MARINE MAMMAL COMMISSION

4 March 2014

Ms. Donna S. Wieting

Chief, Marine Mammal and Sea Turtle Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1335 East-West Highway
Silver Spring, MD 20910-3226

ATTN: Vessel Speed Rule Petition

Dear Ms. Wieting:

The Marine Mammal Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the National Marine Fisheries Service (NMFS) *Federal Register* notice (79 *Fed. Reg.* 4883) requesting comments on a petition to exempt dredged channels from vessel speed restrictions in seasonal management areas to protect endangered North Atlantic right whales, and offers the following comments.

RECOMMENDATIONS

The Marine Mammal Commission recommends that the National Marine Fisheries Service deny the petition for rulemaking to exclude federally maintained dredged channels and pilot boarding areas from existing rules restricting the speed of vessels greater than 65 feet in designated seasonal management areas off U.S. ports from New York to Jacksonville, Florida, and retain the existing rule unchanged.

BACKGROUND

On 10 October 2008 NMFS adopted a rule (73 *Fed. Reg.* 60173) to restrict the speed of vessels greater than 65 feet to 10 knots in 10 seasonal management areas with important North Atlantic right whale habitats. Recognizing that in some cases vessels may need to exceed 10 knots in those areas for navigational safety, the rule allows vessels to operate at higher speeds when oceanographic, hydrographic or meteorological conditions severely restrict vessel maneuverability. In those cases, the time, location and reasons for using higher speeds are to be recorded in the vessel's logbook. The rule became effective on 8 December 2008, and was adopted to protect endangered right whales from lethal collisions with ships. Analyses of right whale mortality records between the 1970s and 2008 when the rule was initially adopted had identified ship strikes as the most significant human-related cause of right whale deaths. It was specified in the 2008 rule that it was to remain in effect for five years, but on 9 December 2013, the rule was extended indefinitely (78 *Fed. Reg.* 73726).

In its 31 July 2013 comments on the proposed rule extension, the American Pilots' Association (APA) asserted that the speed restrictions posed a significant risk to navigational safety

for ships transiting dredged channels and that it was burdensome and confusing for ship captains to be required to record the reason for any decision on their part to exceed the 10-knot speed limit. The APA therefore recommended that the rule be changed to exempt all dredged channels in seasonal management areas off Atlantic ports between New York and Jacksonville, Florida. It states that such a change would be a very minor alteration because dredged channels comprise an aggregate area of only about 15 square miles within the 76,000 square miles of regulated waters off mid-Atlantic ports. Also, the ATA comments argued that restrictions in channels were unnecessary because "NOAA has already taken this approach for the ports of Boston, Portsmouth, Portland, Searsport, Bar Harbor and Eastport."

NMFS has considered this requested change to the rule, as suggested by the APA, to constitute a petition to amend current regulations and is asking for comments.

RATIONALE

The Marine Mammal Commission (the Commission) recognizes that there are occasions when ships navigating entrance channels to harbors may need to exceed 10 knots for purposes of navigational safety. However, it believes the current provisions are appropriate and adequate to address those situations and that the recommended changes are neither necessary nor consistent with right whale protection needs. The existing rules provide for exceptions when, in the Captain's judgment, conditions require exceeding 10 knots. Provision for such discretion is entirely consistent with maritime tradition. The APA asserts that it is an administrative burden to record in ship's logs the conditions that require vessels to exceed the 10-knot limit in these areas. The Commission sees no reason why this should be so. Captains and pilots are trained and directed as a matter of prudent seamanship to record such information in ship's logs whenever navigational safety issues arise. The APA has provided no rationale for why recording such information with regard to the need to travel faster than 10 knots should be any different or more burdensome than in other hazardous situations. Moreover, the APA has provided no information or analysis on how often vessels have had to exceed the 10-knot speed restriction in regulated areas or the frequency of hydrologic, meteorological, oceanographic conditions requiring such action. Nor has the APA provided an objective analysis demonstrating that the 10-knot restriction represents navigational safety risks in the designated areas or an analysis of whether such risks differ by vessel type. Absent that information, the Commission does not believe the APA has established the merits of its claim that the existing rule creates unsafe conditions or that it is administratively burdensome.

The APA's implication that its requested change is an insignificant reduction in protection also is not substantiated. The Commission believes that it would significantly weaken protection for right whales. The Commission's staff and colleagues at the New England Aquarium recently completed the enclosed article on the effectiveness of the existing seasonal management areas, including those off the ports between New York and Jacksonville, which is currently in press in the scientific journal *Endangered Species Research*. This analysis concludes that the 10-knot speed restrictions have significantly reduced vessel-related right whale deaths along the U.S. East Coast since they went into effect in December 2008. Whereas there was an average of 0.72 ship strike carcasses per year found inside or outside but within 45 nmi of management area boundaries in the

18 years before the rule went into effect, none have been found in those areas since December 2008. This marks the longest such period without the discovery of a dead ship-struck whale in those areas since efforts to locate and record such deaths were improved substantially in the early 1990s. Of the 13 right whale carcasses whose deaths were attributed to ship strikes before the vessel speed rule went into effect, all had wounds indicating the animal had been struck and killed by a ship greater than 65 feet long, and 10 of those carcasses were found in or near the management areas which include the dredged channels that the APA now proposes to exempt.

The APA suggests that because the dredged channels constitute a total of only about 15 nmi^2, which is less than 0.1 percent of the entire regulated area, exempting those channels would have an insignificant effect on right whale protection. However, the APA provides no analysis to support this suggestion. The Commission is aware of no reason why ships transiting dredged channels would be any less likely to hit whales than those transiting other parts of regulated management areas. Indeed, available data suggest that many, if not most, of the whales struck and killed before the rules were adopted were hit by ships using dredged channels inside seasonal management area boundaries. All of the dredged channels between New York and Jacksonville have been in place since the 1990s. Therefore, for navigational safety reasons, it seems reasonable to believe that ships were using those same channels just as regularly before the rules went into effect as afterwards. Because all right whale carcasses examined closely and determined to have been killed by ships during the 18-year pre-rule period had evidence they were hit by large ships, it seems reasonable to assume that many if not most were struck by ships following the dredged or marked channels. The risks are further supported by available right whale sighting data from NMFS-supported aerial surveys and satellite tracking data[1] that show migrating right whales travel close to shore where they would necessarily have to cross dredged channels. On the basis of both the likelihood that ship strikes have occurred in or near these channels and the fact that migrating right whales occur near shore, the Commission believes that continuing to require speed restrictions in dredged channels is a vital component of right whale protection afforded by the existing rule and that exempting those channels would significantly reduce that protection.

