North Atlantic Right Whale (*Eubalaena glacialis*) Vessel Speed Rule Assessment

June 2020

NOAA Fisheries, Office of Protected Resources

EXECUTIVE SUMMARY

The North Atlantic right whale (*Eubalaena glacialis*) remains one of the most endangered large whales in the world with an estimated population size of about 400 individuals at the end of 2018 (Pace et al. 2017; Hayes et al. 2019). Despite decades of protection, a combination of anthropogenic impacts and a low calving rate continue to impede recovery of the species (Kraus et al. 2016; Corkeron et al. 2018; Hayes et al. 2019). The most pressing threats to right whale survival include entanglement in fishing gear and collisions with vessels, which combined are responsible for a minimum of 86 mortalities and serious injuries in the U.S. and Canada between 2000 and 2017 (Waring et al. 2004; Waring et al. 2009; Waring et al. 2013; Hayes et al. 2019) representing approximately 20% of the extant population.

In 2008, the National Marine Fisheries Service (NMFS) implemented a seasonal, mandatory vessel speed rule in certain areas along the U.S. East Coast to reduce the risk of vessel collisions with right whales. We conducted a review of the speed rule to evaluate how effective it is at reducing the incidence of right whale mortality and serious injury due to vessel strikes and where it could be improved. While it is not possible to determine a direct causal link, the number of documented vessel strike mortalities and serious injuries decreased from 12 during the 10 years prior to the rule's implementation to 8 in the 10 years since implementation. This overall decline demonstrates progress but also indicates additional action is warranted to further reduce the threat of vessel collisions.

The level of mariner compliance with the speed rule increased to its highest level (81%) during 2018-2019. In most Seasonal Management Areas (SMAs) more than 85% of vessels subject to the rule maintained speeds under 10 knots, but in some portions of SMAs mariner compliance is low, with rates below 25% for the largest commercial vessels outside four ports in the southeast.

Evaluations of vessel traffic in active SMAs revealed a reduction in vessel speeds over time, even during periods when SMAs were inactive. An assessment of the voluntary Dynamic Management Area (DMA) program found limited mariner cooperation that fell well short of levels reached in mandatory SMAs. An examination of AIS-equipped small vessel traffic (< 65 ft in length) in SMAs, not subject to the rule, found the densest activity in the Mid-Atlantic where less than 50% of transit distance was below 10 knots. Off New England, small vessel traffic was sparser with 83% of transit distance under 10 knots.

Our investigation of navigational safety revealed no indication of impacts from implementation of the speed rule. Finally, an economic impact assessment was conducted to evaluate the cost of compliance to the regulated community. The yearly cost to industry is estimated to be $28.3 to $39.4 million annually, with the majority of the cost (58 -70%) borne by the container ship sector.

Findings from this review include recommendations for further action, including addressing low compliance in some SMA port entrance areas and insufficient cooperation with voluntary DMAs. More attention is needed to further investigate the impact of non-lethal vessel collision injuries to

right whales, assess conservation concerns with small vessel traffic and strengthen our ability to enforce the speed regulations.

ACKNOWLEDGEMENTS

We wish to acknowledge the advice, comments and valuable contributions provided by the following people: Jeff Adams, Shannon Bettridge, Lisa Lierheimer, and Eric Patterson from the Office of Protected Resources; Casey Brennan, Wynn Carney, Todd Nickerson, and Al Samuels from the Office of Law Enforcement; Joseph Heckwolf, Loren Remsberg, and Duane Smith from the Office of General Counsel; Barb Zoodsma from the Southeast Regional Office; Michael Asaro, Diane Borggaard, Jean Higgins, and Peter Kelliher from the Greater Atlantic Regional Fisheries Office; Tim Cole and Allison Henry from the Northeast Fisheries Science Center; Katie Moore from the U.S. Coast Guard and Brian Morrison and Brendan Cox from Industrial Economics, Inc.

ACRONYM LIST

ATBA - Area To Be Avoided
AIS - Automatic Identification System
CVI - Clean Vessel Incentive
DWAS - Distance Weighted Average Speed
DMA - Dynamic Management Area
ECAs - Emission Control Areas
ESA - Endangered Species Act
FR - Federal Register
gt - gross tons
IEc - Industrial Economics, Inc.
IHS Markit - Information Handling Service Markit
IMO - International Maritime Organization
MARPOL - International Convention for the Prevention of Pollution from Ships
MMPA – Marine Mammal Protection Act
MSRS - Mandatory Ship Reporting System
NDBC - National Data Buoy Center
NGA - National Geospatial Intelligence Agency
NMFS - National Marine Fisheries Service
NMS - National Marine Sanctuary
nm - nautical miles
NOAA - National Oceanic and Atmospheric Administration
NOAA GC - NOAA Office of General Counsel
NOS – National Ocean Service
NOVA - Notices of Violation and Assessment of Administrative Penalty
OCS - NOAA Office of Coast Survey
OGV - Ocean Going Vessel
OLE - NOAA Office of Law Enforcement
OPR - Office of Protected Resources
SMA - Seasonal Management Area
TSS - Traffic Separation Scheme
USACE - United States Army Corps of Engineers
USCG - United States Coast Guard

Recommended Citation:
National Marine Fisheries Service. 2020. North Atlantic Right Whale (*Eubalaena glacialis*) Vessel Speed Rule Assessment. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD.

Cover photo: North Atlantic Right Whale (#3522); taken under NMFS/NOAA permit 655-1652-01 under the authority of the Marine Mammal Protection Act and the U.S. Endangered Species Act. Photo Credit: Brenna Kraus/New England Aquarium

A NOTE ON VESSEL TERMINOLOGY

The following definitions are provided to offer clarity and ensure that the reader understands the vessel terminology used in this report. For the purposes of this report we offer the following explanations:

1. **Ocean Going Vessels (OGVs)** are the largest vessels in operation and are subject to the speed rule. They include only the following vessel types: tankers, cruise ships, container ships, vehicle carriers (commonly referred to as “roll on-roll off” or Ro-Ros), general cargo vessels and bulk carriers.
   i. Within the OGV category, three size classes are commonly used based on terminology for vessels sized for travel through the Panama Canal. For the purposes of this report we use the following definitions:
      i. **Sub-Panamax Vessels**: maximum length overall = 676 feet (ft)
      ii. **Panamax Vessels**: maximum length overall = 966 ft
      iii. **Post-Panamax Vessels**: maximum length overall = 1,201 ft
2. **Mid-sized vessels** are equal to or greater than 65 ft in length and mostly less than 350 ft in length. These vessels are subject to the speed rule and include vessel types such as; towing and pushing, pleasure, fishing, sailboats, whale watching, and most passenger ferries.
3. **Small vessels** are any vessel less than 65 ft in length. These vessels are <u>not</u> subject to the speed rule.
4. **Exempted vessels** are those not subject to the speed rule due to an explicit exemption not related to vessel size. These exempted vessels include mostly military vessels, vessels owned, operated, or contracted by the federal government, and state law enforcement vessels engaged in enforcement or search and rescue activities.

PURPOSE OF THE REPORT

In an effort to reduce the threat of vessel collisions with right whales, the National Marine Fisheries Service (NMFS) implemented a novel rule requiring most vessels equal to or greater than 65 ft in length to transit at speeds of 10 knots or less in designated Seasonal Management Areas (SMAs) along the U.S. East Coast (73 FR 60173, October 10, 2008). The 2008 speed rule included the designation of ten SMAs between Massachusetts and Florida informed by the best available information regarding vessel traffic characteristics and right whale distribution at the time.

In 2013, NMFS published a final rule removing the “sunset clause” from vessel speed restrictions implemented in 2008 (78 FR 73726, December 9, 2013). As part of this action, NMFS committed to publish and seek comment on a report evaluating the conservation value and economic and navigational safety impacts of the rule (50 CFR § 224.105). This report evaluates four aspects of the right whale vessel speed rule: biological efficacy, mariner compliance, impacts to navigational safety, and economic cost to mariners. The report also assesses general trends in vessel traffic characteristics within SMAs over time, provides a detailed assessment of the speed rule’s effectiveness and offers recommendations for strengthening the rule based on these findings.

In addition to the assessment of the vessel speed rule, this report evaluates mariner cooperation with the Dynamic Area Management (DMA) program and investigates small vessel transits patterns through active SMAs.

TABLE OF CONTENTS

BACKGROUND ON RIGHT WHALES AND VESSEL COLLISIONS

The North Atlantic right whale (hereafter "right whale") remains one of the most endangered large whales in the world with an estimated population size of about 400 individuals at the end of 2018 (Pace et al. 2017; Hayes et al. 2019). Despite decades of protection, a combination of anthropogenic impacts and a low calving rate continue to impede recovery of the species (Kraus et al. 2016; Corkeron et al. 2018; Hayes et al. 2019). With fewer than 100 reproductive females, any mortality or serious injury hinders recovery. Currently, the most pressing threats to right whale survival include entanglement in fishing gear and collisions with vessels, which combined are responsible for a minimum of 86 mortalities and serious injuries in the U.S. and Canada between 2000 and 2017 (Waring et al. 2004; Waring et al. 2009; Waring et al. 2013; Hayes et al. 2019) representing approximately 20% of the extant population.

Right whales range widely across the Northwest Atlantic Ocean mostly along the U.S. and Canadian coasts, although some whales are known to travel to the northeast Atlantic periodically (Figure 1; Knowlton et al. 1992; Silva et al. 2012, Davis et al. 2017). Their primary foraging grounds include the greater Gulf of Maine region, Scotian Shelf, and the Gulf of St. Lawrence (Pershing et al. 2009; Davies et al. 2014; Simard et al. 2019). The species' only known winter calving ground lies within the South Atlantic Bight between northern Florida and North Carolina (Keller et al. 2012; Gowan et al. 2014).

Right whales inhabit U.S. waters year-round, but predominate during late fall through early summer. Right whale distribution changes seasonally, and over time the whales favor different foraging habitats based on the quality and abundance of available prey (Pendleton et al. 2012; Record et al, 2019; Davies et al. 2019). Since 2010, broad shifts in habitat preference have led to new high use areas in U.S. waters such as the region south of Martha's Vineyard and Nantucket, MA (Leiter et al. 2017) and increased the risk from anthropogenic threats as the whales moved into habitats with fewer protections in Canadian waters (Meyer-Gutbrod et al. 2018).

The whales' distribution includes seasonal coastal habitats characterized by extensive vessel traffic, which results in increased risk of collisions with vessels, or vessel "strikes". Since 2008, eight right whale mortalities and serious injuries from vessel collisions occurred in (or near) U.S. waters (for details see section "Right Whale Vessel Strikes in U.S. Waters Since 2008"). Right whales experience two main types of vessel interaction injuries: contact with the vessel hull leading to a blunt force trauma injury, and/or contact with the hull or propeller leading to sharp trauma and laceration injuries (Moore et al. 2013; Sharp et al. 2019). Hydrodynamic modeling of whale-vessel interactions indicates that when whale-vessel contact occurs at the surface, whales are more likely to experience blunt force trauma injuries, whereas when contact occurs sub-surface, whales are more likely to be pulled toward the propeller and suffer lacerations (Silber et al. 2010). Furthermore, modeling indicates the intensity of impact and risk of serious injury and/or mortality increases with higher vessel speed (Vanderlaan and Taggart, 2007; Silber et al. 2010; Conn and Silber, 2013).

Right whales are also susceptible to non-contact harassment by vessels which can include disturbance to essential behaviors such as feeding, nursing and communication. Vessel noise can be especially problematic for right whales. Studies indicate low-frequency vessel noise can mask the whales' vocalizations (Clark et al. 2009; Hatch et al. 2012) and that right whales have vocally adapted to noisy environments by modifying the duration and frequency of their vocalizations (Parks et al. 2009; Parks et al. 2011). The pervasiveness of vessel activity in and around right whale habitats can also cause disturbance. In the Bay of Fundy, right whales' stress hormone levels declined following a sudden reduction in vessel traffic and low-frequency vessel noise (Rolland et al. 2012).

Vessel traffic along the U.S. East Coast is extensive and overlaps substantially with important right whale habitats. This traffic includes thousands of the largest ocean going vessels (OGVs) and small/mid-sized recreational, fishing, and other commercial vessels (Table 1). Five of the largest ports in the U.S. are found in this area including the ports of New York/New Jersey, Savannah, Virginia, Charleston and Baltimore. The most common vessel types (> 65 ft) transiting SMAs include fishing boats, pushing/towing vessels and container ships which combined comprised the majority (56%) of total vessel transit distance in active SMAs in 2018-2019.

In most cases, OGVs cannot reasonably be expected to sight whales nor take evasive action to avoid striking whales due to the vessels' enormous size and restricted maneuverability. OGVs operate at night and in poor weather and can strike a whale without perception by those on board. This is best illustrated by instances when OGVs have unknowingly arrived in port with a large whale draped across their bows. Given these realities, spatial distancing and preventatively slowing the speed of OGVs are currently the best strategies to prevent vessels of this size striking whales.

Some mid-sized and small vessels possess the maneuverability to take evasive action if whales are sighted and are more likely to perceive a whale strike. Whale detectability and safe maneuverability, however, can impede a swift response to a sudden whale sighting. Vessel strikes can occur even when circumstances are seemingly optimal for avoidance as illustrated by two right whale vessel strikes involving small research vessels that occurred in Cape Cod Bay during daylight hours (Wiley et al. 2016). In both cases, the vessels (<65 ft) had experienced mariners and whale observers on board. In one case, the vessel was traveling at ~9 knots in excellent conditions, yet the whale was not seen prior to the collision. In the other case, the vessel was returning to port transiting at ~20 knots with winds > 20 knots and 1.3 m seas. The whale was sighted just prior to impact preventing evasive action by the vessel operator. These events illustrate the unpredictability of collisions and how strikes can occur when even vigilant mariners operate in the vicinity of large whales.

There are many cases from around the world of vessels sustaining significant damage, and even sinking, following collisions with whales. For example, in March of 2009 a 30-foot pleasure craft collided with a whale off Hilton Head, SC and sustained damage significant enough to require passenger rescue by the United States Coast Guard (USCG). The whale, of undetermined species, was also injured with large amounts of blood reported in the water. Sailing vessels are at particular risk of substantial damage due to their deliberately light construction (Ritter, 2012). For small and mid-sized vessels, whale awareness is a matter of safety for both mariners and whales.

Right whales are particularly vulnerable to vessel strike due to their penchant for coastal habitats and frequent occurrence at near surface depths. In some habitats, such as Cape Cod Bay, right whales often forage just below the water's surface, rendering them hidden to mariners but vulnerable to vessel collisions (Mayo and Marx, 1990; Parks et al. 2012). Mothers with newborn calves frequently rest and nurse in nearshore habitats at or near the water surface placing them at high risk of vessel interactions on southeast calving grounds, along the mid-Atlantic migratory corridor and in New England (Cusano et al. 2018).

