circumstances (*e.g.*, up to hundreds of miles in ideal conditions), or essentially "line of sight". Reception distances are influenced by the height of the receiving antenna, and 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). In addition, not all transmitted messages are flawless, mostly due to operator error in entering required information into the transponder. We have developed various ways of detecting and eliminating faulty transmissions (Silber and Bettridge, 2010) and a substantial number have been removed from the data set.

Although our analytical approaches are defined in the 2010 report, we provide some basic information here to help orient the reader for the purpose of interpreting our results. Every mention of vessel speed refers to the vessel's "speed over ground" (SOG) as explicitly stated in the rule itself (as opposed to speed through the water) and as provided by the AIS signal itself. Information on "country of origin" and "vessel type" is encoded in the AIS message as established by International Maritime Organization (IMO) protocol and as entered by the operator. As to vessel type, the operator is limited to a finite number of designations, such as cargo, tanker, passenger, tow, pilot, tug, and sovereign. We also developed an "other" category that might include, for example, fishing vessels, sailing or pleasure craft, dredging, and diving vessels. Our reporting of vessel type information below correspond to these categories provided by the vessel operator (with the exception of "tow" and "big tow" which we combined into the single category "tow"). Sovereign vessels (those owned or operated by, or under contract with Federal entities) are not included in our analysis because these vessels are excluded from the provisions of the vessel speed rule. This vessel category may be the subject of subsequent analysis.

This monitoring program involves a substantial data set. As noted, vessels' AIS transponders send a signal multiple times each minute; tens of vessels may be moving through active SMAs at any given time, representing several thousands of coastal transits per month. Given that AIS equipment is required by the IMO's International Convention for the Safety of Life at Sea (SOLAS) for most vessels and by the USCG for vessels in U.S. waters, we assume we are acquiring 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, it is reasonable to assume that vessel operators would use the system; the USCG may also assess penalties if the system is not used.

We therefore regard these as minimum, but reliable, counts of the number of vessel transits. And, because this data set is quite large we believe it enables us to accurately portray vessel operations in SMAs.

Thus, we provide a characterization of vessel operations in SMAs by summarizing information on vessel country of origin, speeds, by type, and overall compliance rates with the speed restrictions. This summary is for the period of January 1, 2009 through December 31, 2011.

By any measure (the number of records removed from analysis notwithstanding), we present information on a formidable fleet that traverses areas vital to the longevity of the right whale population. It appears that large vessels are nearly ubiquitous throughout the range of North Atlantic right whales, and a given individual whale may encounter tens of vessels each day, hundreds each year.

Results and Summaries

A total of 135,057 vessel transits were recorded and analyzed in active SMAs in 2009, 2010, and 2011, comprising of tens of millions of individual location and speed data points. Of these, 46,143 transits were removed from further analysis because they contained (primarily operator) errors. Thus, a total of 88,914 vessel trips were further analyzed and discussed here (Table 1).

Country of Origin

Considering all transits in all active SMAs, the ratio of foreign flagged to domestic vessels was 1.7:1. This is generally consistent across all months except July when only the Great South Channel (GSC) SMA (see Terms and Acronyms List, and Table 1 for lists of acronyms for each of the SMAs) was active, where the ratio was 5:1. The majority of cargo and tanker vessels were foreign-flagged, while not surprisingly all tow and nearly all tug and pilot vessels were U.S. owned and operated. 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 the lowest number of foreign flag relative to domestic vessels occurred in the CCB and MOR SMAs (Fig. 3).

Vessel Type

Cargo vessels constituted the overwhelming majority of ship passages in all SMAs, comprising over 51% of all vessel transits, (and not including the "other" category, for the moment, were) followed by tanker vessels (14%), and tug and tow type vessels (10% each) (Table 2; Fig. 4). Cargo vessels were strongly represented in the NY-NJ, NOR NC-GA and SEUS SMAs, with the NC-GA complex having the highest number of cargo transits of all SMAs (Fig. 5).

The number of tanker vessel transits was higher, proportionally, in northern SMAs than in more southern SMAs, perhaps reflecting the propensity of refineries in the northeast region. 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.

Composition of Vessel Traffic in SMAs

Overall, the greatest vessel traffic volumes were in the NY-NJ, NC-GA and NOR SMAs (Table 1). The NY-NJ SMA had the greatest number of transits (n = 22,989) followed by the NC-GA complex and the NOR SMA (n = 19,649 and n = 14,838 transits, respectively). The number of transits through 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 includes vessels servicing Baltimore, Hampton Roads, and other destinations within the Chesapeake Bay.

Tow-type vessels were common in the CCB SMA, 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.

Relative to the other SMAs, there were proportionally low numbers of vessels transiting through the ORP, GSC, and MOR SMAs. The ORP SMA is active for a relatively short period, which likely accounts for this pattern; but, overall, MOR appears to be one of the smaller volume ports inside SMAs. The relatively low numbers reflected in the GSC SMA are 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. Volume in this area may indicate that (a) vessels are utilizing the Traffic Separation Scheme servicing Boston, which lies outside the GSC SMA and/or they are routing around the Area To Be Avoided established in this area; (b) the 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; or (c) not all transmissions from vessels in the area are being captured given the limitations of the transmission ranges of the AIS signal (GSC is the farthest SMA from shore). Regardless, this is a key feeding area for right whales, which may involve relatively long residency times for the whales, and it is fortuitous that the traffic volume may be low in this area.

Vessel Speeds

There are a number of ways to characterize vessel speeds within SMAs. We examined the *portion* of each transit for which speeds were both below and above 10.0 knots and 12.0 knots as thresholds for characterizing speeds used on a particular trip. This approach provides a means for examining the relative "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 portion?). We assessed the "percent of the transit (distance) >10.0 knots" and "percent of the transit (distance) >12.0 knots" of each transit. We then determined, for each transit, whether most of the trip (>50%) was below or above these two speed thresholds. Thus, as general measures of "compliance", we provide the distribution of vessels traveling (a) at or less than 10.0 knots/12.0 knots for the entire transit, (b) above 10.0 knots/12.0 knots for up to half of the transit, and (c) above 10.0 knots/12.0 knots more than half of the transit distance (Fig. 6). We then used this metric as a means to compare mariner compliance between years.

We also quantified the "maximum speed over ground" achieved during each vessel transit through active SMAs. Although other types of metrics might more accurately capture the nature of the speeds used in these trips, this is a readily accessible metric and it does represent one measure of each transit. And, in the strictest interpretation of the rule, any speed in excess of 10.9 knots within an active SMA constitutes a violation of the speed limit. We recognize that maximum speed may represent only a fraction of the entire transit, thus this measure may overestimate the overall speed of a given transit and upwardly bias summaries of speeds in all transits. 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.

In 2009, 32% (n = 9,198) of recorded transits exhibited maximum speeds at or below 10.9 knots for the entire transit; 58% (n = 16,363) were at or below 12.9 knots for the entirety of the transit. This increased slightly in 2010, when 36% (n = 10,584) transits had maximum speeds at or below 10.9 knots for the entire transit; 62% (n = 18,281) were at or under 12.9 knots for the duration of the transit. In 2011, 53% (n = 16,417) of recorded transits exhibited maximum speeds at or below 10.9 knots for the entire transit; 74% (n = 23,098) were at or below 12.9 knots for the entirety of the transit (Fig. 7). The most common maximum speed category represented was 10.0 (*i.e.*, 10.0 - 10.9) knots; and the majority of all transits had maximum speeds between 10.0 and 14.0 (*i.e.*, 10.0 - 14.9) knots (Fig. 7).

Cargo and pilot vessels exhibited the highest aggregate maximum speeds (with the most traveling in the 15-16 knot range) (Fig. 8). The majority of 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. Generally, domestic vessels had lower aggregate maximum vessel speeds than did foreign-flagged vessels; the latter tended to travel at maximum speeds of 12 knots or greater (Fig. 9).

Another way to characterize vessel transits is by calculating mean speeds, although we acknowledge that there are inherent potential biases involved with this approach. For example, vessels may slow down to board a pilot or anchor within an SMA while waiting to enter port. Typically, vessels transmit AIS data throughout the entire voyage; therefore, in such instances the number of records with lower speeds would dominate the particular transit and average vessel speeds would be biased downward. A vessel may not have traveled at the mean speed for much of the transit, and even brief periods of elevated speeds would bias average speeds upward. Thus, average speeds may not always accurately characterize actual speeds for the entire trip.

These considerations notwithstanding, we decided to quantify aggregate mean speeds to assess general trends. Overall, passenger vessels had the highest mean speeds (11 knots) when travelling through SMAs, followed by cargo vessels (10.9 knots) and tankers (10.8 knots). Tow vessels had the slowest mean speeds (9.1 knots) (Fig. 10). The highest aggregated mean vessel speeds were recorded in the PHI and GSC SMAs, with an average above 11 knots per transit. The slowest aggregate mean speeds were recorded in the CCB SMA, with an average speed of

9.9 knots in 2009 and 9.4 knots in 2010 – an area that is dominated by tug and tow vessels, which travel at lower speeds than other vessel types.

Trends in Vessel Speeds

We were interested in determining if aggregated vessel speeds diminished with time as awareness of the restrictions (including late 2010 enforcement actions -- see section III, below) increased. When considering the *portion* of transits at or below 10.0 knots, we found that 21% of transits in 2009 were completely at or below 10.0 knots for the entire SMA transit. This rate increased slightly to 22% in 2010 and to 33% in 2011. In 2009, 41% of transits were above 10.0 knots for over half of the trip, declining to 37% in 2010 and to 22% in 2011. Thus, for this metric we observed an increase in compliance and perhaps an overall lowering of speeds by the entire fleet between the three years.

When considering the *maximum vessel speed* attained during one transit, 68% of the trips in 2009 exceeded 10.9 knots at some point. This figure decreased slightly to 64% in 2010 and decreased further to 47% in 2011. In general, we see an increase from 2009 to 2011 in the number of trips in which the maximum speed for each trip was below 13 knots, and a decrease in the number of trips in which the maximum speed for all or a portion of the trip was at 14 knots or greater.

Compliance with Vessel Speed Restrictions

It is not clear why initial "compliance" 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. On the other hand, marked improvement in compliance in 2011 is likely attributable, at least in part, to 2010 enforcement actions. Regardless, 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 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.

NMFS developed and implemented an extensive mariner awareness-raising campaign that should have been adequate to notify every mariner transiting U.S. Atlantic coast waters about the requirements of this rule (see Chapter III for a description). Also, NMFS' Office of Law Enforcement issued 149 outreach letters notifying vessel owners and operators of specific violations detected and informing them of the regulations and NOAA's Office of General Counsel issued civil penalties to another 18 vessel owners and operators (7 were issued in late-2010, the balance coming in late 2011). In collaboration with two large shipping industry associations, NMFS developed a program in which over 400 individual vessels were provided with monthly summaries of specific information (*e.g.*, times, dates, locations, speeds) about their recent vessel operations in SMAs. This program began in 2010 and is ongoing. NOAA's Stellwagen National Marine Sanctuary developed a system of notifying mariners about vessel speeds in the sanctuary. Collectively, these actions almost certainly have had a substantial effect on vessel activities and compliance with restrictions in SMAs. We expect to examine these efforts more closely in subsequent analyses and will present the results elsewhere.

III. Mariner Awareness, Education and Outreach: Summary of actions to notify maritime communities about the vessel speed restriction rule

Shannon Bettridge, Cheryl Bonnes, Barb Zoodsma, and Gregory K. Silber

To effectively reduce the likelihood and lethality of vessel collisions, compliance with the ship speed regulations must be high. In turn, compliance with the regulations cannot be anticipated without first ensuring mariner awareness of the requirements of the regulations. In other words, before expecting high compliance rates with the vessel speed rule, information must be clearly delivered and correctly understood by affected maritime communities. To achieve this, NMFS and its partners launched an extensive outreach campaign in advance of the ship speed rule going into effect and while the regulations were in effect. We developed a program geared specifically to distributing information about the provisions of the regulation through as many outlets and media as possible. The goal was to provide information about the requirements of the rule to as many of the various affected elements of the maritime industry as possible, even if redundant.

While these actions to communicate the provisions of the rule to mariners were undertaken prior to establishing the rule and during the period it was in effect, we do not describe outreach efforts that began in 2006 including public scoping meetings, solicitation of public comment, Federal Register notices, coast-wide presentations in key ports, and other actions associated with NMFS's Advanced Notice of Proposed Rulemaking, Proposed Rulemaking, the draft and final Environmental Impact Statements, and related actions. Descriptions of these can be found in the Final Environmental Impact Statement to Implement the Vessel Operational Measures to Reduce Ship Strikes to the North Atlantic Right Whale (Anonymous, 2008; and at http://www.nmfs.noaa.gov/pr/shipstrike/archive.htm).

Characterization of outreach efforts

Although not a direct assessment of effectiveness, the 2008 workshop participants agreed it was essential to not only develop and implement an extensive program to inform all potentially affected entities about the requirements, but also to quantify NMFS's efforts to do so. The workshop report recommended that NMFS monitor outreach efforts by quantifying, for example, the amount of material distributed and numbers of broadcasts made, and attempt to estimate the extent of the audience reached.

Heeding the workshop recommendations, NMFS tracked awareness-raising efforts since October 2008 directed at domestic and foreign flagged vessels, recreational boaters, fishermen, Federal agencies, whale watch vessels, passenger ferries, and other affected entities since October 2008. These actions are described below.

Navigational Aids

Beginning in the early 2000s, NMFS routinely published information in relevant U.S. *Coast Pilot* books on the threat of vessel strikes to sea turtles and large whales (right whales in particular), and other matters. The information is updated annually and information on the vessel speed restrictions was added in 2008/2009 and runs currently. The U.S. *Coast Pilot* is a series of

nautical books that cover a range of information important to navigators of coastal and intra-coastal waters and the Great Lakes. Issued in nine volumes, they contain supplemental information that is difficult to portray on a nautical chart, including Federal regulations applicable to navigation. Routinely updated by NOAA's Office of Coast Survey readily available, each volume contains sections on local operational considerations and navigation regulations, followed by chapters that contain detailed discussions of coastal navigation.

It is important to note that knowledge of requirements, precautions, and safety at sea provisions contained in U.S. *Coast Pilots* is a requirement for all vessels sailing in U.S. waters. Because carrying *Coast Pilots* is mandated and enforced by the USCG and NMFS Office of Law Enforcement (OLE), reason might suggest that these outlets, *alone* (perhaps as coupled with the rulemaking itself, accompanying changes in the U.S. Code of Federal Regulations, and notification by shipping company parent organizations), would be sufficient to ensure mariner adherence to the requirements of U.S. law. Nonetheless, in the following sections, we identify additional steps taken to inform mariners and the general public about U.S. regulations.

As to those vessels sailing internationally, details of the ship speed rule are also articulated in *Sailing Directions*, a 42-volume American navigation publication prepared by the National Geospatial-Intelligence Agency (NGA), and a companion document, *Notice to Mariners*. These publications, used by mariners to plan international voyages, describe general features of ocean basins and country-specific information (such as military operational areas, pilotage requirements, regulations, search and rescue information, ship reporting systems) as well as features of coastlines, ports, and harbors. NMFS provides annual updates to these publications. Information appearing in *Notice to Mariners* and *Sailing Directions* is also generally incorporated into another international sailing guide, the United Kingdom's *Admiralty Publications.* While these three publications are not required for passage in U.S. waters, they are widely distributed and highly regarded as an essential source of information on safety of navigation at sea.

SMA boundaries are not depicted on NOAA-produced paper or electronic navigational charts. Having this information shown directly on nautical charts would almost certainly further mariner knowledge of, and improve compliance with, the provisions of these regulations. This is a key shortcoming toward improving compliance. Although special notes to mariners about the vessel speed restrictions appear on the charts and are provided on the NOAA electronic navigational charts, these certainly are no substitute for the potency of chart-depicted speed requirements for inbound vessels in U.S. waters particularly those owned and operated by foreign entities.

Notices to Mariners

Information about vessel speed restrictions and locations of right whales is also provided to mariners through various official broadcast media, including Broadcast and Local Notices to Mariners, satellite-linked marine safety broadcasts, and NOAA Weather Radio. The NGA, in collaboration with NOAA and the USCG, publishes weekly Notices to Mariners, which provide corrections to navigational publications and nautical charts. The U.S. Notice to Mariners officially amends NGA and NOAA nautical charts with new information collected from many sources, among them the Local Notice to Mariners published by the various U.S. Coast Guard

districts. The need to adhere to ship speed regulations are announced regularly via Local and Broadcast Notices to Mariners, particularly as they come into force seasonally. Periodic announcements about the rule are also made on NOAA Weather Radio broadcasts on specifically designated maritime radio frequencies. Broadcasts containing information about the speed rule are issued hourly (or as time permits) from Brunswick, GA, to Melbourne, FL, from 15 November to 15 April, annually; and from Mamie, NC to Hardeeville, SC from 1 November to 30 April, annually.

Here again, *all* mariners are responsible for adhering to any information regarding navigational safety contained in the above-listed notices. Given that they are tailored regionally, the broadcasts would be received when mariners are in, near, or approaching SMAs. Thus, because this information is delivered by regionally-specific broadcasts that are routinely monitored by nearly all mariners and contain information that is required as a matter of port entry for safe navigation in particular waters, one might argue that these requirements, alone, would suffice in ensuring all mariners entering these areas are cognizant of what is required. (A significant gap is the omission of SMAs on NOAA's nautical charts.) In addition, most mariners routinely monitor NOAA Weather Radio to assess local conditions while at sea and would, therefore, be expected to receive information about the requirements from that source.

Mandatory Ship Reporting Systems

Information is also provided to mariners on the ship speed rule via the Mandatory Ship Reporting systems (MSR). The MSR systems, jointly funded and operated by NMFS and the USCG, are aimed at increasing mariners' awareness of the problem of ship strikes of right whales. Beginning July 1999, all commercial ships 300 gross tons and greater are required to report to a shore-based station when they enter two areas off the east coast of the United States: one in waters off Massachusetts and one off Georgia and Florida (Silber *et al*., submitted). The reporting system off Massachusetts operates year round, while the one off Georgia and Florida operates annually from 15 November to 15 April, which corresponds with periods of right whale occurrence in the region. Ship operators are required to report their vessel name, call sign, course, speed, location, destination, and route. In return, the vessel receives an automated message that provides specific (< 24 hours old) right whale sighting locations and guidance on sources for the latest information about and avoidance procedures that may prevent a collision. Thus, mariners receive updated information immediately and in real-time at the same time they enter areas of right whale aggregations. A total of 2,000-3,000 of these return messages are sent to vessels annually.

When SMAs are in effect the MSR systems advise mariners to refer to navigational publications such as the U.S. *Coast Pilot, Sailing Directions*, and nautical charts for information on relevant regulations, and the boundaries of right whale critical habitats and SMAs. Because these systems are mandatory and the return message goes immediately and directly to mariners entering right whale aggregation areas, mariners are reminded in real-time of active SMAs. For more information on the MSR systems, see: http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/msr.

Unlike the information contained in the U.S. *Coast Pilot* and Local and Broadcast Notice to Mariners, which includes precautions mariners are required to heed, information contained in the

MSR outgoing message is advisory in nature (*e.g.*, based on this information, mariners may or may not choose to alter their actions based on locations of recent right whale sightings). However, reporting into the system is required. Because reporting is mandatory, the USCG has cited, and will cite, mariners who fail to report into the systems. Therefore, each ship that reports (hundreds per year) receives the information directed to that specific vessel and in real-time in the same locations and times that some SMAs are in effect. For these reasons, one might reasonably expect mariners in these waters to be knowledgeable of the vessel speed restriction requirements, and might also expect these messaging systems to influence their actions in subsequent voyages into U.S. ports.

National Buoy Data Center Weather Buoy Web Sites

Notices regarding SMAs are also posted via National Buoy Data Center web sites for 90-100 weather buoys stationed in waters off all eastern seaboard states and extending into some Canadian waters. Messages available to mariners seeking regionally-specific weather data are tailored regionally and may read something like "*Caution: Right whales may be active in northeast waters year-round. Mandatory speed restrictions of 10 knots apply to vessels 65 feet or greater in specific areas and times along the US east coast. Voluntary speed restrictions may be in effect in other areas and times. For current information on speed-restricted areas, go to: http://www.nmfs.noaa.gov/pr/shipstrike*".

Community Oriented Policing and Problem Solving (COPPS) Letters

NOAA recognized that mariners may not have been fully aware of the speed restrictions immediately after the rule took effect. Therefore, for approximately one year after enactment of the restrictions, NOAA's Office of Law Enforcement (OLE) sent outreach letters, rather than citations, to vessels observed traveling in excess of the specified speeds. These letters (Appendix C) were part of OLE's Community Oriented Policing and Problem Solving (COPPS) program. The letters were informative rather than punitive but contained specific information on where and when violations occurred. Between September 2009 and March 2011, OLE issued 149 COPPS letters (to over 57 companies or vessel owners).

Separate analysis is underway to determine if the COPPS letter program and other actions, including some of those identified here, have had a specific and discernable effect on mariner compliance with the speed rule.

Notices of Violation (NOVA)

Following the first year of the rule's implementation, NOAA's Office of General Counsel began issuing Notices of Violation and Assessment of civil penalties (NOVAs), to some of the more egregious (by distance, speed, or frequency) violators. Between November 2010 and November 2011, the owners and operators of 18 vessels were issued NOVAs with penalties ranging from $11,500 to $92,000 depending on the number of violations charged. NOAA's Office of General Counsel anticipates issuing additional NOVAs as soon as investigations are completed and case packages are forwarded from NMFS' OLE.

At-Sea Hailings

Through a program that ran from 2009-2011, USCG cutters directly hailed 46 vessels in SMAs that were exceeding the speed restrictions. Using VHF radio, cutter crews notified vessel operators of speed restrictions and requested that the vessel slow to appropriate speeds.

Electronic Mail Notifications and Monthly Summaries to Individual Vessels

Each time the various SMAs went into effect, NMFS and its partners sent numerous electronic mail reminders to mariners and a host of related or interested parties. Regular e-mail announcements were sent to distribution lists of 605 and 546 recipients maintained by NMFS Northeast and Southeast Regional Offices, respectively. These distribution lists include shipping agents, port authorities, scientists, non-governmental organizations, owners and operators of cruise lines, passenger vessel operators, pilots, among others. In addition, the State of Massachusetts, the Chamber of Shipping of America (CSA), the World Shipping Council (WSC), the Maritime Administration (the Administration has jurisdiction over hundreds of commercial vessels), and Lloyd's Registry sent electronic reminders to their members and distribution lists. NMFS also maintains a "rwsightings" e-mail address and when messages are sent to it, an automatic return e-mail is sent providing information on currently active SMA and DMAs. Collectively, these messages were routinely distributed to several thousand recipients.

In a separate program initiated by the shipping industry, NMFS worked collaboratively with the World Shipping Council and the Chamber of Shipping of America to directly provide feedback to shipping companies on the behavior of their individual ships in SMAs. This program, jointly developed by NMFS and these industry associations, enlisted specific companies who were given the option, and then voluntarily agreed, to participate in the program. In December 2010, NMFS began sending, once each month, reports to interested shipping companies (13 WSC and 4 CSA companies, representing a total of ca. 400 vessels that regularly use U.S. east coast SMAs) providing the dates, locations, and speeds of their vessels as they traveled within SMAs. Vessel operations data were acquired through AIS and provided to companies in the form of an Excel spreadsheet, with one worksheet per vessel. Data fields, each line representing one trip through a SMA, included:

- Vessel name
- SMA name
- Speed over ground (in knots) upon entry
- SMA Entry time
- Maximum speed over ground (in knots) while in SMA
- Date and time when maximum speed over ground was reached
- Speed over ground (in knots) upon exit
- SMA Exit time
- Distance traveled within SMA (in nautical miles)
- Percent of SMA distance traveled at >10 knots
- Percent of SMA distance traveled at >12 knots

Between December 2010 and July 2011, 141 summary reports were sent by electronic mail to shipping companies (see Appendix D for a sample email). Although analysis of this program

and other specific steps to improve compliance is underway and will be presented elsewhere, we believe that providing rapid turnaround information on individual transits to specific vessel operators will be an important means to improve compliance and might serve as a model in other settings. Overall, NMFS has received positive response from the industry on this program, and NMFS intends to continue the program for the foreseeable future, as resources allow.

Transit Speed Summaries provided by the Stellwagen Bank National Marine Sanctuary
Starting in 2009, the Stellwagen Bank National Marine Sanctuary and NMFS worked with the US Coast Guard, NOAA's OLE, International Fund for Animal Welfare, and the maritime industry to provide information directly to shipping company owners about the speeds of their vessels transiting the Off Race Point and Cape Cod Bay SMAs, each of which overlap a portion on the sanctuary. In addition to highlighting the provision of the vessel speed restriction rule, each letter contained a map showing:

- Vessel Name
- Date(s) and track of that vessel's SMA transit(s),
- speed histogram(s) for each of the vessel's transits showing distance traveled in the SMA at speeds of <10 knots, 10.1-11 knots and >11 knots,
- percent of distance traveled in an SMA during which the vessel transit was out of compliance with the rule, and
- an analysis of the vessel's least compliant transit (if one existed) calculating how much time it would have taken for the vessel to transit the SMA at compliant speed (10 knots).

Data were compiled using AIS data collected by receivers located around the sanctuary. Letters (192 in 2009 and 227 in 2010) were sent to company addresses provided by the USCG and the Massachusetts Port Authority.

Compliance Guides
In advance of the speed rule going into effect, NMFS developed and widely distributed a "Compliance Guide for Mariners" (Appendix E and http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/compliance_guide.pdf). This two-sided brochure includes maps, coordinates, and dates for the SMAs prescribed in the rule. It also provides relevant text from the rule, as well as website addresses for more information. The Compliance Guide is laminated to provide waterproof protection while at sea.

In addition to posting on its ship strike reduction website, NMFS distributed nearly 3,000 laminated Compliance Guides to mariners through a number of outlets. The guides have also been distributed via electronic mail, downloaded from the NMFS website, and printed in other publications. These outlets included, among others:

- NOAA Office of Law Enforcement
- NOAA's shipping and maritime liaisons, including its Navigational Managers program and industry liaisons working under contract with NMFS
- U.S. Coast Guard, including Local Notices to Mariners
- U.S. Army Corps of Engineers

- U.S. DOT Maritime Administration (MARAD), reaching maritime labor unions (>50 companies) and a fleet of commercial vessels under contract to the Administration
- Harbor and bar pilot associations
- Marine Exchanges, these are companies that work in conjunction with ports to facilitate safe and efficient activities in individual ports
- Lloyd's Register (including ca. 2,000 companies, ca. 7,000 ships internationally)
- Maritime academies
- State police and natural resources agencies
- Shipping companies
- Shipping agents
- Whale watch companies
- Environmental organizations
- Local, regional, and national print and electronic news media
- Right whale protection notebook

Computer Training Resources

NOAA, in conjunction with the USCG and the North Atlantic Right Whale Recovery Plan Southeast Implementation Team and with input from the shipping industry, produced a computer-based, interactive guide and training resource for shipboard operations as they relate to avoiding ship-strike interactions with North Atlantic right whales. The guide, titled "A Prudent Mariner's Guide to Right Whale Protection," is available in CD-ROM format or for free download from the Internet **(**http://www.nero.noaa.gov/shipstrike/doc/mtr.html). It was updated in April 2009 to include information specific to the ship speed rule. Since spring 2009, NOAA has distributed more than 2,500 "Prudent Mariner" CD-ROMs.