The APA also suggests that because the dredged channels off Boston, Massachusetts, and Portland, Maine, are not subject to similar speed restrictions, exempting dredged channels off other ports would seem to be unnecessary. This reasoning is not valid. Right whale sighting and movement data analyzed when the speed restrictions were first proposed in 2006 indicated a clear risk for the ports along the mid-Atlantic coast, but did not justify speed restrictions within 20 nmi of port entrances off Boston and Portland. Therefore, speed restrictions in dredged channels off those ports (as well as other areas within 20 nmi of those ports) were not adopted. As there is no new evidence to suggest the movements of right whales have changed since 2006, the Commission believes that the risk of collision between ships and right whales remains higher along the U.S. mid-Atlantic and south Atlantic coast than in those dredged channels in the northeast. The difference between mid-Atlantic coast ports and those in the Northeast underscores the importance of data in decision making. The ports north of Boston mentioned by APA were excluded on the basis of data;

[1] Schick, R.S, P.N. Halpin, A.J. Read, C.K. Slay, S.D. Kraus, B.R. Mate, M.F. Baumgartner, J.J. Roberts, B.D. Best, C.P. Good, S.R. Loarie, and J.S. Clark. 2009. Striking the right balance in right whale conservation. Canadian Journal of Fisheries and Aquatic Science. 66:1399-1403

the mid-Atlantic coast ports were included on the basis of data. The APA petition can be entertained only when accompanied by relevant, supporting data. In the absence of such data, the petition should be denied.

Finally we note that there has been no demonstrable progress in addressing the second major source of human-caused right whale mortality – the death and injury of right whales due to entanglement in commercial fishing gear. Given this situation, it is even more important not to weaken what appear to be the only effective measures now in place for reducing human-caused right whale mortality – especially since the current vessel speed management measures already include provisions for navigational safety. Accordingly, the Marine Mammal Commission recommends that the National Marine Fisheries Service deny the petition for rulemaking to exclude federally maintained dredged channels and pilot boarding areas from existing rules restricting the speed of vessels greater than 65 feet in designated seasonal management areas off U.S. ports from New York to Jacksonville, Florida, and retain the existing rule unchanged.

I hope these comments and recommendations and the attached paper are useful. We thank you for the opportunity to comment on the petition to exempt dredged channels from vessel speed restrictions in seasonal management areas to protect endangered North Atlantic right whales.

Sincerely,

Rebecca J. Lent, Ph.D.
Executive Director

Attachment

Effectiveness of Mandatory Vessel Speed Limits for Protecting North Atlantic Right Whales

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ABSTRACT

To reduce right whale deaths caused by ship collisions along the U.S. East Coast, a rule was implemented on 8 December 2008 requiring all vessels ≥ 65 feet (19.8 m) to travel 10 knots (5.1 m/s) or less in ten seasonal management areas (SMAs). To evaluate its effectiveness, we plotted locations of all right whale and humpback whale carcasses attributed to ship-strikes since December 1990 in U.S waters to determine their proximity to SMA's. In the 18-year pre-rule period, 13 of 15 (87%) right whales and 12 of 26 (46%) humpback whales killed by ships were found inside eventual SMA boundaries or within 45 nmi (74 km) of their perimeters during eventual active dates. In the first 5 years after the rule became effective, no ship-struck right whales were found inside or within 45 nmi of any active SMA. This was nearly twice as long as the longest pre-rule period without discovery of a ship struck carcass in those areas during effective time periods. Based on the 18-year pre-rule period, bootstrap resampling analyses revealed that the probability of finding no ship-struck whales in or near SMAs during the first five-year post-rule period was a statistically significant reduction in such deaths ($p = 0.031$). The results suggest the rule has been effective at reducing right whale deaths. We suggest a recent petition to exempt dredged channels in SMAs from existing speed restrictions be denied, and that SMAs be enlarged to include additional parts of the right whale migratory corridor.

Key Words: North Atlantic right whales, humpback whales, ship strikes, conservation, vessel speed limits

INTRODUCTION

The North Atlantic right whale (*Eubalaena glacialis*) was hunted nearly to extinction by 1,000 years of whaling that ended in the early 1900s (Reeves et al 2001). Now one of the world's most endangered large whales (Marine Mammal Commission 2008), the species currently occurs almost exclusively over the continental shelf off the eastern United States and Canada. As of late 2013, it was estimated to number about 500 whales (http://www.narwc.org/papers.php?mc=3). The principal threats to its survival – vessel collisions and entanglement in fishing gear (Knowlton &

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Kraus 2001, Moore et al. 2004, Knowlton et al. 2012, van der Hoop et al. 2013) – are the main constraints to its recovery (National Marine Fisheries Service 2005). From 1990 through 2012, more than half of all dead right whales found stranded or floating at sea (39 of 73) have been attributed to ship collisions (n=23) or entanglement (n=16) (Knowlton & Kraus 2001, Moore et al. 2004, Marine Mammal Commission 2013). With no apparent progress in reducing entanglement deaths (Knowlton et al. 2012, van der Hoop et al. 2013), reducing vessel collisions has become even more important.