Researchers lack a full understanding of how right whales perceive and react to vessel traffic. A whale's response to an approaching vessel may be influenced by its activity state, ability to detect the vessel, and position in the water column relative to the vessel. Studies of right whale reactions to vessel noise indicate a lack of response, possibly from habituation to vessel noise (Nowacek et al. 2004). Right whales' positive buoyancy near the ocean surface may also be problematic for risk avoidance. When diving at the surface, their buoyancy may slow descent and when passively ascending they may lack the maneuverability to take vertically evasive action to avoid a vessel at the surface (Nowacek et al. 2001). There is evidence, however, that some whales can and do take evasive action when encountering vessel traffic (Szesciorka et al. 2019) and that slowing vessel speeds assists whales with vessel avoidance (Gende et al. 2011; Conn and Silber, 2013).

Numerous modeling exercises have indicated that slowing the speed of vessels reduces the risk of lethal vessel collisions, particularly in areas where right whales are abundant and vessel traffic is common and otherwise traveling at high speeds (Vanderlaan and Taggert, 2007; Conn and Silber, 2013; Van der Hoop et al. 2014; Martin et al. 2015; Crum et al. 2019). Previous investigations indicate that the speed rule has effectively reduced the risk of vessel strikes to right whales (Conn and Silber, 2013; Laist et al. 2014; Crum et al. 2019). The increased use of recommended routes through SMAs may also be contributing to a reduction in vessel strike risk (Crum et al. 2019). These key management tools, reducing vessel speed and separating whales and vessels via routing measures, continue to offer the most effective options available to reduce vessel collisions with right whales in U.S. waters.

VESSEL STRIKE PREVENTION: REGULATIONS AND PROGRAMS

NMFS has implemented a multi-pronged approach towards mitigating vessel strike risk to right whales. These efforts rely on a combination of regulatory requirements, voluntary programs, and outreach efforts aimed at modifying mariner behavior and/or increasing mariner awareness of right whale presence. Together, these efforts address three aspects of reducing vessel strike risk: 1) reducing the spatial overlap of right whales and vessels, 2) reducing the speed of vessels transiting through right whale habitat, and 3) promoting mariner awareness of right whale presence. While we lack a full understanding of vessel strike risk and how right whales perceive vessel traffic, all agency programs are based on the best available data regarding the nature of vessel strike risk, right whale distribution, and vessel traffic patterns. Below is a summary of vessel strike reduction actions implemented by NMFS and other federal partners to date.

Statutory Protections

“Take” Prohibitions

Both the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) generally prohibit the unauthorized “take” of North Atlantic right whales. Under the ESA, “take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” (16 USC § 1532(19)). Under the MMPA, “take means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill.” (16 USC § 1362(13)).

ESA Section 7 Consultations

As required by Section 7(a)(2) of the ESA, as amended (ESA; 16 U.S.C. §1531 et seq.), all U.S. Federal agencies must consult with NMFS to ensure that any actions they authorize, fund, or carry out that may affect ESA listed species under NMFS jurisdiction are not likely to jeopardize the continued existence of those species or adversely modify or destroy their designated critical habitat. As part of the Section 7 consultation process, NMFS and its federal partners regularly evaluate vessel strike risk to right whales and, where appropriate, NMFS recommends federal agencies implement reasonable and prudent measures to minimize such risk.

Regulatory Protections

500 Yard Minimum Approach Distance

In 1997, NMFS implemented a minimum approach distance for vessels in the vicinity of right whales in an effort to reduce harassment and risk of injury (62 FR 6729, February 13, 1997). It is illegal for a vessel to approach within 500 yards (1,500 ft) of a right whale and if a vessel finds itself within 500 yards it “must steer a course away from the right whale and immediately leave the area at a slow safe speed” (50 CFR § 224.103(c)(1-2)). Exceptions are made if “compliance would create an imminent or serious threat to a…..vessel”. (50 CFR § 224.103(c)(3)). These regulations were promulgated under the authority of the ESA and MMPA.

Right Whale Vessel Speed Rule

In 2008, NMFS implemented a rule (hereafter “speed rule”) requiring most vessels equal to or greater than 65 ft in length to transit at speeds of 10 knots or less in designated SMAs (73 FR 60173, October 10, 2008) pursuant to its authority under the MMPA and ESA. Some vessels are exempt from this requirement including military vessels, vessels owned, operated or contracted by the federal government, and vessels engaged in enforcement or search and rescue activities. (50 CFR § 224.105(a)). Although these vessels are exempt from the speed rule they are not exempt from consultation under Section 7 of the ESA. During consultations, mitigation measures, including speed restrictions, may be recommended to reduce the threat of vessels collisions with right whales. In addition, subject to specific requirements, vessels may deviate from the speed restriction (i.e., exceed the speed limit), under limited circumstances, to maintain safe maneuvering speeds (50 CFR § 224.105(c)). Vessels employing this safety deviation must make a notation in the vessel log detailing the event.

Ten SMAs were designated along the U.S. East Coast with seasonally active periods reflective of temporal trends in right whale habitat use (Figure 2), and are depicted on NOAA navigational charts. The location of the SMAs was informed by vessel traffic (i.e. port entrances were assumed high traffic areas relative to other areas) and right whale distribution data at the time the rule was established. NMFS selected the 10-knot speed limit based on analyses of large whale vessel strike events where the vessel speed at the time of impact was known. Researchers found the probability of whale mortality increased substantially with vessel speed, with the greatest increase occurring between speed of 10 to 14 knots (Vanderlaan and Taggert, 2007). Based on these findings, NMFS determined that the use of speed restrictions was an effective means to reduce the likelihood and severity of vessel collisions.

Mandatory Ship Reporting (MSR) System

In 1998, a mandatory reporting program for all vessels > 300 gross tons was introduced in important right whale habitat areas off New England and Florida/Georgia (66 FR 58066, November 20, 2001) under the authority of the Ports and Waterways Safety Act. Under the provisions of the MSR program, applicable vessels are required to report to the USCG when entering either of the two MSR areas. In response, reporting vessels receive an automated message that provides information about the latest right whale sightings, right whale vulnerability to vessel collisions, and actions mariners can take to avoid collisions. The MSR boundary is included on NOAA navigational charts.

Non-Regulatory Actions

Great South Channel Area To Be Avoided (ATBA)

An ATBA is an International Maritime Organization (IMO) established vessel routing measure within a specified area to avoid navigational hazards or environmentally sensitive areas. In June 2009, an ATBA was established in the Great South Channel to the east of Cape Cod, MA after gaining approval from the IMO. Due to frequent right whale foraging aggregations in the area, all vessels ≥ 300 gross tons (gt) are recommended to avoid this area between April 1 and July 31. The Great South Channel ATBA is included on NOAA navigational charts.

Recommended Routes

In 2006, a joint USCG/NOAA effort established recommended routes for vessels transiting across Cape Cod Bay and into/out of ports in Florida and Georgia. The routes are recommended between January and May in Cape Cod Bay and between November and April off Florida and Georgia. Mariners are recommended to follow the routes to minimize their transit distance through important right whale habitat areas. NMFS continues to monitor the routes and there is evidence of regular mariner use of routes in the southeast (Crum et al. 2019). If the routes are not routinely used, consideration may be given to making the routes mandatory. All recommended routes are included on NOAA navigational charts.

<u>Modification to the Boston Traffic Separation Scheme (TSS)</u>

In 2007, following a successful application to the IMO led by the Stellwagen Bank National Marine Sanctuary and NMFS, a modified TSS (commonly referred to as a shipping lane) was implemented to the north of Cape Cod, MA for vessel traffic navigating to and from the Port of Boston. The modification narrowed the TSS and shifted its route to the north around Cape Cod to reduce the overlap with large whale foraging grounds. The Boston TSS is included on NOAA navigational charts.

<u>Dynamic Management Areas (DMA)</u>

The agency acknowledged that right whale foraging aggregations may form outside of designated SMA boundaries, thus leaving these aggregations without protection from fast moving vessels. To address this, NMFS implemented a voluntary DMA program concurrently with the mandatory speed rule. A DMA is triggered when a group of 3 or more right whales are sighted in close proximity. Following the trigger, NMFS establishes a DMA boundary around the whales for 15 days and encourages vessels either to avoid the area or transit through at speeds less than 10 knots. DMAs may be extended if whales remain in the area. The agency alerts mariners to DMA declarations through emails to lists of interested parties, Local Notices to Mariners, and Broadcast Notices to Mariners.

Increasing Global Use of Vessel Speed Limits for Whale Protection

Since implementation of the speed rule in 2008, the use of mandatory, voluntary and incentive-based speed limits has become a core strategy to reduce the risk of large whale vessel strikes globally. The speed rule and associated SMAs have been cited as exemplar programs by other nations, including Canada, when they reviewed options to reduce vessel strike risk in Canadian waters in 2017 (DFO, 2017). Below are examples of voluntary and mandatory speed restrictions in place today:

1. In January 2007, Spain became the first nation to initiate a voluntary speed measure (< 13 knots) to protect whales in the Strait of Gibraltar shipping lanes (Silber et al. 2012).

2. NOAA has long encouraged vessels to reduce speed in whale habitat areas along the California coast. Starting in 2008 in the Santa Barbara Channel and 2014 off San

Francisco, NOAA formally introduced voluntary 10-knot speed restrictions for vessels 300 gt or larger. Vessels are requested to slow to 10 knots between May 1 - November 15 each year within the Vessel Speed Reduction Zone off San Francisco Bay and May 15 - November 15 in the Whale Advisory Vessel Speed Reduction Zone off southern California.

3. In June 2013, Canada implemented a voluntary 10-knot speed reduction zone in the Gulf of St. Lawrence Estuary to reduce the risk of vessel strikes for several whale species (Chion et al. 2017).

4. In September 2013, the Port of Auckland implemented the Hauraki Gulf Transit Protocol for Commercial Shipping, which included a voluntary speed restriction of 10 knots for vessels transiting the Hauraki Gulf to protect endangered Bryde's whales (Constantine et al. 2015). Cooperation with the speed reduction program is strong.

5. In 2014, a collaborative effort between NOAA's Channel Islands National Marine Sanctuary (NMS) and county level Air Pollution Control Districts called "Protecting Blue Whales and Blue Skies" began offering financial and positive public relations incentives to participating shipping companies that voluntarily slowed their vessels to 10 knots or less in designated areas along the California coast. This program is unique in having multiple goals of reducing the risk of large whale vessel collisions, reducing pollution emissions from Ocean OGVs along the California coast, and an additional benefit of reducing ocean noise. Since its inception, the program has expanded to include the central coast National Marine Sanctuaries (NMSs) and the Bay Area Air Quality Management District off San Francisco Bay.

6. In December 2014, the Panama Canal Authority implemented a mandatory 10-knot seasonal speed limit in designated areas within the Gulf of Panama from August 1 to November 30 each year to protect humpback whales and other cetaceans (IMO, 2016).

7. In the summer of 2017, following a series of right whale deaths in the Gulf of St. Lawrence, Canada introduced a large mandatory 10-knot speed zone for vessels > 65 ft in length in the Gulf (Davies and Brillant 2019b) and mandatory dynamic speed zones in major shipping lanes. Canada continues to renew and refine the details of the 10-knot speed regulations each year and in 2019 modified their rules to include vessels 42 ft or greater in length.

8. In 2019, the Commonwealth of Massachusetts announced a mandatory 10-knot speed limit in Cape Cod Bay during the months of March and April for most vessels under 65 ft in length (MA DMF, 2019). This state regulation compliments the federal speed rule in the Cape Cod Bay SMA, effectively requiring most vessels of any size to maintain speeds of 10 knots or less during these months. This was the first program in the U.S. to restrict the speed of small vessels to mitigate collisions with large whales, although programs limiting

small vessel speeds to protect other marine mammals, such as manatees, have been in place for many years.

EVALUATION OF VESSEL SPEED IN SEASONAL MANAGEMENT AREAS

Mariner Compliance with the Speed Rule: Goals and Methods

Mariner compliance with the vessel speed rule is critical to effectiveness. It is essential to evaluate mariner adherence with the rule across all SMAs to gain insight regarding the rule's effectiveness. Our evaluation of vessel activity focused on understanding differences and trends in compliance temporally, regionally, by vessel size class and by vessel type. This is a critical step in assessing how effective the rule is currently and whether the rule's effectiveness could be enhanced if higher levels of mariner compliance are achieved in the future.

We conducted a broad assessment of vessel traffic patterns in SMAs to evaluate compliance with the speed rule and changes in vessel traffic characteristics over time. We assembled and analyzed available data on vessel types, characteristics, speeds, and transits through SMAs using the USCG's National Automatic Identification System (AIS) network and other vessel databases.

AIS vessel tracking data are essential to monitor vessel transits through SMAs. AIS is an automatic vessel tracking system which uses data sent via onboard transponders to track vessel locations. USCG carriage requirements dictate that most (non-military) vessels greater than 65 ft in length carry and operate AIS units. If a vessel fails to follow these USCG AIS requirements, or unlawfully disengages their AIS equipment, we have no mechanism to track this undetected vessel traffic.

In 2016, updated carriage requirements came into effect adding all (commercial) fishing vessels (> 65 ft in length) to the regulations (80 FR 5281, January 30, 2015). This resulted in a large increase in fishing vessel AIS traffic data as hundreds of fishing vessels began using AIS for the first time. Additionally, many mariners not required to carry AIS units, such as pleasure boats and sailboats, increasingly do so voluntarily, as the cost of AIS units has fallen. As a result, the quality and comprehensiveness of AIS data available today far exceed that of earlier years.

Using AIS data from shore-based receivers, we established a set of decision rules to process the data, remove incomplete or error filled records, and classify vessel types. The AIS network relies on mariners to enter static information about their vessel characteristics, which is then transmitted to the AIS receiver stations. If a mariner makes a mistake entering a vessel's characteristics that error will be passed along to the USCG AIS database. Where possible, we linked AIS vessel identification records to the Information Handling Services (IHS) Markit database of vessels to confirm or correct vessel information entered into the AIS system. The IHS Markit database includes all OGVs and many mid-sized vessels (>100 gt) but not smaller vessels (< 65 ft). For smaller vessels, we lacked a secondary database to confirm the accuracy of reported information. Figure 3 presents the detailed decision tree used to process all AIS data to establish vessel type and length.

The AIS system classifies vessels by a combination of vessel type and vessel activity. These categories did not always align well with vessel type classifications of relevance for this assessment. Using the IHS Markit “Statcode 5 Shiptype Coding System” we reclassified vessels in the AIS data according to their alignment with this industry standard categorization of vessel types. This effort resulted in 26 vessel categories (Figure 4). For vessels subject to the rule we also assigned vessels into two overarching type categories: 1) OGVs and 2) mid-sized vessels (as defined at the beginning of the report).