This interactive CD program provides educational and support information intended to raise awareness of shipboard operators in areas where North Atlantic right whales may be present. Focused on operations along the U.S. Atlantic coast, the program delivers crew training information about right whales, including an introduction to right whales, recommended navigational actions when operating in right whale habitat, a guide to reporting sightings of dead or injured right whales, an informative video presentation, and a short follow-up quiz. The program also includes guidelines for compliance with the Mandatory Ship Reporting systems and a tool for submitting a report to the Mandatory Ship Reporting system. Review and knowledge of this information and having taken the follow-up quiz are required for all captains and crew of the entire cruise line industry.

Right Whale Notebooks and Merchant Mariner Education Module

NMFS has designed and distributed Shipboard Right Whale Protection Program Notebooks, which are binders of information for mariners about North Atlantic right whales. The binders contain: (a) Crew and Watchstander Training; (b) Sighting Information Sources and Collection; (c) Precautionary Measures for the Prudent Mariner; (d) "A Prudent Mariner's Guide to Right Whale Protection" dvd, and (e) Mandatory Ship Reporting Requirements, Guidelines for Mariners Placards, and Compliance Guide for Right Whale Ship Strike Reduction Rule. Between January 2009 and August 2011, NMFS distributed 544 notebooks via 10 industry, trade, or private organizations and 18 federal or state agencies or their affiliates (Appendix F).

(In addition, NMFS personnel and shipping industry liaisons distribute materials (compliance guides and notebooks) at industry specific events and conferences which accounts for an additional 250 notebooks not included in Appendix F.) Notebooks are available upon request and at no cost.

The North Atlantic Right Whale Recovery Plan Northeast Implementation Team and a contractor developed a merchant mariner education module on large whale ship strikes for maritime academy instructors in mariner safety, certification, licensing, or licensing upgrade courses to educate ship's captains. The self-contained, multi-unit module includes a Right Whale Ship Strike Curriculum Package with an Instructor's Manual and two PowerPoint education modules intended to provide Federal, state, and international maritime academic and training institutions and fleet managers with, discussion notes, implementation strategies, resource materials, and student assessments on the prevention of ship strikes of North Atlantic right whales.

The modules' lessons are geared toward use in courses on Voyage Planning, Bridge Management, Terrestrial and Coastal Navigation, Social Responsibility, Safety and Environmental Training, and Certification, Re-certification, and License Testing for mariners operating in coastal waters of the United States and Canada. The modules may also be used in sea semester training and fleet training scenarios. To date, the curricula were implemented at six mariner academies, including the USCG Academy, Maine Maritime Academy, Massachusetts Maritime Academy, Texas A&M University at Galveston, SUNY Maritime College, and the U.S. Merchant Marine Academy. These curricula are available free of charge upon request.

Trade Journal and On-line Articles

NMFS staff prepared and published articles explaining the threats to right whales and the provisions of the rule. These were submitted to 31 different trade journals in the U.S. Of these, ten journals published a total of 23 articles about the rule between December 2008 and December 2009. The target audiences of the journals included maritime industry professionals, recreational power boaters and sailors, marine engineers, and commercial and recreational fishermen. The journals are published in the U.S., in English, and circulation was primarily to U.S. residents.

The vessel speed rule was also publicized through online media. At least 63 articles about the rule were published on the Internet by numerous news groups between October 2008 and March 2011 (Appendix G). For many of these articles, NMFS staff was contacted by the authors to provide interviews.

Press Releases

NMFS, NOAA's OLE, and USCG issued 7 press releases in advance of the rule's effectiveness and again annually when SMAs were set to resume (Appendix H). These resulted in a number of stories on local and national broadcast and print media.

Events and Oral Presentations

NMFS and NOAA OLE staff took numerous opportunities to raise awareness about the rule, including providing oral presentations at conferences and public events. Public events included boat shows, whale festivals, industry meetings, conferences, and training sessions.

Between September 2008 and June 2011, NMFS staff gave at least 66 oral presentations on the rule to a combined audience of more than 2,500 individuals. Audiences included port operators, harbor safety committees, maritime associations, maritime exchanges, environmental organizations, and FM radio audiences, among others (Appendix I).

NMFS Ship Strike Reduction Web Pages

NMFS Office of Protected Resources regularly updated its ship strike reduction website with maps of active SMAs and DMAs (www.nmfs.noaa.gov/pr/shipstrike). Among other things, the ship strike reduction and large whale conservation website (Appendix J) provides links to the *Federal Register* notice announcing and explaining the final rule, the Compliance Guide, maps of all SMAs and DMAs, contact information for reporting a ship strike, information on other ship strike reduction efforts (such as routing measures and the Mandatory Ship Reporting systems) and related supporting documents.

Two additional NMFS websites relay information about the speed rule: the Northeast Regional Office and Southeast Regional Office websites each contain web pages specific to right whale conservation and the prevention of ship strikes, http://www.nero.noaa.gov/shipstrike/ and http://sero.nmfs.noaa.gov/pr/mm/rightwhales/rwconservation.htm, respectively.

Summary

In sum, in addition to providing annual updates in the U.S. *Coast Pilot*, international navigational publications, *e.g.*, *Sailing Directions* and *Notice to Mariners*, and USCG Local and Broadcast Notice to Mariners – which contain precautions and announcements for which mariners must heed as a matter of U.S. port entry - NMFS and its partners provided information about vessel speed restrictions through:

- Periodic, timely, and regionally-focused announcements issued on NOAA weather radio and NOAA weather buoy web sites;
- 149 NMFS Office of Law Enforcement's Community Oriented Policing and Problem Solving (COPPS) advisory letters going directly to vessel owners;
- 18 NOVAs (containing multiple counts of violations) issued by NOAA's Office of General Counsel;
- Annually, 2,000-3,000 automated outgoing messages sent directly to mariners entering right whale aggregation areas via the Mandatory Ship Reporting system;
- Several thousand recipients of reminders via e-mail distribution lists maintained by the World Shipping Council (WSC), the Chamber of Shipping of America (CSA), Maritime Administration, Lloyds List, NMFS's Northeast and Southeast Regional Offices and shipping liaison officers;

- Monthly summaries reporting specific vessel operations (*e.g.*, dates, times, and vessel speeds) in SMAs to WSC and CSA companies representing about 400 individual vessels;
- Reminder e-mails about DMAs and the opening of SMAs are sent to a distribution list of hundreds of maritime interest groups and individual recipients;
- Nearly 3,000 compliance guides distributed by harbor pilot associations, marine exchanges, maritime academies, shipping companies, environmental groups, whale watch companies, Lloyd's Register, and several federal agencies;
- 2,500+ interactive training CDs distributed;
- Over 550 Right Whale Protection Program notebooks distributed;
- Merchant Marine training curricula modules implemented in six merchant marine academies and provided free of charge via the Internet;
- Over 20 articles published in industry trade journals;
- Seven press releases;
- Over 60 oral presentations at meetings of, for example, port authorities, harbor safety committees, maritime associations, marine exchanges, environmental organizations, schools with total estimated audiences of over 2,500 individuals;
- Numerous spots, interviews, or stories appearing on local or national television or radio media;
- At least nine oral presentations or exhibits maintained at boat shows, public events, or scientific meetings; and
- Updates and reminders provided on several ship strike related web sites.

As discussed above, the effectiveness of the speed rule at reducing ship strikes is directly dependent upon compliance with its provisions, and compliance with the rule is in turn dependent upon mariner awareness. Given the inherent relationship between compliance with the rule and an awareness/understanding of it, NMFS and its partners distributed information about the ship speed rule as broadly, as often, and as clearly stated as possible. NMFS staff has solicited recommendations from the shipping industry on outreach venues and media and has pursued or developed modified outreach efforts accordingly.

We believe the mariner awareness program and actions taken within it to be quite comprehensive, in part because it includes outlets (*e.g.*, U.S. *Coast Pilots*, the USCG's Local and Broadcast Notice to Mariners) providing information that mariners are required to know and understand and to which they are expected to adhere, as well as a broad range of ancillary outlets, media, and targeted recipients. Given the breadth of this effort, we believe that a lack of knowledge about the restrictions can be ruled out as a source of observed low mariner compliance with the rule. We also believe aspects of this program may be a useful model for outreach programs contemplated for other maritime regulations. Nonetheless, we believe there are ways to improve this program (as identified in the "Recommendations" section, below). And, as noted in other sections of this report, compliance with the provisions of the rule has not been strong -- the reasons for this are not obvious.

NMFS and its partners expect to continue to distribute outreach materials related to the vessel speed restrictions through as many media as possible and continue to seek opportunities to

educate mariners about the rule. The agency will also ensure that messages and materials are kept updated and accurate, while also quantifying outreach and education efforts. Many NMFS and OLE staff in the Northeast Region, Southeast Region, and Headquarters carefully tracked outreach efforts associated with the speed rule. Without their assistance in maintaining these records, this summary would not have been possible.

IV. Economic Impacts: Initial[1] estimate of economic impact of the right whale ship strike reduction vessel speed restrictions

Gregory K. Silber, Shannon Bettridge, Richard Blankfeld[2], and Gerardo Ayzanoa

Issuance of the 2008 vessel speed restriction rule was accompanied by an Environmental Impact Statement (Anonymous, 2008) and an "Economic analysis for the Final Environmental Impact Statement of the North Atlantic right whale ship strike reduction strategy" (Nathan Associates, Inc., 2008). These reports provided estimates of expected direct and indirect costs as a result of the ship strike reduction rule as it affects the shipping industry, commercial whale watch entities, passenger and fishing vessels, and associated maritime communities. These estimates also considered potential impacts to such things as intermodal (*i.e.*, land-based) transport, ports, and associated businesses.

The 2008 workshop participants recognized that any action (*e.g.*, continuation or modification) regarding the provisions of the rule needed to be accompanied by an updated analysis of the 2008 economic analysis. They also recognized the value of any retrospective analysis of the impacts of the rule (as opposed to projections), because in the years following enactment of the rule, new data would be available from actual observation (or, at a minimum, updated and refined information) that would enhance any conclusions regarding economic effects. Further, whereas many aspects of the transport of goods and other elements of maritime activities may have remained relatively consistent since implementation of the rule, others may have changed. Thus, the workshop participants recommended that economic impacts be re-assessed because right whale conservation efforts should realistically be weighed against possible negative consequences.

Assessments made in 2007/2008 (Nathan Associates, Inc., 2008) relied on 2003/2004 USCG data on vessel port calls, 2004 vessel operating costs, and 2008 fuel costs. The latter two, in particular, have changed in recent years and new data information was needed to revise the estimates.

An update to the 2008 estimates was performed under contract by the same analytical team. A report of their initial assessments of direct and indirect economic impacts is provided in Appendix K and a summary is provided here. A key data improvement is the availability of Automatic Identification System (AIS) vessel operation information. These data enable analysis of *actual* vessel speeds used rather than reliance on assumptions about expected at-sea speed capabilities (actual speed data were not available for the 2008 analysis), and a quantification of

[1] NMFS regards these as "initial estimates" because they may be subject to some refinement. For example, additional or updated information on passenger ferries may be added at a later date, and some values may change as new data are acquired. However, these changes, if any, are expected to have little overall effect on the estimates provided here. Therefore, NMFS regards these estimates as the best available at this time.

[2] Richard Blankfeld and Gerardo Ayzanoa are with Nathan Associates, Inc., 2101 Wilson Blvd., Arlington, VA 22201

the actual number and frequency of trips through SMAs in 2009, rather than estimates prepared from 2004 USCG port-call data. The analysis described here includes all of 2009 which provided operating information for 58,459 vessel transits through areas affected by the rule. Of these, 30,669 transits (52.5%) occurred during periods when the rule was in effect and 27,790 transits (47.5%) in times when the rule was not in effect (Appendix K, Table 1).

The goal was to estimate the economic impact to the shipping industry and overall economy from the full implementation of the rule. The analysis assumes 100% compliance with the rule (see Section II for a discussion of compliance rates). That is, the analysis assumes that all vessels subject to the rule sail at a maximum speed of 10 knots within the restricted areas when they are in effect -- and as such represents the *maximum* economic impact on the shipping industry and general economy.

The primary operational impact of the rule on the shipping industry is the extra sailing time caused when vessels limit their speed within SMAs. To make this estimate, the 10-knot speed limit was compared with the actual sailing speeds of vessels in 2009, by vessel type and size, for each area when speed restrictions were not in effect (

Table 3 and Appendix K, Table 2). Thus, estimates of the extra sailing time were calculated by subtracting the time required to sail through each restricted area in periods when the rule was not in effect from the time required at a sailing speed of 10 knots. This provides the most robust estimate for actual vessel operations and operating speeds without the influence of the rule. Only average vessel speeds of greater than 10 knots during non- rule periods were used for these calculations.

The overall weighted average delay for all vessels was 0.30 hours (18 min) and ranged from 0.03 hours (2 min) for towing vessels to 0.43 hours (26 minutes) for refrigerated cargo ships (Appendix K, Table 3). Consultant updates to the U.S. Army Corps of Engineer vessel operating costs (Appendix K, Table 4) were prepared using the retrospective annual average price of bunker fuels for 2009 and current 2012 bunker fuel prices (Appendix K, Table 5). These estimates were then used to calculate the cost of the delays for each of the vessel types and sizes.

The total estimated direct cost of the rule (assuming 100% compliance and thus the maximum estimated impact) was $22.0M and $34.8M for 2009 and 2012 bunker fuel costs, respectively (Appendix K, Tables 6 and 7).

The AIS data captures the vast preponderance of commercial maritime activity that would be subject to the speed restrictions and other operational measures. However, there are some market segments that also may be impacted by the speed restrictions. Those market segments or potential impacts include cumulative effect of multi-port strings for containerships; re-routing of southbound coastwise shipping, passenger time on ferries, and indirect economic impact of port diversions. Estimates of direct economic impacts to these segments or operations have been included in the analysis (Appendix K, Table 8). In addition, depending on the nature and significance of the direct economic impact, it is possible that implementation of the operational measures could have indirect economic impacts, including increased intermodal costs due to missed rail and truck connections, diversion of traffic to other ports, impact on local economies of decreased income from jobs lost due to traffic diversions. Estimates of these indirect costs

have also been considered and included here in overall estimates of economic impact (Appendix K, Table 8), using both 2009 and 2012 bunker fuel prices.

Therefore, the maximum overall estimated direct and indirect economic impacts are $52.4M and $79.0M for 2009 and 2012 bunker fuel prices, respectively (Table 4). By way of comparison, the 2008 estimates (based on a number of assumptions[3] and less precise vessel speed information) of economic impact was $137.3M (Nathan Associates, Inc., 2008).

[3] Among other things, the 2008 estimates assumed a 100% compliance rate with DMAs which are voluntary. See Section V for a description of the DMA program.

V. Dynamic Management Areas Compliance Analysis: Vessel operations in and around Dynamic Management Areas

Jeffrey D. Adams, Gregory K. Silber, Michael J. Asaro, and Shannon Bettridge

Voluntary conservation measures have been used in a variety of marine living resource conservation efforts, including for the reduction of vessel collisions with endangered large whale species (Vanderlaan and Taggart, 2009; Wiley *et al*., 2011; Silber *et al*., submitted). These have included voluntary vessel routing measures (Vanderlaan and Taggart, 2009; Silber *et al*., submitted), voluntary speed advisories (M. McKenna, pers. comm.; Tejedor Arceredillo, *et al*., 2008), and avoidance guidance for whale watch vessels (Wiley *et al*., 2008).

As indicated earlier in this report, as a counterpart to its mandatory vessel speed restrictions, NMFS developed a program whereby it could quickly respond with protective measures for right whale aggregations that occurred outside of historically predictable areas of occurrence by establishing Dynamic Management Areas (DMAs) that were finite in geographic scope and duration. The purpose was to provide protection to these whales, while also minimizing economic impacts to the maritime community imposed by areas in which vessel speed limits are required. Mariners were advised, but not required (*i.e*., voluntary compliance was encouraged) to either avoid DMAs or travel through them at 10 knots or less. By definition, these areas would be established immediately upon confirmation of right whale sighting locations and would expire 15 days after the date they were established. At the same time, NMFS created a program to monitor vessel operations in both required (in effect seasonally) and voluntary (in effect temporarily) vessel speed restriction zones using vessel AIS technologies. Here, we provide a brief summary of the results of a study of vessel operations within DMAs. The full results will be , or have been, provided elsewhere (Adams *et al*., 2011) and in submissions to the peer-reviewed literature (*e.g.*, Asaro, 2012).

Establishing DMAs

The onset of a DMA was triggered by a reliable sighting (derived primarily from systematic aircraft surveys for marine mammals) of three or more right whales in U.S. waters within a 75 square nautical mile (nm) (138.9 km^2) area, such that right whale density was greater than or equal to 0.04 right whales per nm^2. This is consistent with a protocol suggested by Clapham and Pace (2001), and based on the assumption that whale groups at these densities would persist for an extended period. Additional (15 nm) buffer areas were then developed around the sighting location to account for potential whale movement and incorporated into a single polygon encompassing both the sighting location and its surrounding zone. Each DMA expired 15 days after the date of being established; however, if whale aggregations that met the density threshold persisted into the DMA's second week, the DMA was extended for an additional 15 days. DMAs were not established in, and therefore did not overlap, with SMAs.

The maritime community was notified about the creation of a DMA in these ways: NOAA Weather Radio broadcast on a regular basis for the full duration of the DMA; USCG broadcast notice to mariners; an email distribution list (605 recipients of shipping industry liaisons and industry representatives, pilots associations, harbor masters, marine exchanges, etc); the

Mandatory Ship Reporting automatic return message to vessels; postings on NMFS' Office of Protected Resources ship strike web site and Northeast Fisheries Science Center interactive right whale sightings "mapper"; and an automatic return message sent to mariners requesting information by electronic mail.

Vessel Operations in DMAs

A total of 69 DMAs were established between December 2008 and June 2011 (we limited our analysis to those DMAs enacted prior to June 2011). Of these, 59 occurred in waters off New England and 10 off the southeast U.S. coast. All but one of the 59 DMAs established in New England waters were rectangular in shape, while those occurring in waters off Georgia and Florida tended to be irregular in shape due to their juxtaposition to existing SMAs, broadly distributed whale sighting locations, or other (*e.g.*, oceanographic) features. Three of the 10 DMAs off the southeast U.S. were omitted from the analyses due to their proximity to active SMAs, because the presence of an SMA might skew results with regard to the behavior (*e.g.*, vessel speed) of vessel operators. The areas encompassed a combined estimated total of 905 individual whale sightings, although these included repeat sightings of the same individual whales that recurred in the same areas between or within the same years (Appendix L).

The 59 DMAs analyzed in northeast U.S. waters occurred in all months of the year, and most were established in November (n = 6), December (n = 9), and January (n = 8). The relative frequency of the occurrence of DMAs throughout the year were influenced not only by the seasonal occurrence of right whales, but also by a varying amount of aircraft survey effort throughout the year and the DMA protocol itself which indicates that DMAs would not be overlain with established SMAs. Thus, the locations of DMAs may not necessarily be a true reflection of right whale occurrence in all locations and times, but they do reflect a substantial amount of right whale occurrence outside SMA boundaries.

We used vessel positions gathered from the USCG's National AIS program to assess vessel operations within 66 DMAs. Vessel position information was aggregated into individual transits using methods similar to those described in Chapter II, above, and in Silber and Bettridge (2010). Unlike the SMA analysis, we did not limit the analysis to vessels over 65 feet (19m) because the 2008 rule did not stipulate a vessel size or class. All speeds reported here refer to "speed over ground."

Vessel transit speeds and routes were examined to determine if basic vessel operations changed in response to the DMAs. Specifically, transit speeds were analyzed to detect whether vessels altered speed as they entered the DMAs. We limited analysis to transits that included at least 5 nautical miles (nm) of travel both inside of the DMAs and in 10 nm buffers drawn around the DMAs. To ensure representative travel speeds, we limited the analysis to transits that had minimum speeds of 5 knots or greater. Vessel speeds inside DMAs and outside DMAs (*i.e.*, buffers) were compared using paired t-tests for all vessels combined, as well as for cargo, tanker, and passenger vessels.

Vessel routes were also examined to quantify the number of transits that may have involved course alterations to avoid traveling through the DMAs. For vessels whose transits were located

entirely within the 10 nm buffer, the first and last points of the transit were used to create line features. If the line features intersected the DMA, the transit was considered a potential avoidance transit (Appendix M). This analysis was conducted for transits initiated during the effective periods as well as the two-week periods directly preceding and following the effective periods.

Results and Discussion

A total of 3,324 transits that consisted of at least one nautical mile occurred within the DMAs during their respective effective periods. These transits were made by 1,100 individual vessels. The majority of the trips were made by tankers (n = 961), cargo vessels (n = 781), and tugs (n = 370) (Appendix L).

We observed lower mean speeds in the active DMAs relative to the 10 nm buffer areas surrounding the active DMAs, but the differences were small (Appendix N). The largest difference was observed for passenger vessels, whose mean speed was 16.1 knots in the 10 nm buffers and 14.1 knots in DMAs (Appendix O). Mean speeds for all analyzed vessel types were above the requested maximum speed of 10 knots. Avoidance transits during the active periods of DMAs were detected for 18 of the 66 DMAs analyzed (Appendix P). For 11 of 18 DMAs with avoidance transits during the active period, avoidance transits were also detected in either the two-week period directly preceding and/or following the active period, suggesting that other factors (*e.g.*, recommended vessel routes, traffic separation schemes, etc.) most likely play a role in the routes of the avoidance transits.

Although the DMA program may have had some tacit benefit in raising the awareness of mariners to the problem of right whale vulnerability to ship strikes, when measured by vessels either avoiding an area or restricting speed while in it, the DMA program likely had little or no impact in reducing the occurrence of ship strikes. The nuances of these data (*e.g.*, perhaps with regard to adherence to the provisions of DMAs by certain vessels or certain vessel types, or in certain times or locations) will be explored further in subsequent analysis.

Voluntary measures have received considerable use in a variety of environmental issues (National Research Council, 2002; Morgenstern and Pizer, 2007). As a means to alter human behavior, voluntary approaches are generally preferable to regulatory actions (at least as a first tier approach), because the former do not require the development of potentially costly monitoring, policing, and penalty regimes, are less prone to litigation, and can promote innovation and solutions by the affected community (Khanna, 2001; Rivera and de Leon, 2004). However, in many cases in which voluntary approaches have been tried, they have not attained their intended goals.

As to large whale vessel strike reductions, voluntary measures appear to have been successful in some situations and relatively unsuccessful in others (Wiley *et al*., 2008; Vanderlaan and Taggart, 2009; Lagueux *et al*., 2011; Silber *et al*., submitted; M. McKenna[4], *pers. comm.* 2011)

[4] Megan McKenna, U.S. Marine Mammal Commission, Bethesda, MD.

at least as success is measured by vessel operator adherence to the requested actions. Based on this study, we conclude that DMAs, as measured by mariner response to the voluntary measure, likely had only modest, if any, consequence in lowering the risk of vessel collisions with right whales.

VI. Conclusions and Recommendations

Conclusions

Vessel speed restrictions were established in certain times and locations to reduce the likelihood of ship strikes of the highly depleted North Atlantic right whale. The restrictions were set to expire five years from the date of issuance (*i.e.*, 9 December 2013) and in issuing the restrictions, NMFS indicated it would assess the effectiveness of the rule. It convened a workshop in 2008 to determine the means for doing so. NMFS has completed the analysis and herewith presents findings and considerations for next steps.

These results are based on statistical analyses of 55 large whale ship strike deaths or serious injuries having occurred over the course of 10 years; literally hundreds of millions of AIS data points used to characterize vessel operations and economic impacts represented in hundreds of thousands of passages taken by thousands of individual vessels both within and outside Seasonal and Dynamic Management Areas; and maritime community awareness-raising efforts organized by a number of NMFS personnel and through hundreds of contacts using various print and broadcast media. Although these data sets were substantial, it is not possible at this time to make definitive statements about the biological effectiveness of the rule. The time allotted to determine the biological effectiveness was simply too brief.

Participants in the 2008 workshop indicated that several years was almost certainly too brief a period to determine if the vessel speed restrictions were effective in substantially reducing ship strikes – and that several years would not be sufficient to determine if recovery was being influenced at a population level. Nonetheless, NMFS set out to assess various aspects of the program although some of these (*e.g.*, vessel monitoring) are only indirect measures of "effectiveness." These constraints notwithstanding, we have found that certain conclusions, summarized below, can be made from these assessments.

Known ship strikes – Changes in the rate of whale ship strike deaths cannot be detected in two or three years. Using the method identified here, it may be possible to detect some rather large (*e.g.*, a reduction of 30-60%) changes in five to seven years. Therefore, based on results presented here, definitive statements cannot be made about the effectiveness of reducing the occurrence of vessel strikes using vessel speed restrictions – longer time series are needed to better make such an assessment.

Vessel operations – Strict adherence to 10 knot speed restrictions was unacceptably low, but it improved through time and there are signs that an across-the-board lowering of vessel speeds will continue. The improvements are most probably due to upgraded enforcement efforts and other specifically targeted efforts to improve compliance. Foreign-flagged vessels exhibited lower compliance rates than did domestically owned and operated vessels.

Outreach – Overall, hundreds of individual efforts were made to communicate or provide material to mariners and the maritime community. We believe this to be a highly comprehensive

outreach effort (and may serve as a model for other programs), but there are ways in which it might be improved, more effectively reaching foreign flagged vessels, for example.

Economics – Actual economic impacts were substantially lower than projected in 2008. Revisions to the original estimates based on updates to such things as actual bunker fuel costs (in 2009) and the use of 2009 AIS data to quantify (rather than estimate) vessel operations indicate that the economic impact was $52.4M ($79.0M using 2012 bunker fuel prices). The 2008 projected economic impact was $137.3M. The revised estimates also assume 100% compliance (*i.e.*, all trips in all active SMAs did not exceed 10 knots) and therefore should be regarded as the maximum economic impact on the shipping industry and general economy.

Dynamic Management Areas - Mariner observation of voluntary speed restrictions or voluntary avoidance of DMAs was minimal. NOAA made extensive efforts to notify mariners about DMAs, and although it is beyond the scope of our study to determine why adherence was low, we believe that the lack of adherence to the DMAs was due more to their voluntary nature than to a lack of awareness of the management zones.