Several early studies indicated reducing ship speed in key right whale habitats could reduce vessel-related whale deaths. Knowlton et al. (1995) modeled hydrodynamic forces around ships traveling at different speeds and concluded that objects the size and density of a whale can be pulled towards hulls and propellers of large ships with a force that increases as speeds increase above 10 knots. Clyne (1999) also simulated risks of collisions with vessels traveling at various speeds and found that collision with the bow were more likely when speeds increased above 10 knots. Laist et al. (2001) examined accounts of accidental collisions with whales by vessels travelling at known speeds and concluded that lethal collisions increase sharply between speeds of 10 to 14 knots (5.1-6.7 m/s) and were rare at speeds below 10 knots. Based on those findings the seasonal distribution of right whales, the location of ship struck carcasses, and input from the shipping industry, Russell et al. (2001) recommended seasonal management areas with 10-knot speed limits off major ports and in key habitats along the eastern United States. Assuming vessel collisions whale deaths due to ships are strictly a function of impact force and vessel hydrodynamics, Vanderlaan and Taggart (2007) concluded that the greatest rate of change in the probability of lethal collisions was between vessel speeds of 8.6 to 15 knots (4.4 - 7.7 m/s) and that the probability of death declined by 50 percent at speeds of less than 11.8 knots (6.1 m/s).

Based largely on those findings and its own analyses, the National Marine Fisheries Service (NMFS) adopted a rule to limit vessel speeds in key U.S. right whale habitats as part of its "right whale ship strike reduction strategy" (NMFS 2008a). The rule became effective on 8 December 2008 for a five-year period (i.e., until 8 December 2013). Although intended to protect right whales, the measure was also expected to provide some protection to humpback whales (*Megaptera novaeangliae*) and other large whales whose ranges overlap right whales (NMFS 2008b). The rule requires all vessels 65 feet (19.8 m) or longer (also herein referred to as "ships") to use speeds of 10 knots or less when transiting ten Seasonal Management Areas (SMAs) along the U.S. East Coast during periods of peak right whale occurrence (Figure 1). The ten SMAs include six that extend 20 nmi (37 km) from shore off major ports along the species' coastal migratory corridor between southern New England and Georgia (effective 1 November to 30 April); three in feeding areas off Massachusetts (i.e., Cape Cod Bay effective 1 January to 15 May, the Great South Channel effective 1 April to 31 July, and an area immediately east and north of Cape Cod effective 1 March to 30 April); and one in the core of the species' calving grounds off the southeastern U.S. coast of Georgia and Florida (effective 15 November to 15 April).

In addition to SMAs, the NMFS ship-strike reduction strategy included new vessel routing measures for the port of Boston in Massachusetts and three ports in the southeastern U.S. right whale calving grounds, and established two other types of management areas: Dynamic Management Areas (DMAs) and a seasonal "Area To Be Avoided" (ATBA). DMAs are temporary 15-day management areas established on short notice to protect aggregations of three or more right whales found at unpredictable locations outside of active SMAs. When DMA boundaries are announced through customary maritime communication media (e.g., voice radio and local notices to

mariners) ships are asked, but not required, to limit speeds to 10 knots or to steer clear of those areas. ATBAs, established under the authority of coastal nations after approval of the International Maritime Organization, are areas where ship operators are asked, but not required, to avoid transits. Such an area off Nova Scotia, Canada, has been shown to be effective at reducing the risk of lethal vessel strikes in right whale habitats (Vanderlaan et al. 2008). The ATBA for right whale protection lies principally within the boundary of the Great South Channel SMA east of the shipping lanes that run along that SMA's western edge (Figure 1). The new routing measures (1) narrowed and shifted the east-west leg of track of vessel traffic separation lanes leading into Boston harbor to reduce overlap with right whale habitat in Cape Cod Bay (Silber et al. 2012), and (2) recommended routes through Cape Cod Bay and off the ports of Jacksonville, Fernandina, and Brunswick to minimize transit distances through areas used most intensively by right whales (Lagueux et al. 2011).

Initially proposed in June 2006 (NMFS 2006), the rule finally adopted in 2008 was subject to a protracted review by high level officials in the U.S. government. Concerned about its economic impacts and skeptical of the measure's effectiveness, several changes were imposed on the action preferred by NMFS. In part, the width of SMAs along the species' migratory corridor was reduced from 30 to 20 nmi (55 to 37 km) and a sunset provision was added requiring the rule to expire five years after its effective date (i.e., 8 December 2013). During the five-year period NMFS was to evaluate effectiveness of the speed requirement for reducing whale deaths and decide whether to extend, modify, or allow it to lapse. Another required change was making the 10-knot speed limit in DMAs voluntary instead of mandatory. On 9 December 2013, the the rule was extended indefinitely subject to further review to determine if dredged channels through SMAs should be exempted from its provisions as requested by petition (NMFS 2013).

After the 2008 rule was adopted, NMFS developed a plan to evaluate its effectiveness (Silber & Bettridge 2009). Based on the first three years of post-rule experience, NMFS examined vessel compliance rates and economic impacts using data from an Automatic Identification System for ships (Silber & Bettridge 2012) and evaluated its biological effectiveness based on intervals between all documented collisions with large whales along the east coast two years before the rules went into effect versus two years afterwards (Pace 2011). From those analyses, NMFS concluded that biological data was not yet sufficient to reach statistically meaningful conclusions, but that "…there may be 'a meager amount of evidence in support of a reduction in ship-strike deaths and serious injuries of large whales" (Silber & Bettridge 2012).

Several other studies have investigated compliance with the new speed restrictions in both SMAs (Lagueux et al. 2011, Mueller et al. 2011, Wiley et al. 2011, Silber & Bettridge 2010) and DMAs (Asaro 2012, Silber et al. 2012). Initial compliance in SMAs was poor, but improved after warnings began to be issued in late 2009 and improved further after notices of violations with speed limits were issued in late 2010 (Silber & Bettridge 2012). Most ships, however, reduced their speed to varying degrees, although not necessarily to 10 knots. Compliance with DMAs was very poor. This result was similar to a voluntary request asking vessels to travel at 10-knots off Southern California to protect blue whales, which resulted in almost no change in vessel speeds (McKenna et al. 2012). Still other studies have recently provided further evidence that collision risks increase as vessel speeds increase above 10 knots based on hydrodynamic effects (Silber et al. 2010) and whale deaths are correlated with vessels traveling at increasing speeds (Conn & Silber 2013)

The reason why slow speeds are thought to reduce lethal collisions is subject to debate. Some suggest it is due solely to reduced impact and hydrodynamic forces (Vanderlaan and Taggart 2007, Silber et al. 2010); others suggest it provides added time for whales to avoid oncoming ships (Laist et al. 2001, Gende et al. 2011). Regardless of the mechanism and its intuitive rationale, the effectiveness of speed requirements remains poorly documented and is still subject to doubt by some. To further explore whether speed restrictions have been effective at reducing lethal whale collisions, we examined information on known and possible ship-strike deaths of right and humpback whales found in and near SMAs before and after the NMFS implemented its rules limiting ship speeds along the U.S. East Coast.