Following the AIS data processing and re-classification, vessel transits through SMAs containing a minimum of two data records were compiled and used to calculate the following key indicators of vessel traffic characteristics and compliance with the speed rule:

1. Distance weighted average speed (DWAS). We used DWAS as a measure of vessel speed to correct for the bias introduced by the over-representation of AIS records at lower speeds and for differences in AIS signal transmission/reception rates between vessels. DWAS was calculated by first determining the total distance traveled by a vessel as the sum of individual transit segment distances at each unique speed. The speed of each transit segment was then multiplied by the fraction of the total distance traveled and summed to produce an average speed weighted by the contribution of each transit segment.

2. Proportion of total transit distance in each of the following speed bins: <10 knots, 10 -12 knots, 12.1 - 15 knots, >15 knots.

3. Transit Distance. Total transit distance allowed us to understand the total amount of vessel traffic present in each area of assessment and examine changes in traffic patterns over time. Along with vessel speed, transit distance is an important metric for understanding overall risk of vessel traffic to whales.

SMA transits were temporally organized by SMA “seasons” rather than by calendar year. This is due to the seasonality of the active SMA periods. SMAs become active starting in fall/winter/spring and become inactive the following spring and summer. For example, the SMA season 2012-2013 refers to SMAs active between November 1, 2012 and July 31, 2013.

Lastly, there is an important limitation to this assessment of compliance. Data detailing the number of safety deviations used on individual transits are not readily available so we are unable to determine what proportion of transits lawfully invoked the safety deviation clause. In general, any transit in excess of the 10-knot speed limit should be considered potentially non-compliant, recognizing that a vessel master may have invoked the safety deviation clause.

General Vessel Speed Characteristics in SMAs

Average vessel transit speeds have decreased in active SMAs since the speed rule was established. For those vessels subject to the rule, the DWAS in active SMAs fell from 10.05 knots during the 2008-2009 season to 8.52 knots during the 2018-2019 season (Figure 5). Interestingly, a decrease also occurred in inactive SMAs when no speed restriction was in effect. The DWAS in inactive SMAs declined from 11.94 knots during the 2008-2009 season to 8.43 knots during the 2018-2019 season. The same trend holds true for OGV with DWAS dropping from 11.41 knots to 9.45 knots in active SMAs and from 13.51 to 12.42 during inactive periods. This general trend towards slower vessel transit speeds in inactive SMAs indicates that factors other than the speed rule may be influencing vessel speed in these areas, but given changes in mid-size vessel AIS adoption over time we must be cautious about interpreting speed trends for this vessel size class.

While vessel speeds declined, the total distance transited by mid-sized vessels across all SMAs may have increased. The total distance transited by mid-sized vessels in active SMAs increased dramatically from 131,354 nautical miles (nm) in 2008-2009 to 584,424 nm in 2018-2019 (Figure 6). This increase in transit distance is partly an artifact of available AIS data and changes to AIS carriage requirements since the rule came into effect in 2008. The substantial jump in total transit distance in 2015-2016 coincides with new AIS requirements for all fishing vessels > 65 ft in length. The number of fishing vessels appearing in the AIS data during active SMAs increased substantially that season from 187 to 451 vessels (Table 1). Furthermore, the number of vessels voluntarily carrying AIS has increased over time. These factors have led to a greater number of vessels in the AIS data system and makes it challenging to separate out real increases in vessel traffic from artifacts of the data.

When looking only at OGVs, a different story emerges with the total transit distance generally remaining stable over time (Figure 6). OGV traffic accounted for less than half the total transit distance (43%) for all vessels within active SMAs for 2018-2019. This trend for OGVs is likely to be real and more accurate due to long standing and consistent AIS requirements for vessels of this size.

The size of OGVs has changed over time in SMAs, with the proportion of Post-Panamax sized OGVs increasing from <1% of OGV transits in active SMAs during the 2008-2009 season to a high of 24.7% in the 2017-2018 season (Figure 7). The proportion of Sub-Panamax vessel transits remains consistent over time with the proportion of Panamax vessel transits declining and replaced by Post-Panamax vessel traffic. In the 2018-2019 season Post-Panamax size vessels made up 37.2% of OGV transits in the North Carolina to Georgia SMA and > 20% of OGV transits in the Race Point, Great South Channel, New York and Chesapeake SMAs (Figure 8). The proportion of Post-Panamax size vessels transiting through SMAs is expected to increase further in the future.

Compliance in Seasonal Management Areas (SMAs)

Compliance with the vessel speed rule has increased across all SMAs each season since implementation in 2008 (Figure 9). Overall compliance, for vessels subject to the rule, reached a high of 81% during the 2018-2019 season but the proportion of vessel traffic exceeding 15 knots has increased to 3.99% after a low of 2.71% in 2012-2013. Furthermore, despite the overall high compliance rate in 2018-2019, vessels transited just under 200,000nm across active SMAs in excess of 10 knots.

The level of compliance varies across SMAs with the Cape Cod Bay, Race Point, and Great South Channel SMAs having compliance rates in excess of 80% over all years while the North Carolina to Georgia SMA had the lowest compliance rate at 63.05% (Figure 10). Looking at the most recent season (2018-2019), compliance in SMAs from Delaware northward exceeded 85% (Figure 11). Morehead City (87.47%) and Southeast (84.6%) also had high compliance in 2018-2019. The Chesapeake (78.08%) and North Carolina to Georgia (69.49) SMAs demonstrated notably lower compliance rates in 2018-2019. A very high proportion of vessel traffic exceeding 12 knots (20.73%) was noted in the North Carolina to Georgia SMA.

In 2018-2019, the total vessel transit distance was highest in the North Carolina to Georgia and Southeast SMAs with 588,374 and 392,633 nautical miles of vessel traffic recorded, respectively (Figure 11). The high amount of vessel traffic in this region is a function of the larger size and nearshore coverage of these SMAs. Examining vessel traffic relative to SMA size reveals the highest density of vessel traffic occurs in the Mid-Atlantic region within the New York, Delaware Bay, and Chesapeake SMAs (Figure 12). A similar pattern emerges when examining the subset of vessel traffic transiting at speeds in excess of 10 knots with the highest level of non-compliant vessel traffic occurring in the North Carolina to Georgia SMA (80,401nm) but the densest non-compliant traffic occurring in the Mid-Atlantic region (Figure 13).

Evaluating vessel traffic by type reveals the prevalence of certain vessel types in active SMAs. Fishing vessels, container ships and towing/pushing vessels accounted for the majority of vessel traffic in all SMAs during 2018-2019 (Figure 14). It is useful to note that the number of unique vessels operating in SMAs does not necessarily align with the distance transited by that vessel type through SMAs. In some cases, a small number of vessels are responsible for a large amount of transit distance (e.g., dredging vessels) while in other cases a large number of vessels (e.g., tankers) are responsible for a relatively moderate amount of transit distance (Figure 14).

Vessel compliance varied considerably by vessel type in active SMAs during 2018-2019 (Figure 15). Fishing vessels showed the highest level of compliant transit (93%) while other cargo (44%) and pleasure vessels (31%) had particularly low levels of compliance. Of the three most prevalent vessel types (fishing, container, and towing/pushing), container ships demonstrated the lowest level of compliance at 76%. Examining the total distance transited by vessels in excess of 10 knots demonstrates container ships, pleasure vessels and tankers had the longest non-compliant transit distances in active SMAs during 2018-2019 (Figure 16). Notably, the total transit distance in excess of 12 knots for container ships and pleasure vessels (47,585 nm) exceeded the same total for all other vessel types combined (44,388 nm).

Examining vessel metrics by individual SMA reveals key differences along the coast. The proportion of non-compliant transit distance generally decreased over time in each SMA (Figures 17-26) and the proportion of the highest speed traffic (> 15 knots) had declined to <1% in five SMAs by 2018-2019 (Figures 17-20 and Figure 21). However, in the North Carolina to Georgia SMA (Figure 25) the proportion of vessel traffic transiting at speeds in excess of 15 knots has increased in recent years reaching a high of 10.41% in the 2017-2018 season. Additionally, in the New York (Figure 21), Chesapeake (Figure 23), Morehead City (Figure 24), and Southeast (Figure 26) SMAs, the proportion of vessel traffic transiting at speeds in excess of 12 knots has varied in recent years or increased moderately.

The composition of vessel types transiting active SMAs and their rates of compliance varied substantially during the most recent 2018-2019 season (Figures 27-36). In the northern SMAs, mid-sized vessel traffic was most prevalent (Figures 27-30). In Race Point, Great South Channel and Block Island SMAs fishing vessels dominated the vessel traffic while in Cape Cod Bay towing/pushing vessels were dominant. Morehead City had a similar profile with fishing, dredging, and towing/pushing vessels most common (Figure 34).

For SMAs directly off major ports, vessel traffic included a greater mix of vessel types and size classes. Container ships made up the greatest proportion of transit distance in the New York, Chesapeake, and North Carolina to Georgia SMAs with towing/pushing, tanker, and fishing vessels also making up large proportions of total vessel transit distance (Figures 31, 33, and 35). Across all SMAs, pleasure vessels and passenger vessels (both other and cruise ships) were often the least compliant with particularly high percentages of high speed (> 15 knots) transit distance. In the Morehead City, North Carolina to Georgia, and Southeast SMAs pleasure vessels were both highly non-compliant and made up more moderate levels of total transit distance relative to other SMAs (Figures 34-36). In the Great South Channel, general cargo and bulk carrier vessels demonstrated low compliance levels (<60%) which were not observed in other SMAs (Figure 29).

In summary, the proportion of total vessel transit distance through active SMAs at speeds < 10 knots reached an all-time high (81%) in 2018-2019. However, compliance has generally leveled off over the past few years (~79-81%) and a significant amount of vessel traffic (nearly 200,000nm) continues to transit active SMAs at speeds in excess of 10 knots. Compliance is generally higher in the four most northern SMAs and particularly excessive vessel speeds (> 12 knots) are an issue in the North Carolina to Georgia SMA.

Ocean Going Vessel (OGV) Compliance in Port Entrance Areas within SMAs

Following implementation of the speed rule, NMFS was petitioned in 2013 to exclude federally maintained dredged channels and pilot boarding areas from the rule over concerns for navigational safety involving OGVs. NMFS denied the petition in 2015 (80 FR 62008, October 15, 2015), finding that the petitioners lacked "substantial information indicating that that exclusion of these areas is necessary". The agency noted that the safety deviation provision provided mariners with an exemption to the rule if conditions existed that restricted vessel maneuverability preventing safe navigation at speeds of 10 knots or less. Given the interest in these entrance zones, we analyzed the characteristics of OGVs traffic in these areas specifically to gain a better understanding of compliance within these discrete portions of SMAs.

We identified 11 entrance channel areas accommodating OGV traffic within SMAs from Cape Cod, MA to Jacksonville, FL. Entrance channel zones that fell within SMAs included: Cape Cod Canal East, New York, Delaware Bay, Chesapeake Bay, Morehead City, Wilmington, Charleston, Savannah, Brunswick, Fernandina and Jacksonville (Figure 37). We evaluated vessel compliance in these zones using the same procedure used for SMAs overall.

OGV compliance varied dramatically between the 11 port entrance areas (Figure 38). Across all active “seasons” the proportion of total vessel transit distance < 10 knots was highest in the New York entrance area (75.73%) and lowest in Brunswick (12.62%). The New York and Savannah entrance areas had the densest vessel traffic and in Savannah 60.4% of the traffic (338,311nm of transit) exceed 10 knots. The total transit distance of vessels within these zones varied considerably but was unrelated to compliance rates. Vessel transit distance reflects a combination of vessel traffic density and the varying length of entrance channels with ports south of Cape Hatteras requiring longer entrance channels due to more naturally shallow bathymetry in port approaches. During the 2018-2019 season, the southern entrance areas (with the exception of Morehead City) revealed notably lower proportions of transit distance under 10 knots relative to the northern/Mid-Atlantic areas (Figure 39). Only 11.16% of transit distance through the Charleston entrance area was under 10 knots while compliance within Cape Cod Canal East reached 90.04%.

An assessment of compliance over time in each entrance area (Figures 40-50) demonstrated more variability. Compliance rates were highest overall in more northern areas with Delaware Bay, Chesapeake Bay, and Morehead City showing large improvements (Figures 42-44). Compliance in entrance areas outside the ports of Wilmington, Charleston, and Brunswick were exceptionally low, never reaching over 20% since 2008 except for the first season in Wilmington (Figures 45, 46 and 48). Rates of compliance were less than 30% for Savannah in recent years after achieving 66.5% during the 2012-2013 (Figure 47). The DWAS in entrance areas between Cape Cod and Morehead City ranged from 8.22 to 10.4 knots but increased outside more southern ports with DWAS ranging from 10.19 - 13.48 knots. Many entrance areas demonstrated improvements in compliance rates over time, but the ports south of Morehead City showed little change over time or a declining rate of compliance.

Lower compliance rates in some entrance channel areas may coincide with employment of the speed rule’s safety deviation provision. However, low compliance rates in certain entrance areas demonstrated little change year to year, across all vessel types, which points to other causes for the low compliance rates.

Examination of port entrance areas within active SMAs revealed extremely low levels of compliance, particularly in Wilmington, Charleston, Savannah, and Brunswick. This is concerning in Charleston and Savannah given the higher levels of transit distance and longer entrance channels into these busy ports. In contrast, New York, with high levels of transit distance, has had compliance levels in excess of 75% since 2010-2011, although that level has slipped from a high of 87.34% in 2013-2014.

Other Considerations Regarding Vessel Speed

Operational Need to Slow Vessels

Mandatory and recommended maritime speed restrictions are commonplace and used in a number of contexts. For example, slowing vessels to speeds under 10 knots outside U.S. ports is a routine, and generally required, part of day-to-day operations for OGVs entering harbors. OGVs are required to use local harbor pilots to enter ports and must slow to speeds less than 10 knots in order to embark or disembark the local pilot. Depending on the port and the size of the OGV, designated pilot boarding areas may be as close as a few miles from an inner harbor or up to 15 miles offshore. Usually, a vessel slows to a safe speed and a pilot embarks or disembarks using an external ladder on the lee side of the ship. Pilot associations commonly recommend OGVs slow to speeds ranging from 5-10 knots for pilot boarding. For example, when boarding pilots OGVs are requested to slow to 5-7 knots outside Morehead City, 8-10 knots outside Charleston, 5-9 knots at Brunswick and 8-10 knots at Jacksonville (NOS, Coast Pilot Vol. 4, 2019). Additionally, the USCG has established vessel speed limits in certain port entrances and adjacent rivers for national security purposes (66 FR 53712, October 24, 2001; 67 FR 41337, June 18, 2002) and U.S. Army Corps of Engineers (USACE) requests certain vessel classes to maintain speeds under 10 knots when transiting the Cape Cod Canal.