Recommendations and considerations for reducing vessel strikes of right whales through a vessel speed restriction program

The purpose of this section is to offer generalized suggestions about agency considerations if modifying the provisions of the vessel speed restriction rule and its related programs is warranted. Based on the results presented here, "lessons learned" in implementing the program, and other observations, we offer a number of recommendations about next steps and ways to improve the program to further right whale ship strike reduction. They are actions for consideration to further the goal of maximizing protection of right whales using the best available science while also considering economic impacts to the shipping industry and other maritime communities. These suggestions will require proper vetting, in some cases further analysis, may require rulemaking, and will be subject to adequate funding. Some components of this program (*e.g.*, outreach efforts, vessel monitoring) likely should be continued with only small modifications; while others (*e.g.*, dimensions of SMAs) may need re-evaluation. Because a number of aspects of this program -- regulating vessel speed in large geographic areas; monitoring a regulation using AIS; and use of a precise and remotely-sensed technology to assess vessel compliance and economic impacts -- were novel and heretofore not attempted, they are not flawless, and we therefore also provide thoughts on ways to improve these systems and programs.

A list of recommendations below is followed by a section that provides a discussion of, further information about, or justification for each recommendation.

List of Recommendations

Recommendations regarding modification of the vessel speed restriction rule

- *Vessel speed – While it is not possible to make definitive statements about the biological effectiveness of the vessel speed regulations at this time, existing evidence (based on studies appearing in the scientific literature both before and after enactment of the rule) is persuasive in indicating that vessel speed restrictions should continue as a means to reduce ship strikes of right whales. Therefore, NMFS should continue to use this tool as a means to reduce lethal vessel collisions with whales.*
- *Modification of the rule – Consideration should be given to modifying certain aspects of the regulation to enhance its capacity to reduce vessel strikes, while also giving strong consideration to economic and other impacts to various maritime communities.*
- *Size of SMAs – Consideration should be given to either expanding the sizes of the SMAs to encompass a large portion, if not all, of the recurring DMAs, or to establishing new SMAs.*
- *Vessel size – Consideration should be given to means to include smaller vessels in speed restrictions or other means to reduce strikes inflicted by small vessel classes.*
- *Dynamic Management Areas and Mandatory vs. Voluntary Measures*
    - To improve the conservation value of the DMA program, *NMFS should consider (a) doing away with it altogether and focus these efforts on more pragmatic and effective means of reducing ship strikes, (b) making the conditions of dynamically managed areas mandatory for vessel operators, or (c) expanding mandatory SMAs into areas and in times where DMAs are predictably recurring*.
    - *Possible limitations of both voluntary and mandatory measures as briefly addressed here should be considered when these types of measures are contemplated in the future*.
- *Sovereign Vessels – Exemptions for sovereign vessels should be retained in any subsequent rulemaking for the reasons indicated in the rule, namely due to the need to avoid hindering efforts with regard to such things as national security, safety of life at sea, and other vital missions. However, all vessel operations under control of federal entities should be the subject of consultation under section 7 of the ESA if not already subject to an existing Biological Opinion.*

- *Requested deviations from vessel speed restrcitions – In developing modifications to the vessel speed rule, the Office of Protected Resources should work with the Office of Law Enforcement, General Counsel, the shipping industry, and others to review and evaluate existing exemptions in the rule (including for state law enforcement vessels) to determine if they should re-instated, modified, and/or streamlined in any way.*

Recommendations regarding monitoring and compliance

- *Monitoring –*
    - *Maintain strong monitoring programs.*
    - *Continue use of AIS, or a related system, preferably through a single, centralized system, for monitoring vessels.*

    - *Anticipate and plan for analysis of reasonably long time series to monitor the rate of ship struck right whales – possibly using the metric used here. An assessment should be done and a report provided every five years regarding trends in right whale ship strike deaths and serious injuries and to assess elements of this program.*
    - *Efforts to detect and necropsy right whale ship strike deaths should continue at appropriate levels to ensure adequate sample sizes for ongoing analysis.*
    - *Aerial and shipboard right whale surveys should continue at appropriate levels to ensure proper notification to mariners of right whale locations (i.e., through the aircraft survey programs, MSR system) and to determine when and where to establish (or extend) DMAs.*
- *Improving compliance –*
    - *It is likely that enforcement programs are key to the success of this or any regulation, and adequate resources and plans for execution are essential.*
    - *Emphasis should be placed not only on attempting to determine the causes of discrepancies in compliance between domestic- and foreign-flagged vessels, but in finding ways to improve compliance among international communities, in particular.*
- *Raising mariner awareness –*
    - *An examination should be conducted, likely through a set of surveys of maritime communities, to determine whether outreach efforts are reaching their intended audiences, whether they have in fact resulted in a change in behavior of the recipient, and to ensure outreach efforts are cost-effective.*

Discussion of Recommendations

Vessel speed

The use of vessel speed restrictions to reduce lethal vessel strikes of right whales was based largely on analysis by Laist *et al*. (2001), Pace and Silber (2005), and Vanderlaan and Taggart (2007). These studies, alone, indicate that the likelihood of serious injury and death in whales struck by vessels is diminished by reduced vessel speed. The latter two analyses indicate that the probability of death or a serious injury to a struck whale is rapidly when vessel speeds are below 12 knots diminished (and the probability decreases as speed decreases). Using this logic, vessel speed restrictions are being used in other locations to reduce the threat of ship strikes to large whale species (*e.g*., humpback whales in Glacier Bay, AK; fin and sperm whales in the Mediterranean Sea).

Based on probability analysis alone (*e.g*., Pace and Silber, 2005; Vanderlaan and Taggart, 2007), the vessel speed restrictions are expected to reduce lethal ship strikes – and they, alone, likely justify continuation of the restrictions – although it is not possible to demonstrate this statistically in restricted time frames. The original ideas and findings have been backed by additional, more recent studies.

Since enactment of the vessel speed rule, several studies have appeared in the peer-reviewed literature on this topic that appear to confirm these conclusions. Among them, Vanderlaan *et al*.

(2009; right whales along the U.S. and Canadian eastern seaboard), Vanderlaan and Taggart (2009; right whales in Canadian waters), and Gende *et al*. (2011; humpback whales in Alaskan waters) concluded that vessel speed restrictions are effective in reducing the occurrence or severity of vessel strikes of right and other large whale species in various geographic locations. More specific to the context of this report, Lagueux *et al*. (2011) and Wiley *et al*. (2011) reported that implementation of NOAA's 2008 vessel speed restrictions have reduced the probability of lethal vessel strikes of North Atlantic right whales by 39% and 57% in waters off the southeast U.S. and off New England, respectively. In addition, Silber *et al*. (2010) found that both the size of the zone of influence (*i.e*., the area in which a whale is vulnerable to a strike or might be drawn into a strike) around the hull of a vessel, and acceleration (*i.e*., impact force) experienced by the whale, increases as vessel speed increases.

Therefore, based on these original results and conclusions having appeared in the peer-reviewed literature since the rule was enacted, we *recommend that vessel speed restrictions be maintained as a means to reduce ship strikes. We further recommend that consideration be given to modifying certain aspects of the regulation to enhance its capacity to reduce vessel strikes, perhaps by increasing the scope, while also giving strong consideration to economic and other impacts to various maritime communities*.

Modification of the rule
*Provisions of the vessel speed rule include certain variables (*e.g.*, vessel length, vessel speed) that, if modified, may increase their overall conservation value. For example, in its November 2008 rulemaking, NMFS indicated that*

> "Based on available data, NMFS will consider adjusting the regulations. Such actions would be taken through additional rulemaking. Measures that NMFS could consider may involve vessel size, vessel routing (*e.g*., making recommended routes mandatory), vessel speed, making dynamically managed areas mandatory, and the size and duration of the areas where the restrictions apply."

Therefore, in keeping with the thinking that adjusting one or more of these variables may be used to further limit ship strikes, NMFS might consider *modifying certain aspects of the regulation to enhance its capacity to reduce vessel strikes, while also considering economic impacts and related factors.*

Dimensions of Seasonal Management Areas
With regard to SMA sizes and the locations of their boundaries, NMFS indicated in the Rule's preamble that it would

> "…continue to monitor right whale sighting locations relative to these boundaries and may modify [the size of SMAs], as appropriate, if changes are warranted based on shifts in right whale occurrence or additional analysis."

While such analysis has not been conducted for the purposes of this report, NMFS should evaluate the size and locations of the SMAs to determine if modifying their dimensions to

enhance the extent of their protection is warranted. Establishment of these management zones was predicated on encompassing areas where right whales could reliably and predictably occur, while also limiting their size to minimize economic impacts to maritime communities.

Analysis of the number, timing, and locations of DMAs (Asaro, 2012; Adams *et al*., this report) indicate that a relatively large number of DMAs have occurred regularly in certain locations in waters off New England. These studies suggest that to include a large number of right whale observations that have occurred incidentally outside SMAs, *consideration should be given to either expanding the sizes of the SMAs to encompass a large portion, if not all, of the recurring DMAs, or to establishing new SMAs*. In addition, Schick *et al*., 2009 concluded that hypothetical SMAs that extended to 30 nm from shore and around port entrances would provide more protection for migrating right whales than do the existing SMAs with 20 nm radii. Such studies and other sources, such as an evaluation of right whale sighting information obtained since implementation of the rule should be important assets in making determinations of the locations, timing, and size of SMAs, as counterbalanced against economic impacts, in future rulemaking.

Vessel Size

Decisions regarding the size of vessels to which the vessel speed restrictions would apply were based, in large part, on conventions adopted by the USCG, the International Maritime Organization, and the maritime community whereby many regulations and guidelines are based on vessel sizes of either 300 gross tons or 65 feet in length. Nonetheless, in its rulemaking, NMFS acknowledged the occurrence of vessel strikes of right whales by vessels less than 65 feet in length and that these vessels may pose a threat to right whales. Indeed, since implementation of the rule, one known vessel strike of a right whale occurred by a (sovereign) vessel that was 50 feet in length. In its rulemaking, NMFS, therefore, indicated that it would

> "…continue to consider means, including future rulemaking, to address vessel classes below 65 ft (19.8 m). Additionally, in collaboration with other organizations, NMFS will continue to engage in education and outreach programs regarding right whale vulnerability to ship strikes specific to the recreational, fishing, and other coastal maritime activities that involve vessels less than 65 ft (19.8 m)."

As noted in the "Education and Outreach" paper contained in this report, NMFS has engaged in a number of awareness- raising efforts in regard to small vessels operation. These efforts may or may not be sufficient to limit strikes occurring in these vessel classes. Therefore, *NMFS should consider means to include smaller vessels, if possible, in speed restrictions or other means to reduce strikes in such vessels*.

One significant consideration in this regard is that adherence to rules and other activities by such vessel classes may be difficult to monitor. As noted, NMFS is currently monitoring vessel operations using AIS technologies; however, by international convention and USCG requirements, only vessels 65 feet or greater are required to carry AIS transmitters. Therefore, if smaller vessel classes are included, monitoring adherence to rules affecting these vessels would be difficult, and means to do so would need to be developed. In addition, smaller vessel classes include a wide variety of vessel types including self-, wind-, jet-propelled craft. Therefore,

whereas these vessels may pose a threat to right whales, means to include them, including the consideration about, for example, appropriate vessel lengths and classes and means of propulsion, in ship strike reduction measures may be challenging.

Dynamic Management Areas and Voluntary vs. Mandatory Measures
In efforts to reduce lethal vessel strikes of whales, NMFS has taken a number of management actions – some requesting voluntary changes in vessel operations, some mandatory (*e.g*., vessel speed restrictions). Although the virtues of voluntary measures are not being specifically addressed here, some studies have indicated that voluntary changes to vessel operations to reduce strikes have been adhered to (in the case of recommended routes (Lagueux *et al*., 2011)) and an International Maritime Organization-endorsed Area To Be Avoided (Vanderlaan and Taggart, 2009); while others have not (in the case of whale watch boats avoiding whales (Wiley *et al*., 2008)).

In its 2008 rulemaking, NMFS indicated it would:

> "…monitor voluntary compliance with designated DMAs. If adherence is not satisfactory, NMFS will consider making them mandatory, through a subsequent rulemaking."

The analysis of DMAs contained in this report (Adams, *et al*., above) about vessel operations and the relatively low adherence to vessel speed advisories within DMAs should be an important consideration in assessing whether DMAs should be made mandatory and whether the DMA program should continue at all. Bearing in mind, too, that our analysis indicates that even requisite changes in vessel operations (*i.e*., required vessel speed restrictions) are no guarantee that they will be adhered to and compliance will be automatic. Therefore, *the limitations of both voluntary and mandatory measures should be considered when required or voluntary measures are contemplated in the future*.

Adherence to the conditions of DMAs is voluntary, and the number of vessels avoiding or traversing these areas at 10 knots or less, as recommended, is low. Therefore, to improve the conservation value of this program, *NMFS should consider (a) doing away with the DMA program and focus these efforts on more pragmatic and effective means of reducing ship strikes, (b) making the conditions of dynamically managed areas mandatory for vessel operators, or (c) expanding mandatory SMAs into areas and in times where DMAs are predictably recurring.*

Deviations from Requirements of the Rule
The existing Rule provides certain deviations from the provisions of the rule to those vessels subject to the vessel speed restrictions under adverse meteorological or oceanographic conditions that might jeopardize navigational safety. A ship's captain can, based on local conditions and his or her judgment of those conditions and the safety of the vessel, deviate from the 10 knot speed restriction. Any such deviations and the justification for doing so must be properly documented in the ship's logbook. NMFS continues to believe that allowing such deviations is necessary for the safety of life at sea, but NMFS also has reason to believe some vessel operators regularly deviate from the required ten knot speed limit when conditions do not require it. Therefore, in

developing modifications to the vessel speed rule, *the Office of Protected Resources should work with the Office of Law Enforcement, General Counsel, the USCG, the shipping industry, and others to review existing exceptions in the rule to determine if they should be re-instated, modified, and/or streamlined in any way* and in such a manner to ensure navigational safety while also enhancing the conservation value of the restrictions. While some exceptions are probably necessary, there may be ways to improve how these are implemented and recorded.

Sovereign Vessels

Sovereign vessels – those vessels owned or operated by Federal agencies or through contract with Federal agencies – are not required to comply with provisions of the existing rule. This includes vessels operated by the U.S. Navy (USN) (and foreign sovereign vessels when they are engaging in joint exercises with the USN), the USCG, the Army Corps of Engineers (ACOE), NOAA, and several other agencies. The reasons for this, as stated in the 2008 rule, are

> "the national security, navigational, and human safety missions of some agencies may be compromised by mandatory vessel speed restrictions."

NMFS indicated further that:

> "[h]owever, this exemption will not relieve Federal agencies of their obligations to consult, under section 7 of the ESA, on how their activities may affect listed species. NMFS acknowledges that a number of agencies already provide guidance to vessel operators and fleets with regard to conservation measures to protect right whales and other endangered species, as well as contribute to conservation efforts generally."

We recommend that exemptions for sovereign vessels remain in place if subsequent rulemaking that is contemplated. The reasons for the exceptions remain. In addition, some federal entities such as the USN, USCG, and the ACOE either consult with NMFS under section 7 of the Endangered Species Act (ESA) in regard to their vessel operations, or operate under the provisions of existing ESA Section 7 Biological Opinions. In addition, for years, the USN and USCG have had standing orders for their Atlantic fleets to adhere, to the extent possible, to right whale ship strike reduction measures. These programs should be updated, if needed, and continued.

However, as noted above, text in the preamble of the rule indicates that NMFS would recommend that all federal entities operating in U.S. east coast waters to initiate consultations under the ESA. In large part, these consultations have not occurred. Perhaps most notable is that vessel operations housed in various NOAA programs have not undergone consultation. A case in point is a right whale struck and perhaps seriously injured by a vessel operated under a NOAA National Marine Sanctuary program did not result in the initiation of a consultation. This track record needs to be improved. Therefore, we recommend, as previously indicated in the 2008 Rule, that *all vessel operations undertaken under control of federal entities (i.e., operations of all sovereign vessels) be the subject of consultation under Section 7 of the ESA if not already subject to an existing Biological Opinion*, or re-initiated as new information related to the Opinion is received.

Monitoring

Strong monitoring programs provide mechanisms for improving conservation programs. We, therefore, recommend that *attention be given to maintaining a strong vessel monitoring program* for both voluntary and mandatory measures.

Monitoring -- Vessels

With regard to monitoring vessel operations, and therefore compliance with the speed restrictions, we have found that the use of AIS has provided a comprehensive, cost-effective, and precise means to monitor vessel operations and we *highly recommend AIS, or a related system, be maintained for monitoring vessel operations* (although new monitoring technologies should also be considered as they are developed), *preferably in a single, centralized network.* In addition to providing a platform for a detailed analysis of vessel operations, this system has been compatible with the development of programs that provide feedback directly to vessel operators about their actions to improve compliance (this has been done in both conjunction with this program and by Wiley *et al*., 2011), and a means to supplement enforcement actions. In another program initiated by the World Shipping Council, NMFS has been working in collaboration with the Council and USCG in an attempt to use existing AIS outgoing messaging capabilities to provide immediate feedback to mariners that exceed 10 knot speed restrictions. Although initiated, the program may take several years to develop.

An AIS-based program has had a number of virtues. Data were collected remotely and cost-effectively. For the analysis presented here and in a host of related analyses, NMFS relied heavily on the USCG's established network of receiving stations. Although aspects of the USCG's system are still under development (and some may be becoming obsolete and others unfunded), it has been an invaluable resource to this program and any effort to continue or enhance it should be encouraged. Given the rate at which data are transmitted and the wealth of information they contain, the AIS is highly precise in assessing vessel positional and speed operations. And, as the 2008 workshop participants recommended, such a system would logically be *based on a centralized AIS network*. There are, nonetheless, downsides to this system as well: the amount of incoming data for archiving, processing and analyzing is formidable and not all transmissions are flawless due primarily to operator error.

Monitoring -- Whale deaths and serious injuries

As noted above, one to five years is not an adequate time to assess whether ship strike deaths have been lowered. Therefore, NMFS should *anticipate and plan for analysis of reasonably long time series to monitor the rate at which right whales are struck by vessels*. The metric described and used here (time elapsed between subsequent large whale ship strike deaths) is one very good possibility for ongoing monitoring, and there may be other related means to conduct this type of assessment. In addition, NMFS should plan on continuing these monitoring efforts and *should provide a report every five years of right and large whale ship strike death and serious injury rates and trends*. Related to this, *efforts to detect and necropsy right whale ship strike deaths should continue at appropriate levels*.

Improving Compliance and Improving Awareness

Compliance with the restrictions generally has been low – but, indications are that speeds across all vessels sampled were trending lower by 2011 (see Bettridge and Silber, above). It is not clear why compliance rates were low and this matter should be the subject of additional study. This, and analysis that will be presented elsewhere, indicates that compliance improved among certain sectors of the shipping industry particularly when NMFS' Office of General Counsel began to issue citations. (At the time of this writing more citations are being processed). Therefore, it is likely that *enforcement programs are key to the success of this or any regulation, and adequate resources and plans for execution are essential*.

Our analysis (Bettridge and Silber, above) also indicates that compliance was notably lower in foreign-flagged vessels than was exhibited by those owned and operated by domestic entities. Here, again, the reasons for this are not clear and factors may include infrequent or irregular U.S. port calls, notifications having never reached operators of foreign flagged vessels, communications were received but not well understood possibly due to language barriers, a lack of understanding of U.S. regulations, or other reasons. Whatever the reason, *emphasis should be placed on not only attempting to determine the causes of these discrepancies, but in finding ways to improve compliance in these segments of the shipping community*.

One clear first step toward improving compliance is that NOAA should work, immediately, to *ensure vessel speed SMAs are depicted on NOAA's paper and/or electronic charts*. In addition, consideration should be given to the translation of some materials into other languages and/or the consideration of new outlets for distribution. Another approach to consider is wider distribution of articles in foreign trade magazines. As a related matter, *federal agencies that own or operate vessels (including those under contract) should consult, or be encouraged to consult, with NMFS under the provisions of the Endangered Species Act regarding the operation of their vessels*.

As noted above, NMFS has made efforts to communicate the requirements of the vessel speed restrictions to various maritime communities and through a variety of media. The goal was to blanket the affected communities as completely as possible. Viewed in terms of quantity and amount of coverage, we regard this program as highly successful. Indeed, the structure and scope of this effort may be a model for outreach programs for other regulatory actions. Although extensive in scope and coverage, one shortcoming of this effort is an assessment of whether the efforts have achieved desired outcomes.

Although not known with certainty, it is possible that compliance was improved by the extensive outreach program undertaken, and inasmuch as most material and broadcasts are produced and distributed relatively inexpensively, these may be highly cost-effective ways to alter vessel operations. Intuitively, among these, steps taken through customary or required media for those navigating in U.S. waters, U.S. *Coast Pilots*, Broadcast and Local Notices to mariners, for example, are likely the most effective in directly reaching the shipping industry. Mailings going directly to shipping companies with information about the operations of their vessels, specifically, likely were also strong motivators for vessel operators to understand and abide by the restrictions.

The agency has tracked and quantified its outreach efforts; however, the impacts of these efforts have had on relevant entities have not been determined and there may be ways to improve the program. NMFS has not conducted an analysis of whether (a) these various media outlets reached their intended targets, (b) once distributed, they reached actual vessel operators; or (c) they actually resulted in changes in behavior. Nor has an assessment been done to determine which of the individual outreach efforts have had the most (or most cost-effective) impact. The participants of the 2008 workshop discussed the possibility of performing a marketing survey to assess awareness about the rule. To date, no such survey has been conducted, but doing so (subject to funding availability) would be useful in determining whether outreach efforts were successfully targeting relevant affected entities, whether they were prompted in some way to respond, and if so, whether behavior actually changed; or conversely, whether the materials, approach, or outlets should be modified. Therefore, we believe it advisable to conduct a set of surveys to answer these questions as a means to improve the effectiveness and cost-effectiveness of outreach efforts.

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FIGURES

Fig. 1. Locations of vessel speed restriction Seasonal Management Areas (NMFS 2008)

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

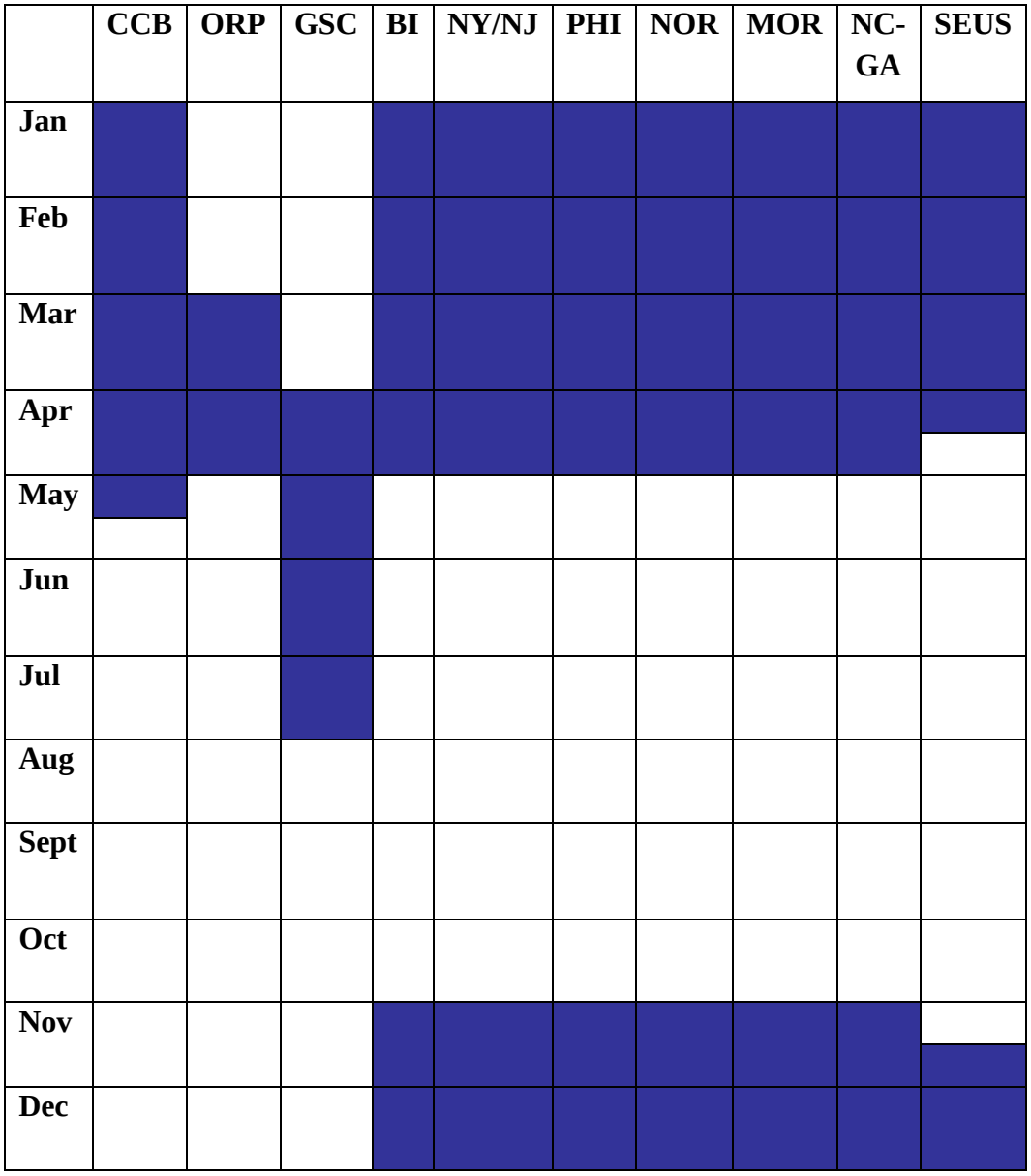


Fig. 3. Proportion of use of each SMA by domestic and foreign flag vessels in 2009, 2010, and 2011.