Specifically, we examined the locations and discovery dates of all right whale and humpback whale carcasses attributed to ship strikes or unknown causes to determine their proximity to SMA boundaries and their occurrence relative to SMA effective dates before and after the rule went into effect on 8 December 2008. We did not include fin whales because, unlike right whales or humpback whales, they can be carried thousands of kilometers into ports on the bows of ships making it unclear where they were struck (Laist et al. 2001). We also did not consider other large whales (i.e., sperm, blue, sei, or minke whales) because they occur infrequently in areas where SMAs have been designated and because lethal collisions with those species along the U.S. east coast have been rare over the past 25 years (Laist et al. 2001). We hypothesized that the average annual tally of right whale carcasses, and possibly also humpback whale carcasses, attributable or possibly attributable to ships discovered in or near SMA boundaries during SMA timeframes would be lower after the ship-strike reduction rule went into effect.

METHODS

We searched the National Marine Mammal Stranding Database maintained by the NMFS for records of all known right whale and humpback whale deaths attributed to ship strikes along the eastern United States and Canada after 8 December 1990. For right whales, we also examined the Right Whale Photo-identification Catalogue maintained by the New England Aquarium for such deaths. Because the NMFS ship-strike reduction strategy is focused on U.S. waters, our analyses of SMA effectiveness used only records of dead whales found within the U.S. Exclusive Economic Zone. We sought records from Canada (i.e., waters north and east of the Hague Line that serves as the boundary between the U.S. and Canadian Exclusive Economic Zones; Figure 1), the only other area where North Atlantic right whales are known to have been killed by ships, to provide readers a basis for understanding what part of the ship collision problem occurs in U.S. waters. For right whales, our study period extended through 8 December 2013, the latest date for which records were available from the Right Whale Photo-identification Catalogue. Because of delays in entering stranding data into the national database, analyses of humpback whales extended only through 8 July 2011.

We also searched for records of all right whale deaths after 8 December 1990 that were attributed to unknown causes because some of those whales may have been killed by ship strikes (e.g., some whales were documented floating offshore but were not examined closely). We selected 8 December 1990 as the start of our study period because (1) that date generally corresponds with the time when East Coast carcass recovery efforts expanded and necropsy teams began flensing carcasses to the bone to look for internal ship collision injuries not always apparent externally, and (2) it was statistically convenient to use the same day and month as the 8 December 2008 effective date for the NMFS rule. Data recorded for each dead whale in the national stranding database

189 includes the date, latitude and longitude, and general description of where the carcass was first seen;
190 the cause of death if it can be determined; the whale's decomposition state; and a summary of
191 necropsy results (if conducted) or other findings explaining the assigned cause of death. When
192 those data for right whales were missing, supplemental information was obtained as possible from
193 the Right Whale Photo-identification Catalogue.
194
195 Carcass locations were mapped using ArcGIS Version 10.0. SMA boundaries were added
196 using coordinates available from the NMFS. Separate maps showing carcass discovery locations
197 before and after the rule went into effect on 8 December 2008 were prepared for right whales killed
198 by ships and for right whales that died of unknown causes that might have involved ship collisions.
199 To identify carcasses possibly killed by ships, we narrowed the list of carcasses attributed to
200 unknown causes by eliminating those that were thoroughly necropsied and had no signs of ship
201 collision injuries. We also prepared a map for humpback whales, but only for deaths attributed to
202 ship strikes; 275 humpback whale carcasses attributed to unknown causes were not plotted. Much
203 less effort is made to retrieve and necropsy dead humpback whales than right whales, and thus
204 unlike right whales, almost no records of humpback whales could be ruled out as possibly being
205 collision-related (i.e., affirmative information that they had neither external or internal injuries
206 consistent with a ship strike was rarely not available). Because of the large number of carcasses
207 attributed to unknown causes and the inability to exclude any that were clearly not caused by ship
208 collisions, we concluded it would not be possible to distinguish meaningful trends potentially related
209 to ship collisions and implementation of SMAs.
210
211 From plotted locations we identified all right whale carcasses attributed to ship strikes and to
212 unknown causes potentially involving ship strikes found inside SMA boundaries during effective
213 timeframes before and after the ship strike reduction rule went into effect. For all other right whale
214 carcasses in U.S. waters, we calculated their distance to the nearest SMA boundary. To account for
215 carcasses that may have drifted outside SMA boundaries after whales were struck and before they
216 were found dead, we considered any carcasses inside SMAs or within 45 nmi (74 km) of SMA
217 boundaries during their active timeframes (hereafter referred to as "in or near active SMAs") to be
218 potential victims of collisions inside SMA boundaries. We did the same for humpback whale
219 carcasses, but only for those attributed to ship strikes. We then calculated the average annual
220 number of ship-struck carcasses found in or near active SMAs for each species during the 18-year
221 pre-rule period and for post-rule periods of 5.0 yr (1,826 d) for right whales and 2.5 yr (942 d) for
222 humpback whales (i.e., the latest dates for which data were available).
223
224 The drift distance of 45 nmi was based on estimates of carcass degradation and drift rates.
225 Almost all right whale deaths attributed to ship collisions in this study were found moderately
226 decomposed (Code 3) or fresher according to the five category ranking system (with Code 5 the
227 most degraded) used to describe carcass degradation states (Geraci and Lounsbury 2005). We
228 estimated it would take six days or fewer for a right whale carcass to become moderately
229 decomposed. This was based on a right whale named Staccato (Catalogue # 1014) that was
230 photographed alive and uninjured on 15 April 1999 and next seen five days later floating dead off
231 Cape Cod, Massachusetts after being struck by a ship. Its carcass was towed ashore the same day it
232 was sighted and necropsied the following day (i.e. 21 April), at which time it was recorded as being
233 moderately decomposed (i.e., Code 3). Although carcass degradation can proceed at different rates
234 depending on temperature, because right whales along the U.S. East Coast almost always occur in
235 cool water similar to temperatures in Cape Cod Bay in April, we considered the April 1999 case to
236 be the best available estimate of time needed for a right whale to degrade to a Code 3 condition.