Other Factors Influencing Vessels Transit Speeds

OGVs are a significant contributor to pollution emissions in the coastal region. In 2010, the IMO designated an Emission Control Area (ECA) along the East Coast of the U.S. (among many other regions) through amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL). Beginning in August of 2012, new vessel emissions standards were established for ECAs which became effective in 2013 and continue to be strengthened over time. OGVs usually achieve compliance with emission standards by switching to cleaner burning fuels within ECAs, such as marine diesel oil, slowing their speed and/or employing exhaust gas cleaning systems known as “scrubbers”. Most types of OGVs see substantial fuel consumption savings when steaming at lower speeds which in turn reduces pollution emissions. The extent of the savings and the speeds needed to achieve them vary according to the vessel size, design, and transit draft. Numerous sectors have recently urged the IMO to set speed limits for OGVs in an attempt to further reduce greenhouse gas emissions.

In 2013, the Port Authority of New York and New Jersey implemented a Clean Vessel Incentive (CVI) Program aimed at reducing air pollution from the many large vessels coming to the port.[1] One component of the CVI program provides financial incentives for participating vessels which maintain speeds of 10 knots or less within a 20 nm boundary seaward of the territorial sea line. Fortuitously, this outer boundary overlaps exactly with the New York SMA for right whales. As a result, vessels who transit this area under 10 knots during the active SMA period and register for the CVI program are both reducing emissions and helping to reduce the risk of vessel strike to whales.

Fuel costs make up a substantial portion of the operating costs for many vessel types, and transiting at a slower speeds can result in fuel savings (Maloni et al. 2013). Moreover, marine fuel prices can vary substantially from year to year, leading to large swings in vessel operating costs. There is no set definition for an optimal slow speed for fuel savings, rather it is usually a percentage reduction from a vessel's design or service speed. For a fast moving container vessel, this can mean 14 knots while for a slower oil tanker, it could mean 10 knots. OGVs may experience considerable fuel consumption savings by operating at slower speeds although the benefits may not extend to speeds as low as 10 knots for all vessel designs.

In light of possible cost savings, the NY/NJ CVI program, and more rigorous emissions standards in ECAs moving forward, OGVs in particular may have multiple incentives for transiting at slower speeds within SMAs whether they are active or not. This development is positive news for whales. Vessel traffic is increasing along the U.S. East Coast, so if external factors are ushering in a shift to slower vessel speeds, that may contribute to a lower risk of vessel collision for whales.

MARINER COOPERATION WITH VOLUNTARY DYNAMIC MANAGEMENT AREAS (DMAs)

Between December 2008 and May 2019, a total of 195 DMAs were declared in response to right whale sightings outside the boundaries of active SMAs. DMAs are triggered when aggregations of three or more right whales are detected and remain in effect for 15 days. During this period mariners are requested to avoid the DMA or slow all vessels to 10 knots or less to prevent collisions with right whales within DMAs. To investigate mariner cooperation with voluntary DMA slow down requests, we examined the DWAS of vessel transits (> 65 ft in length) and the proportion of vessel transit distance under 10 knots through designated DMAs.

DMAs were excluded from evaluation if they: 1) occurred during the first year of the program (2009), 2) overlapped with an active SMA, 3) included an error in the original DMA communication, or 4) the DMA notice was not included in the USCG Notice to Mariners. These exclusions were necessary to ensure that mariners had ample time to become aware of the DMA program (1 above) and had access to complete and accurate communications regarding DMA specifics (3 and 4 above). Additionally, DMAs overlapping active SMAs were removed (2 above) from the analysis to ensure that the presence of an active SMA did not influence mariner behavior in the DMA.

[1] https://www.panynj.gov/port/en/our-port/clean-vessel-incentive-program.html

Using vessel traffic data processed in the same manner as the SMA vessel traffic data, we examined vessel operations in 86 DMAs established between January 2010 and May 2019 (Figure 51). Of these, 76 occurred in waters off New England and the Mid-Atlantic and 10 off the coasts of Georgia and Florida. This geographic distribution is expected and comports with the prevalence of frequent right whale foraging aggregations in the New England area. When examining only OGV traffic, a subset of these DMAs (n=79) was used due to a lack of OGV traffic in 7 DMA areas.

To evaluate cooperation with DMAs, we compared vessel transits through each active DMA to vessel traffic in the same area during the week directly prior to the DMA declaration. We chose to evaluate a truncated time period within the active DMA (beginning 4 days from the original whale sighting trigger) to ensure that all mariners would have had ample time to learn about the DMA declaration. In some instances, DMAs were extended in time due to new right whale sightings in the same area. In these cases, DMAs were consolidated into one DMA analysis unit as long as the spatial extent of the DMA remained unchanged. We employed paired Wilcoxon signed-rank tests to compare vessel speeds and transit distance within active DMAs with those in the DMA area during the week prior to the DMA declaration.

The size of DMAs included in the analysis ranged from 404 nm^2 to 4953 nm^2 with total transit distances through individual DMAs ranging from 5.6 nm to 21,330 nm. Some DMAs had very light vessel traffic with only 1-2 applicable vessels transiting while others had in excess of 250 unique vessels transit during the analysis period.

Comparing the DWAS of vessels in active DMAs vs. the week before in the same area yielded significant but small differences ($Z = 3.28$, $p = 0.001$). During the study period, the mean DWAS declined from 11.83 knots to 11.52 knots with the median declining from 11.88 knots to 11.22 knots (Figure 52). While the change is significant and provides evidence of slower vessel speeds during DMAs, the degree of cooperation remains insufficient to bring down the DWAS to under 10 knots in the active DMAs.

A similar result was found when comparing only OGV traffic in DMAs, which again yielded small but significant differences in vessels' DWAS during active DMAs vs. the week earlier ($Z=3.88$, $p= 0.001$). The mean DWAS of OGVs declined from 13.6 knots to 12.53 knots with the median declining from 12.92 knots to 12.33 knots (Figure 53). Only four DMAs had OGV traffic with a DWAS equal to less than 10 knots.

The proportion of vessel traffic cooperating with the 10-knot speed request increased during DMA active periods. The mean increased from 39.8% to 46.9% and median increased from 35.55% to 50.62% (Figure 54) demonstrating a shift to lower speeds during the active DMA period. However, the increase in cooperative vessel traffic remains modest and fails to approach levels achieved in mandatory SMAs. Only a small portion of vessels are modifying their speed to less than 10 knots within active DMAs.

Comparing the transit distance of vessels in active DMAs vs. the week before in the same area resulted in no significant difference ($Z=0.19$, $p= 0.846$). If vessels were avoiding active DMAs, we would expect to see a decrease in vessel traffic. The lack of change in transit distance indicates mariners may not be modifying their routes to avoid active DMAs.

Cooperation from the mariner community is essential for any voluntary speed program. This assessment demonstrates that some mariners are cooperatively decreasing their speed in active DMAs but not to levels sufficient to be compliant if a 10-knot speed restriction were to be mandatory. These findings echo earlier assessments of DMA effectiveness which found similar patterns of modest cooperation that fell short of program goals (Silber, 2012a). OGVs, which made up 35% of the total distance transited through DMAs, are a particular concern given their higher overall average speeds. Vessels continue to transit thousands of nautical miles at speeds above 10 knots through active DMAs, where right whales are known to have aggregated.

SMALL VESSEL TRAFFIC IN SEASONAL MANAGEMENT AREAS (SMAs)

Given the number of small vessel collisions with whales documented during the past 20 years (see section below on Vessel Size Classes Involved in Right Whale Collisions), we undertook a review of small vessel traffic patterns in SMAs to better understand vessel strike risk associated with small vessels. USCG AIS carriage requirements do not apply to most vessels under 65 ft in length but many smaller vessels voluntarily carry AIS for safety or enjoyment. Because AIS use by small vessels is voluntary, the data are likely biased and not a representative sample of small vessel operations in SMAs. Bearing this in mind, we cannot draw holistic conclusions from this review of small vessel operations. Rather, this assessment provides a first level examination of AIS-equipped small vessel operations in active SMAs and their possible threat to right whales.

We focused on examining AIS data from the most recent SMA season available, 2018-2019. Since more small vessels adopt the use of AIS each year, more recent years are likely to have the most comprehensive data. The vessel transit data were processed in the same manner as described above for vessel type, speed, and transit distance. We applied three vessel size categories originally developed by the Florida Fish and Wildlife Conservation Commission's Marine Mammal Pathology Lab for the study of manatee vessel strikes. These categories include; category I vessels (<16 ft in length); category II (16-39 ft in length), and category III (40-65 ft).

During the 2018-2019 season, AIS-equipped small vessels transited 279,176 nm across all active SMAs. The majority of this traffic occurred in the North Carolina to Georgia (141,742 nm) and Southeast (49,509 nm) SMAs (Figure 55). Examining the amount of transit distance relative to the area of each SMA reveals the densest traffic in SMAs between New York and Georgia (Figure 56). Off New England, both the overall distance traveled and the density of traffic is much lower, possibly due to poor weather conditions during winter months in more northern areas.

The proportion of AIS-equipped small vessels transiting under 10 knots varied considerably between SMAs. In the four New England SMAs, more than 83% of all small vessel traffic transited at 10 knots or less, while in the New York, Delaware Bay, and Chesapeake SMAs, less than 50% of transit distance was below 10 knots. The southern SMAs were more mixed with 55-74% of small vessel transit distance at speeds under 10 knots.

The majority of AIS-equipped small vessel traffic in active SMAs came from four vessel types; pleasure, sailing, pilot and fishing vessels (Figure 57). Of these, sailing and fishing vessels traveled at lower speeds with nearly 100% of sailing vessel traffic traveling at speeds of under 10 knots. In contrast, more than 50% of pleasure vessel transit distance exceeded 10 knots and that number rose to more than 85% for pilot vessels. Given the ubiquity of small pleasure and pilot vessel traffic in some SMAs and the high speeds at which many travel, these vessel types may pose a particular threat to right whales.

Approximately 85% of small vessel traffic was made up of category III size vessels (40-65 ft in length), 15% were category II vessels and less than 1% were category I. This size breakdown must be regarded with some caution, however, as it likely underestimates the smallest vessel size classes active on the water during this period because they may lack adequate power supplies to operate AIS units and/or vessel operators may see no need for AIS if they make mostly short, daytime trips close to shore. Looking at the traffic breakdown by SMA again (Figure 58), the North Carolina to Georgia SMA has the most transit distance and the most category II and III vessel size traffic.

The best available AIS data indicate that a substantial amount of small vessel traffic traveling at speeds in excess of 10 knots is present in active SMAs particularly in the Mid-Atlantic and to a lesser degree in the southeast. Pleasure and pilot vessels account for the majority of traffic transiting over 10 knots. Most vessels fall within size category III, although this sample of small vessels may be biased. Vessels under 65 ft in length are known to cause mortalities and injuries in right whales. The speed and characteristics of the small vessel traffic detailed here warrant further assessment.

Vessel Size Classes Involved in Right Whale Collisions

In 2013, Costidis and Knowlton completed an assessment of vessel size classes involved in right whale collisions through 2012.[2] Based on photographs of propeller laceration injuries and some reports of vessel strikes, they evaluated a subset of these events and determined the likely size of vessels involved. From the 37 records between 1999 and 2012, sufficient information was available to evaluate 18 injury cases. Of these, 11 cases (61%) involved small vessels < 65 ft in length, three involved vessels either under or over 65 ft and four were the result of strikes by vessels > 65 ft in length. Furthermore, based on photo ID records they were

[2] Knowlton AF, Costidis A. Unpublished. 2013. Case Studies of Vessel Struck Right Whales (*Eubalaena glacialis*) documented off the East Coast of North America. Report prepared for The Volgenau Foundation. Available from the John H. Prescott Marine Laboratory, New England Aquarium, Central Wharf, Boston, MA.

able to narrow down the area where some of these vessel strikes occurred. Three collisions likely occurred on the southeast calving ground and one in Cape Cod Bay.

They were also able to identify the vessel size involved in eight mortality or serious injury cases either from photographs or vessel strike reports by mariners. In six cases these vessels were > 65 ft in length and in two cases the vessels were found to be under 65 ft. Of these small vessel cases, one was a March 2005 mortality off Georgia where a 43-ft vessel was involved and the other a serious injury from April 2006 in Cape Cod Bay where a right whale was struck by a 50-ft research vessel.

The proportion of small vessels involved in collisions with whales is concerning because the vessel speed rule does not apply to this vessel size class (< 65 ft in length). Small vessel collisions may be less likely to result in a serious injury or mortality, but at least one mortality and one serious injury were the result of small vessel collisions during this period.

NAVIGATIONAL SAFETY

Navigational safety is of paramount importance to NMFS. When the agency published the final rule implementing the 10-knot vessel speed restriction on October 10, 2008 (73 FR 60173, October 10, 2008) the rule included a provision allowing vessels to deviate from the speed rule under certain conditions for reasons of safety. Specifically, the rule states that “a vessel may operate at a speed necessary to maintain safe maneuvering speed instead of the required ten knots only if justified because the vessel is in an area where oceanographic, hydrographic and/or meteorological conditions severely restrict the maneuverability of the vessel” (50 CFR § 224.105 (c)).

It was always understood that there may be limited situations, such as inclement weather, in which operating at 10 knots or less may severely impact the maneuverability of a vessel. Notwithstanding the inclusion of this safety deviation provision, in 2012 a petition was made by the American Pilots’ Association to NMFS as part of comments to the proposed rule to eliminate the speed rule's sunset provision (78 FR 34024, June 6, 2013). The Association indicated that safe navigation could be hindered in certain areas by vessels traveling at or below 10 knots and recommended that NMFS “exclude federally-maintained dredged channels and pilot boarding areas (and the immediately adjacent waters) for ports from New York to Jacksonville” from the vessel speed restrictions. NMFS decided to accept this comment as a petition for rulemaking but later denied the petition finding it presented no “substantial information indicating that exclusion of these areas is necessary to address the concerns” (80 FR 62008, October 15, 2015). At the same time, USACE commented on the petition, indicating a potential increased risk of vessel grounding incidents in the Charleston entrance harbor due to diminished vessel maneuverability when operating at or below ten knots. Given these previous comments, and the agency’s ongoing commitment to safety at sea, we undertook additional efforts to review the navigational safety impacts of the speed rule to date.

Marine Casualty Events: Groundings

A vessel grounding is a type of marine casualty incident where a vessel has an impact with the seabed or side of a waterway. To investigate whether there was an increase in grounding incidents in any active SMAs since the speed rule went into effect, we reviewed the USCG "Marine Casualty & Pollution" database for groundings events along the east coast (United States Coast Guard, 2019).

The casualty database includes data on all marine casualty events reported to USCG from January 2002 through July 2015. Based on this data availability, we examined casualty data for a period of 6.5 years before and 6.5 years after the rule was enacted. We analyzed all grounding events within the current SMA boundaries and identified whether the incidents occurred during the active or inactive seasons for each SMA (Figure 59).