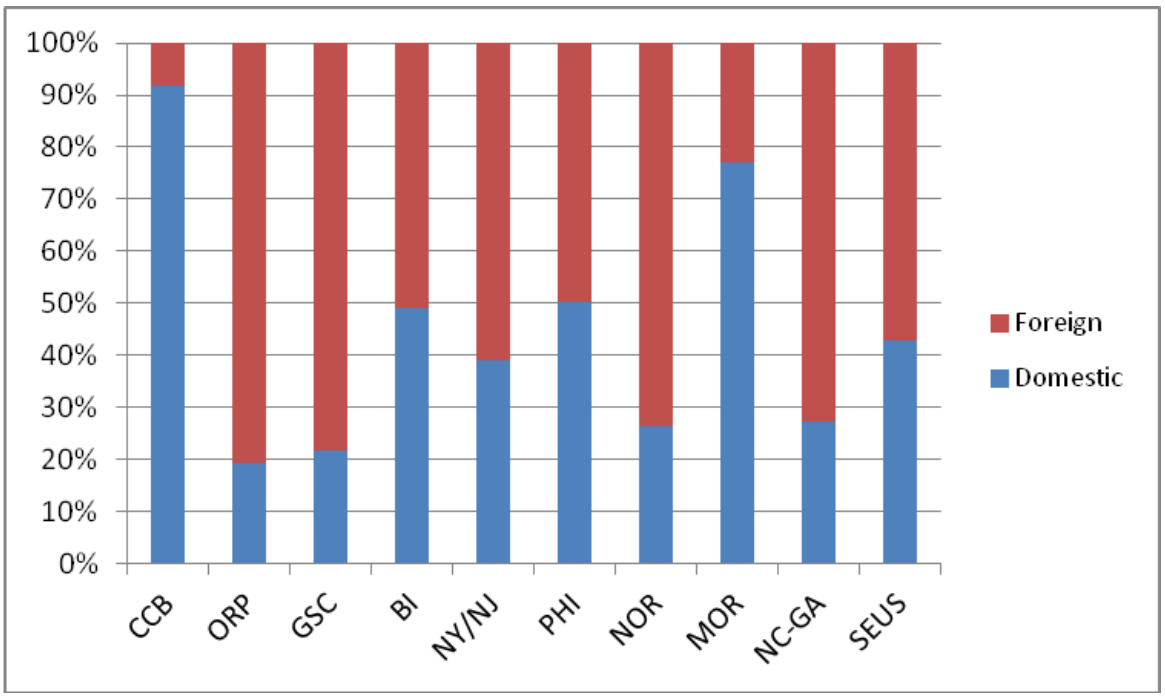


Fig. 4. Distribution of vessel types transiting all SMAs in 2009, 2010, and 2011.

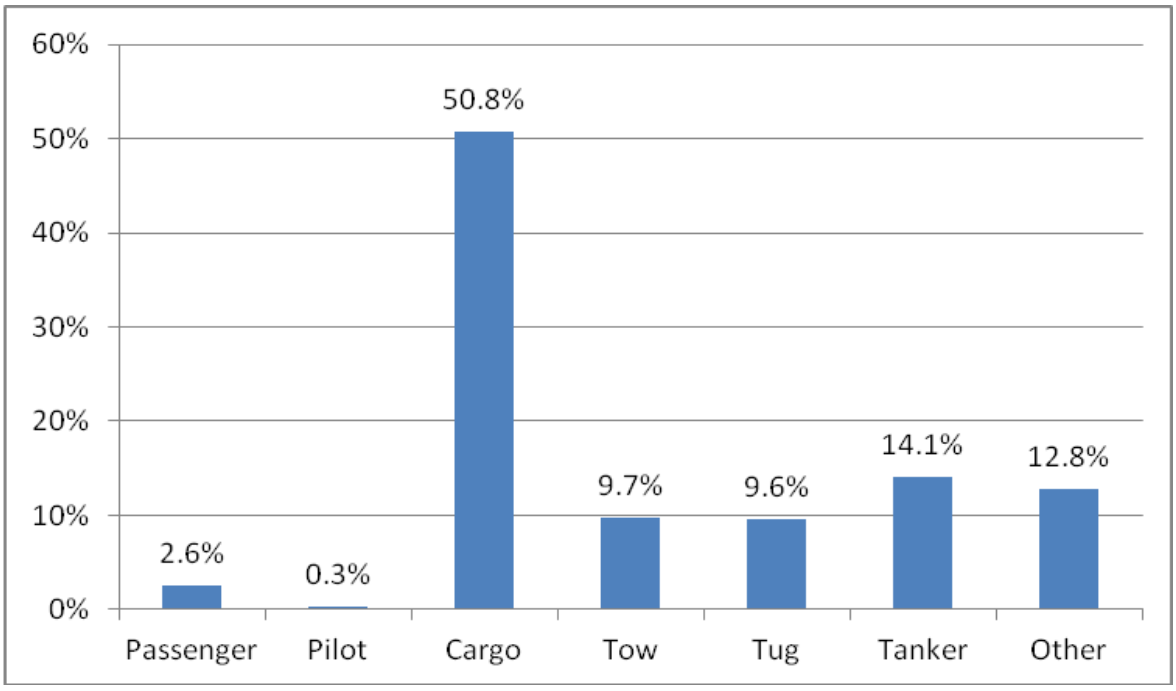


Fig. 5. Number of transits in each SMA by vessel type in 2009, 2010, and 2011. (Note: CCB, GSC, and ORP SMAs were collapsed into "NEUS" category for this figure because the numbers of transits in each of these SMAs were imperceptible given the scale of this graph.)

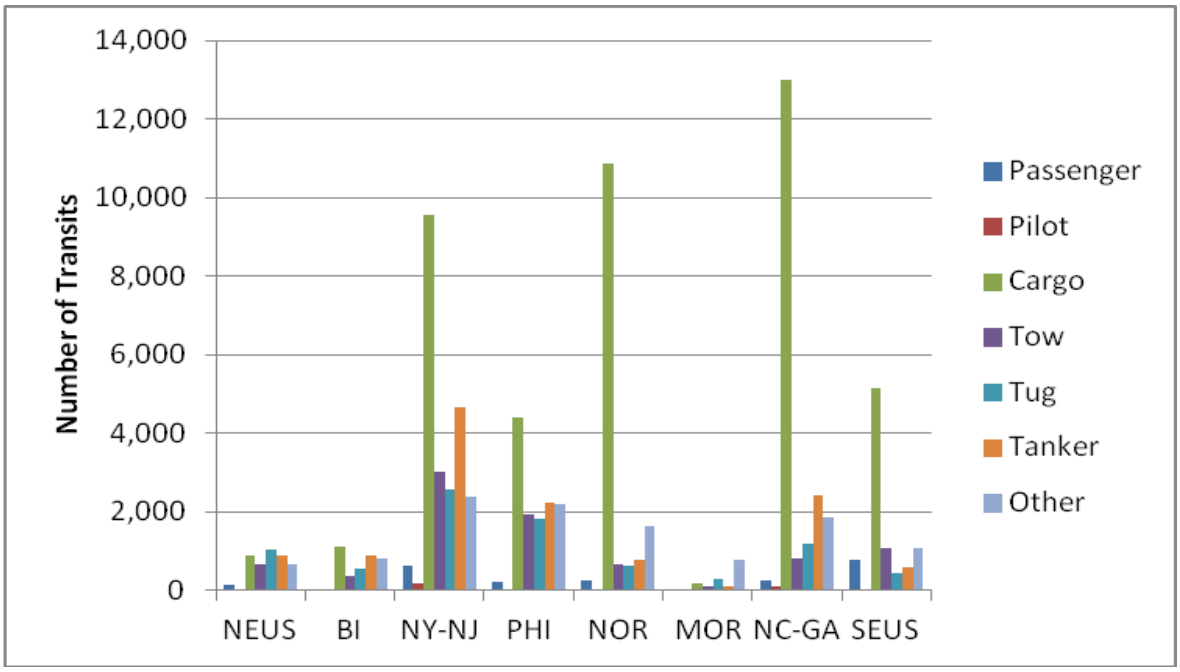


Fig. 6a. Proportion of transits in which vessel speed was at or below 10.0 knots for the entire distance; above 10.0 knots for 1-50% of the distance; or above 10.0 knots for 51-100% of the distance, for all SMAs in 2009, 2010, and 2011.

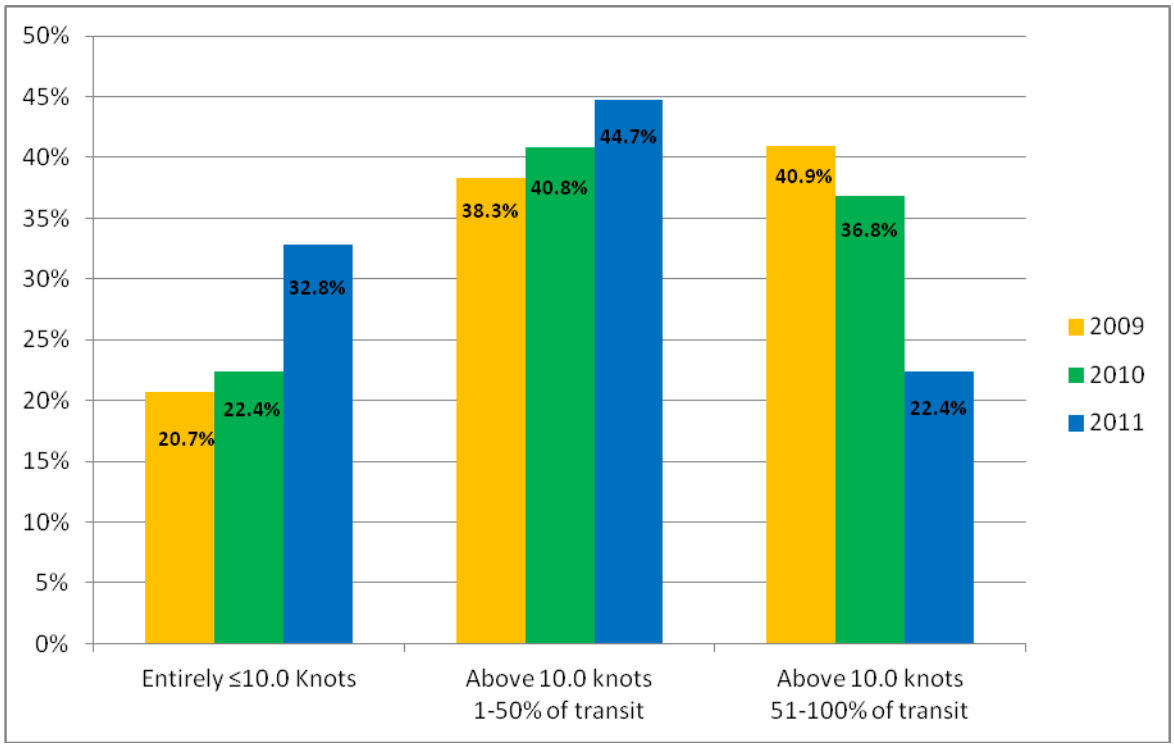


Fig. 6b. Proportion of transits in which vessel speed was at or below 12.0 knots for the entire distance; above 12.0 knots for 1-50% of the distance; or above 12.0 knots for 51-100% of the distance, for all SMAs in 2009, 2010, and 2011.

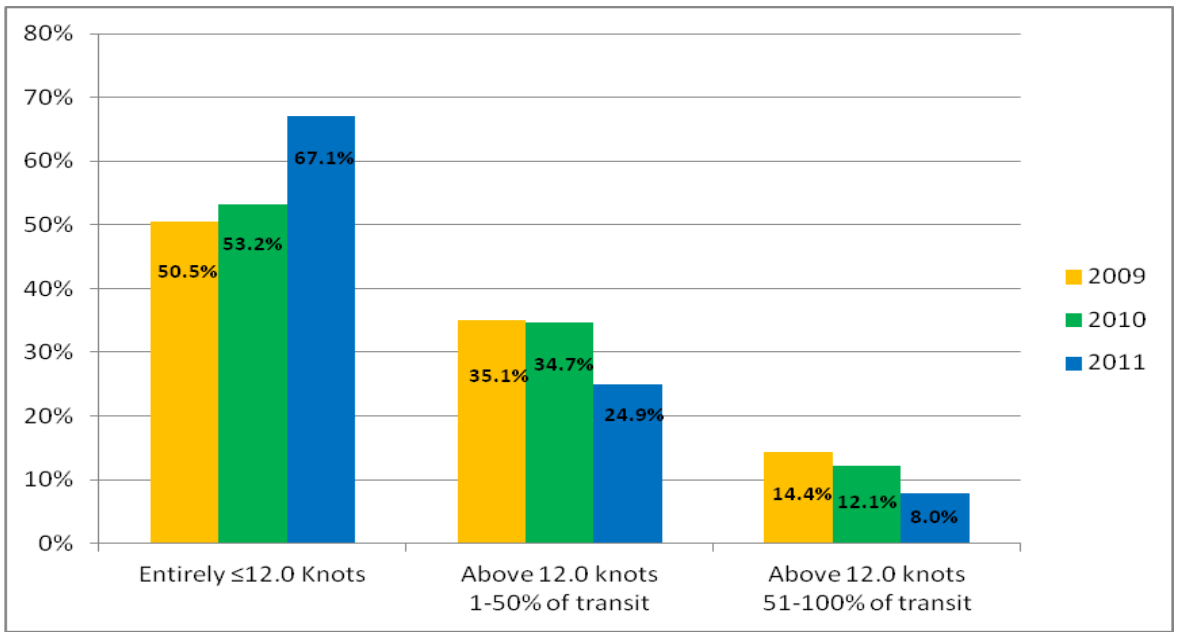


Fig. 7. Distribution of vessel speeds, as described by "maximum speed over ground" in all SMAs in 2009, 2010, and 2011.

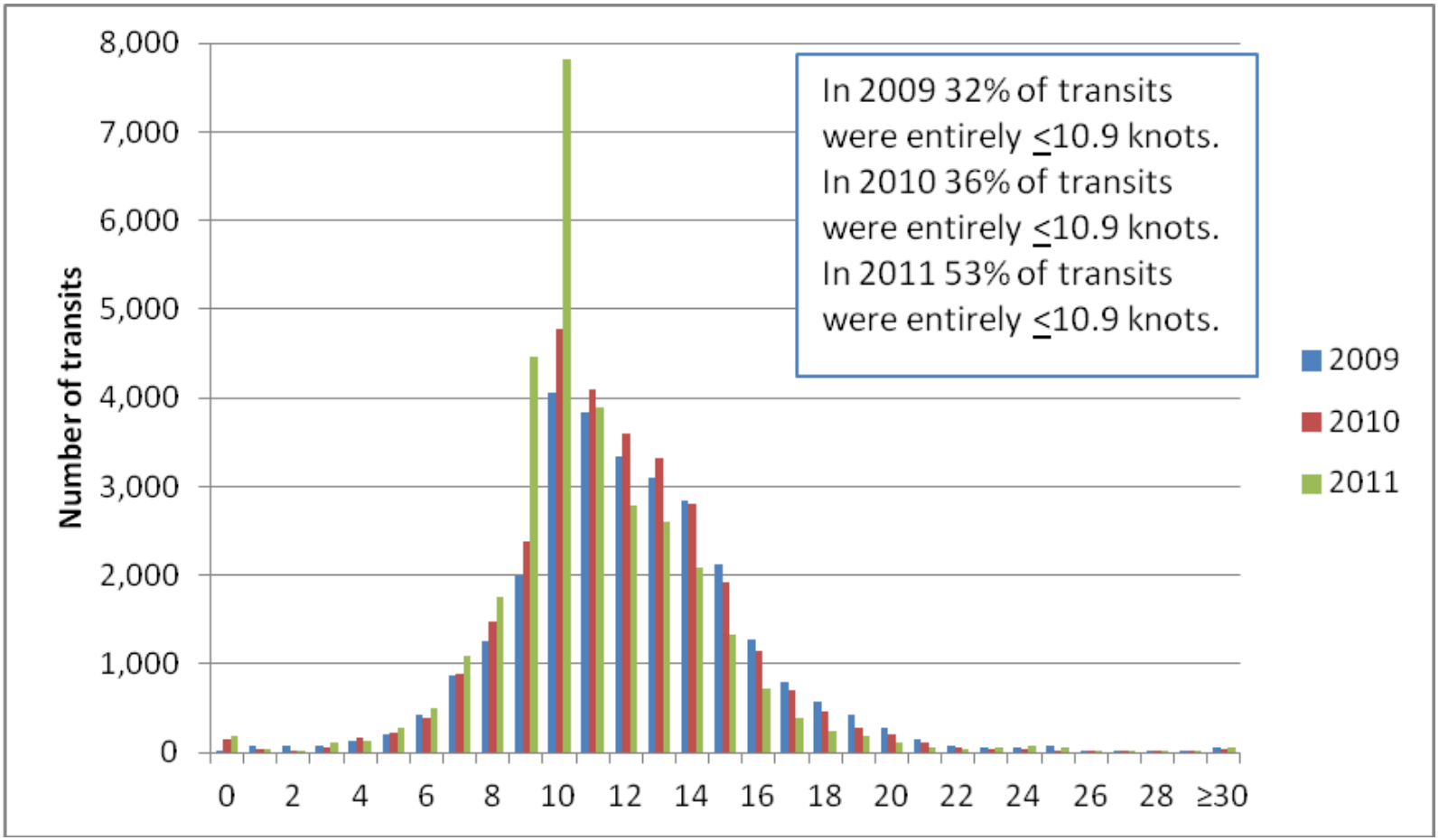


Fig. 8. Distribution of vessel speeds through SMAs, displayed as a percent of the total transit, as a function of "maximum speed over ground" by vessel type.

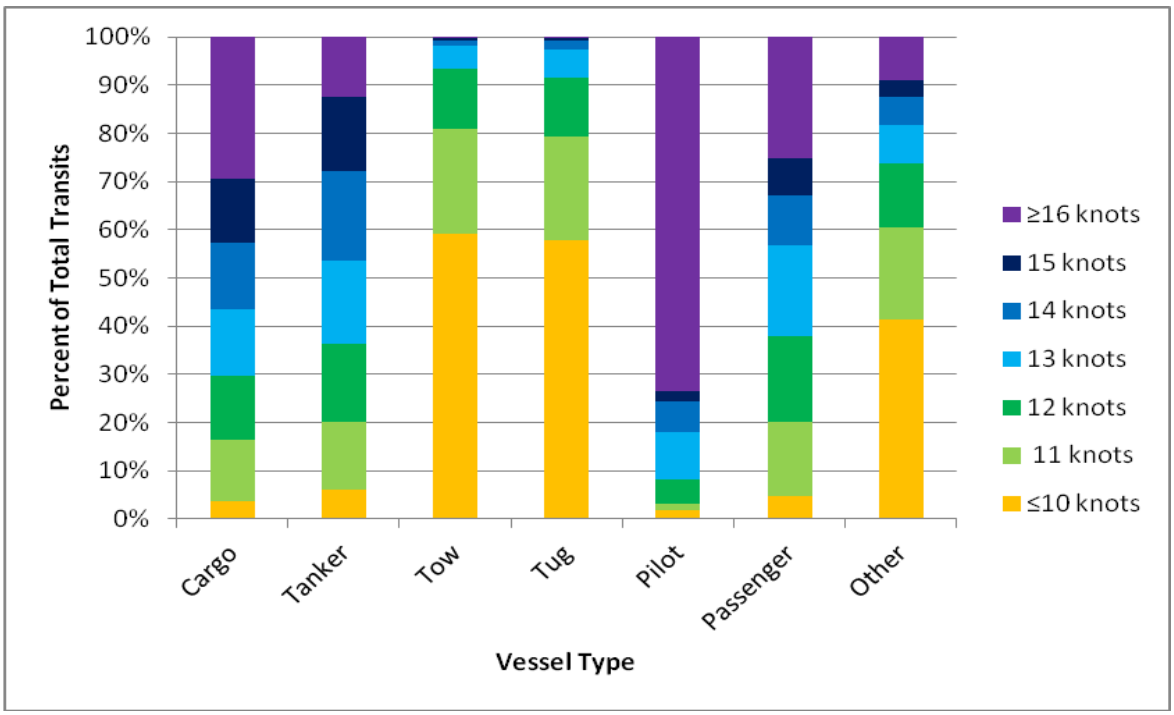


Fig. 9. Maximum vessel speed as a function of country of origin, 2009, 2010, and 2011.

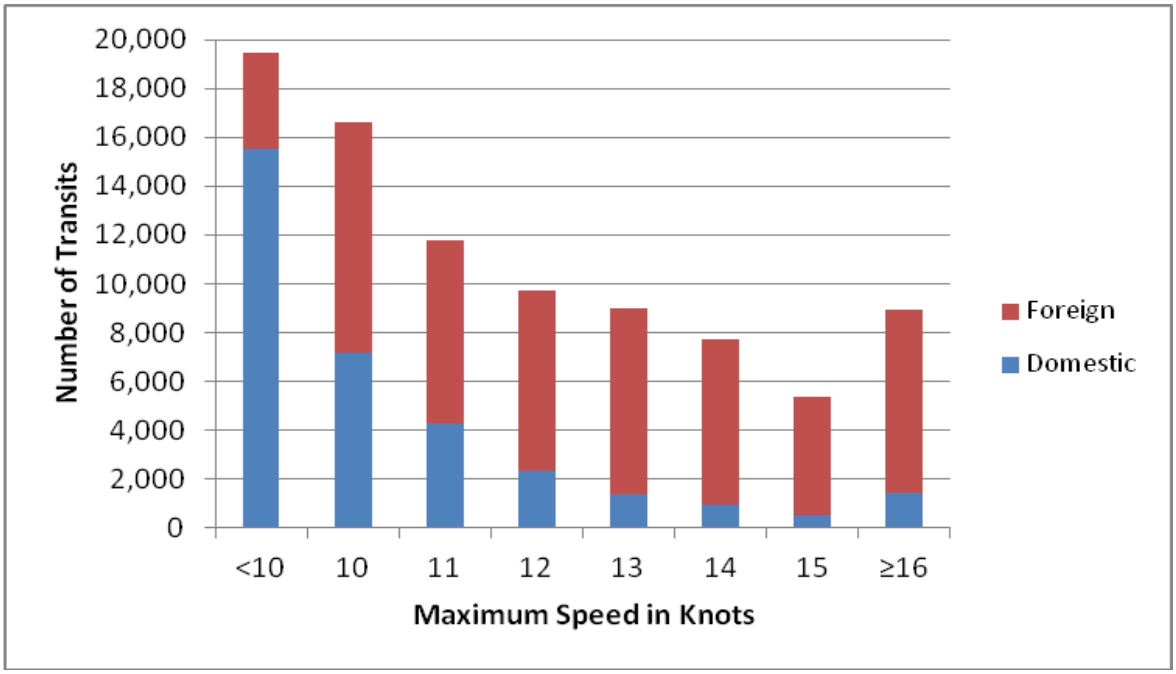
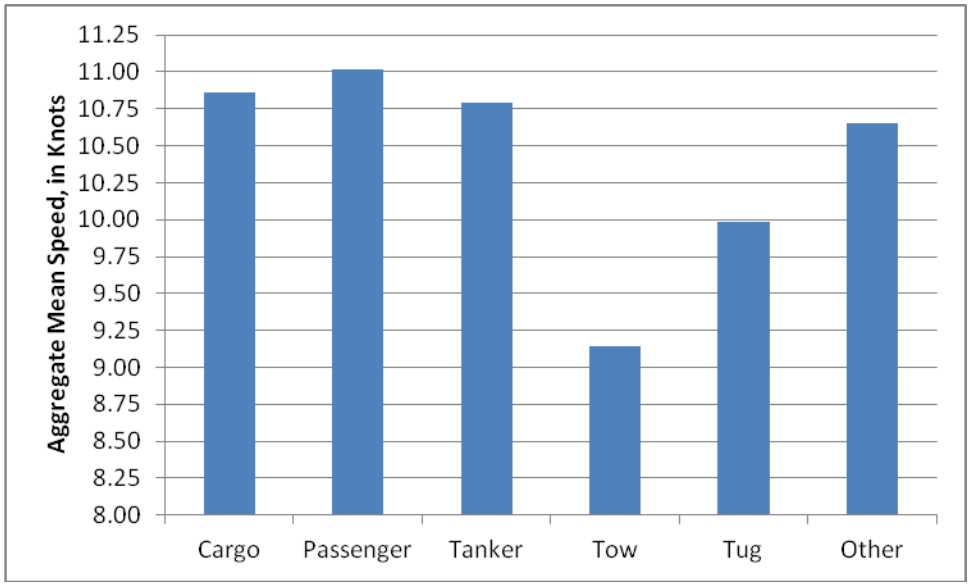


Fig. 10. Aggregate mean vessel speeds within all SMAs, 2009 and 2010.



TABLES

Table 1. Dates of active SMAs, number of days analyzed in each, and number of transits analyzed in each in 2009, 2010 and 2011.

Region	Acronym	Times "Active"	Number of SMA days	Number of SMA transits analyzed 2009	Number of SMA transits analyzed 2010	Number of SMA transits analyzed 2011	Total number of transits analyzed
Cape Cod Bay	CCB	1 January – 15 May	135	718	748	594	2,060
Off Race Point	ORP	1 March – 30 April	61	217	235	214	666
Great South Channel	GSC	1 April – 31 July	122	410	539	632	1,581
Block Island	BI	1 November – 30 April	181	1,240	1,256	1,242	3,738
New York	NY	1 November – 30 April	181	7,651	7,660	7,678	22,989
Philadelphia	PHI	1 November – 30 April	181	3,857	3,910	5,068	12,835
Norfolk	NOR	1 November – 30 April	181	4,790	4,720	5,328	14,838
Morehead City	MOR	1 November – 30 April	181	475	424	572	1,471
North Carolina to Georgia	NC-GA	1 November – 30 April	181	6,172	6,743	6,734	19,649
Southeast U.S.	SEUS	15 November – 15 April	152	2,773	3,209	3,105	9,087
TOTAL			**5,636**	**28,303**	**29,444**	**31,167**	**88,914**

Table 2. Number of transits analyzed, by vessel type, in each of the SMAs in 2009, 2010, and 2011.

SMA	Passenger	Pilot	Cargo	Tow	Tug	Tanker	Other	Total
CCB	4	0	61	601	992	143	259	2,060
ORP	12	0	276	47	53	243	35	666
GSC	108	0	564	20	10	489	390	1,581
BI	17	0	1,101	357	536	897	830	3,738
NY-NJ	631	165	9,570	3,020	2,579	4,647	2,377	22,989
PHI	203	31	4,409	1,927	1,839	2,247	2,179	12,835
NOR	254	9	10,857	673	640	774	1,631	14,838
MOR	15	0	194	94	279	115	774	1471
NC-GA	262	99	12,981	831	1,193	2,432	1,851	19,649
SEUS	768	2	5,161	1,071	434	577	1,074	9,087
Total	2,274	306	45,174	8,641	8,555	12,564	11,400	88,914

Table 3. Average Vessel Operating Speed by Type and Size of Vessel for Areas Subject to Rule During Periods When Rule is Not in Effect, 2009 (knots)

	DWT Size Range (000s)																		
Vessel type	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-60	60-70	70-80	80-90	90-100	100-120	120-150	150+	Total
Bulk Carrier	-	11.1	11.2	11.9	9.6	11.4	11.0	10.7	11.2	11.9	12.4	11.3	11.5	10.8	-	-	12.8	10.8	11.3
Combination Carrier (e.g. OBO)	-	13.9	-	-	-	-	-	10.1	-	-	-	-	9.8	-	-	12.7	-	-	10.6
Container Ship	12.5	13.0	14.1	13.6	13.1	14.9	14.5	13.9	14.0	13.9	14.4	13.9	13.6	14.1	-	-	-	-	14.0
Freight Barge	9.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.4
General Dry Cargo Ship	11.5	11.4	13.8	12.3	12.9	12.2	12.6	11.2	12.3	12.9	10.7	-	-	-	-	-	-	-	12.3
Passenger Ship a/	10.6	15.9	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.4
Refrigerated Cargo Ship	-	14.8	14.7	15.0	-	-	11.3	-	13.4	-	13.7	-	-	-	-	-	-	-	14.0
Ro-Ro Cargo Ship	8.3	13.3	13.6	14.3	13.7	13.2	13.9	15.3	13.4	14.3	13.6	13.4	-	-	-	-	-	-	13.6
Tank Ship	-	12.3	11.6	12.7	10.8	12.2	12.1	12.4	12.0	12.0	11.8	12.0	11.2	11.3	10.6	11.3	10.2	11.2	11.8
Towing Vessel	8.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.2
a/ Includes recreational vessels.																			
Source: Prepared by Nathan Associates Inc. from AIS data as described in text.																			