Average carcass drift rate was estimated from the distances of movements reported for five right whale carcasses seen drifting in U.S. waters and later resighted at another location. These carcasses were first seen floating on the following dates: 3 September 2002, 6 September 2002, 7 February 2004, 27 June 2010, and 2 March 2012. Coordinates for initial and resighting locations documented drift distances of at least 77 nmi (143 km) in 22 d, 112 nmi (204 km) in 8 d, 54 nmi (100 km) in 2 d, 21 nmi (39 km) in 3 d, and 27 nmi (50 km) in 5 d, respectively, for an average drift distance of 7.3 nmi (13.5 km) per day or about 45 nmi (83 km) in six days. Although these records do not reflect all possible conditions that could influence carcass drift rates, they reflect at least some range of conditions in different seasons and areas and are the best available data at this time.

We conducted a bootstrap resampling analysis (Efron & Tibshirani 1993) to test the hypothesis that the average annual number of ship-struck whale carcasses found after the speed rule went into effect would be less than the average number during the 18 years before the speed rule went into effect. This hypothesis was tested separately for right whale carcasses found in or near active SMAs and for right whale carcasses found more than 45 nmi from SMAs. We did the same for ship-struck humpback whale carcasses. For right whales, annual carcass totals from the 18-year pre-rule period were resampled one million times with each sample consisting of a random selection of five annual carcass totals to match the number of years in the post-rule period. After each annual total was selected, it was returned to the pool of eligible years so that each draw in a five-year sample had 18 annual totals from which to select (i.e. random selection with replacement).. We followed the same procedure for humpback whales, but had only 2.5 years of post-rule data. Therefore, each bootstrap sample for humpback whales consisted of a random selection of three annual pre-rule carcass totals. The mean of each bootstrap sample was calculated and those values were sorted in ascending order. The limits of the upper 95% of values were used as the confidence interval. The percentage of mean values less than the lower bound constituted the p-value.

To investigate the hypothetical probability of discovering ship-struck right whale carcasses in or near SMAs in the sixth post-rule year, we did an additional bootstrap resampling as described above, but drew six values instead of five from the pool of 18 pre-rule annual ship strike carcass totals in or near SMAs. From those samples we calculated the probability of discovering zero whales in the first five years, followed by discovering ≤ 1 and ≤ 2 carcasses in the sixth year. We considered only zero, one, or two carcass discoveries because these were the only values observed in any given year during the pre-rule period (Table 1), and thus were the only values possible in the bootstrap samples.

We also compared maximum waiting times between discovery of ship-struck right whale and humpback whale carcasses found in or near active SMAs during pre- and post-rule periods to determine the extent to which intervals between recorded ship-collision deaths differed.

RESULTS

Over the entire study period 23 of 72 confirmed right whale deaths (31.9%) were attributed to ship collisions. Three-fourths of those deaths were in U.S. waters (17 deaths including 15 pre-rule and two post-rule) and one-fourth (six deaths) was in Canadian waters (Table 1, Figure 2). During the 18-year pre-rule period 10 of the 15 carcasses in U.S. waters were inside SMAs, and three others were within 45 nmi of SMA boundaries (including two within just six nmi) during eventual SMA active dates. Together, those 13 carcasses comprised 87% of all known ship-strike deaths (Table 4)

in U.S. waters during the pre-rule period for an average carcass discovery rate of 0.72 right whales per year in or near active SMAs.

The decomposition state of all ship-struck right whale carcasses found in or near eventual SMA boundaries in the pre-rule period was moderate or fresher suggesting they may have drifted up to 45 nmi between the time of death and carcass discovery. The three longest waiting times between finding such carcasses in the pre-rule period were 2.8 yr (i.e., 1,057 d between 17 March 2001 to 7 February 2004), 2.2 yr (i.e., 785 d between 6 December 1993 to 30 January 1996), and 1.9 yr (i.e., 709 d between 30 December 2006 to 8 December 2008). Only two pre-rule ship strikes were found outside the potential reach of eventual SMA protection provisions; both were inside or within 45 nmi of SMA boundaries, but were discovered seven weeks or more outside eventual SMA active dates. During the first 5.0 post-rule years, no ship-struck right whales were found in or near any active SMAs for a carcass discovery rate of zero per year. During that period, two ship-struck right whales were found in U.S. waters; both were found within the active dates of the nearest SMA, but were more than 45 nmi away from the nearest SMA boundary (one 47 nmi in Code 4 condition, the other 112 nmi away in Code 3 condition).

Thirty-three right whale deaths were attributed to unknown causes over the entire study period; 29 in U.S. waters and 4 in Canada. Eight of the 29 in U.S waters were recovered in moderate to fresh condition (mostly neonates) and were ruled out as possible ship collision victims based on necropsy results that found no evidence of collision injuries. Therefore, 25 of all mortalities attributed to unknown cause might have been due to ship strikes; 21 in U.S. waters (14 pre-rule and 7 post-rule) and four in Canada (Table 2, Figure 3). During the 18-year pre-rule period, eight of the 14 possible ship strike carcasses in U.S. waters (57.1%) were found either inside (N = 5) or within 45 nmi (N = 3) of SMA boundaries during their eventual effective dates for an annual pre-rule discovery rate of 0.44 right whale carcasses per year in or near active SMAs. During the first 5.0 years after the rule's effective date, 4 of 7 carcasses (57.1%) found in U.S. waters attributed to unknown causes that may have included ship strikes were inside (N = 1) or within 45 nmi (N=3) of active SMAs for an average discovery rate of 0.80 carcasses per year (Table 4).