The analysis showed that 58 grounding events met this criteria, with 31 occurring prior to the speed rule and 27 occurring after it was implemented. Of the 31 earlier casualty grounding incidents, 71% occurred in the months when SMAs would have been active and 29% in the months when they would have been inactive. A different trend appeared after the speed rule was in effect. Of the 27 grounding incidents since December 2008, only 41% occurred when SMAs were active, while 59% occurred when SMAs were inactive. Thus, there was actually a reduction in grounding events within active SMAs following implementation of the vessel speed rule. There are insufficient data to draw any conclusion as to the cause of this decrease, but regardless, the initiation of the 10-knot speed rule is not associated with an increase in grounding incidents. Furthermore, USCG Sector Charleston has had no reports, to date, of a mariner citing the right whale speed rule as a causal factor in any type of marine casualty event.

Charleston Entrance Channel (Fort Sumter Range)

In May 2019, USACE released a navigation study detailing vessel simulations conducted to evaluate different widening alternatives proposed as part of the ongoing Charleston Harbor Deepening and Widening Project (USACE, 2019). Part of this assessment examined the Fort Sumter Range, a channel segment often referred to as the "entrance channel" to Charleston harbor. Only one alternative was considered for Fort Sumter Range, which included no widening to the existing 800 ft (1000 ft overall) channel. Simulations were run for this no-widening alternative to examine two-way traffic issues, based on an 800 ft wide channel deepened to 54 ft, and an overall 944 ft wide channel deepened to 49 ft along the sides (Figure 60). The simulations used an exemplar container ship with the following dimensions: length 1,201 ft, beam 160 ft and draft 49.9 ft. This is the maximum size for a Post-Panamax vessel.

Two-way traffic runs (i.e. two ships passing) in the channel were simulated on ebb and flow tides with a 30-knot crosswind under two speed conditions: 1.) unrestricted speeds, and 2.) speeds restricted to 10 knots in keeping with the vessel speed rule. The conditions were chosen to reflect "credible worst-case scenarios." Pilots conducting the simulations observed a decrease in steerage and an increase in the ship's "effective beam" during the restricted runs.

The pilots also experienced groundings on some runs while trying to pass each other in the channel. Two-way traffic was deemed viable at 10 knots but with poorer handling. In contrast, the pilots reported being able to better control ships at unrestricted speeds (typically 13-14 knots).

These simulations were designed to test the limits of safe navigation, using the largest vessels, under poor weather conditions, with two-way traffic in the channel. Fortunately, the simulated scenario described in the report is rare. During the active SMA period in this region (November 1 - April 30), 30-knot winds are an uncommon event. Based on wind data from the National Data Buoy Center (NDBC) between 2016 and 2018, wind speeds of 30 knots or higher never exceeded 3% of wind speed observations at the NDBC offshore buoy #41004 during any month the SMA was active. Of the 18 months of data we reviewed, 13 months had no observations of winds ≥ 30 knots. Wind speeds of 25 knots or higher were also infrequent and never exceeded 16% of wind speed observations at the offshore buoy during any month the SMA was active. At an inshore station (#FBIS1), closer to the harbor entrance, wind speeds of 30 knots or higher never exceeded 2% of wind speed observations during any active month and wind speed events of 25 knots or higher never exceeded 3% of wind speed observations during any active month.

Another key factor in the simulations is two-way vessel traffic in the entrance channel. Two-way entrance channel traffic is limited to some extent by certain inner harbor channels, which only permit one-way traffic. One report examining vessel traffic in the entrance channel during February 2019 found 13.7% of transits involved two-way (Post-Panamax) traffic in the channel and 33.1% of transits involved two-way traffic of any size OGVs.[3] Additional assessment is needed to more fully evaluate the prevalence of two-way Post-Panamax vessel traffic in the Charleston entrance.

The size of OGVs transiting the Charleston entrance channel during the active SMA period has changed substantially since the speed rule was implemented. During the 2008-2009 SMA season, only 1.4% of OGV transits in the channel were Post-Panamax vessels (Figure 61). By the 2017-2018 season, 59.2% of vessel transits were made by Post-Panamax vessels. Whether this proportion will continue to grow remains to be seen, but it is clear that Post-Panamax vessels now predominate OGV transits in Charleston.

Given the growing size of OGVs transiting the Charleston entrance channel and the episodic high wind events that occur during the SMA active period, it is reasonable to assume that mariners may need to use the safety deviation provision when encountering extreme wind combined with two-way Post-Panamax traffic in the channel. Based on our findings, the majority of transits should be able to maintain 10 knots in the channel given the generally favorable weather predominant during the SMA active months and the mostly one-way Post-Panamax vessel traffic in the entrance channel.

[3] Lang, J., Goldstein, N., Newman, O., and Goldstein, A. Unpublished 2020. Compliance with Speed Restrictions to Protect Right Whales from Ship Strikes. Rhode Island Marine Animal Patrol. 44p.

There is no indication that the vessel speed rule has negatively impacted navigational safety. Vessel grounding incidents have declined within SMAs since the speed rule went into effect. USACE simulated traffic runs into and out of the Port of Charleston highlighted some concerns regarding safe passage in the entrance channel for two-way traffic involving Post-Panamax vessels under high wind scenarios at slow speeds. Fortunately, the confluence of conditions detailed in the model simulations are uncommon and should not prevent routine safe transit at 10 knots in the entrance channel.

BIOLOGICAL EFFECTIVENESS

Minimizing right whale vessel strike mortalities and serious injuries remains the core objective of the right whale speed rule. As such, to evaluate the biological efficacy of the speed rule we examined the number of mortalities, serious injuries, and non-serious injuries of right whales related to vessel strikes both before and after implementation. In addition, as the speed rule may benefit other large whale species, despite being developed specifically for right whales, we examined mortality, serious injury, and non-serious injury data for humpback, sei, fin, and minke whales all of which have a history of vessel strike events inside SMAs.

NMFS defines a serious injury as “any injury that will likely result in mortality (50 CFR 229.2) and further interprets the word “likely” as presenting a “greater than 50 percent chance of death” (NMFS, 2012). This definition can also include dependent calves when the mother has died. Injuries not meeting this standard are considered non-serious injuries (hereafter injuries).

Right Whale Mortalities, Serious Injuries, and Injuries from Vessel Collisions (1999 - 2018)

NMFS examined available data on right whale vessel collisions over a 20-year span, including 10 years prior to the implementation of the vessel speed rule (1999-2008) and 10 years post implementation (2009-2018). Between 1999 and 2018 a total of 57 confirmed right whale vessel collisions were documented as U.S. events or first detected in U.S. waters (Table 2, Figure 62; Cole et al. 2005; Glass et al. 2008; Henry et al. 2015; Henry et al. 2019; Henry et al. in press). These include 14 mortalities, 6 serious injuries, and 37 non-serious injuries. Most of the individuals involved in these collisions were juveniles (age class 1-8 years; 45.6%; n=26), with adults making up 28.1% (n=16), calves 15.7% (n=9), and animals of unknown age 10.5% (n=6). Females comprised 54.4% (n=31) of the total, males 33.3% (n=19), and individuals of unknown sex 12.2% (n=7). Examining the mortality and serious injury incidents on a per capita basis suggests a downward trend in recent years (Figure 63).

Table 3. North Atlantic right whale vessel strike mortalities, serious injuries, and injuries 1999-2018 (n = 57). Data includes both confirmed U.S. events and events first sighted in U.S. waters but of unconfirmed geographic origin.

Time Period	US Mortalities	US Serious Injuries	US Injuries	First Seen US Mortalities	First Seen US Serious Injuries	First Seen US Injuries	Total
1999-2008	10	2	5	0	0	8	25
2009-2018	3	4	10	1	0	14	32
Total	13	6	15	1	0	22	57

We used chi-square tests to determine departures from expected vessel strike events for sex. Significantly higher female mortality, serious injury, and injury occurred during this period (total vessel strikes: 31 females and 19 males; $\chi 2 = 9.495$, $p = 0.002$) based on the 2015 estimated sex ratio of 59.4 males to 40.6 females (Pace et al. 2017). The proportion of calves in the population never exceeded 10% during this period (Pace et al. 2017) yet calves made up 17.6% (n=9) of individuals involved in collisions for which an age class could be determined. With juveniles, a similar result emerges. Juveniles comprise 50.9% (n=26) of collisions for which an age class could be determined but based on best available estimates they make up between 24.7 and 31.1% of the population (Hamilton et al.1998).

The high proportion of female, juvenile, and calf vessel collisions is consistent with other assessments of right whale vessel collisions (Laist et al. 2001, van der Hoop et al. 2013). Calves are particularly vulnerable to vessel strike likely due to their tendency to remain near the ocean surface. Cusano et al. (2018) found that 74% of a calf's day was spent resting at the surface or just subsurface on the southeast calving ground and 70% of the time was spent resting at the surface or just subsurface when in Cape Cod Bay. Mothers are also at heightened risk for vessel strikes in the southeast calving ground while tending to very young calves; they spend the majority of their time at or near the surface and were found to dive shallower and for shorter periods of times than other right whales in the same area (Cusano et al. 2018).

Juveniles' habitat use may differ from adults inadvertently increasing their risk of vessel strike. Juveniles have a higher probability of migration to the southeast calving grounds than other (non-reproductive) adults, possibly due to lower energetic demands releasing them from the need to forage all winter (Gowan et al. 2019). Research indicates that to maximize traveling efficiency right whales may utilize depth strata proportional to their body size, with smaller individuals found closer to the surface (Nousek McGregor, 2010). This behavior could render smaller whales at a higher risk of collision.

Of the 57 documented collisions, 25 occurred prior to implementation of the speed rule and 32 occurred after (Table 3, Figure 64). This increase in the total number of detected collisions may be cause for concern; however, it is important to consider the severity of these events. The number of right whale mortalities dropped after the speed rule came into effect but the number of serious injuries increased. Of the 14 documented U.S. mortalities, 10 occurred prior to implementation of the speed rule and four afterward (one first sighted in the U.S.). Two serious injuries occurred prior to the speed rule and four serious injuries (including two prorated injuries) occurred after implementation. Thirteen injuries were documented prior to the rule and 24 post-implementation.

Interpretation of apparent increases in serious injuries and injuries warrants some caution. Following implementation of the speed rule, NMFS conducted extensive mariner outreach. Part of these efforts included raising awareness about the problem of large whale vessel collisions and encouraging all mariners and members of the public to report vessel strike incidents. Additionally, the period between 2009 and 2018 has seen increasing levels of right whale monitoring and associated photographs of whales. It is possible that these factors have led to more comprehensive reporting and detection of vessel strike events.

Alternatively, it is possible that right whales are better able to avoid fatal vessel collisions due to slower vessel speeds and thus whales are now more frequently seriously or non-seriously injured by vessel interactions but more work is required to fully evaluate this likelihood. Another concern is that minor vessel collisions may not kill an animal directly, but may weaken or otherwise affect it so that it is more likely to become vulnerable to further injury (Hayes et al. 2019). Finally, confirmed collisions only reflect those that were detected.

The decrease in observed vessel strike mortality is a positive sign, and provides evidence that the speed rule may have helped to reduce mortality. Nonetheless, the increase in injuries (both serious and non-serious) needs to be monitored closely in the future. Furthermore, over the 20-year study period changes in whale monitoring efforts, protocols for determining serious injuries, as well as mariner awareness may have impacted vessel strike detection and injury classification.

Finally, NMFS should examine sub-lethal and delayed lethal effects of vessel strike injuries to better understand their impact on individual and population health. For example, a female right whale (“Lucky”) survived lacerations from a 1991 vessel collision when she was a calf, only to die in January 2005 when she became pregnant for the first time and the old wounds reopened. Continued monitoring of whales with apparently non-serious vessel strike injuries remains essential to understanding the long-term health consequences of these events.

Right Whale Vessel Strikes in U.S. Waters Since 2008

It is critical to learn from vessel strike mortalities and serious injuries that have occurred since the speed rule went into effect. Below is a brief summary of the eight vessel collisions that resulted in mortalities or serious injuries since the speed rule was implemented (Henry et al. 2015; Henry et al. 2019):

1. Mortality: A dead juvenile female (ID #3901) was first sighted to the southwest of Grand Manan Island, Canada in U.S. waters on July 2, 2010 with two large ventral lacerations deeper than 10 cm. A necropsy was not performed and it was not possible to estimate the size of the vessel involved. This mortality is designated as “first sighted” in U.S. waters. Because of the close proximity of the carcass to Canada it was not possible to determine if the lethal vessel collision occurred in U.S. or Canadian waters.

2. Serious Injury: A live juvenile male (ID# 3853) was sighted offshore of Hunting Island, SC on January 20, 2011 with 16 deep (>10cm) lacerations across its back. Based on photographs of the lacerations the vessel involved was estimated to be longer than 65 ft. This individual was previously sighted uninjured on January 15th off Georgia narrowing the timing for this vessel strike to January 15-20, 2011. No resights of this individual have been reported.

3. Mortality: A dead adult female (ID #1308) stranded in Nags Head, NC on March 27, 2011. A necropsy was performed demonstrating evidence of a vessel strike, including a fractured skull. Scars from a previous entanglement were also visible. She was found to be lactating and was last sighted alive on the 31st of January 2011 with her calf.

4. Serious Injury: The dependent calf of the dead adult female (ID #1308) was declared a serious injury following the death of its mother in March 2011.

5. Serious Injury: On Dec 7, 2012 a recreational vessel (46 ft long, traveling 12-13 knots) reported a collision with a whale (later determined to be a right whale) off Ossabaw Island, Georgia. No whales were seen prior to the collision. The mariner did not see the injured whale; however, he believed two whales were present. A ~40 ft whale was observed swimming around a large pool of blood (65 ft diameter). The size and sex of the whale are unknown.

6. Serious Injury: On Apr 9, 2014, a research vessel (39 ft long traveling 9 knots) reported a right whale surfacing under it while underway in Cape Cod Bay. The vessel reported a small amount of blood in the water and some lacerations of unknown depth on the whale. The size and sex of the whale are unknown.

7. Mortality: A dead male calf (ID #4681) was first sighted on May 3, 2016 floating off Morris Island, Chatham, MA. A necropsy revealed 9 large deep lacerations and fractured/shorn bones. The calf was last sighted with its mother on April 28th 2016 in Cape Cod Bay, 7 miles east of Plymouth, MA. The calf was estimated to have died 2-5 days earlier and a hindcast[4] model was run to estimate the location of the vessel strike

[4] The term “hindcast modeling” refers to the process of modeling back in time where a dead whale may have drifted from using information on oceanographic and weather conditions. These estimates can help narrow down the location where a vessel strike occurred. Hindcast models are most helpful when a whale dies within 5-6 days of being sighted, otherwise the time between the strike and discovery of the carcass may be too long for useful modeling.

event. The hindcast modeling indicates (Figure 65) the calf was struck within the Off Race Point SMA possibly near the Boston shipping lanes. The SMA may or may not have been active when the strike occurred as this SMA becomes inactive on April 30th.