Table 4. Total Economic Impact of Rule Using 2009 and 2012 Bunker Fuel Prices, ($000s).

	Bunker fuel prices of	
Impact	2009	2012
Direct economic impact		
Shipping industry vessels	21,976	34,776
Cumulative effect of multi-port strings	3,593	5,685
Re-routing of southbound coastwise shipp	1,298	2,054
Pasengers' time on passenger ferries	5,191	5,191
Whale watching vessels	1,336	1,336
Subtotal direct economic impact	33,393	49,041
Indirect economic impact of port diversions	18,970	30,019
Total economic impact	52,363	79,061
Source: Prepared by Nathan Associates as described in text.		

APPENDICES

Appendix A Conclusions excerpted from "*Report of a workshop on assessing the effectiveness of the right whale ship strike reduction rule*" (Silber and Bettridge, 2009)

Report of a Workshop on Assessing the Effectiveness of the Right Whale Ship Strike Reduction Rule

November 19-20, 2008
Silver Spring, Maryland

Gregory Silber
Shannon Bettridge
Office of Protected Resources
National Marine Fisheries Service, NOAA

March 2009

Introduction

The U.S. National Marine Fisheries Service's (NMFS) final rule to reduce the severity and likelihood of vessel strikes to North Atlantic right whales went into effect on 9 December 2008 (73 FR 60173; 10 October 2008). The stated goal of the rule is "*to reduce or eliminate the threat of ship strikes [of North Atlantic right whales] - the primary source of mortality in the endangered population*". The rule requires certain vessels to travel at 10 knots or less in certain areas of right whale aggregation and near several key port entrances along the U.S. eastern seaboard. One provision of the rule is that NMFS will develop ways to monitor its effectiveness in attaining its intended goal. The rule expires in 5 years. Therefore, within a few years, NMFS will need to (a) devise a way to monitor the rule's effectiveness, (b) assess its overall effectiveness, and (c) generate a report of the findings.

On November 19-20, 2008, NMFS' Office of Protected Resources convened a Workshop on Assessing the Effectiveness of the Right Whale Ship Strike Reduction Rule. The goal of the workshop was to develop a strategy, involving multiple components, to monitor and assess whether vessel speed regulations are achieving the rule's intent of reducing the occurrence of ship strikes in right whales (*i.e.*, whether the rule is "effective"). Appendix 1 is a list of workshop participants and the workshop Terms of Reference are provided in Appendix 2.

Workshop Conclusions

By way of summary, key workshop conclusions are provided here; background information and descriptions of principal discussions follow.

The final rule contains a provision that the regulations would expire five years after implementation. With regard to the expiration, the workshop concluded that at that time, NMFS would (a) re-issue the regulations, (b) modify the regulations, or (c) allow them to expire. Therefore, if the regulations are to be modified or re-issued by the December 2013 expiration date through the rulemaking process, it will be necessary to have conclusions regarding effectiveness in hand for National Oceanic and Atmospheric Administration (NOAA) leadership by December 2011. As a result, data collection should start immediately and summaries and reports regarding the rule's effectiveness should be available by December 2011.

Workshop participants agreed that the timeframe for implementing adequate and rigorous metrics is quite short. In fact, given the suite of variables contributing to ship strikes, detecting meaningful biological effects of the regulations would be difficult. Variables complicating a rigorous assessment of effectiveness include changes in maritime commerce, oceanographic features contributing to shifts in whale distribution, and the rarity of a ship strike event. Much longer time series are typically needed to detect statistically meaningful effects. Nonetheless, within these rather arbitrary time constraints, workshop participants understood the charge to develop metrics, as possible.

Workshop participants agreed that NOAA will use four basic parameters to monitor effectiveness.

1. Biological data

Only one metric can be used to statistically evaluate the rule's effectiveness given the short time constraints: through assessments of observed time lapses between known ship strike related deaths of all large whale species. Thus, the rates of known ship strike deaths and serious injuries, both before and after implementation of the regulations, will be compared statistically to determine whether the regulations have resulted in a reduced rate (as opposed to the actual number) of known ship strikes. Although the rule focuses geographically on waters inhabited by right whales, adequate sample sizes can only be obtained by using data on all large whale species ship strike deaths. Certain assumptions (*e.g.*, constancy of detection effort) need to be assured. Other measures, *e.g.*, whale demographics, relative abundance, number of ship strike deaths, and scarring were discussed and considered not appropriate because much longer time series and larger sample sizes would be needed for sufficient statistical rigor. As a second component, NMFS will continue to collect and synthesize right whale sighting data to confirm that elements

of the regulations (*e.g*., the size, time periods, and dimensions of Seasonal Management Areas (SMAs)), are on appropriate scales, or modify them as appropriate. Thus, NMFS might determine that the regulations could be more effective if dimensions of the SMAs were changed.

Other measures, discussed below, constitute indirect assessments of effectiveness.

2. Human behavior

Mariner compliance rates are one measure of effectiveness. Therefore, NMFS will quantify mariner compliance with the regulations using Automated Identification System (AIS). Receipt and analysis of ship-transmitted AIS data will allow precise quantification of the number of mariners that are exceeding 10 knots; NMFS will develop periodic summary reports of compliance. As a corollary to this, NMFS will use the same means to quantify mariner compliance with voluntary measures, such as Dynamic Management Areas and recommended routes established as protective measures for right whales.

3. Mariner awareness

To be effective, all segments of affected entities and industries need to be fully aware of the regulations. Therefore, NMFS will quantify the number of outgoing messages, printed material distributed, press releases, and direct communications with maritime industries and estimate the audiences reached and potential receivers of the information.

4. Economics

NMFS will assess potential economic impacts of the regulations by confirming, updating, and possibly improving economic impacts estimations made prior to implementation of the regulations. Conditions affecting shipping and other economic activities will be subject to many factors, including global and domestic economics. We will try to filter the effects of the regulation within the overall economic scenario.

Therefore, in sum:

NMFS's program to assess the effectiveness of the ship strike reduction rule will consist of these components and conditions.

- Data collection should start immediately and synthesis and reports regarding the rule's effectiveness should be available by December 2011.

- Biological:
    - Ensure consistency of monitoring efforts
    - Continue ongoing efforts to monitor large whale deaths known to have resulted from ship strikes
    - Conduct statistical analysis of changes in rate of time elapsed between known large whale ship strike deaths
- Human behavior:
    - Seek to develop or utilize a coast-wide centralized AIS monitoring system
    - Provide periodic reports of mariner compliance
- Education and Outreach
    - Monitor outreach efforts by quantifying, for example, the amount of material distributed, numbers of broadcasts made, and attempt to estimate audience reached
- Economic
    - Gather data on economic impact of rule
    - Conduct economic analysis for Environmental Impact Statement
- Related analysis
    - Continue to gather and analyze right whale sightings and ship strike records to assess appropriateness of SMA dimensions; and number, size and compliance with DMAs

Frequency of Whale and Vessel Collisions on the US Eastern Seaboard: Ten Years Prior and Two Years Post Ship Strike Rule

by Richard M. Pace

NOAA National Marine Fisheries Service Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration National Marine Fisheries Service
Northeast Fisheries Science Center Woods Hole, Massachusetts

August 2011

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INTRODUCTION

Protected species science programs are frequently asked to provide management advice based on imperfect data associated with occurrence rates of rare events such as strandings, road kills or other rarely detected mortalities. Ship strikes of large whales and right whales are such settings, and they are of particular interest because economically significant management actions have been enacted to hopefully reduce their occurrence. These measures are of unknown effectiveness while possibly causing annual industry costs ranging from tens of thousands to exceeding $100 million (shipping regulations). Following implementation of what have been termed "the Ship Strike Rules" (Federal Register 2006) which became effective 9 December 2008, the National Marine Fisheries Service (NMFS) will likely be challenged to demonstrate the recovery benefits of these expensive conservation measures in terms of effectiveness measures (e.g. whales saved). An added question on the minds of managers, industry representatives and conservation organizations is, "How long need actions be in place before we know if they are effective?" For the analyst, this entails evaluating a Poisson process of relatively rare events for significant decreases in rates of occurrence. Data on ship strikes include a highly scrutinized time series of dates when whale mortalities that resulted from whale-ship collisions were detected during 2000-2010. With only 8 years of data prior to implementation of the Ship Strike Rule, uncertainty about the *status quo* rate will still be large. Further, whale-ship collisions that produce whale deaths will likely not be eliminated by management actions. Therefore, it is the amount by which they may have been reduced concomitant with adherence to regulations that must be investigated. Herein, I examine the timing of detected ship strikes of large whales to see whether there has been any reduction in their rate of occurrence detected ship-strike related mortalities. I also provide some advice on increasing the length of the time series after rule enactment to detect different effect sizes.

METHODS

Serious injury and mortality data for large whale stocks in the US Atlantic were evaluated for evidence of collisions with ships from necropsy and gross observations reported to the Northeast Fisheries Science Center (NEFSC) (see Glass et al. 2009 for a description). From these data, I included all reports judged to be mortalities or serious injuries (hereafter mortalities) to fin (*Balaenoptera physalus*), sei (*B. borealis*), right (*Eubalaena glacialis*) and humpback (*Megaptera novaeangliae*) whales during the period 1 January 1999-31 December 2010. Strikes of each species should resemble a Poisson process, each with its own inherent rate, and because Poisson processes are summable, events pooled across species should also resemble a Poisson process. Using the discovery date associated with each strike, I calculated the time elapsed since the previous event, which I refer to as "waiting time," and I refer to the times since the Ship Strike Rule went into effect as event times (events occurring prior to the rule were coded as negative event times). I first examined the waiting time data relative to fits of models of exponential waiting times. Competing models included, in descending order of complexity:

1 Variable rates among years (*i.e.*, 12 rates, 1 per year 1999-2010),

2 2 rates, one prior to the rule and one after, and

3 A single rate.

Preliminary evaluations of similar data suggested that a more powerful approach at detecting changes may be to develop regressions of event times against order of occurrence, and to compare models with and without change points. I fit both classical linear models and their Bayesian counterparts to examine the evidence for a change in the rate of ship strikes since the implementation date of the Ship Strike Rule. Competing models included:

1 a single slope (a constant ship strike rate)

2 a fixed change point having 2 slopes on either side of the implementation date

3 2 distinct regression models for before and after the rule, and

4 a free-floating, single change point analysis with 2 slopes on either side of an arbitrary change date, where that date was also allowed to vary and achieve the bit fit.

The latter 2 models were only evaluated in the Bayesian framework. All Bayesian models were evaluated using WinBugs (ver. 1.4.3) (Lunn, et al. 2000) and were structured with broad flat priors on all parameters (Carlin and Louis 2000). Model Selection was based on DIC, an information criterion similar to AIC for likelihood models (Spiegelhalter 2002).

In addition to examining the available data on detected ship strike mortalities, I examined the potential to detect a change in rates of ship strikes using a set of simulation trials. Specifically, I estimated the mean of the exponential distribution that best fit the pre-Rule waiting times. I simulated sets (1000 each) of waiting times that would occur, if the estimated rate of occurrence of ship strikes were 66, 50 and 33% of the pre-Rule rate for 2, 5 and 7 years post implementation. I then tested the hypothesis that a change point model with rates differing before and after implementation of the rule (model 5 above) fit these simulated data better than a constant regression model (model 4 above). The percent rejections (alpha=0.05) were taken as measure of power to detect a true change for the 9 combinations of 3 study durations and 3 effect sizes.

RESULTS

A total of 58 ship strikes of large whales that were deemed to be serious injuries or mortalities were included in NEFSC data during 1 Jan 1999 – 31 December 2010. These included 17 humpback, 16 fin, 21 northern right, and 4 sei whales. The most consistent evaluation of these data occurred beginning in 2000 (TVN Cole, Pers. Comm.), so I limited analysis to event times starting with the first strike in 2000 (n=55). A simple plot of the data gives an appearance of heterogeneity among years with 2005 appearing as a particularly nasty one (Figure 1). However, there was no statistical support for heterogeneity in event waiting times among years (Appendix A). As with most biological data, waiting times between detected ship strikes appear somewhat more variable than those associated with a simple Poisson process (ship strikes per year).

Comparing change point models for these data offered a meager amount of evidence for an increase in the time between events after rule implementation, which equates to fewer ship strike mortalities detected per annum. Based on AICc, the classical regression model with a fixed change after the rule (model 5 above) received weight of 0.75 vs. the single rate regression (model 4 above) weight of 0.25, with an estimated effect size of only 3 days longer between strikes after rule implementation (Appendix B). Similarly, only weak distinctions were possible among Bayesian change point models with DIC values of 64.7, 63.0, 63.2, and 53.3 (Appendix C) for single slope

(model 4 above), two slopes on either side of the implementation date (model 5 above), 2 distinct regression models (model 6 above), and a free-floating, single change point analysis (model 7 above), respectively (smaller values are better). The one exception was the free-floating change point model, which rather convincingly suggested that, if one change occurred in these data, it was a significant decrease in time between strikes starting in early 2004 (Appendix C; Figure 2). Using the Bayesian framework to evaluate the before and after rule model (fixed change point referred to as model 5 above), the estimated times between ship strikes were 62 days before the rule and 88 days after the rule (Figure 3). Although this effect size differed considerably from the classical framework estimates, the posterior distribution for the rate of mortalities after the ship strike rule was enacted included a relatively large amount of variance (Figure 3).

Clearly there would be more power to detect change the large that change is and the longer the period of evaluation after the rule is enacted. In my simulations, correct detections of significant changes in times between ship strikes ranged from 1% when a 33% reduction in the rate of ship strikes occurred and post-rule monitoring existed for only 2 years to a 99.7 correct detection rate when a 66% reduction in ship strikes occurred and monitoring included 7 years of data after the ship strike rule was enacted (Table 1).

CONCLUSIONS

Based on the analysis of change points, there was only weak evidence to support an increase in the time between detected ship strike mortalities of large whales on the eastern U.S. seaboard after enactment of the Ship Strike Rule. Rates of detected serious injuries and mortalities of large whales resulting from ship-whale collisions appeared to show somewhat greater variability during the 11 years evaluated than what might be expected by chance alone. The estimated size of the effect, if one existed, depended heavily on the frame work (classical regression or Bayesian MCMC) in which the time series of ship strike dates were evaluated. Due to the lack of a clear outcome from the evaluation of ship strike event times when coupled with the results of the simulation study, I suggest at least 5 years of data be evaluated prior to passing judgment on the biological effectiveness of the Ship Strike Rule.

ACKNOWLEDGEMENTS

Data used in this paper come from numerous sources. A. G. Henry and T.V. N. Cole are largely responsible for collating and often evaluating the level of evidence from a report to determine if it warrants a serious injury and were it not for their diligence and consistent treatment of reports, my evaluation would have little meaning. Determinations of causes of mortality are due in large part to a few highly skilled biologists that form a part of the stranding network and were essential in developing these data.

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Table 1. Detection rates (%) of false null hypotheses for simulated times between ship strikes assuming that the rates estimated for serious injuries and mortalities detected between 1 January 2000 and 8 December 2008 were reduced as indicated.

	YEARS OF POST RULE MONITORING		
REDUCTION IN RATE	2	5	7
33%	1	50.8	65.9
50%	2.5	80.5	92.8
66%	6.1	94.6	99.7

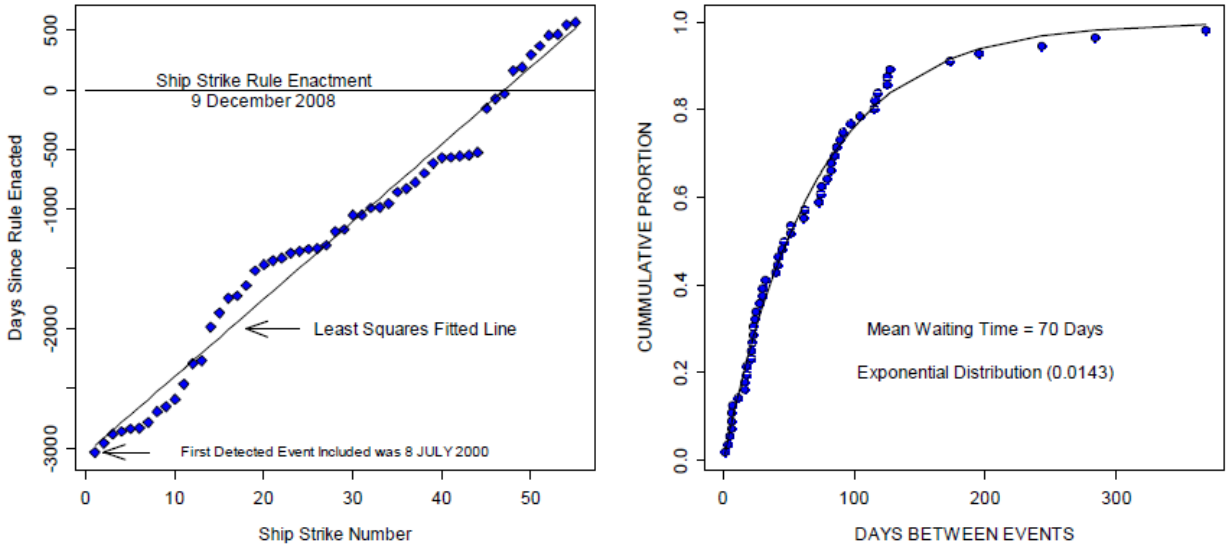


Figure 1. Whale and ship collisions resulting in serious injuries or mortalities detected along the US Eastern seaboard 2000-2010. Graphs represent timing of events in chronological order (A) and the cumulative distribution (B) resulting from the best generalized linear model fit to time between events (model 4 above).

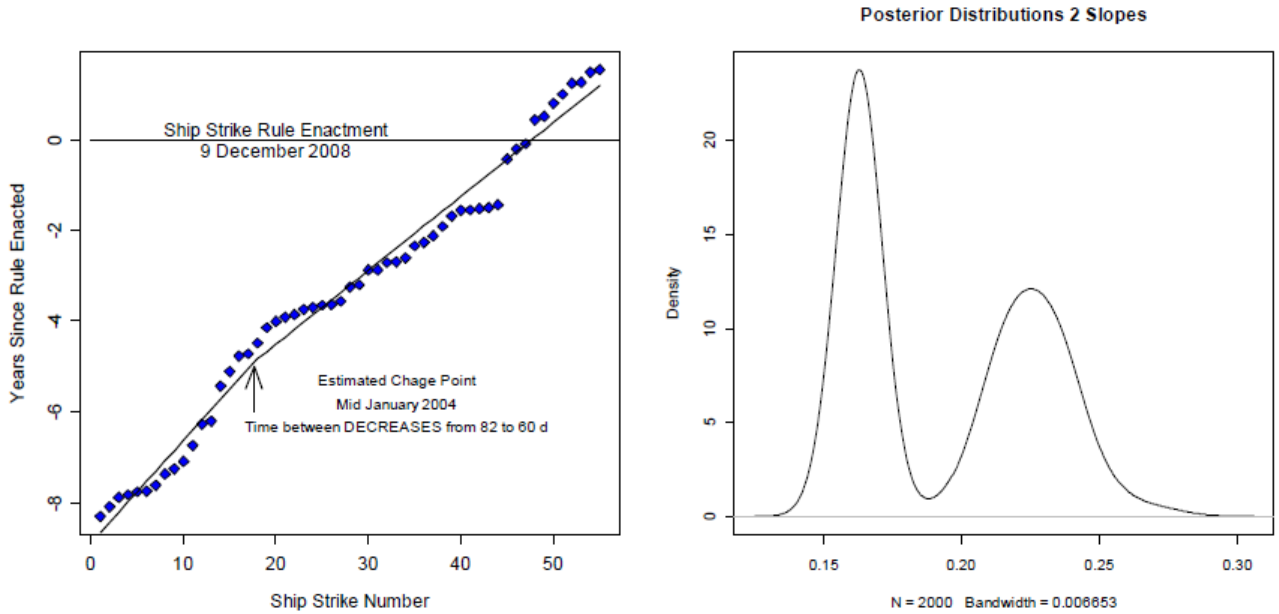


Figure 2. Whale and ship collisions resulting in serious injuries or mortalities detected along the US Eastern seaboard 2000-2010. Graphs depict fit resulting from a Bayesian framework used to estimate a free floating change point for the timing of events in chronological order (A) and the posterior distributions of estimated of rates (1/years between events) for change point model (model 7 above).

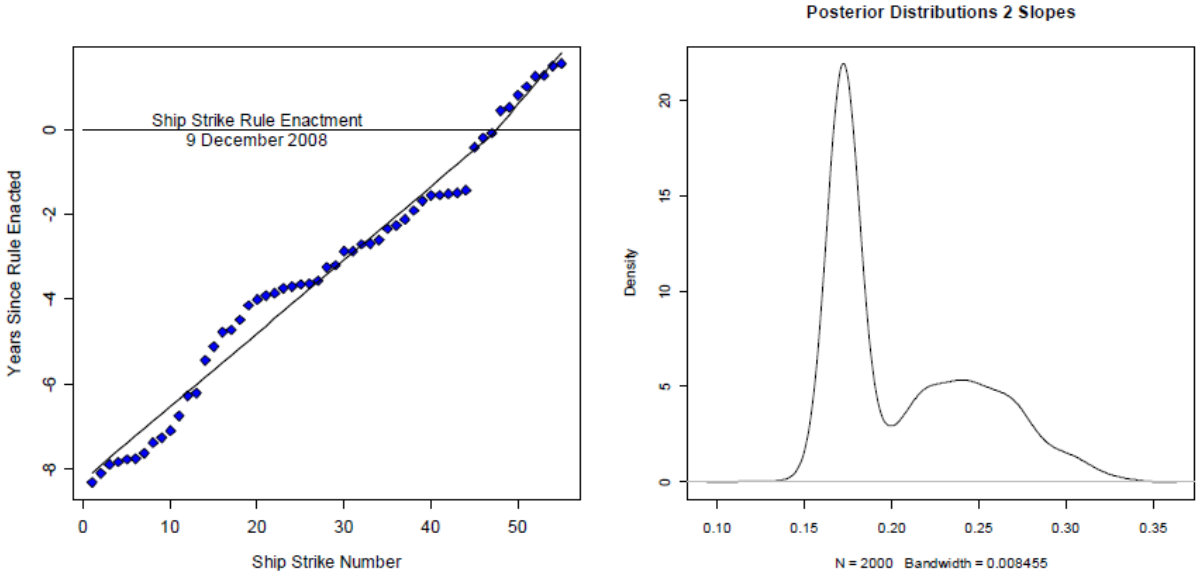


Figure 3. Whale and ship collisions resulting in serious injuries or mortalities detected along the US Eastern seaboard 2000-2010. Graphs depict Bayesian model fit of rate of events that included a change point fixed at Ship Strike Rule enactment date estimated for the timing of events in chronological order (A) and the posterior distributions of estimated of rates (1/years between events) for change point model (model 5 above).

APPENDIX A. CLASSICAL STATISTICAL COMPARISONS

```
summary(model 1, dispersion=1)

Call:
glm(formula = TimeBetween ~ as.factor(Year), family = Gamma,
    data = LW_00)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.4383  -0.6774  -0.2990   0.4531   1.5846

Coefficients:
                     Estimate  Std. Error z value Pr(>|z|)
(Intercept)          0.007576   0.004374   1.732   0.0833 .
as.factor(Year)2001  0.016562   0.010118   1.637   0.1016
as.factor(Year)2002  0.001770   0.006946   0.255   0.7989
as.factor(Year)2003 -0.002576   0.005624  -0.458   0.6470
as.factor(Year)2004  0.006154   0.007110   0.866   0.3867
as.factor(Year)2005  0.022959   0.011648   1.971   0.0487 *
as.factor(Year)2006  0.011614   0.007749   1.499   0.1339
as.factor(Year)2007  0.026907   0.014741   1.825   0.0680 .
as.factor(Year)2008 -0.001453   0.005624  -0.258   0.7961
as.factor(Year)2009  0.002424   0.006643   0.365   0.7152
as.factor(Year)2010  0.012626   0.011007   1.147   0.2513
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Gamma family taken to be 1)

    Null deviance: 59.892  on 54  degrees of freedom
Residual deviance: 41.073  on 44  degrees of freedom
AIC: 577.83

Number of Fisher Scoring iterations: 6


summary(model 2, dispersion=1)

Call:
glm(formula = TimeBetween ~ as.factor(Rule), family = Gamma,
    data = LW_00)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.5103  -0.9778  -0.2913   0.3310   2.0157

Coefficients:
                   Estimate Std. Error z value Pr(>|z|)
(Intercept)        0.016006   0.002413   6.633 3.28e-11 ***
as.factor(Rule)1 -0.005896   0.003888  -1.516    0.129
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(Dispersion parameter for Gamma family taken to be 1)

    Null deviance: 59.892  on 54  degrees of freedom
Residual deviance: 57.864  on 53  degrees of freedom
AIC: 581.3

Number of Fisher Scoring iterations: 6
```

summary(model_3, dispersion=1)

```
Call:
glm(formula = TimeBetween ~ 1, family = Gamma, data = LW_00)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.5532  -0.9853  -0.3895   0.2659   2.2856

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) 0.014334   0.001933   7.416 1.20e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Gamma family taken to be 1)

    Null deviance: 59.892  on 54  degrees of freedom
Residual deviance: 59.892  on 54  degrees of freedom
AIC: 581.51
Number of Fisher Scoring iterations: 6
```

Confidence set for the best model

```
Method:  raw sum of model probabilities

95% confidence set:
```

	Model	K	AICc	Delta AICc	AICcWt
intercept only	3	2	581.74	0.00	0.46
Before and After Rule	2	3	581.77	0.04	0.46
All Years	1	12	585.26	3.52	0.08

```
Model probabilities sum to 1

Conclusion --- Note that the AICc for intercept only model and 2 rate model
are the same even though 1 parameter was added: only one rate is supported
```

APPENDIX B. CLASSICAL CHANGE POINT ANALYSIS

summary(model.oneslope) (Model 4)

```
Call:
glm(formula = DaysSince2 ~ count, data = LW_00)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-328.93  -112.88   -15.83    98.70   299.95

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -3041.774     41.798  -72.77   <2e-16 ***
count          64.675      1.299   49.80   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

    Null deviance: 59213198  on 54  degrees of freedom
Residual deviance:  1238754  on 53  degrees of freedom
AIC: 713.31
```

summary(model.change) (Model 5)

```
Call:
glm(formula = DaysSince2 ~ 1 + count:as.factor(Rule), data = LW_00)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-258.13   -88.46   -29.35    72.82   306.03

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)           -2998.680     45.336  -66.14   <2e-16 ***
count:as.factor(Rule)0    62.087      1.756   35.36   <2e-16 ***
count:as.factor(Rule)1    65.025      1.269   51.24   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

    Null deviance: 59213198  on 54  degrees of freedom
Residual deviance:  1140740  on 52  degrees of freedom
AIC: 710.78
```

AICc Comparison --- Confidence set for the best model

```
Method:  raw sum of model probabilities
95% confidence set:
                  K  AICc    Delta AICc  AICcWt
Change After Rule 4 711.58        0.0     0.75
One Slope         3 713.78        2.2     0.25
```

Conclusion - with an evidence ratio of 3:1, the change point is somewhat preferred, but the estimated difference in rates before and after the Rule (62 vs 65 days between) was small.