Over the entire study period, 32 humpback whale ship-strike deaths were discovered. hey were all in U.S. waters (Table 3, Figure 4) and included 26 during pre-rule years and six during the first 2.5 post-rule years. During the pre-rule period 12 of 26 ship struck humpback whales (46%) were found inside (N = 6) or within 45 nmi (N = 5) of SMA boundaries during eventual SMA effective dates for a discovery rate of 0.61 carcasses per year (Table 4). The longest waiting time between finding at least one such carcass in pre-rule years were 5.6 yr (i.e., 2,064 d between 14 April 1992 and 10 December 1997), 2.9 yr (i.e., 1,090 d between 10 December 1997 and 4 December 2000), and 2.8 yr (i.e., 1,045 d between 8 February 2002 and 19 December 2004). During the 2.5 yr (912 d) post-rule period no ship-struck humpback whales were found inside active SMAs, but two were within 45 nmi of active SMAs for a post-rule discovery rate of 0.80 humpback whale carcasses per year.

From our bootstrap resampling analysis, the upper 95% confidence interval around the annual pre-rule mean number of right whale ship strike deaths in or near SMAs (0.72 carcasses per year) was 0.2 - 2.0. As of 5.0 years after the rule's adoption, the post-rule annual mean number of ship strike deaths in or near SMAs was zero. The probability of a five-year post-rule carcass discovery rate of zero is significantly lower ($p = 0.031$) than the pre-rule mean. An additional bootstrap resampling analysis was conducted to estimate the probabilities of finding zero, ≤ 1, or $\leq$

2 carcasses in the sixth post-year rule after five consecutive years of no deaths. Those probabilities were estimated to be $p = 0.012$, $p = 0.024$, and $p = 0.031$, respectively.

We found no other significant or borderline significant differences between pre- and post-rule carcass discovery rates. For right whales, there were no apparent differences for (i) ship-struck carcasses found more than 45 nmi from active SMAs ($p = 0.99$); or (ii) carcasses attributed to unknown causes that might halve included ship strikes either in or near active SMAs ($p = 0.92$) or beyond 45 nmi of the nearest active SMA ($p = 0.87$). For humpback whales, there was no significant difference in discovery rates for ship-struck carcasses either within or near active SMAs ($p = 0.68$) or beyond 45 nmi of the nearest active SMAs ($p = 0.85$).

DISCUSSION

Right Whales

Results of this study indicate that the locations and timeframes of SMAs were well-chosen to protect North Atlantic right whales from ship strikes. During the 18 years before SMAs were implemented, 87% (13 of 15) of all right whales known to have been killed by ships in U.S. waters were found inside or within 45 nmi of SMAs during eventual SMA effective dates. Indeed, most of those carcasses (i.e., 12 of 15 or 80%) were inside or within 6 nmi of SMA boundaries. It therefore appears that most right whales killed by ships before December 2008 were found in or near areas where SMAs were eventually established during their eventual effective dates.

The results also suggest that SMAs have effectively reduced the number of whale deaths due to ships. Average annual discovery rates of ship-struck right whale carcasses in or near active SMAs declined significantly from 0.72 to 0 carcasses per year for at least the first 5.0 years after the rule went into effect. This measure of reduction is likely to be conservative given that estimates of the size of the North Atlantic right whale population increased over the study period from about 295 whales in 1992 (Knowlton et al. 1994) to about 500 whales in 2013 with the addition of about 80 whales from 2008 through 2013 (New England Aquarium, unpublished data) thereby increasing the number of whales available to have been struck in post-rule years. In addition, the absence of any confirmed ship-struck right whale carcasses in or near an active SMA over at least the first 5.0 years since rule implementation is nearly twice as long (and still counting as this was written) than the longest time waiting time (i.e. 2.8 yr) between carcass discoveries during the 18-year pre-rule period.

These results are encouraging, but require a longer time period to confirm if the apparent effectiveness holds up over time. The recommended routing changes off Boston, the new recommended routes in Cape Cod Bay and the southeastern U.S. calving grounds and new ATBA also may have contributed to the apparent reduction in right whale ship-strike deaths by directing traffic through habitats used somewhat less frequently by whales. For example, Wiley et al. (2006) predicted a 58 % reduction in collision risks for a segment of the Boston shipping lanes and Fonnesbeck et al. (2008) predicted as much as a 44% reduction with new shipping lanes through the calving grounds. However, the new routes must still cross key right whale habitats and no useful routing alternatives exist for mid-Atlantic ports along the right whale's coastal migratory corridor where nearly half of all vessel-related right whale deaths have been discovered. Thus, although there should be some uncertain amount of risk reduction from new routes now in place, we believe speed

restrictions are likely to be a more important factor in reducing collision risks along the U.S. East Coast.

We found no indication that SMAs have reduced the number of right whale deaths attributed to unknown causes. The percentages of such deaths in or near active SMAs in the pre-rule (57.1%, 8 of 14) and post-rule (57.1%, 4 of 7) periods were identical and the average annual carcass recovery rate actually increased from 0.44 carcasses per year to 0.80 carcasses per year during the post-rule period. The most parsimonious interpretations for the increase in deaths due to unknown causes are that (1) most ship strikes misclassified as deaths due to unknown causes were struck in times and areas more than 45 nmi from the nearest active SMA, or (2) most right whale deaths attributed to unknown causes are not caused by ship collisions and the increase reflects stochastic variability. As indicated below, an example of the first possibility may be the cluster of four carcasses attributed to unknown causes found in the southern Great South Channel area in winter. This is an area with high ship traffic and limited winter survey effort. The second possibility has some support from past experience. During a four-year period between 1993 and 1996, the annual discovery rate for right whale carcasses attributed to unknown causes in or near eventually active SMAs was 0.75 carcasses per year (3 of 4 carcasses), which approaches the post-rule rate of 0.80 (Table 2).

Other studies have found little or no evidence that recent management measures have reduced vessel-related right whale deaths along the U.S. East Coast. Analyses to date, however, have been too broad in scope, or involved timeframes ill-suited for assessing effectiveness of the SMA network. For example, van der Hoop et al. (2013) found no noticeable reduction in large whale vessel and entanglement-related deaths from 2003 through 2009 (when a number of management actions were implemented including outreach efforts to advise mariners of collision risks), compared to earlier years. That study, however, was not designed to assess the effectiveness of site-specific measures or specifically of SMA vessel-speed restrictions. In particular, it included only one year of data after SMAs were established.