8. Mortality: A dead female juvenile (ID #4694) was first sighted in Cape Cod Bay north of Barnstable, MA on the 13th of April 2017. A necropsy revealed deep hemorrhage and muscle tearing consistent with blunt force trauma. She was last sighted alive on the 9th of April 2017 in Cape Cod Bay. She was estimated to have died 48 hours before being discovered so a hindcast model was run which indicated the strike may have occurred in Cape Cod Bay to the east of the entrance to the Cape Cod Canal (Figure 66). This vessel strike occurred within the active Cape Cod Bay SMA.

Since the implementation of the speed rule, vessel strikes have continued to occur along the east coast of the U.S. in habitats commonly used by right whales. The seasonality of these events (December - July) corresponds to the months when large numbers of right whales are known to be present in U.S. waters. There is no discrete spatial or temporal clustering that would indicate a new “hot zone” for vessel strikes, rather right whales continue to experience collisions in areas similar to before implementation of the speed rule. Additionally, blunt force trauma and propeller lacerations continue to cause right whale deaths and serious injuries.

The two mortalities off Cape Cod and the serious injury in Cape Cod Bay require further evaluation. The greater Cape Cod area includes major shipping lanes and is a preferred right whale habitat, particularly in winter and spring. It is also one of the most protected areas for right whales. To have had three significant collision events in this relatively small area, and within active SMAs is concerning.

Massachusetts has recently (2019) implemented a mandatory seasonal speed limit of 10-knots in Cape Cod Bay for most vessels less than 65 ft in length during the months of March and April each year. This new seasonal regulation is active during the time frame when all three of the events occurred (or likely occurred). Cape Cod may continue to require unique consideration as a region with large aggregations of right whales and reliable foraging habitats in U.S. waters.

Right Whale Mortalities of Undetermined Cause (1999 - 2018) and Unobserved Mortality

We also reviewed right whale mortalities of undetermined cause given the high number of these events during the study period. A mortality is considered undetermined when insufficient information is available to determine a cause of death. This often occurs when a carcass is unrecoverable or so decomposed as to prevent a cause of death determination. In many cases, these carcasses are able to be identified to species.

Between 1999 and 2018, 82 right whale mortalities were observed in the U.S. and Canada. Researchers were able to identify a cause of death in 59.7% (n=49) of cases, with 10.2% dying from natural causes, 38.8% from vessel collision, and 51.0% from entanglement (Moore et al.

2005, Sharp et al, 2019). In the remaining 40.2% (n=33) of cases, no cause of death could be determined. Despite this paucity of information, it is likely that some portion of these undetermined mortalities were due to vessel strikes. While we will never know the cause of death, it is important to acknowledge these additional right whale mortalities.

Unobserved mortality, serious injury and injury from vessel strike is a challenging factor to evaluate. Despite considerable efforts to detect dead or injured right whales, including public outreach to report whales in distress, many right whale mortalities go undetected. Efforts are underway to estimate the level of this “cryptic mortality”. Additionally, unlike entanglement injuries which usually leave visible scars, blunt force trauma injuries from vessels are difficult or even impossible to detect visually by external assessment. Given that not all right whale mortalities can be assigned a cause of death and that unobserved mortalities clearly occur, the actual number of mortalities from vessel strikes will likely always be higher than those that are detected.

Other Large Whale Vessel Strike Mortality and Injury Data (1999 - 2017)

Vessel strike mortality, serious injury and injury data was available for four mysticetes between 1999-2017; humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*) and minke whales (*Balaenoptera acutorostrata*) (Cole et al. 2005; Glass et al. 2008; Henry et al. 2015; Henry et al. 2019; Henry et al. in press). There were no records of blue whale vessel strikes during this period but historically they have occurred along the U.S. East Coast. Unlike right whales, fin, sei, and minke whales are known to be periodically transported into ports, draped across the bulbous bows of large ships (Rockwood et al. 2017). The location of these vessel strikes may occur far out at sea and not in any proximity to where they were first discovered. Additionally, due to their lower buoyancy, these species may be more likely to sink than right whales following a vessel collision and thus go undetected (Rockwood et al. 2017).

Table 4. Large whale (not including known right whale) vessel strike mortalities, serious injuries and injuries 1999-2017 (n = 131). Data includes both confirmed U.S. events and events first sighted in U.S. waters but of unconfirmed geographic origin.

Species	Humpback			Fin		Minke	Sei	Unknown	Total
	Mortalities	Serious Injuries	Injuries	Mortalities	Injuries	Mortalities	Mortalities	Injuries	
1999 - 2008	13	1	11	11	2	2	4	0	44
2009 - 2017	25	4	22	12	2	10	6	6	87
Total	38	5	33	23	4	12	10	6	131

A total of 131 vessel collisions were documented between 1999-2017 (Figure 67) with collisions involving 27 fin whales, 76 humpback whales, 12 minke whales, 10 sei whales and 6 whales of unknown species. Nearly all vessel strikes recorded for fin, sei, and minke whales occurred in the Mid-Atlantic region between North Carolina and New York, although 17 of these were individuals found on the bows of ships or with injuries consistent with having been draped across a ship's bow. Of the 38 humpback whale mortalities, 9 occurred in New England and the rest (29) in the Mid-Atlantic region. Of the 53 mortalities that occurred after the speed rule implementation, 13.2% of carcasses (n = 7) were located within active SMAs with three found in the Chesapeake SMA.

In the 10 years prior to implementation of the speed rule, 13 humpback whale mortalities, 1 serious injury and 11 injuries were recorded, but in the nine years after implementation, 25 mortalities, 4 serious injuries and 22 injuries were identified (Table 4). For fin whales, 11 mortalities and two injuries were documented before and 12 mortalities and two injuries after implementation. Two minke whale mortalities were documented before and ten after implementation. Four sei whale mortalities were documented before implementation and six afterward.

Based on the limited data available, evidence suggests an increase in vessel strike mortalities for these species, especially in the mid-Atlantic region, though as noted earlier, this may be the result of increased awareness and reporting on whale-vessel interactions. Additionally, the increase in the humpback population (Hayes et al. 2019) may have also played a role in the higher numbers. Regardless, taken at face value, these data suggest that the speed restrictions put in place for right whales are not providing additional protection for other large whale species. As such, an in-depth assessment may be required to develop management options tailored to these species.

In conclusion, the reduction in observed right whale mortality since 2008 is a promising sign, but the increase in serious injuries and non-serious injuries is cause for concern. Assessment of the full extent of right whale vessel strike mortality and injury during the study period is stymied by the high number of undetermined mortalities and an unknown number of unobserved mortalities, serious injuries and injuries. Additionally, since 2010, there appears to have been a considerable change in right whale habitat use patterns in areas where most of the population has been observed in previous years (Hayes et al. 2019). It is important to recognize some limitations when considering the effectiveness of the speed rule as a standalone program. A number of vessel strike prevention measures are in effect that may have contributed to changes in the rates of vessel strikes and it is not possible to separate out the individual contribution of one vessel strike reduction program from another. The downward trend in detected right whale vessel strike mortality is encouraging and may be the result of the comprehensive suite of programs now in place.

ECONOMIC ASSESSMENT

An economic assessment of the vessel speed rule using the most up to date information available was conducted for NMFS by an outside consultancy, Industrial Economics, Inc. (IEc).

The complete report from IEc is provided in Appendix B. The following is a summary of the major findings.

The economic assessment used 2017 vessel data, provided by NMFS, detailing vessel transits through SMAs during both active and inactive periods. IEc focused on the impact of the speed restrictions on transit times, evaluating the additional time required to complete a transit during the active period due to the speed rule. Using information on distance-weighted average transit speeds for different vessel types when SMAs were active and inactive, IEc calculated the expected delay experienced for each individual transit when SMAs were active.

Using this approach, IEC used two different methods to evaluate the delays:

> Method 1: Comparison of mean vessel speeds
> This method assumes that in the absence of speed restrictions, the average distance weighted speed of vessels during the active period would be identical to the average distance weighted speed of vessels during the inactive period. This method treats all transits during the active period as affected by the speed rule.
>
> Method 2: Comparison of high-speed transits only
> This method assumes that only a portion of transits during the active period are affected by the speed restrictions. In this case, only transits that would have occurred at speeds in excess of 10 knots are considered. First, they calculated the proportion of vessel transits during the inactive period in excess of 10 knots. Next, assuming that the same percentage of transits during the active period would have occurred at speeds greater than 10 knots, they identified analogous transits during the active period starting with the highest speed transit until the same target proportion was reached.

Another consideration in the assessment was the treatment of non-compliant transits. It is important to take non-compliance into effect to evaluate the economic impact of the speed rule based on actual compliance. It can also be useful to understand the impact if full compliance were to be achieved. To this end, a full compliance scenario was evaluated using both methods to assess delay and is available in the report (Appendix B).

To determine the economic impact of delays, hourly vessel operating costs are required for each vessel type to ensure an accurate assessment. Given the extensive range of vessel types transiting the SMAs, IEc used a variety of data sources and methods to estimate vessel operating costs. For OGV's, fuel costs can make up a substantial proportion of a vessel's operating costs and vessel fuel consumption generally increases exponentially with increasing speed. Unfortunately, detailed fuel consumption data were unavailable so estimates were based on a vessel's service speed, usually well in excess of 10 knots. As a result, fuel consumption, and therefore also OGV operating costs, were likely overestimated given the reduced speeds at which OGVs transit active SMAs. Actual OGV operating costs would likely be lower at reduced speeds, with less fuel consumption.

Based on the methods described above and the best available data for 2017, IEc estimates the direct cost of the speed rule at approximately $28.3 million (method 1) to $39.4 (method 2) per year based on actual compliance (Table 5). A large proportion of the cost is attributable to commercial shipping which accounted for $24.8 million (method 1) to $29.2 million (method 2) each year, with container ships bearing most of the cost due to the high number of transits through active SMAs.

Trade data indicate that the value of goods entering and leaving East Coast ports recovered following the 2008 economic downturn and has remained relatively constant ever since. A review of the data suggest no impact from the speed rule on the volume or economic activity at potentially affected ports (Appendix B). Furthermore, the yearly direct cost estimates to commercial shipping as a percent of trade value at affected East Coast ports is approximately 0.005%.

ENFORCEMENT

The NOAA Office of Law Enforcement (OLE) and NOAA Office of General Counsel (NOAA GC) have primary responsibility for enforcement of the vessel speed rule. OLE is supported by the USCG, which works in close collaboration with NMFS to assist with mariner compliance of federal regulations. Working together, OLE, NOAA GC, and USCG spearhead a trio of enforcement contacts with mariners each year which include the following:

1. Notices of Violation and Assessment of Administrative Penalty (NOVAs) and Written Warnings

   Based on OLE's investigations, NOAA issues NOVAs or Written Warnings to vessels found to have exceeded the 10-knot speed limit in SMAs. NOVAs issued by NOAA GC assess a civil penalty commensurate with the charges involved, and are most often issued in cases where a vessel operator(s) has demonstrated a substantial or repeated failure to adhere to the speed rule. Written warnings may be issued by NOAA GC or OLE and are most often issued in less egregious cases.

2. Compliance Assistance Letters

   OLE sends out compliance assistance letters to mariners found to have exceeded the 10-knot speed limit. These letters address conduct that does not reach the level of a NOVA or a Written Warning but, rather, serve to educate mariners on the requirements of the speed rule and potential enforcement actions if the alleged conduct continues in the future.

3. Hail and Inform Efforts

   The USGC hails applicable vessel operators who they detect transiting in excess of 10 knots in active SMAs. Mariners are reminded of the speed rule and informed that they should reduce their speed accordingly. Vessel compliance with hail instructions is noted and reported to NMFS.

In recent years (2017-2019), NOAA GC, OLE, and USCG have had a total of 178 enforcement related contacts via these three avenues. There were 60 contacts in 2017, 54 in 2018 and 64 in 2019. Since most vessels transit repeatedly through SMAs, one enforcement contact may cover numerous transits in possible violation of the speed rule. When enforcement investigations commence, as allowed by the rule, vessel operators are given an opportunity to provide evidence that they deviated from the requirements of the rule to maintain safe maneuvering speed, specifically due to oceanographic, hydrographic and/or meteorological conditions on transits which were in alleged violation of the speed rule.

OUTREACH

Any successful vessel strike reduction strategy designed to achieve meaningful protection for right whales demands mariner awareness, comprehension, cooperation, and compliance. To this end, NMFS and its partners have developed a broad suite of initiatives to inform, educate, and hold vessel operators transiting through right whale habitat along the U.S. East Coast accountable. These include, real-time awareness of right whale sightings, engagement with the professional maritime community, regulatory reminders, notices of dynamic actions, and corporate responsibility programs. The goal of these efforts is to reach out to mariners through both established and innovative ways to promote a “whale aware” mariner environment and the adoption of prudent practices to reduce the likelihood of vessel strike events. Below are the descriptions of specific actions, programs and other initiatives carried out by NMFS, NOAA’s National Ocean Service (NOS), USCG and other partners in support of the agency’s vessel strike reduction strategy.

Corporate Responsibility Initiatives

<u>Partnership with the Shipping Industry</u>

Beginning in 2010, NMFS partnered with the World Shipping Council and the Chamber of Shipping of America to provide data to shipping companies on the performance of OGVs while transiting active SMAs. Shipping companies voluntarily participate, and receive a monthly report detailing the dates, locations, and speeds of their vessels while within SMAs. The complete list of data provided includes the following:

1. Vessel name
2. SMA name
3. Speed over ground (in knots) upon entry
4. SMA Entry time
5. Maximum speed over ground (in knots) while in the SMA
6. Date and time when maximum speed over ground was reached

7. Speed over ground (in knots) upon exit
8. SMA Exit time
9. Distance traveled within the SMA (in nautical miles)
10. Percent of SMA distance traveled at >10 knots
11. Percent of SMA distance traveled at >12 knots

This outreach program provides shipping companies with large fleets a mechanism by which to evaluate the operations of individual vessel compliance with the speed rule. This gives corporate shipping managers the ability to monitor which vessels in their fleet are consistently compliant and which may require intervention. Currently, summary reports are provided each month to 18 companies covering approximately 1,000 OGVs.

Right Whale Corporate Responsibility Project

The Right Whale Corporate Responsibility Project was launched in 2010 by NOAA's Stellwagen Bank National Marine Sanctuary (NMS), in collaboration with NMFS, the International Fund for Animal Welfare, the USCG, and the Massachusetts Port Authority.[5] The project team tracks vessels transiting the Stellwagen Bank NMS which overlaps with the Cape Cod Bay and Off Race Point SMAs. Vessels and operator companies are graded (A+ to F) based on compliance levels with the 10-knot speed limit in the NMS. Individual vessels and companies are then sent a "report card" package (Figure 68) detailing the vessel's transits, compliance levels, and information about right whales. If a vessel or company receives an A+ or A grade they are awarded a Certificate of Corporate Responsibility. In 2019, the program rated 258 vessels from 110 companies, with 85% of vessels and 86% of companies receiving A or A+ grades. This program is designed to acknowledge and applaud responsible corporate practices and environmental stewardship. Feedback on the report card approach is positive and the program is expected to continue into the foreseeable future.