APPENDIX C. BAYESIAN CHANGE POINT ANALYSIS

(smaller DIC indicate BETTER fit)

Model	DIC
Free Change point	53.287
Fixed Change point	63.012
2 Regressions	63.170
1 Slope	64.706

Conclusion - Fixed change point is slightly preferred over a constant rate. Free change point is much preferred over the rest which indicates some unidentified heterogeneity is dominant over any rate change that might have occurred post-Rule.

Appendix C. Sample Community Oriented Policing and Problem Solving (COPPS) letter.

On (insert date) your vessel (insert name) was allegedly operating in excess of the 10 knot speed limit inside the (insert SMA here).

This letter is an official reminder of regulations regarding the Ship Strike Reduction Rule found at 50 CFR 224.105 promulgated under the authority of the Endangered Species Act and the Marine Mammal Protection Act. All vessels greater than or equal to 65 feet operating in the (insert SMA and applicable dates here) must slow to speeds of 10 knots or less. Vessels may operate at a speed greater than 10 knots only if necessary to maintain a safe maneuvering speed in an area where conditions severely restrict vessel maneuverability.

Atlantic large whales are protected under the Marine Mammal Protection Act (16 USC 1361) and the Endangered Species Act (16 USC 1531). Violations of either act can result in civil penalties, criminal fines and/or imprisonment. The NOAA Fisheries Service Office of Law Enforcement investigates reported violations of the Marine Mammal Protection Act and the Endangered Species Act.
Additional information about the Ship Strike Reduction Rule can be obtained online at www.nero.noaa.gov/shipstrike or by calling Special Agent (name) at (phone)
Sincerely,

Name
Special Agent-in-Charge
NOAA Fisheries Service Office of Law Enforcement
(Name) Enforcement Division

Appendix D. Sample Email to Shipping Companies.

Dear _____:

Attached is an Excel file that includes individual spreadsheets for each (Ship company) ship recorded in “Seasonal Management Areas” (SMA) along the US eastern seaboard in (month, year). The National Oceanic and Atmospheric Administration (NOAA) established vessel speed restriction zones in certain locations and times to reduce the threat of vessel collisions with North Atlantic right whales (http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/compliance_guide.pdf). NOAA's National Marine Fisheries Service (NMFS) is using AIS technologies to track vessel operations in these SMAs and has compiled monthly summaries of (Ship company) vessels that have transited through the active SMAs..

Appendix E. Compliance Guide for Right Whale Ship Strike Reduction Rule (available at http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/compliance_guide.pdf)

Science, Service, Stewardship

Compliance Guide for Right Whale Ship Strike Reduction Rule (50 CFR 224.105)

NOAA FISHERIES SERVICE

Mandatory speed restrictions of 10 knots or less are required in Seasonal Management Areas along the U.S. East Coast during times when right whales are likely to be present. The purpose of this regulation is to reduce the likelihood of deaths and serious injuries to these endangered whales that result from collisions with ships.

Vessels may operate at a speed greater than 10 knots only if necessary to maintain a safe maneuvering speed in an area where conditions severely restrict vessel maneuverability as determined by the pilot or master.

If a deviation from the 10 knot speed restriction is necessary, the following information must be entered into the logbook:

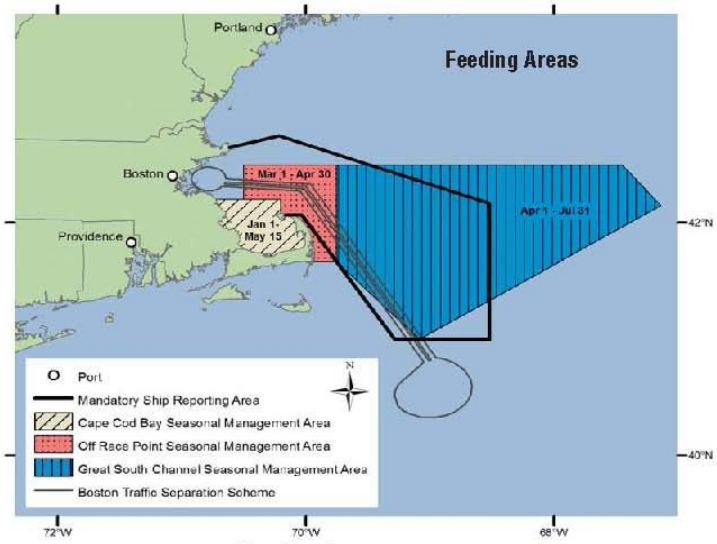
- Reasons for deviation
- Speed at which vessel is operated
- Latitude and longitude at time of deviation
- Time and duration of deviation
- Master of the vessel shall sign and date the logbook entry

Page 1 of 2

ATTENTION: All vessels greater than or equal to 65 ft (19.8 m) in overall length and subject to the jurisdiction of the United States and all vessels greater than or equal to 65 ft in overall length entering or departing a port or place subject to the jurisdiction of the United States.

YOU MUST SLOW TO SPEEDS OF 10 KNOTS OR LESS IN SEASONAL MANAGEMENT AREAS

Northeast U.S. Seasonal Management Areas



Feeding Areas

Cape Cod Bay
January 1 - May 15
Includes all waters of Cape Cod Bay with Northern Boundary of 42°04'56.5"N, 070°12'W to 42°12'N, 070°12'W then due west back to shore.

Off Race Point
March 1 - April 30
Waters Bounded by:
42°04'56.5"N 070°12'W
42°12'N, 070°12'W
42°12'N, 070°30'W
42°30'N, 070°30'W
42°30'N, 069°45'W
41°40'N, 069°45'W
then due west back to shore.

Great South Channel
April 1 - July 31
Waters Bounded by:
42°30'N, 069°45'W
42°30'N, 067°27'W
42°09'N, 067°08'24"W
41°00'N, 069°05'W
41°40'N, 069°45'W
then back to starting pt.

The rule does not apply to waters inshore of COLREGS lines.

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

Migratory Route

November 1 through April 30

Vessel speed is restricted in the following areas:

- Block Island Sound waters bounded by:
  40°51'53.7" N 070°36'44.9" W
  41°20'14.1" N 070°49'44.1" W
  41°04'16.7" N 071°51'21.0" W
  40°35'56.5" N 071°38'25.1" W
  then back to starting point.
- Within a 20-nm (37 km) radius of the following (as measured seaward from the COLREGS lines):
  - -Ports of New York/New Jersey:
    40°29'42.2"N 073°55'57.6"W
  - -Entrance to the Delaware Bay (Ports of Philadelphia and Wilmington):
    38°52'27.4"N 075°01'32.1"W
  - -Entrance to the Chesapeake Bay (Ports of Hampton Roads and Baltimore):
    37°00'36.9"N 075°57'50.5"W
  - -Ports of Morehead City and Beaufort, NC:
    34°41'32.0"N 076°40'08.3"W
- Within a continuous area 20 nm from shore between Wilmington, NC, to Brunswick, GA, bounded by the following:

Point	Latitude	Longitude
A	34°10'30"N	077°49'12"W
B	33°56'42"N	077°31'30"W
C	33°36'30"N	077°47'06"W
D	33°28'24"N	078°32'30"W
E	32°59'06"N	078°50'18"W
F	31°50'00"N	080°33'12"W
G	31°27'00"N	080°51'36"W

and west back to the shore.

Calving and Nursery Grounds

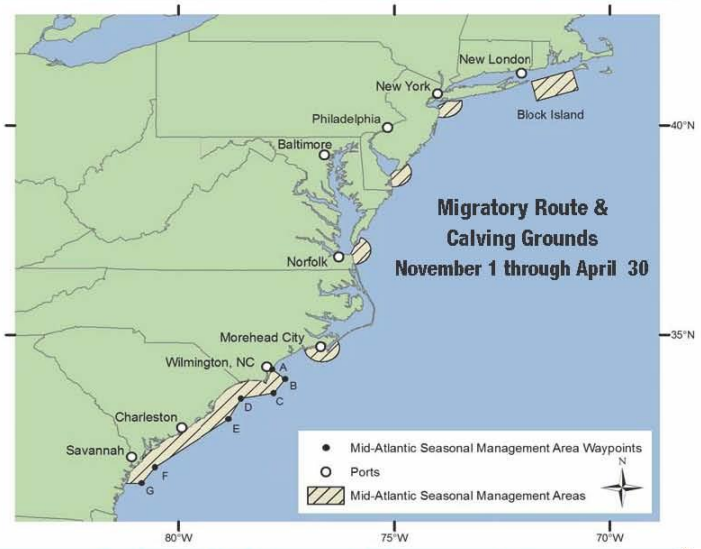
November 15 through April 15

Vessel speed is restricted in the area bounded to the north by latitude 31°27'N; to the south by latitude 29°45'N; to the east by longitude 080°51'36"W.

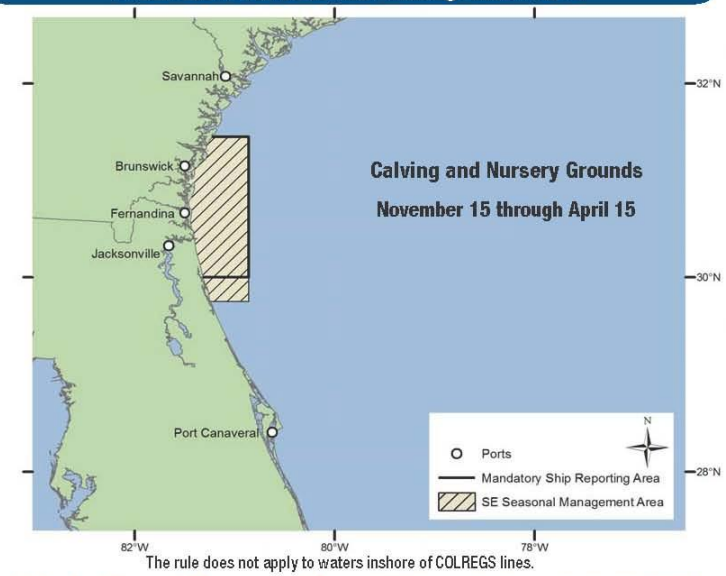
For more information, visit:
http://www.nmfs.noaa.gov/pr/shipstrike
http://nero.noaa.gov/shipstrike
http://rightwhalessouth.nmfs.noaa.gov

Right Whale Ship Strike Reduction Rule expires on December 9, 2013

Mid-Atlantic U.S. Seasonal Management Areas



Southeast U.S. Seasonal Management Area



The rule does not apply to waters inshore of COLREGS lines.

Voluntary Dynamic Management Areas (DMAs) may also be established by NOAA Fisheries Service. Mariners are encouraged to avoid these areas or reduce speeds to 10 knots or less while transiting through these areas. NOAA Fisheries Service will announce DMAs to mariners through its customary maritime communication media.

This serves as NOAA's small entity compliance guide. OMB Control #0648-0580

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

Appendix F. Shipboard Right Whale Protection Program Notebooks Distributed January 2009 – August 2011.

Affiliation	# Sent	Date Sent
New York Maritime Outreach	2	1/15/2009
OMAO's Marine Operations Center	12	5/19/2009
US Shipping	14	6/1/2009
Georgia Ports Authority	5	6/19/2009
US Army Corps of Engineers	16	6/23/2009
(Individual)	1	7/17/2009
Sapelo Island National Estuarine Research Reserve	1	7/21/2009
Moran Shipping Agency	8	9/21/2009
Savannah Maritime Association	48	10/23/2009
Maritime Association of South Carolina	48	10/23/2009
Coast Guard Marine Safety Unit	48	10/30/2009
APL Maritime	8	11/1/2009
Stolt Tankers	107	11/4/2009
USACE- South Atlantic Division	1	12/22/2009
USACE- Wilmington District	1	12/22/2009
USACE- Savannah District	1	12/22/2009
USACE- Charleston District	1	12/22/2009
Liberty Marine Services Inc.	1	12/22/2009
JMTX Agents and Operators Comm	18	1/6/2010
Savannah Maritime Association	12	1/20/2010
JMTX Harbor Safety Committee	8	3/10/2010
Savannah Maritime Association	12	12/15/2010
SC Maritime Assn Operations	24	6/23/2011
Hapag-Lloyd (America) Inc.	20	6/27/2011
Meditarrian Shipping Company	50	7/11/2011
Merritt Island NWR	2	7/11/2011
Riverwalk	2	7/11/2011
Wild Treasure	13	7/11/2011
TFMarine, Inc.	12	8/15/2011
Jacksonville Marine Transportation Exchange	36	8/15/2011
(Individual)	12	8/15/2011

Appendix G. Articles published about the ship speed rule, October 2008 – March 2011.

Publication	Title	Date
High Beam Research	Ship Strike Reduction Rule Aims to Protect North Atlantic Right Whales	10/8/2008
Defenders of Wildlife	Groups applaud new rules to protect right whales, but condemn premature phase-out of rules after only five years	10/8/2008
gCaptain	Reducing Speed to Protect Right Whales	10/9/2008
Marine Log	NOAA sets speed limit to protect right whales	10/9/2008
Bangor Daily News	New rules to protect North Atlantic right whales	10/11/2008
Marine Link	Speed Kills Whales: Restrictions for East Coast	10/16/2008
The Maritime Executive	A Snapshot into the Future: Voyage 231 of the Containership "Compliance"	10/16/2008
The Maritime Executive	Speed Restrictions to Reduce Threat of Ship Collisions With North Atlantic Right Whales to Take Effect	10/16/2008
Science Daily	Ship Strike Reduction Rule Aims to Protect North Atlantic Right Whales	10/20/2008
Journal of Commerce	Whale Rule to Slow Ships	10/30/2008
New England Aquarium	Ship speed limits take effect as whales begin dangerous migration along East Coast	11/1/2008
Trade Only	East Coast Speed Limits Start Next Week	11/19/2008
Professional Mariner	NOAA proposes speed limits to protect North Atlantic right whales	12/1/2008
Trade Only	Right Whale Restrictions Now in Effect	12/3/2008
The Maritime Executive	New Vessel Speed Regulations for U.S. East Coast Ports	12/4/2008
The Maritime Executive	New Vessel Speed Regulations for U.S. East Coast Ports	12/4/2008
Sail Magazine	Save the Whales	12/5/2008
Coosa Valley News	Right Whales Has Hope in Georgia	12/8/2008
Star News	Ships slow down to spare rare whales	12/8/2008
Softpedia	Ships Must Now Avoid Right Whale Paths	12/8/2008
The Boston Globe	Caution! Whale Crossing: Slow to 11 miles per hour	12/8/2008

Publication	Title	Date
The Boston Herald	New speed limit designed to protect rare whales	12/8/2008
Central Maine Morning Sentinel	Ships slow down to save whales	12/8/2008
NOAA	Ships Must Slow Down to Protect North Atlantic Right Whales	12/8/2008
Atlanta Journal-Constitution	Ancient visitors follow instincts to Georgia	12/8/2008
High Beam Research	Ships Must Slow Down to Protect North Atlantic Right Whales	12/8/2008
The Boston Globe	As of today, right whales gain a right of way at sea, US rule takes effect to reduce ship speed	12/9/2008
Conservation Report	MARINE MAMMALS: Right whale shuts down Cape Cod Canal	12/9/2008
Jacksonville Marine Transportation Exchange Website	NOAA Releases Compliance Guide for Speed Rule	12/9/2008
hamptonroads.com and pilotonline.com	Large ships must slow down to limit risk to endangered whales	12/10/2008
Georgia Dept. of Natural Resources	Press Release	12/11/2008
National Data Buoy Center website	Right whales active off the coast	12/22/2008
NGIA Special Notice to Mariners	Notice to Mariners 01/09	1/1/2009
The Post and Courier	Harbor pilots seek exemption from federal slow-down rule	2/18/2009
Village Soup (The Rockland Herald Gazette)	Right whale rule sinks cruise ship visit	3/2/2009
USA Today (blog)	Whales force Royal Caribbean cruise ship to abandon port call in Maine	3/4/2009
Bunkerworld.com	US ports: Speed restrictions to protect whales	3/9/2009
Newsday.com	Monitoring of rare whales near NY harbor ends	3/16/2009
Mariners Weather Log, April 2009:	New Vessel Speed Regulations for U.S. East Coast Ports	4/1/2009
Port World	US ports: Speed restrictions to protect whales	4/9/2009
The Maritime Executive	NOAA Says Changes in Vessel Operations May Reduce Risk of Endangered Whale Shipstrikes	5/28/2009
Georgia Dept. of Natural Resources	Ship Strike Reduction Regulation Information	5/29/2009

Publication	Title	Date
Marine Link	CG Reminder, Slow for Right Whales	5/29/2009
Soundings	Vessels Operations Altered to Prevent Right Whale Strike	6/3/2009
Earth System Monitor	New Regulations and Routing Measures to Protect Endangered Right Whales	7/1/2009
Professional Mariner	Ship speed limit to protect whales goes into effect Sunday	10/30/2009
Marine Link	Waters Changes in Vessel Operations Protects Whales	11/1/2009
Environmental Service News	Ships Sailing U.S. Atlantic Coast Must Slow for Whales	11/2/2009
Soundings	Right Whale Restrictions Now in Effect	11/3/2009
Trade Only	NOAA Puts Whale Compliance Rules Online	11/3/2009
The Maritime Executive	U.S. Coast Guard Reminds Mariners to Slow Down to Protect Right Whales	11/4/2009
Saving Seafood	Ships Sailing U.S. Atlantic Coast Must Slow for Whales	11/6/2009
Action News 9	Chilly Now But Soon to Change Again... "Crafternoon"... Mariners & Right Whales	11/9/2009
NBC New York	Ship Speed Limit Again Proposed to Aid Endangered Whales	1/7/2010
BIMCO	NOAA gets serious with issue of violation notices to Ships in Voluntary Right Whale Speed Restriction Zone	11/1/2010
Port World	NOAA announces vessel speed restrictions to protect endangered right whales	11/4/2010
Examiner.com	Right Whale seasonal management is in effect	11/3/2010
Inchcape Shipping Services	North Atlantic Right Whale Migration and Calving Season	11/4/2010
Live Better Magazine	Southeastern U.S. Right Whale Education and Conservation	11/7/2010
gCaptain	Seven Vessels Accused of Violating Right Whale Rule	11/16/2010
Defenders of Wildlife	Right Whale Protection Has Teeth	11/17/2010
West of England	USA - Right Whale Ship Strike Reduction Rule	11/24/2010
Mondaq	United States: No Speeding—You May Be Subject to a Whale of a Penalty!	3/9/2011

Appendix H. Ship Speed Rule Press Releases Issued December 2008 – November 2010.

Organization	Title	Date	URL
NOAA	Ships must slow down to protect North Atlantic right whales	12/8/2008	http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/pressrelease_effective.pdf
NOAA	Ship strike reduction rule aims to protect North Atlantic right whales	8/8/2008	http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/finalrule_pressrelease.pdf
USCG	Right Whale Ship Strike Reduction Rule Takes Effect Sunday	10/30/2009	http://coastguardnews.com/right-whale-ship-strike-reduction-rule-takes-effect-sunday/2009/10/30/
NOAA- OLE	NOAA Office of Law Enforcement reminds mariners to slow down	11/9/2009	http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/speed_restrictions_southeast.pdf
NOAA	NOAA: Ship Speed Restrictions to Protect Endangered North Atlantic Right Whales	11/1/2010	http://www.noaanews.noaa.gov/stories2010/20101101_shipstrike.html
NOAA	Heightened Mariner Awareness Requested During Right Whale Birthing Season	1/10/2010	NA
NOAA- OLE	NOAA Enforces Right Whale Ship Strike Reduction Rule	11/16/2010	http://www.noaanews.noaa.gov/stories2010/20101116_rightwhale.html

Appendix I. Presentations on ship speed rule given November 2008 through June 2011.

Presenter	Date	Title of Presentation	Name of Event	# of Attendees	Audience
Shannon Bettridge	9/1/2008	Ship Strikes and North Atlantic Right Whales Final Environmental Impact Statement and Ship Strike Reduction Measures	Boston Port Operators Group	50	Ship operators in Boston
Shannon Bettridge	10/1/2008	North Atlantic Right Whale Ship Strike Reduction Efforts	SEIT meeting October 2008	40	Southeast Implementation Team
Greg Silber	11/7/2008	Right Whale Ship Strike Rule	North Atlantic Right Whale Consortium Meeting	100	Right Whale Conservationist
Shannon Bettridge	11/7/2008	North Atlantic Right Whale Ship Strike Reduction Efforts	NGO Constituents Meeting	25	Environmental NGO groups in DC
Kristen Koyama	11/19/2008	Right Whale Update	Boston Port Operators Group meeting	25	Pilots, harbor masters, MASSPORT, USCG, fed/state agencies, tug companies, etc.
Kristen Koyama	12/9/2008	Right Whale Update	Southeastern MA port safety meeting	50	Pilots, harbor masters, passenger vessel industry, fed/state agencies, USCG, local law enforcement, etc.
Don Lewis	12/9/2008	Discussed implementation of Speed rule	Meeting with Cumberland Sound Pilots	75	Cumberland Sound Pilots
Don Lewis	12/9/2008	Discussed implementation of Speed rule	Meeting with Amelia Maritime, Green Island Maritime, and Seaboard Line Agents	75	Commercial shipping companies
Don Lewis	12/10/2008	Discussed implementation of Speed rule	Jacksonville Harbor Safety Committee	75	Jacksonville shipping agents, St Johns Bar Pilots

Presenter	Date	Title of Presentation	Name of Event	# of Attendees	Audience
Michael Henderson	12/11/2008	Right Whale Ship Strike Rule - 2 pg PDF	CG Sector San Juan Harbor Safety Mtg	30	Harbor pilots, port authority, city/commonwealth officials, USCG, CBP, ACOE
Kristen Koyama	12/11/2008	Right Whale Update	Rhode Island port safety meeting	50	Pilots, harbor masters, passenger vessel industry, fed/state agencies, USCG, local law enforcement, etc.
Michael Henderson	12/12/2008	Right Whale Ship Strike Rule - 2 pg PDF	USCG Sector San Juan Harbor Safety Mtg	40	Harbor pilots, port authority, city/commonwealth officials, USCG, CBP, ACOE
Michael Henderson	12/16/2008	Right Whale Ship Strike Rule - 2 pg PDF	Emailed PDF to distribution list for PR & USVI	65	My Navigation Mgr distribution list for PR & USVI
Barb Zoodsma	12/18/2008		R/W presentation to USCG Sector Jacksonville personnel	75	USCG
Don Lewis	1/7/2009	Update of R/W season and new rule	Jacksonville Agents and Operators Meeting	75	Jacksonville Agents and Operators
Don Lewis	1/8/2009	Update of R/W season and new rule	Fernandina Maritime Exchange	75	Port Mariners and Vessel Operators
Michael Henderson	1/21/2009	Right Whale Ship Strike Rule - 2 pg PDF	Savannah Maritime Assn monthly mtg	25	Pilots, port authority, GA DNR, USCG, CBP, ACOE, commercial shipping
Michael Henderson	1/22/2009	Right Whale Ship Strike Rule - 2 pg PDF	CG Sector Charleston Harbor Safety Mtg	35	Pilots, port authority, GA DNR, USCG, CBP, ACOE, commercial shipping

Presenter	Date	Title of Presentation	Name of Event	# of Attendees	Audience
Kristen Koyama	1/23/2009	Right Whale Update	ME/NH Port Safety Forum	30	Pilots, harbor masters, fed/state agencies, passenger vessels, port authority, etc.
Michael Henderson	1/26/2009	Right Whale Ship Strike Rule - 2 pg PDF	Tampa Bay Harbor Safety Mtg	40	Pilots, Ports of Tampa, Manatee, St. Pete, USCG, ACOE Cruise shipping & commercial
Michael Henderson	1/26/2009	Right Whale Ship Strike Rule - 2 pg PDF	Board of Directors - Tampa Propeller Club	18	Senior Tampa Bay maritime officials
Don Lewis	2/7/2009	Seasonal Update and Speed rule	JMTX Board of Directors Meeting	20	Senior Maritime officials in Jacksonville
Michael Henderson	2/11/2009	Right Whale Ship Strike Rule - 2 pg PDF	Key West Maritime Mtg	75	
Shannon Bettridge	2/18/2009	North Atlantic Right Whale Ship Strike Reduction Efforts	MISNA	20	Marine Exchanges, Nationwide
Kristen Koyama	2/18/2009	Right Whale Update	Boston Port Operators Group Meeting	25	Pilots, harbor masters, MASSPORT, USCG, fed/state agencies, tug companies, etc.
Michael Henderson	2/19/2009	Right Whale Ship Strike Rule - 2 pg PDF	Port Everglades (FL) Harbor Safety Mtg	75	Harbor pilots, port authority, city/commonwealth officials, USCG, ACOE
Michael Henderson	2/20/2009	Right Whale Ship Strike Rule - 2 pg PDF	Port of Miami Harbor Safety Mtg	75	Harbor pilots, port authority, city/commonwealth officials, USCG, ACOE
Kristen Koyama	2/25/2009	Right Whale Update	Thames Maritime Coalition meeting	15	Port interests, fed/state reps