Similarly Pace (2011), found no significant reduction in ship collision deaths after the rule went into effect. However, his analysis was based on only two years of post-rule data, measured intervals between collisions involving all species of large whales (i.e., humpback, right, fin, and sei whales), considered all types of vessels (including those less than 65 ft in length that are not subject to regulation), and included all U.S. and Canadian waters (including those not near SMAs). It also did not distinguish between collisions outside of SMA time frames. In contrast, our analysis focuses on those collisions most likely to have occurred in SMA boundaries and dates, the species of greatest concern (i.e., right whales), and vessels most likely to have been subject to management (i.e., all carcasses considered in this analysis had large wounds or contusions indicative of collisions with vessels that likely were greater than 65 feet long). Therefore, we believe this analysis provides a more direct and useful measure of the rule's effectiveness for right whales.

Humpback whales

Our results suggest SMAs have not provided a significant benefit for humpback whales. Whereas 87% of all ship-struck right whales were found in or near SMAs during effective dates in the pre-rule period, less than half (46%) of all such humpback whales were in or near those areas during active dates. However, it is notable that 12 of the other 15 pre-rule humpback whales killed by ships were found in or near SMA boundaries, but were outside of SMA active dates. This pattern persisted in post-rule years when all six of the ship-struck humpback whale carcasses were found in

428 or near SMA boundaries, but only two were within their active dates. Thus, it would seem that
429 SMAs could be beneficial for humpback whales if their effective dates were expanded to better
430 reflect the timing of their seasonal occurrence in SMA boundaries. The occurrence of humpback
431 whale collisions outside of active dates is understandable given that SMA time frames were
432 developed specifically for right whale protection.
433
434 **Uncertainties in the Time and Location of Collisions**
435
436 In addition to constraints from the small sample size of ship-struck carcasses on statistical
437 power of our analyses, two other limitations concern uncertainties about (1) the precise dates of
438 collisions, and (2) the precise locations of collisions relative to SMA dates and boundaries. Because
439 the length of time between a collision and discovery of collision-related carcasses is unknown and
440 variable, there is some uncertainty about whether those whales were struck during SMA active dates.
441 In most cases, we believe carcass discovery dates can be related to active SMA dates with reasonable
442 accuracy. All ship-struck right whale carcasses found in or near SMAs during pre-rule years with
443 information on their decomposition state (i.e. 11 of 13) were moderately decomposed (Code 3) or
444 fresher. Similarly all but one ship-struck humpback whale found in or near SMAs with information
445 on decomposition condition (7 of 8) were Code 3 or fresher. As noted above, right whale carcasses
446 can degrade to a Code 3 condition within a week or less. Because most right whale carcasses
447 attributed to ship strikes along the U.S. East Coast have involved massive injuries, such as fractured
448 skulls or vertebra, severed tail stocks, and long deep propeller wounds (Moore et al. 2004), it seems
449 reasonable to assume that most victims die within a day or two, if not hours, of being hit. By adding
450 those pre- and post-mortem times together, it seems likely that most ship collision deaths reported
451 in this study occurred no more than about seven to eight days before the discovery dates. Only one
452 ship-struck whale or near an SMA was found less than nine days after the beginning or end dates of
453 the nearest active SMA (i.e., a humpback whale with no information on its decomposition state was
454 found eight days after the start of the nearest SMA 22.6 nmi away). Thus, it seems reasonable to
455 believe that most, if not all, carcasses considered to have been struck in or near SMAs during active
456 SMA dates were in fact struck during those periods.
457
458 Far less clear is whether ship-strike victims found in or near SMA boundaries were in fact
459 struck within SMA boundaries. Complicating factors include the possibility of whales swimming
460 some distance after being struck and before they die and drift an additional distance from collision
461 locations. Because of those possibilities, some dead whales discovered outside SMA boundaries may
462 have been struck inside SMA boundaries and *vice versa*. In general, it seems unlikely that lethally-
463 struck whales would swim long distances after being hit. Even if whales do not die instantly or
464 within a few hours, massive injuries typical of collision deaths are likely to leave them moribund or
465 highly immobile. Transport of moribund or dead whales by wind and currents is more difficult to
466 gauge. As noted above, resighted right whale carcasses drifted an average of seven nmi per day, and
467 one drifted 112 nmi (204 km) in 8 d for an average of 14 nmi (26 km)/d. Thus, it is possible that
468 some ship-struck carcasses could have drifted into SMAs from an adjacent area. Indeed, given that 5
469 of 8 right whale carcasses found inside SMA boundaries during pre-rule years were moderately
470 decomposed it would seem likely that at least some drifted 45 miles before being found, which could
471 have put them outside but near SMA boundaries.
472
473 A detailed analysis of carcass drift for ship-strike victims found in the past was beyond the
474 scope of this study. To improve understanding of where ship-strike victims were actually struck
475 relative to SMA boundaries, we recommend conducting a retrospective drift analysis as a routine

part of investigations for future ship-struck right whale carcasses. Where possible, estimates should be made during necropsies of the time between death and the discovery of all carcasses attributed to ship strikes. That time span should then be used to trace the possible drift path back to a predicted location at the time of death based on prevailing winds and currents over that period. Despite uncertainty about precisely where past ship strike victims were struck, the pattern of carcass recovery shown on Figure 2 strongly suggests that nearly 90% of all right whale deaths attributed to ship strikes in U.S. waters since 8 December 1990 and before the rule became effective were struck in or near SMAs during their effective time periods. The possibility that some of those whales were struck in waters adjacent to SMA boundaries underscores the importance of expanding SMA boundaries along the species' migratory corridor (i.e., from Georgia to New York) to the 30-nmi limit originally proposed by the NMFS based on its past assessment of the width of the right whale migratory corridor and relevant new information. In addition, we recommend that further studies be undertaken to better identify the width of the coastal migratory corridor used by right whales in spring and fall between Georgia and New York.