Direct Engagement with the Mariner Community

All major ports maintain harbor safety committees that address port related issues such as safety, security and environmental concerns. Committee members may include government agencies, shipping agents, industry organizations, and public interest groups. Committee meetings provide updates on port issues to federal, state, commercial, and other stakeholders. Each year, liaisons from NMFS attend harbor safety committee meetings at ports adjacent to SMAs to provide seasonal updates, presentations, and reminders about federal regulations pertaining to right whales. Liaisons answer questions and listen to concerns from the maritime community. They often distribute informational documents to shipping agents to pass along to their shipping clients. NMFS representatives also attend meetings of port advisory groups, such as the Boston Port Operators Group, in a similar capacity, to discuss right whale vessel strike reduction regulations and programs.

[5] https://sanctuaries.noaa.gov/news/jun19/right-whale-corporate-responsibility-project-stellwagen-bank-national-marine-sanctuary.html

Navigation Aids

Professional mariners and recreational boaters commonly use official navigation reports to ensure safe transit at sea. NMFS has worked closely with government partners to ensure that details regarding the speed rule, SMAs, and DMAs are integrated into this stream of navigational information for the maritime community. Below is a list of these efforts.

1. Local Notices to Mariners, Broadcast Notices, and Marine Safety Information Bulletins

   The USCG issues several forms of regular updates to mariners including the weekly Local Notice to Mariners, Broadcast Notices to Mariners, and Marine Safety Information Bulletins. When SMAs or DMAs are active, local USCG districts will include related announcements in the “Special Notices” section of their Local Notice to Mariners. These announcements notify mariners to the declaration of, or changes to, voluntary DMAs, SMAs, and other management actions for right whales in relevant areas (Figure 69). They also list resources and websites that provide updated information about right whale training resources for mariners, recommended navigational actions when operating in whale habitat and instructions for reporting sightings of dead and injured right whales. The same information is provided in regionally tailored broadcasts that are routinely monitored by mariners. Some districts, such as Jacksonville, FL, also issue local Marine Safety Information Bulletins, explaining the endangered status of right whales, advising caution when transiting right whale habitat areas and detailing the speed rule requirements.

2. Special Notices to Mariners

   The National Geospatial-Intelligence Agency issues a Special Notice to Mariners each year, which includes a section providing information on protected species vulnerable to vessel strike, including right whales.

3. US Coast Pilot

   The U.S. Coast Pilot is a nautical reference book series that details a variety of navigational information of interest to mariners. NOAA’s Office of Coast Survey (OCS) publishes the U.S. Coast Pilot, which is updated weekly and includes in-depth information about right whale regulations, how to identify right whales, and precautions to take when transiting right whale habitats. The Coast Pilot can be downloaded at the NOAA website.[6]

4. Nautical Charts

   OCS publishes Paper Nautical Charts, Electronic Navigational Charts, and Raster Navigational Charts that include detailed spatial information about right whale related spatial boundaries. These include SMAs, critical habitat, MSR boundaries, right whale

[6] https://nauticalcharts.noaa.gov/publications/coast-pilot/index.html

ATBAs, and recommended two-way whale avoidance routes and tracks. These charting products are essential to mariners and are widely used throughout the professional and recreational marine world. The inclusion of right whale related spatial features in these charts is extremely helpful in ensuring mariner awareness and compliance.

Ongoing Outreach Programs

When the speed rule was first introduced in 2008, NMFS immediately launched a variety of efforts to inform mariners about the new rule, associated SMAs, and the problem of large whale vessel strikes. These activities included outreach to the press, publishing articles in maritime industry trade journals and presentations at relevant public events (festivals, boat shows, etc.) and industry meetings. NMFS developed a suite of outreach materials and mariner education modules. Hundreds of shipboard right whale outreach binders, filled with essential mariner training and educational resources, were handed out at events and made available upon request. Once the agency was confident of mariner awareness, and ongoing communications and education efforts were in place, NMFS refocused its outreach towards long term strategies.

Detailed information on right whale vessel strike reduction regulations and programs is now hosted on NMFS's comprehensive website Reducing Ship Strikes to North Atlantic Right Whales.[7] The website provides maps of the SMAs, information on mariner training and educational resources, links to the most recent right whale sightings, and instructions on how to report a vessel strike. The site is regularly updated and has proven to be a useful resource for vessel strike information.

Due to the seasonal nature of SMAs, mariners experience extended periods when SMAs are inactive. To ensure mariner awareness at the start of an SMA's active period, NMFS and its partners send out email notifications to a variety of distributions lists reminding mariners the SMAs are in effect. These distribution lists include industry associations, shipping agents, port authorities, passenger vessel operators, pilots, scientists, non-governmental organizations and other interested parties. NMFS also sends out notices to these lists when DMAs are declared.

Informational App

In 2012, a joint initiative by the Stellwagen Bank National Marine Sanctuary, USCG, Boston Port Operators Group, Massachusetts Port Authority, the International Fund for Animal Welfare, and other partners launched an innovative informational application (app) called Whale Alert.[8] The app's interactive mapping feature provides information on recent right whale sightings and acoustic detections, and allows users to report a right whale sighting. The app also features practical mariner information in the form of NOAA PORTS tides and currents data for stations along the coast and shows mapped boundaries of active SMAs and DMAs. Users of the app

[7] https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales
[8] http://www.whalealert.org/

include mariners, recreational boaters, scientists, managers and members of the public. Whale Alert is currently active on the east and west coasts of the U.S.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This review evaluated the effectiveness, and impacts, of the right whale vessel speed rule as a tool to prevent right whale mortality and serious injuries. Since the speed rule was implemented, there has been a decline in the total number of documented right whale vessel strike mortalities but an increase in serious and non-serious injuries. This reflects progress made to date but also demonstrates that more effort is required to further reduce the incidence of vessel strikes. While we lack sufficient data to quantitatively demonstrate causality between the implementation of the speed rule and the decline in observed mortality, our assessment shows that the speed rule has had a positive effect in contributing to this change. The decline in mortality is promising and merits the continuation of, if not enhancement to, current management strategies.

Overall compliance with the speed rule continued to improve over the past decade and exceeds 80% collectively across all SMAs for the 2018-2019 season. However, certain discrete areas of poor compliance stand out and require enhanced attention. SMAs in the northeast demonstrated higher compliance rates than SMAs in the Mid-Atlantic and southeast. In particular, the ports of Wilmington, Charleston, Savannah, Brunswick and Jacksonville have compliance rates of less than 50% for OGV transiting into and out of the ports. (These conclusions reflect compliance without considering that some portion of apparently “non-compliant” transits may be covered by use of the safety deviation clause.)

Average (distance weighted) vessel speeds have slowed within SMAs both during active and inactive periods. This indicates factors other than the speed rule may be influencing a move to slower transit speeds including (possibly) emission pollution controls and fuel savings. The total transit distance of OGVs through active SMAs has remained fairly stable over the years, and represented between 41-43% of total vessel transit distance during the past three seasons.

Voluntary cooperation with DMAs has not proven to have a meaningful impact on vessel speed reduction. While there is evidence of mariners slowing down in DMAs, the degree of cooperation falls far short of levels reached in most parts of mandatory SMAs.

An assessment of small vessel traffic speeds in SMAs indicates regional differences in speed patterns. In the New England SMAs, > 80% of small vessel transit distance is below 10 knots, while in the Mid-Atlantic SMAs < 50% of transit distance is below 10 knots due mostly to fast pilot vessels. Most small vessel transits are made up of pilot, pleasure, sailing and fishing vessels, although this may constitute a biased sample. Small vessels in the U.S. are responsible for at least one right whale mortality in 2005 and one serious injury in 2006.

Between 1999 and 2012, small vessels were involved in at least 11 collisions with right whales resulting in injuries.

With regard to mariner impacts from the vessel speed rule, there was no indication that the rule has eroded navigational safety. Our economic impact assessment indicates a total yearly cost to industry of $28.3 to $39.4 million, with the majority of the cost (58 -70%) borne by the container ship sector. Container ships, cruise ships, and vehicle carriers (Ro-Ros) employ the greatest reductions in speed to comply with the rule and have the highest number of transits through active SMAs. As a result, they bear a large share of the total cost of the rule. Acknowledging differences in analysis techniques and variability in vessel traffic/fuel prices over time, when compared to earlier assessments of the direct costs of the speed rule, these estimates are substantially lower than the initial 2008 estimates ($87 million) and in line with the updated 2012 estimates ($19.6 - $34.8 million) (Nathan and Associates, 2008 and 2012; Silber and Bettridge, 2012). Additionally, the yearly direct cost to commercial shipping as a percent of trade value at affected East Coast ports is approximately 0.004%.

Recommendations

This review demonstrates that continued speed restrictions are warranted in light of the positive effect the speed rule has had in reducing the number of serious injuries and mortalities of right whales. Given the gravity of the whales' heath and population status and the continuing level of vessel collisions, we recommend that the rule be strengthened. The January 2020 vessel strike of a newborn right whale calf, recently presumed dead, best illustrates the urgent need for effective enhancements to the speed rule. It is necessary to modify some aspects of the rule to ensure levels of effectiveness consistent with right whale recovery needs. Based on the analyses and data presented in this report, the following specific recommendations are suggested:

- Modify SMAs:
    - NMFS should investigate the locations and timing of SMAs relative to current right whale distribution and vessel traffic patterns. Given what we know about changes in whale distribution, and vessel traffic patterns since development of the 2008 rule, we need to modify the location, timing, or duration of one or more SMAs to maximize their effectiveness.

        - During the past 10 years, at least 25% of DMAs were declared in the region south of Martha's Vineyard and Nantucket, Massachusetts. Right whale foraging activity has steadily increased in this area throughout the years. This zone warrants consideration for designation as an SMA.

        - Three significant vessel collisions have occurred in the area around Cape Cod, Massachusetts, including at least one mortality inside an active SMA. This is an area of particular concern and requires a re-assessment of management actions required to reduce the risk of vessel strikes there.

- Enhance Enforcement and Outreach:
  - The agency currently lacks data on the full extent of vessels' reliance on the safety deviation but there are indications that some vessels may be claiming severe maneuverability constraints without reasonable grounds. There is no efficient mechanism by which the agency can collect such data from the logbook entries required for use of the safety deviation. To aid enforcement of the speed rule, and to better understand the extent of safety impacts, NMFS should investigate modifications to the regulatory language including possible contemporaneous electronic notification of safety deviations.

  - Vessels in certain SMAs exceed 10 knots at disproportionately high levels, especially OGVs in channel entrances. OGVs entering southern ports under pilotage, represent an outsized proportion of vessels traveling at excess speed. Additionally, container ships and pleasure vessels disproportionately operate at speeds in excess of 12 knots. Enforcement and outreach targeted to these industry sectors is needed to ensure compliance and meaningful vessel strike risk reduction across all vessel types.

- Address Vessel Strike Risk from Small Vessels: Small vessels (< 65 ft in length) transiting at speeds in excess of 10 knots are ubiquitous in portions of right whale habitat. The number of documented and reported small vessel collisions with whales necessitates further action both as it relates to potential regulations and outreach to this sector of the mariner community. For example, in 2019, Massachusetts placed seasonal limits on the speed of all vessels < 65 ft in length in Cape Cod Bay, and Canada expanded its Gulf of St. Lawrence speed restrictions to include vessels 42.6 ft (13 meters) in length.

- Modify or Terminate the DMA Program: Mariner cooperation with voluntary speed recommendations in DMAs is generally low and as such, likely does not provide a substantive reduction in vessel strike risk. NMFS should evaluate the DMA program to identify modifications to achieve more meaningful protections for right whales.

- Research Needs:

  - A large proportion of observed right whale vessel strikes between 1999 and 2018 involve females (54.4%) and when broken out by age class juveniles (45.6%) and calves (15.7%) are overrepresented. This finding requires additional investigation to determine if younger whales, and females, are at higher risk of vessel strike due to factors such as behavioral differences, smaller body size, difference in habitat use or inexperience with vessel traffic. A better understanding of the risks to these demographic groups may allow for more tailored management actions.

- Given the number of non-serious vessel collision injuries, an assessment of the sub-lethal impact of vessel strikes is warranted. Researchers have demonstrated that sub-lethal impacts from entanglements likely impeded reproduction. This has serious implications for population recovery. A more complete understanding of sub-lethal impacts from vessel collisions will better inform future right whale population recovery efforts.

LITERATURE CITED

Chion, C., Turgeon, S., Cantin, G., Michaud, R., Ménard, N., Lesage, V., Parrott, L., Beaufils, P., Clermont, Y., and Gravel, C. 2018. A voluntary conservation agreement reduces the risks of lethal collisions between ships and whales in the St. Lawrence Estuary (Québec, Canada): from co-construction to monitoring compliance and assessing effectiveness. PLoS One 13:e0202560.

Clark, C. W., Ellison, W. T., Southall, B. L., Hatch, L., Van Parijs, S. M., Frankel, A. and Ponirakis, D. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series. 395, 201–222.

Cole, T.V.N., Hartley, D.L., and Merrick, R.L. 2005. Mortality and serious injury determinations for large whale stocks along the eastern seaboard of the United States, 1999-2003. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document 05-08; 18 p.

Conn, P. B., & Silber, G. K. 2013. Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. Ecosphere 4(4): 1-15.

Constantine, R., Johnson, M., Riekkola, L., Jervis, S., Kozmian-Ledward, L. Dennis, T., Torres, L., and Aguilar de Soto, N. 2015. Mitigation of vessel-strike mortality of endangered Bryde's whales in the Hauraki Gulf, New Zealand. Biological Conservation. 186.

Corkeron, P., P. Hamilton, J. Bannister, P. Best, C. Charlton, K.R. Groch, K. Findlay, V. Rowntree, E. Vermeulen, and R.M. Pace. 2018. The recovery of North Atlantic right whales, *Eubalaena glacialis*, has been constrained by human-caused mortality. Royal Society Open Science 5:180892.

Cusano, D.A., Conger, L.A., Van Parijs, S.M. and Parks, S.E. 2018. Implementing conservation measures for the North Atlantic right whale: considering the behavioral ontogeny of mother-calf pairs. Animal Conservation, 22: 228-237.

Crum, N., Gowan, T., Krzystan, A., and Martin, J. 2019. Quantifying risk of whale–vessel collisions across space, time, and management policies. Ecosphere 10(4):e02713.

Davies, K.T.A.,Taggart, C.T. and Smedbol, R.K. 2014 Water mass structure defines the diapausing copepod distribution in a right whale habitat on the Scotian Shelf. Marine Ecology Progress Series 497:69-85.