Presenter	Date	Title of Presentation	Name of Event	# of Attendees	Audience
Don Lewis	2/25/2009	Seasonal Update and Speed rule	Jacksonville Maritime Strategic Planning Comm	10	Select maritime exchange members
Kristen Koyama	3/10/2009	Right Whale Update	Southeastern MA port safety meeting	50	Pilots, harbor masters, passenger vessel industry, fed/state agencies, USCG, local law enforcement, etc.
Don Lewis	3/11/2009	Seasonal Update and Speed rule	JMTX Harbor Safety Committee	30	Port Mariners and Vessel Operators
Kristen Koyama	3/12/2009	Right Whale Update	Rhode Island port safety meeting	50	Pilots, harbor masters, passenger vessel industry, fed/state agencies, USCG, local law enforcement, etc.
Shannon Bettridge and Todd Nickerson and Frank Sprtel	3/18/2009	Right Whale Ship Strike Rule	NY Harbor Safety, Navigation and Operations Committee Meeting, Staten Island, NY	75	Pilots, Shipping Cos., Port Authorities, NY DEC, Academia, USCG, etc.
Kristen Koyama Todd Nickerson	3/26/2009	Right Whale Ship Strike Reduction Rule	USCG Industry Day - Small Passenger Vessels	100	Small passenger vessel industry reps, incl. ferries, whale watch, charters, etc
Don Lewis	4/1/2009	Seasonal Update and Speed rule	JMTX Agents and Operators Committee	25	Vessel Agents and Vessel Operators
Don Lewis	4/9/2009	Seasonal Update and Speed rule	Port of Fernandina Maritime Exchange	20	Port Mariners and Vessel Operators
Don Lewis	5/14/2009	Update and new Outreach Materials	Board of Governors, Propeller Club Jacksonville	20	Senior Maritime officials in Jacksonville
Don Lewis	5/20/2009	Update and new Outreach Materials	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	7/1/2009	Update and new Outreach Materials	JMTX Agents and Operators Committee	25	Vessel Agents and Vessel Operators
Don Lewis	7/9/2009	General Briefing and Outreach	Florida Association of Environmental Professionals	20	Environmental Compliance Professionals

Presenter	Date	Title of Presentation	Name of Event	# of Attendees	Audience
Don Lewis	9/9/2009	Season Preparation and Outreach	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	10/4/2009	Season Preparation and Outreach	JMTX Agents and Operators Committee	25	Vessel Agents and Vessel Operators
Don Lewis	11/4/2009	General Briefing and Outreach	Marine Information Services of North America	10	Marine Exchanges and Assn from around nation
Don Lewis	11/10/2009	General Briefing and Outreach	San Jose Rotary Club - Jacksonville	60	Jacksonville Business People
Don Lewis	12/9/2009	Seasonal Update and Compliance	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	1/6/2010	Seasonal Update and Compliance	JMTX Agents and Operators Committee	22	Vessel Agents and Vessel Operators
Don Lewis	1/20/2010	Seasonal Update and Compliance	Savannah Maritime Association	40	Port Mariners and Vessel Operators
Don Lewis	2/3/2010	Seasonal Update and Compliance	JMTX Board of Directors Meeting	20	Senior Maritime officials in Jacksonville
Rich Chesler	3/2/2010	Right Whale and the Ship Strike Rule	Lagoon House in Palm Bay, FL	15	General Public
Don Lewis	3/10/2010	Seasonal Update and Compliance	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	4/7/2010	Seasonal Update and Compliance	JMTX Agents and Operators Committee	20	Vessel Agents and Vessel Operators
Don Lewis	5/19/2010	Seasonal Wrap-Up and Compliance	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	6/2/2010	Seasonal Wrap-Up and Compliance	Port of Fernandina Maritime Exchange	20	Port Mariners and Vessel Operators
Don Lewis	7/7/2010	Seasonal Wrap-Up and Compliance Discussion	JMTX Agents and Operators Committee	20	Vessel Agents and Vessel Operators
Don Lewis	9/8/2010	Season Preparation and Outreach	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	10/6/2010	Season Preparation and Outreach	JMTX Agents and Operators Committee	20	Vessel Agents and Vessel Operators

Presenter	Date	Title of Presentation	Name of Event	# of Attendees	Audience
Don Lewis	12/8/2010	Season Update Intro Greg Schweitzer	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	12/15/2010	Season Update Intro Greg Schweitzer	Savannah Maritime Association	35	Port Mariners and Vessel Operators
	1/10/2011	Ship Strike Rule/ SMA Public Service Announcement	WAMU Radio	?	General public
Don Lewis	1/12/2011	Seasonal Update and Compliance	JMTX Agents and Operators Committee	20	Vessel Agents and Vessel Operators
Michael Asaro	2/16/2011	Presentation- RW Ship Strike Rule	Port of Boston Terminal/USCG Industry Day Event, Boston, MA	50	Vessel Agents and Vessel Operators
Michael Asaro	2/24/2011	Presentation- RW Ship Strike Rule	Maine/New Hampshire Port Safety Forum, Portsmouth, NH-	50	Vessel Agents and Vessel Operators
Don Lewis	3/9/2011	Season Update with Barb Zoodsma	JMTX Harbor Safety Committee	25	Port Mariners and Vessel Operators
Don Lewis	4/13/2011	Seasonal Update and Compliance	JMTX Agents and Operators Committee	20	Vessel Agents and Vessel Operators
Don Lewis	4/21/2011	General Briefing and Outreach	Leadership Nassau - Community Dev.	25	Fernandina Beach Business Leaders
Don Lewis	6/23/2011	Seasonal Wrap-Up and Compliance Discussion	Maritime Association of South Carolina Operations Committee	30	Port Mariners and Vessel Operators Charleston

Appendix J. Screen shot of NMFS Office of Protected Resources Ship Strike Reduction Page. **www.nmfs.noaa.gov/pr/shipstrike**.

Appendix K. Initial Estimate of Economic Impact of the Right Whale Ship Strike Reduction Vessel Speed Restrictions

NATHAN
ASSOCIATES INC.

Memorandum

February 6, 2012

To: Greg Silber and Shannon Bettridge

NOAA/ NMFS/Office of Protected Resources

From: Richard Blankfeld and Gerardo Ayzanoa

Nathan Associates Inc.

Subject: Initial Estimate of Economic Impact of the Right Whale Ship Strike Reduction Vessel Speed Restrictions

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1. Introduction

On December 9, 2008, the Right Whale Ship Strike Reduction Rule (Rule) issued by the U.S. National Marine Fisheries Service (NMFS) went into effect. The rule requires certain vessels to travel at 10 knots or less in certain areas of right whale aggregation and near several key port entrances along the U.S. eastern seaboard.

This memorandum presents an initial assessment of the estimated economic impact of the Rule. In large measure, the economic impact assessment is based on the approach and analysis presented in the FEIS Report, Economic Analysis for the Final Environmental Impact Statement of the North Atlantic Right Whale Ship Strike Reduction Strategy prepared by Nathan Associates Inc. for NMFS in August 2008.

There are several important data and analytical improvements; however that are incorporated in the present assessment that are further described herein.

2. AIS Data and Approach

A key data improvement is the availability of Automatic Identification System (AIS) that uses a Global Positioning System-linked, very high frequency 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 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.

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.

The goal of the economic impact analysis is to estimate the impact on the shipping industry and overall economy from the full implementation of the Rule; it is not designed to identify actual industry compliance with the Rule. As such, the economic analysis assumes 100 percent compliance with the Rule and as such represents the maximum economic impact on the shipping industry and general economy. For these reasons, the economic impact analysis assumes that all vessels subject to the Rule sail at a maximum speed of 10 knots within the restricted areas and time periods. Using the AIS data, the 10-knot speed limit is then compared with the actual sailing speeds of vessels for each area during periods when the speed restrictions are not in effect.

We obtained access to the AIS for the areas relevant to the Rule for the full year of 2009 and for the first 11 months of 2010 from the NOAA Office of Protected Resources. We then spent a significant effort to review the data and fill-in critical missing information for the economic analysis on vessel type and size. This was accomplished by matching various vessel identifiers such as the Maritime Mobile Service

Identity (MMSI) number, call sign, and IMO number. In some instances, information on the type and size of vessel were confirmed based on the name of the vessel, length and cargo type. For vessels that the vessel type was known as well as the gross registered tonnage, the deadweight tonnage was estimated using the regression analysis described in the 2008 FEIS Report, Appendix A, Attachment 5.

As a result of the AIS data review and analysis, we were able to obtain for 2009, operating information for 58,459 vessel transits through areas affected by the Rule. Of these, 30,669 vessel transits (52.5%) occurred during periods when the Rule was in effect and 27,790 vessel transits (47.5%) occurred during periods when the rule was not in effect. Table 1 presents the distribution of the total vessel transits by type and size of vessel.

Table 1. Total Vessel Transits by Type and Size for Areas Subject to Rule, 2009 (includes periods when Rule is in effect and not in effect)

	DWT Size Range (000s)																		
Vessel type	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-60	60-70	70-80	80-90	90-100	100-120	120-150	150+	Total
Bulk Carrier		274	248	206	134	312	229	559	251	277	351	235	699	161	3		20	18	3,977
Combination Carrier (e.g. OBO)		6						44					6	13		2			71
Container Ship	136	571	921	338	684	506	1,172	805	1,379	1,017	3,485	6,308	79	221					17,622
Freight Barge	112	13																	125
General Dry Cargo Ship	351	454	415	265	223	102	82	117	186	100	4								2,299
Passenger Ship a/	2,267	851	159																2,899
Refrigerated Cargo Ship		215	262	54	1	2	96		5		26								661
Ro-Ro Cargo Ship	131	201	928	1,516	931	778	176	79	211	24	317	22							5,314
Tank Ship	12	368	340	481	106	164	298	881	648	2,034	656	474	760	116	424	440	424	287	8,913
Towing Vessel	14,298																		14,298
Other b/	1,743	133	18	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	1,900
Total	19,050	3,086	3,291	2,860	2,079	1,864	2,059	2,485	2,680	3,452	4,839	7,039	1,544	511	427	442	444	305	58,459
a/ Includes recreational vessels.																			
b/ Includes fishing vessels, industrial vessels, research vessels, and school ships.																			
Source: Prepared by Nathan Associates Inc. from AIS data as described in text.																			

3. Average Operating Speeds by Vessel Type and Size

Accurate information on current vessel operating speeds is clearly an important element for the determination of the economic impact of the speed restriction required by the Rule. The AIS information provides the most detailed and accurate information of vessels operating speeds for the areas subject to the Rule. For each area subject to the Rule, we have computed the average operating speeds by type and size of vessel for periods in 2009 when the Rule was not in effect. This provides the most robust estimate for actual vessel operations and average operating speeds without the influence of the Rule. In Table 2 below, we present the data by vessel type and size but summarized across all of the areas affected by the Rule. The fastest average vessel operating speed in these areas observed in 2009 was 14.0 knots for containerships and refrigerated cargo ships. Within some vessel size categories, faster average speeds of 15.9 knots (passenger ships) and 15.3 knots (Ro-Ro cargo ships) were recorded.

Table 2. Average Vessel Operating Speed by Type and Size of Vessel for Areas Subject to Rule During Periods When Rule is Not in Effect, 2009 (knots)

	DWT Size Range (000s)																		
Vessel type	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-60	60-70	70-80	80-90	90-100	100-120	120-150	150+	Total
Bulk Carrier	-	11.1	11.2	11.9	9.6	11.4	11.0	10.7	11.2	11.9	12.4	11.3	11.5	10.8	-	-	12.8	10.8	11.3
Combination Carrier (e.g. OBO)	-	13.9	-	-	-	-	-	10.1	-	-	-	-	9.8	-	-	12.7	-	-	10.6
Container Ship	12.5	13.0	14.1	13.6	13.1	14.9	14.5	13.9	14.0	13.9	14.4	13.9	13.6	14.1	-	-	-	-	14.0
Freight Barge	9.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.4
General Dry Cargo Ship	11.5	11.4	13.8	12.3	12.9	12.2	12.6	11.2	12.3	12.9	10.7	-	-	-	-	-	-	-	12.3
Passenger Ship a/	10.6	15.9	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.4
Refrigerated Cargo Ship	-	14.8	14.7	15.0	-	-	11.3	-	13.4	-	13.7	-	-	-	-	-	-	-	14.0
Ro-Ro Cargo Ship	8.3	13.3	13.6	14.3	13.7	13.2	13.9	15.3	13.4	14.3	13.6	13.4	-	-	-	-	-	-	13.6
Tank Ship	-	12.3	11.6	12.7	10.8	12.2	12.1	12.4	12.0	12.0	11.8	12.0	11.2	11.3	10.6	11.3	10.2	11.2	11.8
Towing Vessel	8.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.2
a/ Includes recreational vessels.																			
Source: Prepared by Nathan Associates Inc. from AIS data as described in text.																			

4. Average Delays due to Rule by Type and Size of Vessel

The primary operational impact of the Rule on the shipping industry is the extra sailing time incurred caused by vessels having to slow down within the restricted areas. Estimates of the extra sailing time were calculated by subtracting the time required to sail through each restricted area using the detailed average vessel operating speeds for that restricted area during periods when the Rule was not in effect from the time required at a sailing speed of 10 knots. Only average vessel speeds of greater than 10 knots during non-Rule periods were used for these calculations. A summary across all restricted areas of the average extra time per vessel transit by vessel type and size is presented in Table 3. The highest average delay by vessel type is 0.43 hours (26 minutes) for refrigerated cargo ships.

Table 3. Average Delays per Vessel Transit due to Rule by Type and Size of Vessel, 2009 (hours)

	DWT Size Range (000s)																		
Vessel type	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-60	60-70	70-80	80-90	90-100	100-120	120-150	150+	Total
Bulk Carrier	-	0.16	0.15	0.29	0.11	0.19	0.19	0.10	0.18	0.22	0.26	0.12	0.17	0.17	-	-	0.20	0.01	0.17
Combination Carrier (e.g. OBO)	-	0.38	-	-	-	-	-	0.05	-	-	-	-	0.02	0.13	-	-	-	-	0.10
Container Ship	0.34	0.25	0.20	0.17	0.11	0.13	0.24	0.24	0.24	0.15	0.17	0.16	0.20	0.15	-	-	-	-	0.18
Freight Barge	0.01	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05
General Dry Cargo Ship	0.14	0.27	0.32	0.23	0.31	0.21	0.25	0.20	0.24	0.18	0.22	-	-	-	-	-	-	-	0.25
Passenger Ship a/	0.07	0.13	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
Refrigerated Cargo Ship	-	0.52	0.46	0.26	0.39	0.04	0.28	-	0.05	-	0.06	-	-	-	-	-	-	-	0.43
Ro-Ro Cargo Ship	0.13	0.16	0.14	0.17	0.21	0.19	0.10	0.11	0.24	0.14	0.09	0.22	-	-	-	-	-	-	0.17
Tank Ship	0.05	0.12	0.19	0.20	0.16	0.21	0.13	0.20	0.18	0.17	0.21	0.14	0.14	0.11	0.12	0.20	0.10	0.23	0.17
Towing Vessel	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
Total	0.12	0.48	0.43	0.43	0.37	0.41	0.42	0.33	0.41	0.37	0.42	0.40	0.26	0.31	0.17	0.25	0.14	0.25	0.30
a/ Includes recreational vessels.																			
Source: Prepared by Nathan Associates Inc. from AIS data as described in text.																			

5. Vessel Operating Costs at Sea by Type and Size of Vessel

The USACE prepares estimates of vessel operating costs to be used by planners in studies to determine the potential benefits of harbor improvement projects. Vessel operating costs include annual capital costs as determined by the replacement cost of the vessels and application of capital recovery factors; estimates of fixed annual operating costs such as for crew, lubricating materials and stores (supplies), maintenance and repair, insurance and administration; the number of operational days per year; and fuel costs at sea and in port.

The type and DWT size of vessels for which operating costs are reported by the USACE is shown in Table 4 below. Vessel operating costs are presented separately for U.S. flag and foreign flag vessels, for five vessel types, and up to 14 vessel DWT sizes within a vessel type.

Table 4. Type and Size of Vessels for which USACE Reports Vessel Operating Costs (DWT)

Foreign flag					U.S. flag				
General cargo vessel	Container ship	Bulk carrier	Tanker (double hull)	Tanker (single hull	General cargo vessel	Container ship	Bulk carrier	Tanker (double hull)	Tanker (single hull
11,000	9,000	15,000	20,000	20,000	11,000	9,000	15,000	20,000	20,000
14,000	14,000	25,000	25,000	25,000	14,000	14,000	25,000	25,000	25,000
16,000	17,000	35,000	35,000	35,000	16,000	17,000	35,000	35,000	35,000
20,000	20,000	40,000	50,000	50,000	20,000	20,000	40,000	50,000	50,000
24,000	23,000	50,000	60,000	60,000	24,000	23,000	50,000	60,000	60,000
30,000	28,000	60,000	70,000	70,000	30,000	28,000	60,000	70,000	70,000
	31,000	80,000	80,000	80,000		31,000	80,000	80,000	80,000
	35,000	100,000	90,000	90,000		35,000	100,000	90,000	90,000
	39,000	120,000	120,000	120,000		39,000	120,000	120,000	120,000
	42,000	150,000	150,000	150,000		42,000	130,000	150,000	150,000
	49,000	175,000	175,000	175,000		49,000		175,000	175,000
	55,000	200,000	200,000	200,000		55,000		200,000	200,000
	66,000		265,000	265,000		66,000		265,000	265,000
	82,000		325,000	325,000					

Source: U.S. Army Corps of Engineers, Economic Guidance Memorandum 02-06, Deep Draft Vessel Operating Costs

We applied regression techniques to the USACE vessel operating cost data in order to match with the vessel size categories used in our analysis of U.S. East Coast vessel arrivals. A logarithmic equation was specified relating hourly operating costs at sea with vessel DWT for each of the vessel types used in this economic impact analysis.

A concern over the use of the USACE operating cost estimates is the variability of actual vessel operating costs due to the fluctuations in the price of bunker fuel. The USACE estimates include the assumed fuel consumption per day at sea for the primary propulsion and auxiliary propulsion for each vessel type and DWT size. The primary propulsion is assumed to use heavy viscosity oil while the auxiliary propulsion is assumed to use marine diesel oil. We updated the USACE vessel operating costs to reflect the average bunker fuel prices per ton for New York for using an annual average 2009 calculated from data reported by Bunkerworld. The average price for heavy viscosity oil for 2009 was $347 per metric ton and marine diesel oil was $685 per metric ton. The resulting estimates of vessel operating costs by type and size of vessel for 2009 are presented in Table 5. These estimated vessel operating costs for 2009 represent the best method to value the actual impact on the shipping industry of the Rule that year.

Table 5. Hourly Vessel Operating Costs at Sea for Foreign Flag Vessels by Type Size of Vessel Using Average 2009 and January 2012 Bunker Fuel Prices

	DWT Size Range (000s)																	
Vessel type	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-60	60-70	70-80	80-90	90-100	100-120	120-150	150+
Foreign Flag 2009 Hourly Operating Costs at Sea																		
Bulk Carrier	786	805	825	845	865	886	907	929	951	974	1,010	1,059	1,110	1,164	1,221	1,311	1,477	1,703
Combination Carrier (e.g. OBO)	826	846	866	887	908	930	952	975	999	1,023	1,060	1,112	1,166	1,223	1,282	1,377	1,551	1,789
Container Ship	788	888	1,000	1,126	1,267	1,427	1,607	1,809	2,037	2,294	2,740	3,474	4,405	5,584	7,080	10,107	-	-
Freight Barge	485	594	728	892	1,093	1,339	1,641	2,010	2,463	3,017	-	-	-	-	-	-	-	-
General Dry Cargo Ship	485	594	728	892	1,093	1,339	1,641	2,010	2,463	3,017	-	-	-	-	-	-	-	-
Passenger Ship a/	3,551	5,069	7,237	10,962	13,897	-	-	-	-	-	-	-	-	-	-		-	-
Refrigerated Cargo Ship	1,774	1,997	2,249	2,532	2,851	3,211	3,615	4,071	4,583	5,161	6,166	-	-	-	-	-	-	-
Ro-Ro Cargo Ship	867	977	1,100	1,238	1,394	1,570	1,767	1,990	2,241	2,523	3,014	3,822	4,845	-	-	-	-	-
Tank Ship	960	978	996	1,015	1,034	1,053	1,073	1,093	1,113	1,134	1,166	1,210	1,256	1,304	1,353	1,431	1,570	1,755
Towing Vessel	960	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other b/	485	594	728	892	1,093	1,339	1,641	2,010	2,463	3,017	-	-	-	-	-	-	-	-
Foreign Flag Jan 2012 Hourly Operating Costs at Sea																		
Bulk Carrier	1,180	1,209	1,238	1,269	1,300	1,332	1,364	1,398	1,432	1,467	1,522	1,597	1,677	1,760	1,847	1,987	2,242	2,593
Combination Carrier (e.g. OBO)	1,239	1,269	1,300	1,332	1,365	1,398	1,433	1,468	1,504	1,541	1,598	1,677	1,760	1,848	1,940	2,086	2,355	2,723
Container Ship	1,166	1,325	1,506	1,712	1,946	2,212	2,514	2,858	3,249	3,693	4,476	5,783	7,472	9,655	12,475	18,323	-	-
Freight Barge	710	871	1,068	1,311	1,608	1,972	2,419	2,967	3,640	4,465	-	-	-	-	-	-	-	-
General Dry Cargo Ship	710	871	1,068	1,311	1,608	1,972	2,419	2,967	3,640	4,465	-	-	-	-	-	-	-	-
Passenger Ship a/	5,299	7,784	11,432	17,902	23,132	-	-	-	-	-	-	-	-	-	-		-	-
Refrigerated Cargo Ship	2,622	2,981	3,388	3,852	4,378	4,977	5,657	6,431	7,310	8,309	10,070	-	-	-	-	-	-	-
Ro-Ro Cargo Ship	1,282	1,457	1,657	1,883	2,140	2,433	2,766	3,144	3,574	4,062	4,923	6,361	8,219	-	-	-	-	-
Tank Ship	1,347	1,373	1,400	1,427	1,454	1,483	1,512	1,541	1,571	1,601	1,648	1,713	1,780	1,850	1,922	2,037	2,242	2,516
Towing Vessel	1,347	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other b/	710	871	1,068	1,311	1,608	1,972	2,419	2,967	3,640	4,465	-	-	-	-	-	-	-	-
a/ Includes recreational vessels.																		
b/ Includes fishing vessels, industrial vessels, research vessels, and school ships.																		
Source: Prepared by Nathan Associates Inc. as decribed in text from data provided in U.S. Army Corps of Engineers, Economic Guidance Memorandum 05-01,																		
Deep Draft Vessel Operating Costs and adjusted for bunker fuel prices reported by Bunkerworld for IFO380 and MDO for New York for the year 2009 and as of January 20, 2012.																		

Table 5 also presents estimated hourly vessel operating costs using bunker prices of January 2012. Given that the future of bunker fuel prices is unknown, the January 2012 may represent the best estimate for vessel operating costs in future years. The price for heavy viscosity oil in New York for January 20, 2012 was $672 per metric ton and marine diesel oil was $998 per metric ton.

6. Estimated Direct Economic Impact on Shipping Industry Vessels

The estimated direct economic impact on the shipping industry of the Rule in 2009 is presented in Table 6. Across all restricted areas, the total direct economic impact is estimated $22.0 million. More than 62 percent of the total direct impact incurred by containerships at $13.7 million, followed distantly by refrigerated cargo ships at $2.5 million and Ro-Ro cargo ships and passenger ships each at $1.8 million.

Table 6. Direct Economic Impact of Rule on Shipping Industry by Type and Size of Vessel, 2009 Using Average 2009 Bunker Fuel Prices ($000s)

	DWT Size Range (000s)																		
Vessel type	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-60	60-70	70-80	80-90	90-100	100-120	120-150	150+	Total
Bulk Carrier	-	29	38	24	8	39	27	75	59	52	89	49	135	21	-	-	12	4	663
Combination Carrier (e.g. OBO)	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Container Ship	18	153	332	93	207	247	617	503	854	646	3,072	6,551	76	314	-	-	-	-	13,682
General Dry Cargo Ship	35	57	102	51	62	25	40	29	103	76	-	-	-	-	-	-	-	-	580
Passenger Ship a/	471	901	406	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,777
Refrigerated Cargo Ship	-	170	215	45	-	-	64	-	7	-	21	-	-	-	-	-	-	-	522
Ro-Ro Cargo Ship	4	56	361	676	441	350	99	65	147	18	286	12	-	-	-	-	-	-	2,514
Tank Ship	-	74	50	108	13	39	46	236	131	454	147	104	121	12	69	93	46	75	1,817
Towing Vessel	279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	279
Other b/	132	8	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	142
Total	939	1,450	1,503	997	731	700	895	908	1,300	1,246	3,615	6,715	332	347	69	93	59	78	21,976
a/ Includes recreational vessels.																			
b/ Includes fishing vessels, industrial vessels, research vessels, and school ships.																			
Source: Prepared by Nathan Associates Inc. from AIS data as described in text.																			

Table 7 presents the impact for 2009 vessel but using the average vessel operating costs based on January 2012 bunker fuel prices. The total direct economic impact increases to $34.8 million with containerships accounting for $22.4 million or 64.2 percent of the total.

Table 7. Direct Economic Impact of Rule on Shipping Industry by Type and Size of Vessel, 2009 Using 2012 Bunker Fuel Prices, ($000s)

	DWT Size Range (000s)																		
Vessel type	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-60	60-70	70-80	80-90	90-100	100-120	120-150	150+	Total
Bulk Carrier	-	44	58	36	12	58	41	114	89	79	134	74	204	32	-	-	19	5	1,000
Combination Carrier (e.g. OBO)	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Container Ship	26	228	500	141	318	383	966	794	1,362	1,040	5,017	10,903	129	542	-	-	-	-	22,351
General Dry Cargo Ship	51	84	149	74	91	37	59	43	153	112	-	-	-	-	-	-	-	-	853
Passenger Ship a/	702	1,383	641	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,725
Refrigerated Cargo Ship	-	254	324	69	-	-	100	-	10	-	34	-	-	-	-	-	-	-	791
Ro-Ro Cargo Ship	5	83	544	1,028	677	542	155	102	234	28	467	20	-	-	-	-	-	-	3,887
Tank Ship	-	104	71	152	19	54	64	332	185	642	207	147	171	18	98	132	66	107	2,567
Towing Vessel	392	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	392
Other b/	194	12	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	208
Total	1,370	2,195	2,285	1,501	1,117	1,076	1,388	1,385	2,032	1,900	5,860	11,144	504	592	98	132	85	112	34,776
a/ Includes recreational vessels.																			
b/ Includes fishing vessels, industrial vessels, research vessels, and school ships.																			
Source: Prepared by Nathan Associates Inc. from AIS data as described in text.																			