Davies, K.T., Brown, M.W., Hamilton, P.K., Knowlton, A.R., Taggart, C.T., & Vanderlaan, A.S. 2019. Variation in North Atlantic right whale Eubalaena glacialis occurrence in the Bay of Fundy, Canada, over three decades. Endangered Species Research 39:159-171.

Davies, K.T. and Brillant, S.W. 2019b. Mass human caused mortality spurs federal action to protect endangered North Atlantic right whales in Canada. Marine Policy 104:157-162.

Davis, G.E., Baumgartner, M.F., Bonnell, J.M., Bell, J., Berchok, C., Bort Thornton, J., et al. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014. Scientific Reports 7:13460.

Department of Fisheries and Oceans Canada (DFO). 2017. Review of the Effectiveness of Recovery Activities for North Atlantic right whales. Retrieved from: https://dfo-mpo.gc.ca/species-especes/publications/mammals-mammiferes/whalereview-revuebaleine/review-revue/narightwhale-baleinenoirean/index-eng.html#81 Accessed on: 3/15/20.

Gende, S. M., A. Noble Hendrix, K. R. Harris, B. Eichenlaub, J. Nielsen and S. Sanjaypyare. 2011. A Bayesian approach for understanding the role of ship speed in whale–ship encounters. Ecological Applications 21:2232–2240.

Glass, A.H., Cole, T.V.N., Garron, M. 2008. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2004-2008. NOAA Technical Memorandum NMFS-NE-214.

Gowan, T.A. and Ortega-Ortiz, J.G. 2014. Wintering habitat model for the North Atlantic Right Whale (*Eubalaena glacialis*) in the southeastern United States. PLoS ONE 9(4):e95126.

Gowan, T.A., Ortega-Ortiz, J.G., Hostetler, J.A., Hamilton, P.K., Knowlton, A.R., Jackson, K.A., George, R.C., Taylor, C.R., and Naessig, P.J. 2019. Temporal and demographic variation in partial migration of the North Atlantic right whale. Scientific Reports 9:353.

Hamilton P. K. Knowlton A. R. Marx M. K. and Kraus S. D. 1998. Age structure and longevity in North Atlantic right whales (*Eubalaena glacialis*) and their relation to reproduction Marine Ecology Progress Series 171:285–292.

Hatch, L.T., Clark, C.W., Van Parijs, S.M., Frankel, A.S. and Ponirakis, D.W. 2012. Quantifying Loss of acoustic communication Space for Right whales in and around a U.S. National Marine Sanctuary. Conservation Biology 26:983-994.

Hayes, S.A., Josephson, E., Maze-Foley, K. and Rosel, P.E. 2019. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2018. NOAA Technical Memorandum NMFS NE 258; 291 p.

Henry, A.G., Cole, T.V.N., Hall, L., Ledwell, W., Morin, D. and Reid, A. 2015. Mortality and serious injury determinations for baleen whale stocks along the Gulf of Mexico, United States east coast and Atlantic Canadian provinces, 2009-2013. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document 15-10; 48p.

Henry, A., Garron, M., Reid, A., Morin, D., Ledwell, W. and Cole, T.V.N. 2019. Serious injury and mortality determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2012-2016. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document. 19-13; 54 p.

Henry, A.G., T.V.N. Cole, L. Hall, W. Ledwell, D. Morin, and A. Reid. *in press*. Mortality determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast and Atlantic Canadian Provinces, 2013–2017. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document.

International Maritime Organization (IMO). 2016. Identification and Protection of Special Areas and PSSAs, Information on recent outcomes regarding minimizing ship strikes to cetaceans. Submitted by the International Whaling Commission. MEPC 69/10/3.

Keller, C., Garrison, L., Baumstark, R., Ward-Geiger, L. and Hines, E. 2012. Application of a habitat model to define calving habitat of the North Atlantic right whale in the southeastern United States. Endangered Species Research 18:73–87.

Knowlton, A.R., Sigurjónsson, J., Ciano, J.N. and Kraus, S.D. 1992. Long distance movements of North Atlantic right whales (*Eubalaena glacialis*). Marine Mammal Science 8(4):397–405.

Kraus, S.D., Kenney, R.D., Mayo, C.A., McLellan, W.A., Moore, M.J. and Nowacek, D.P. 2016 Recent Scientific Publications Cast Doubt on North Atlantic Right Whale. Frontiers in Marine Science 3:137.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet and M. Podest. 2001. Collisions between ships and whales. Marine Mammal Science 17:35–75.

Laist, D. W., Knowlton, A. R., and Pendleton, D. 2014. Effectiveness of mandatory vessel speed limits for protecting North Atlantic right whales. Endangered Species Research 23:133–147.

Leiter, S.M, K.M. Stone, J.L. Thompson, C.M. Accardo, B.C. Wikgren, M.A. Zani, T.V.N. Cole, R.D. Kenney, C.A. Mayo and S.D. Kraus. 2017. North Atlantic right whale *Eubalaena glacialis* occurrence in offshore wind energy areas near Massachusetts and Rhode Island, USA. Endangered Species Research 34:45–59.

Maloni, M., Paul, J.A. and Gligor, D.M. 2013. Slow steaming impacts on ocean carriers and shippers. Maritime Economics & Logistics 15(2):151–171.

Martin, J., Sabatier, Q., Gowan, T.A., Giraud, C., Gurarie, E., Calleson, C.S., Ortega-Ortiz, J.G., Deutsch, C.J., Rycyk, A. and Koslovsky, S.M. 2016. A quantitative framework for investigating risk of deadly collisions between marine wildlife and boats. Methods in Ecology and Evolution 7:42-50.

Massachusetts Division of Marine Fisheries. 2019. Seasonal Small Vessel Speed Limit in Cape Cod Bay. Marine Fisheries Advisory. Retrieved from: https://www.mass.gov/files/documents/2019/03/08/Whale%20Speed%20Limit_030819.pdf Accessed on: 1/9/2020.

Mayo, C. A. and Marx, M. K. 1990. Surface foraging behaviour of the North Atlantic right whale, *Eubalaena glacialis*, and associated zooplankton characteristics. Canadian Journal of Zoology 68:2214–2220.

Meyer-Gutbrod, E., Greene, C.H., & Davies, K. 2018. Marine Species Range Shifts Necessitate Advanced Policy Planning: The Case of the North Atlantic Right Whale. Oceanography 31(2):16-20.

Moore, M.J., A.R. Knowlton, S.D. Kraus, W.A. Mc Lellan and R.K. Bonde. 2005. Morphometry, gross morphology and available histopathology in North Atlantic right whale (*Eubalaena glacialis*) mortalities. Journal of Cetacean Research and Management 6:199–214.

Moore, M.J., van der Hoop, J., Barco, S.G., Costidis, A.G., Gulland, F.M.D., Jepson, P.D. Moore, K.T., Raverty, S.A. and McLellan, W.A. 2013. Criteria and case definitions for serious injury and death of pinnipeds and cetaceans caused by anthropogenic trauma. Diseases of Aquatic Organisms 103(3):229-64.

Nathan Associates Inc. 2008. Economic Analysis for the Final Environmental Impact Statement of the North Atlantic Right Whale Ship Strike Reduction Strategy. Submitted to the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, August 2008.

Nathan Associates Inc. 2012. Economic Analysis of North Atlantic Right Whale Ship Strike Reduction Rule. Submitted to the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, December 2012.

National Ocean Service (NOS). U.S. Coast Pilot 4: Atlantic Coast Cape Henry, VA to Key West, FL. 2019. 51st Edition. p. 465.

Nousek McGregor, A.E. 2010. The cost of locomotion in North Atlantic right whales (*Eubalaena glacialis*). Dissertation, Duke University. 160 p. Retrieved from https://hdl.handle.net/10161/3088 Accessed on: 2/3/2020.

Nowacek, D.P., Johnson, M.P., Tyack, P.L., Shorter, K.A., McLellan, W.A. and Pabst D.A. 2001. Buoyant balaenids: the ups and downs of buoyancy in right whales. Proceedings of the Royal Society of London B: Biological Sciences 268:1811–1816.

Nowacek, D.P., Johnson, M.P. and Tyack, P.L. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London B: Biological Sciences 271:227–231.

National Marine Fisheries Service (NMFS). 2012. Process for Distinguishing Serious from Non-Serious Injury of Marine Mammals. NMFS Policy Directive PD 02-238. 4 pp. Available online: https://www.fisheries.noaa.gov/webdam/download/64690368.

Pace, R.M., Corkeron, P.J. and Kraus, S.D. 2017. State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution 7(21):8730-8741.

Parks, S. E., Urazghildiiev, I., and Clark, C. W. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. Journal of the Acoustic Society of America 125(2):1230–1239.

Parks, S. E., Johnson, M., Nowacek, D., and Tyack, P. L. 2011. Individual right whales call louder in increased environmental noise. Biology Letters 7:33–35.

Parks, S. E., Warren, J. D., Stamieszkin, K., Mayo, C. A., and Wiley, D. 2012. Dangerous dining: surface foraging of North Atlantic right whales increases risk of vessel collisions. Biology Letters 8:57–60.

Pendleton, D. E., Sullivan, P. J., Brown, M. W., Cole, T. V. N., Good, C. P., Mayo, C. A., et al. 2012. Weekly predictions of North Atlantic right whale *Eubalaena glacialis* habitat reveal influence of prey abundance and seasonality of habitat preferences. Endangered Species Research 18:147–161.

Pershing, A.J., Record, N.R., Monger, B.C., Mayo, C.A. et al. 2009. Model-based estimates of right whale habitat use in the Gulf of Maine. Marine Ecology Progress Series 378:245-257.

Record, N.R., J.A. Runge, D.E. Pendleton, W.M. Balch, K.T.A. Davies, A.J. Pershing, C.L. Johnson, K. Stamieszkin, R. Ji, Z. Feng, S.D. Kraus, R.D. Kenney, C.A. Hudak, C.A. Mayo, C. Chen, J.E. Salisbury, and C.R.S. Thompson. 2019. Rapid climate-driven circulation changes threaten conservation of endangered North Atlantic right whales. Oceanography 32(2):162–169.

Ritter, F. 2012. Collisions of sailing vessels with cetaceans worldwide: First insights into a seemingly growing problem. Journal of Cetacean Research and Management 12(2).

Rockwood, R. C., Calambokidis, J., and Jahncke, J. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PLoS One 12:e0183052.

Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., et al. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society of London B: Biological Sciences 279:2363–2368.

Sharp, S.M., W.A. McLellan, D.S. Rotstein, A.M. Costidis, S.G. Barco, K. Durham, T.D. Pitchford, K.A. Jackson, P.Y. Daoust, T. Wimmer, E.L. Couture, L. Bourque, T. Frasier, B. Frasier, D. Fauquier, T.K. Rowles, P.K. Hamilton, H. Pettis and M.J. Moore. 2019. Gross and histopathologic diagnoses from North Atlantic right whale *Eubalaena glacialis* mortalities between 2003 and 2018, Diseases of Aquatic Organisms. 135 (1):1-31.

Silber, G. K., Slutsky, J., and Bettridge, S. 2010. Hydrodynamics of a ship/whale collision. Journal of Experimental Marine Biology and Ecology 391:10–19.

Silber, G.K, A.S.M. Vanderlaan, A. Tejedor Arceredillo, L. Johnson, C.T. Taggart, M.W. Brown, S. Bettridge, R. Sagarminaga. 2012. The Role of the International Maritime Organization in Reducing Vessel Threat to Whales: Process, Options, Action and Effectiveness. Marine Policy 36:1221–1233.

Silber, G.K., Adams, J.D. and Bettridge, S. 2012a Vessel operator response to a voluntary measure for reducing collisions with whales. Endangered Species Research 17:245-254.

Silber, G.K. and S. Bettridge. 2012. An Assessment of the Final Rule to Implement Vessel Speed Restrictions to Reduce the Threat of Vessel Collisions with North Atlantic Right Whales. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-OPR-48, 114 p.

Silva, M.A., L. Steiner, I. Cascao, et al. 2012. Winter sighting of a known western North Atlantic right whale in the Azores. Journal of Cetacean Research and Management 12:65–69.

Simard, Y., Roy, N., Giard, S. and Aulanier, F. 2019. North Atlantic right whale shift to the Gulf of St. Lawrence in 2015 as monitored by long-term passive acoustics. Endangered Species Research 40:271-284.

Szesciorka, A.R., Allen, A.N., Calambokidis, J., Fahlbusch, J., McKenna, M. F., Southall, B. 2019. A Case Study of a Near Vessel Strike of a Blue Whale: Perceptual Cues and Fine-Scale Aspects of Behavioral Avoidance. Frontiers in Marine Science 6:716.

U.S. Army Corps of Engineers (USACE), May 2019. Charleston, South Carolina, Navigation Study. Charleston Harbor Deepening and Widening Ship Simulation Results. U.S. Army Corps of Engineer Research and Development Center.

U.S. Coast Guard (USCG). Marine Casualty and Pollution Data for Researchers. Retrieved from: https://www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Inspections-Compliance-CG-5PC-/Office-of-Investigations-Casualty-Analysis/Marine-Casualty-and-Pollution-Data-for-Researchers/ Accessed: 10/21/2019.

Van der Hoop, J.M., Moore, M.J., Barco, S.G., Cole, T.V., Daoust, P.-Y., Henry, A.G., McAlpine, D.F., McLellan, W.A., Wimmer, T. and Solow, A.R. 2013. Assessment of Management to Mitigate Anthropogenic Effects on Large Whales. Conservation Biology 27:121-133.

Van der Hoop, J. M., Vanderlaan, A. S., Cole, T. V., Henry, A. G., Hall, L., Mase-Guthrie, B., Wimmer, T. and Moore, M. J. 2014. Vessel Strikes to Large Whales Before and After the 2008 Ship Strike Rule. Conservation Letters 8(1):24-32.

Vanderlaan, A.S.M., and C.T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science 23:144–156.

Waring, G.T., R.M. Pace, J.M. Quintal, C.P. Fairfield, and K. Maze-Foley, Editors. 2004. Gulf of Mexico Marine Mammal Stock Assessments -- 2003. NOAA Technical Memorandum NMFS NE 182; 475 p.

Waring, G.T, Josephson, E., Fairfield-Walsh, C.P., Maze-Foley, K., editors. 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2008. NOAA Technical Memorandum NMFS NE 210; 440 p.

Waring, G.T., Josephson, E., Maze-Foley, K., Rosel, P.E., editors. 2013. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2012. NOAA Technical Memorandum NMFS NE 223; 419 p.

Wiley, D.N., Mayo, C.A., Maloney, E.M. and Moore, M.J. 2016. Vessel strike mitigation lessons from direct observations involving two collisions between noncommercial vessels and North Atlantic right whales (*Eubalaena glacialis*). Marine Mammal Science 32:1501-1509.

APPENDICES

- Appendix A: Tables and Figures
- Appendix B: IEC Economic Impact Analyses