7. *Total Economic Impact of Rule Including Other Market Segments and Indirect Economic Impact*

The AIS data captures the vast preponderance of commercial maritime activity that would be subject to the speed restrictions and other operational measures. However, there are some market segments that may be impacted by the speed restrictions and other operational measures whose maritime activities are not adequately captured in the AISA data. In this section, we identify the most relevant of these market segments and discuss the potential economic impact. Those market segments or potential impacts include:

- Cumulative effect of multi-port strings for containerships
- Re-routing of southbound coastwise shipping
- Passenger time on ferries
- Indirect economic impact of port diversions

The economic impact for each of these elements is presented below[5].

Cumulative effect of Multi-Port Strings for Containerships

Many of the vessels arrivals at U.S. East Coast ports occur as part of a "string" of port calls by the vessel. For containerships, ro-ro cargo ships and some specialty tankers these multi-port calls constitute a scheduled cargo service offered by the shipping lines. Other types of vessels may have multiple U.S. East Coast port calls as part of a coastwise cabotage service, for delivery of specialty chemicals or other products, or to lighten or top off in order to maximize vessel utilization. There are several reasons why the cumulative effect of multiple port calls at restricted ports could impact a vessel more than the sum of the individual direct impacts presented in the prior sections. First, the delays incurred from speed restrictions at one port when combined with speed restrictions at a subsequent port may diminish the ability of the vessel to maintain its schedule and could result in missed tidal windows. Second, even brief delays at arrival at the second port could result in increased costs for scheduled, but unused, port labor. Third, some shipping lines felt that the cumulative impact of three or four port calls at port areas with restrictions could cause them to rework vessel itineraries and could result in dropping of one of the port calls in order to maintain a weekly service without having to add an additional vessel to the service.

[5] In the 2008 FEIS, other market segments such as commercial fishing, charter fishing and whale watching vessels were analyzed separately. However for this economic impact assessment, the availability of the AIS data permitted those market segments to be analyzed as part of the overall shipping industry analysis.

However, these cumulative factors will not affect every vessel making multiple port calls at restricted ports. Also the impact may vary from an 8-hour delay due to a missed tidal window to incurring charges for unused labor if a vessel is late arriving at the port.[6] It is realistic to assume that the shipping industry will revise their itineraries to account for the delays imposed by the speed restrictions and that occurrences of missed tidal widows will be rare. We have used an average additional delay of 11 minutes for each containership transit that is part of a multi-port string to account for this cumulative impact.[7] The economic value of this additional time has been calculated for each port area based respectively on the average 2009 vessel operating and the January 2012 vessel operating costs for containerships. As shown in Table 8, the estimated impact for 2009 is$3.6 million and in 2012 $5.7 million.

Re-routing of Southbound Coastwise Shipping

Coastwise shipping or cabotage trade along the U.S. East Coast has always been an important segment of our nation's maritime heritage. In recent years, attention has been focused on the further development of coastwise shipping (also referred to as short-sea shipping) as a means of reducing highway congestion on the Eastern Seaboard. Benefits of coastwise shipping also include lowering transport and environmental costs and reducing our demand for imported fuel. For these reasons, it is important that the speed restrictions not unduly affect the development of increased coastwise shipping.

However, for commercial and navigation purposes, it appears unlikely that the speed restriction would significantly affect coastwise shipping. Northbound vessels prefer to use Gulf Stream further offshore and benefit from the enhanced operating speed and fuel efficiency. Southbound traffic routes closer to the U.S. East Coast; generally within 7-10 nautical miles of the shoreline. However, during the proposed seasonal management periods, masters of southbound vessels would likely route outside of seasonal speed restricted areas incurring an overall increase in distance. This affects southbound vessels between the entrance to the Chesapeake Bay and Port Canaveral.

[6] While tides occur on 12-hour cycle, it is assumed that a tidal window is open for 2 hours before and after high tide. This results in an 8-hour waiting period between tidal windows.

[7] Only a small portion of vessel arrivals should be affected by this additional delay. It is assumed that 7.5 percent of vessels could be affected by as much as an additional 8-hour delay due to missing the tidal window. This results in an average additional delay per vessel of 36 minutes.

The speed restrictions in the mid-Atlantic region are implemented for a radius of 20 nautical mile buffer around each port area for port areas north of Wilmington, NC.[8] A continuous 20-mile buffer was implemented from Wilmington, NC through Savannah to the northern boundary of the Southeastern SMA. The additional distance incurred by southbound vessels would be 56 nautical miles. The economic impact for this extra sailing distance is estimated at $1.3 million using 2009 vessel operating costs and $2.1 million using January 2012 vessel operating costs.

Impact on Ferry Passengers

The proposed operational measures will have a direct economic impact on ferry passengers whose travel time will be increased due to the speed restrictions. As recognized by the U.S. Department of Transportation, time saved from travel may be devoted to other activities, such as remunerative work or recreation.[9] The USDOT guidelines recommend hourly values of travel-time savings to be used in all economic analysis of transportation regulatory actions. Specific values of travel time are recommended for local travel and intercity travel and whether the travel is for business or personal purposes.

The USDOT guidelines recommend using the median household income (divided by 2000 hours) as the basis for valuation of intercity business travel time, and 70 percent of that value for intercity personal travel time. Hence, based on the 2000 Census data, they recommend hourly values of $21.20 for intercity business travel and $14.80 for intercity personal travel. We have updated the USDOT recommended values using 2005 data for median household income reported by the U.S. Census Bureau.[10] Based on that data, the hourly value of intercity business travel time is $23.16 and intercity personal travel time is $16.21.

The estimated economic impact of proposed operational measures on Southern New England ferry passengers is presented in Table 8. The estimates are the same as those presented in the 2008 FEIS, as a

[8] The exception is the Block Island Sound speed restriction area that is configured as a rectangle with a width of 30 nautical miles.

[9] U.S. Department of Transportation, Office of the Secretary of transportation, The Value of Travel Time: Departmental Guidance for Conducting Economic Evaluations, April 9, 1997 http://ostpxweb.dot.gov/policy/Data/VOT97guid.pdf and Revised Departmental Guidance, Valuation of Travel Time in Economic Analysis, February 11, 2003 http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf.

[10] U.S. Census Bureau, Income, Poverty and Health Insurance Coverage in the United States: 2005, issued August 2006. http://www.census.gov/prod/2006pubs/p60-231.pdf

separate analysis of the impact on ferry passengers was not conducted for this initial estimate of the economic impact of the Rule.

Estimated Indirect Economic Impact

Depending on the nature and significance of the direct economic impact, it is possible that implementation of the proposed operational measures could have indirect economic impacts. Potential indirect economic impacts include:

- Increased intermodal costs due to missed rail and truck connections
- Diversion of traffic to other ports
- Impact on local economies of decreased income from jobs lost due to traffic diversions

There are many factors that influence a shipping line's decision to call at specific ports. These include the adequacy and suitability of port facilities and equipment, the ability of the terminal operator to quickly turnaround the vessel, overall cargo demand, efficiency of intermodal transportation, port charges, and the port location relative to other ports and cargo markets. If cargo is to divert to other ports this would be because the total additional costs associated with those routes are less than the cost of vessel time due to delays at the current port. Hence it would be double-counting to also include any additional overland transport costs to the estimated impact already presented.

A good portion of a port's traffic is often considered captive to that port. For cargoes that are destined for the port's immediate hinterland, it does not make economic sense to call at a distant port and then to ship back to the port via expensive land transport. However, most ports also accommodate traffic that is not destined for its immediate hinterland but is through traffic that may have economically attractive routing alternatives. Port areas in the Northeast and northern parts of the mid-Atlantic region serve as gateways to the inland population centers and industrial areas such as western New York, western Pennsylvania, Ohio, Indiana, Illinois and Michigan. These areas may be served via the Canadian ports of Halifax and Montreal without incurring delays caused by the right whale ship strike reduction measures.[11] These Canadian ports currently compete with Northeast U.S. ports for cargo destined for

[11] Vessels may divert to other U.S. ports in addition to those diverting to Canada. While this is possible, for the total economic impact analysis only diversions to non-U.S. ports are included. For diversion to ports within the U.S. the negative economic impact for one U.S. port are offset by gains in another U.S. port.

the mid-eastern U.S. and the speed restrictions implemented in the U.S. and not in Canada could shift the current competitive balance to the advantage of Canadian ports.

The Maritime Administration (MARAD), an agency of the U.S. Department of Transportation has developed a Port Economic Impact Kit that allows users to assess the economic impact of port activity on a region's economy. The MARAD Port Economic Impact Kit uses an adaptation of input-output analysis that is a widely established tool for undertaking economic impact assessments. The model calculates the total economic impacts or multiplier effect of deep-draft port industry and includes an indirect effect that reflects expenditures made by the supplying firms to meet the requirements of the deep-draft port industry as well as expenditures by firms stocking the supplying firms.The model also includes an induced effect that corresponds to the change in consumer spending that is generated by changes in labor income accruing to the workers in the deep-draft port industry as well as employment in the supplying businesses.

We have estimated the indirect economic of port diversions based on the detailed methodology described in the 2008 FEIS adjusted for the actual observed delays incurred in 2009 from the AIS data analysis and using the updated vessel operating costs for 2009 and January 2012. As shown in Table 8, the estimated indirect economic impact of port diversion for 2009 is $19.9 million and for January 2012 it is $30.0 million.

Table 8. Total Economic Impact of Rule Using 2009 and 2012 Bunker Fuel Prices, ($000s)

	Bunker fuel prices of	
Impact	2009	2012
Direct economic impact		
Shipping industry vessels	21,976	34,776
Cumulative effect of multi-port strings	3,593	5,685
Re-routing of southbound coastwise shipp	1,298	2,054
Pasengers' time on passenger ferries	5,191	5,191
Whale watching vessels	1,336	1,336
Subtotal direct economic impact	33,393	49,041
Indirect economic impact of port diversions	18,970	30,019
Total economic impact	52,363	79,061

Source: Prepared by Nathan Associates as described in text.

The total economic impact of the Rule including direct and indirect impacts is estimated at $52.4 million using 2009 vessel operating costs and $79.1 million using January 2012 vessel operating costs.

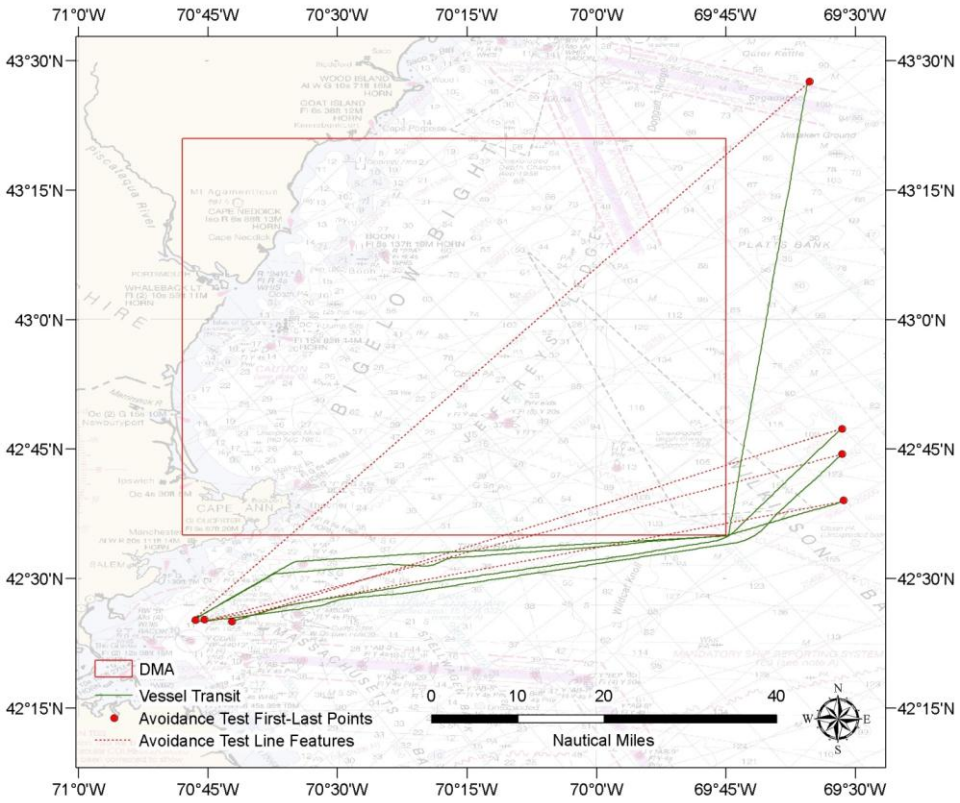
Appendix L. Number of transits by vessel type that had at least 1 nautical mile of travel within the DMAs during their respective effective periods.

DMA	# Whales	General Location	Area (nm^2)	Start Date	End Date	Tanker	Cargo	Pass.	Pilot	Tow	Tug	Other	Total
NE_01	11	Jeffreys Ledge	1767	12/11/2008	12/25/2008	11	1	0	1	11	11	8	43
NE_02	43	Jordan Basin	1576	12/11/2008	12/28/2009	6	0	0	0	0	0	0	6
NE_03	3	Cashes Ledge	1356	12/11/2008	12/25/2009	21	3	0	0	0	0	0	24
NE_04	28	Jeffreys Ledge	1997	1/13/2009	2/10/2009	39	14	0	0	23	32	17	125
NE_05	3	Jeffreys Ledge	1605	1/16/2009	1/29/2009	32	21	3	0	20	19	10	105
NE_06	6	Northern Jeffreys Ledge	1448	2/11/2009	2/25/2009	14	6	0	0	5	7	3	35
NE_07	5	Southern Jeffreys Ledge	1456	2/11/2009	2/25/2009	27	18	0	0	3	5	5	59
NE_08	12	Great South Channel	2419	2/11/2009	2/25/2009	12	18	0	0	0	0	5	36
NE_09	3	Georges Shoal	1592	3/17/2009	3/28/2009	1	0	0	0	0	0	0	1
NE_10	5	Georges Shoal	1764	4/13/2009	4/25/2009	0	1	0	0	0	0	0	1
NE_11	15	Cashes Ledge	1926	5/12/2009	5/27/2009	13	4	0	0	0	0	6	23
NE_12	3	Jordan Basin	1602	5/13/2009	5/27/2009	22	1	0	0	0	1	3	27
NE_13	44	Cashes Ledge	4391	6/2/2009	6/29/2009	41	30	8	0	1	0	21	102
NE_14	3	Cashes Ledge	4391	7/9/2009	7/21/2009	20	22	3	0	0	0	24	72
NE_15	5	Fippenies Ledge	1644	9/2/2009	9/16/2009	8	2	4	0	2	0	15	31
NE_16	26	Jeffreys Ledge	2124	10/15/2009	11/11/2009	18	5	11	0	17	17	30	98
NE_17	24	Jordan Basin	1918	10/22/2009	12/1/2009	49	2	1	0	1	0	4	59
NE_18	16	Cashes Ledge	2441	10/27/2009	11/10/2009	9	2	2	0	2	0	0	15
NE_19	41	Jeffreys Ledge	3661	11/10/2009	12/17/2009	71	15	6	0	7	10	37	148
NE_20	47	Cashes Ledge	3403	11/10/2009	11/24/2009	19	9	0	0	0	0	1	29
NE_21	27	Jordan Basin	4198	12/4/2009	12/19/2009	7	0	0	0	0	0	0	7
NE_22	37	Jordan Basin	3768	1/4/2010	1/15/2010	3	0	0	0	0	0	0	3
NE_23	13	Jeffreys Ledge	1887	1/5/2010	1/28/2010	34	6	0	0	10	13	10	73
NE_24	3	Nantucket MA	1527	2/1/2010	2/15/2010	0	0	0	0	4	0	2	7
NE_25	14	Nantucket MA	1922	3/8/2010	3/22/2010	1	0	5	0	1	0	1	8

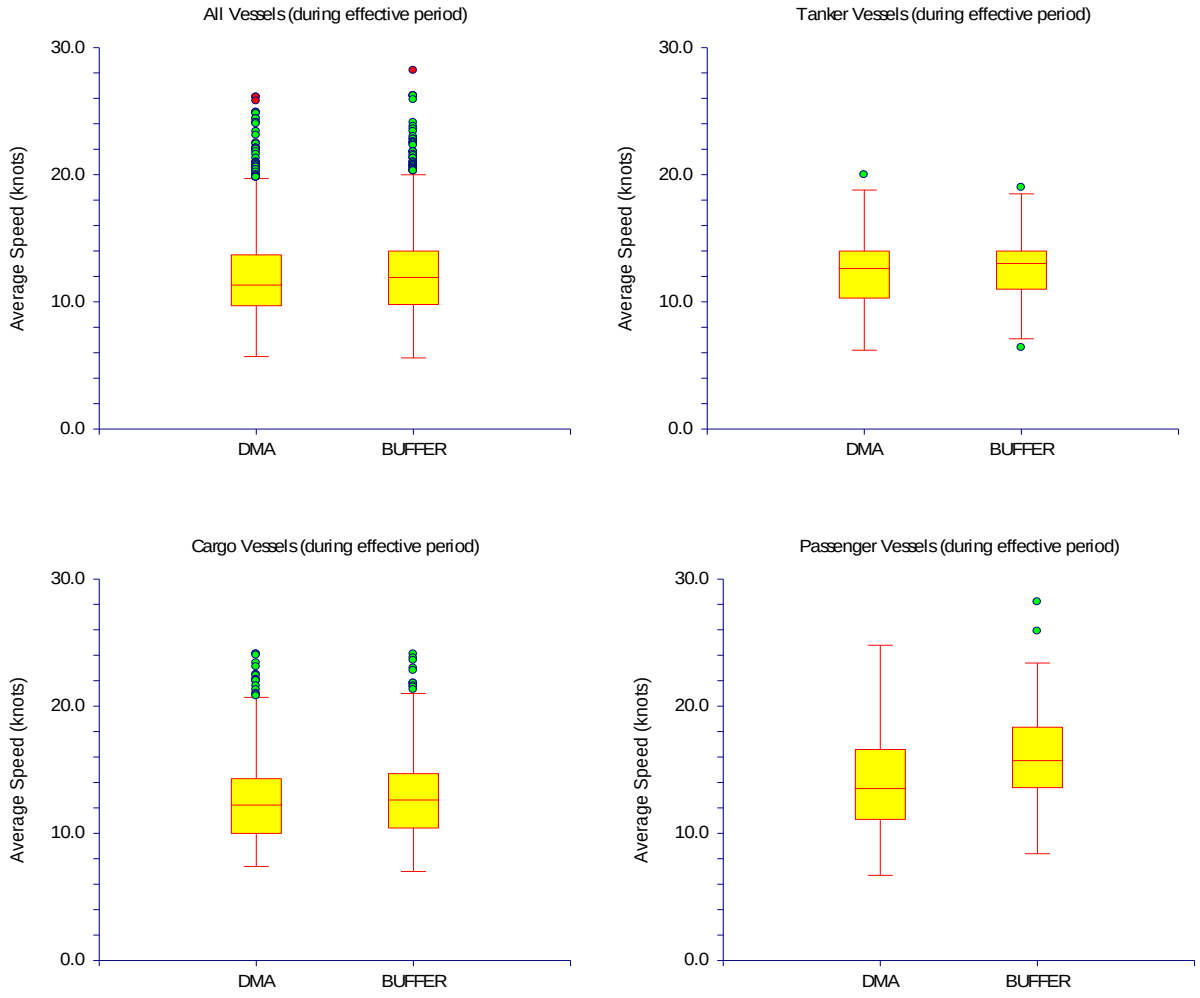
DMA	# Whales	General Location	Area (nm^2)	Start Date	End Date	Tanker	Cargo	Pass.	Pilot	Tow	Tug	Other	Total
NE_26	6	Great South Channel	1697	3/12/2010	3/24/2010	7	11	0	0	0	0	3	21
NE_27	8	Great South Channel	1941	3/22/2010	4/4/2010	15	19	10	0	1	0	1	47
NE_28	3	Nantucket MA	1566	4/14/2010	4/28/2010	0	0	15	0	1	0	5	22
NE_29	18	Block Island	886	4/22/2010	5/5/2010	25	16	2	0	9	33	25	115
NE_30	80	Block Island	1682	4/30/2010	5/5/2010	8	9	3	0	7	16	15	61
NE_31	11	Cashes Ledge	2460	5/24/2010	6/5/2010	20	10	2	0	0	2	12	46
NE_32	3	Jeffreys Ledge	1591	7/27/2010	8/9/2010	21	22	5	3	7	16	50	125
NE_33	4	Jeffreys Ledge	1591	8/9/2010	8/23/2010	26	19	9	4	8	11	55	135
NE_34	10	Jeffreys Ledge	1591	8/18/2010	9/1/2010	24	22	6	2	9	14	52	131
NE_35	6	Jeffreys Ledge	1591	9/1/2010	9/14/2010	16	15	11	4	8	12	30	97
NE_36	4	Mount Desert Island	1707	9/13/2010	9/25/2010	5	1	8	0	0	0	0	14
NE_37	7	Jeffreys Ledge	1591	9/13/2010	9/27/2010	27	19	20	8	10	20	16	121
NE_38	10	Cashes Ledge	2308	10/14/2010	10/28/2010	13	1	6	0	0	0	7	27
NE_39	8	Jeffreys Ledge	1818	10/14/2010	10/28/2010	14	10	14	2	3	13	14	70
NE_40	4	Jordan Basin	1471	10/14/2010	10/28/2010	1	2	1	0	0	0	0	4
NE_41	14	Jeffreys Ledge	1818	10/28/2010	11/8/2010	10	4	2	0	2	6	6	33
NE_42	10	Jeffreys Ledge	3754	11/16/2010	11/27/2010	24	24	1	0	3	20	8	80
NE_43	14	Cashes Ledge	2760	11/16/2010	11/27/2010	7	9	0	0	0	0	2	18
NE_44	12	Jordan Basin	2447	11/16/2010	11/27/2010	0	1	0	0	0	0	1	2
NE_45	7	Jeffreys Ledge	2299	11/29/2010	12/14/2010	15	2	0	0	5	9	8	41
NE_46	16	Jordan Basin	2413	12/1/2010	12/14/2010	4	0	0	0	0	0	0	4
NE_47	4	Cashes Ledge	1683	12/1/2010	12/14/2010	9	0	0	0	0	0	1	10
NE_48	28	Cashes Ledge	4032	12/21/2010	1/2/2011	24	13	0	0	1	0	0	38
NE_49	5	Jordan Basin	1561	12/21/2010	1/2/2011	2	1	0	0	0	0	1	4
NE_50	3	Jeffreys Ledge	1579	1/4/2011	1/15/2011	15	5	0	0	2	6	2	31
NE_51	4	Cashes Ledge	1680	1/4/2011	1/15/2011	1	0	0	0	0	0	0	1
NE_52	8	Jordan Basin	2108	1/4/2011	1/15/2011	2	0	0	0	0	0	0	2

DMA	# Whales	General Location	Area (nm^2)	Start Date	End Date	Tanker	Cargo	Pass.	Pilot	Tow	Tug	Other	Total
NE_53	3	Sandy Hook	1592	1/10/2011	1/23/2011	86	196	13	0	33	23	18	372
NE_54	5	East of Cape Cod	1612	2/25/2011	3/11/2011	11	28	21	0	0	1	1	64
NE_55	5	East of Nantucket	1813	3/15/2011	3/29/2011	3	6	0	0	0	0	1	10
NE_56	3	Nantucket Sound	899	4/27/2011	5/10/2011	0	1	18	0	5	6	8	39
NE_57	13	Martha's Vineyard	1995	5/2/2011	5/15/2011	8	12	10	0	13	19	18	83
NE_58	21	East of Cape Cod	648	5/3/2011	5/17/2011	13	22	0	0	1	0	10	52
NE_59	21	East of Cape Cod	1163	5/3/2011	5/17/2011	8	18	0	0	0	0	9	37
SE_01	16	Ponce de Leon Inlet	693	1/12/2010	2/5/2010	0	0	0	0	2	2	3	7
SE_03	19	Ponce de Leon Inlet	774	2/1/2010	3/24/2010	0	0	0	0	3	6	3	12
SE_05	33	Cape Canaveral	1476	2/22/2010	3/15/2010	12	35	29	0	34	14	13	138
SE_07	8	Palm Coast	673	1/12/2011	1/27/2011	0	2	0	0	0	0	1	3
SE_08	4	Palm Coast	635	1/31/2011	2/15/2011	0	1	0	0	1	1	1	4
SE_09	5	Palm Coast	404	2/24/2011	3/11/2011	0	1	0	0	1	1	1	4
SE_10	5	Brunswick	845	2/28/2011	3/15/2011	7	44	0	0	3	4	4	62
Totals	905					961	781	249	24	279	370	607	3324

Appendix M. Map depicting four avoidance transits that were detected during the active period of DMA NE 16.



Appendix N. Box plots of mean average vessel transit speeds within the Dynamic Management Areas (DMA) and a 10 nautical mile buffer located outside of the DMAs. Red bars within the box plots represent the median of mean speeds and the green and red dots are mild and extreme outliers, respectively.



Appendix O. Mean vessel transit speeds (± standard errors) inside of active DMAs and 10 nautical mile buffers located outside of DMAs.

Vessel Types	n	Buffers	DMAs
All	1799	12.33±0.10	12.00*±0.09
Tanker	615	12.63±0.08	12.31*±0.09
Cargo	525	13.21±0.21	12.89*±0.19
Passenger	93	16.05±0.39	14.10*±0.39
Other	566	10.57±0.20	10.49±0.18

**mean speeds in DMAs were significantly lower ($p < 0.05$) than mean speeds in 10 nautical mile buffers*

Appendix P. Counts of avoidance transits detected in DMAs during their active period and two-week periods directly before and after the active periods. Only DMAs in which avoidance transits were detected during the active periods are included, and shading is used to highlight DMAs where avoidance transits were not detected in the two-week periods directly before and/or after the active periods.

DMA	Vessel Type	Avoidance Transits		
		Before DMA	During DMA	After DMA
NE_04	Tanker	0	4	0
NE_07	Tug	1	1	1
NE_08	Tanker	1	1	0
NE_11	Tanker	0	1	0
NE_13	Tanker	0	1	1
NE_14	Tanker	0	1	0
NE_15	Passenger	0	3	1
	Tanker	0	1	1
NE_16	Passenger	0	2	0
	Tanker	0	2	0
NE_17	Passenger	0	1	0
NE_18	Passenger	0	1	0
	Tanker	0	0	2
NE_31	Other	0	1	0
	Tanker	0	0	1
NE_33	Tanker	0	1	0
NE_38	Passenger	0	1	0
NE_57	Cargo	1	0	0
	Other	0	0	1
	Pleasure	0	0	1
	Sailing	0	0	2
	Tanker	5	2	1
NE_58	Sailing	1	0	0
	Tug	0	2	2
SE_03	Towing	0	0	1
SE_05	Cargo	0	1	0
	Pleasure	0	0	1
	Tug	0	1	1
SE_10	BigTow	1	0	0
	Cargo	7	5	7
	Dredging	1	0	0
	Tanker	0	1	0