Seasonal Management Area Boundaries

With half of all known right whale deaths in U.S. waters since 1990 due to ship strikes found along the species' migratory corridor – which is thought to extend to approximately 30 nmi from shore (Schick, 2009, Keller et al. 2012) – failure to include waters between 20 and 30 nmi in SMA boundaries leaves a potentially significant gap in protection of right whales from ship collisions. Its lack of inclusion also complicates evaluations of SMA effectiveness. With current SMA boundaries along the migratory corridor set as 20-nmi arcs around port entrances, it is possible that vessels entering or leaving port may hit whales in the offshore third of the species' presumed migratory corridor (i.e., 20 to 30 nmi from shore) where speed limits do not apply. Those carcasses may drift into SMAs and be assumed incorrectly to have been struck by ships complying with speed restrictions inside an SMA. Also, because carcass detection and retrieval becomes more difficult as distance from shore increases, whales struck and killed in this offshore zone that do not drift towards shore may be underestimated.

To more rigorously protect right whales and reduce uncertainty about whether ship-strike victims are struck just beyond SMA boundaries where speed restrictions do not apply, we recommend that (1) the boundaries of the SMAs along the species' migratory corridor be extended to 30 nmi from shore as initially proposed by the NMFS, (2) the configuration of SMAs be modified from an arc to a rectangle with boundaries extending perpendicular from the points where current SMA perimeters intersect with land out to 30 nmi offshore to cover a greater portion of vessel tracks across core migratory areas, and (3) SMAs be made effective indefinitely with a view towards retaining them unless further analyses demonstrate they are ineffective or should be modified. Changing SMA boundaries along the migratory corridor from arcs to rectangles that extending 20 (or 30 nmi) from shore would increase their size by about 25 percent, and would increase the probability that ships entering or leaving port along routes that are not perpendicular to the coast would travel at speeds safe for whales when transiting areas closer than 20 nmi (or 30 nmi) where migrating whales are more likely to be encountered. In addition, we recommend that further studies be undertaken to better define the distances from shore that most right whales transit during their spring and fall migrations between Georgia and New York.

It is also interesting that several right whale deaths due to unknown causes possibly including ship strikes were found offshore at distances and/or at times of year where retrieval was more

difficult. In this regard, 4 of 15 right whale deaths whose cause was not determined were clustered in or near the southern tip of Great South Channel SMA from December through February when that SMA is not in effect (Figure 2). Those deaths, which occurred at a time of year with poor weather in an area where carcass retrieval is very difficult, lie near an area where several heavily used vessel traffic corridors intersect (Ward-Geiger et al. 2005). That area may therefore be an additional site where ship collision risks could be high and where designation of an SMA should be considered. As a general matter, carcasses are less likely to be found farther offshore because of reduced survey effort. We do not believe this bias would alter our conclusions because, with the exception of waters in the Gulf of Maine, right whale occurrence is believed to decrease in waters beyond 30 nmi from shore. In addition, those areas have not been subject to regulation either before or after the rules went into effect and thus their occurrence in or near SMAs should not differ. Their distance from shore also may make it less likely they would drift into SMAs.

CONCLUSIONS

Analyses of the locations where ship-struck whale carcasses are found provide useful methods for evaluating the biological effectiveness of SMAs established to protect North Atlantic right whales. The overall pattern of carcass discovery locations shown in Figure 2 strongly suggests that a large majority of ship collision victims found in pre-rule years were struck by ships entering and leaving ports where the ten SMAs were eventually designated during their effective dates. The increased waiting time between discovery of ship collisions in or near active SMAs after the December 2008 implementation (i.e., 5.0 years as of the date of this analysis) also suggests that the seasonal 10-knot speed limit has been effective, although additional time is needed to confirm long term trends. When the rule was adopted, it was thought it would also benefit humpback whales, but there is no evidence from this analysis that this has been true. Numerous collisions involving humpback whales were found in or near SMA boundaries, but most were not during active SMA dates.

Based on these results, speed restrictions and the existing SMAs are tools that should be kept in place indefinitely. Dredged channels passing through SMAs should not be exempted from restrictions as requested by petition because whales must travel across those channels and are at no less risk of being struck in those channels. The rules appear to have been effective and remain needed to prevent ship-related right whale deaths. However, to better cover areas where whales are at greatest risk, SMA boundaries along the right whale migratory corridor should be extended from 20 to 30 nmi from shore as originally proposed by NMFS. In addition, consideration should be given to (1) changing the configuration of SMA boundaries off ports in mid-Atlantic states from arcs to rectangles to better protect whales migrating farther offshore, (2) establishing a new winter SMA along a segment of designated shipping lanes south of the Great South Channel SMA where four unretrieved right whale carcasses possibly struck by ships have been found in the months of December through February, and (3) extending the dates of SMAs to better cover times when humpback whales are likely to occur in SMA boundaries. Given the apparent effectiveness of reduced speed limits and experience indicating a lack of compliance with voluntary requests to use reduced speeds (Silber et al. 2012, McKenna et al. 2012), we also recommend that speed limits in short-term Dynamic Management Area zones be made mandatory, rather than voluntary, to protect periodic right whale aggregations found outside of active SMAs. Our study provides encouraging evidence that 10-knot speed restrictions are effective for reducing vessel-related right whale deaths.

571 Such restrictions should be considered as an option for mitigating vessel strikes of large whales in
572 other parts of the world where this problem is considered significant.
573
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575
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764
765 Table 1. Date and distance from Seasonal Management Areas (SMAs) of all North Atlantic right
766 whale carcasses attributed to ship collisions along the U.S. East Coast: 1 January 1990 – 8
767 December 2013. (* = carcass found in or within 45 nmi (74 km) of SMA boundaries
768 during active time frames; Decomposition codes: 1 = alive, 2 = fresh, 3 = moderate
769 decomposition, 4 = advanced decomposition, Unk = unknown condition)
770

Date	Nearest SMA	Inside SMA Dates?	Inside SMA Boundary?	Distance from SMA (in nmi/km)	Decomp. Code
Before 8 December 2008 Rule Effective Date					
03/12/91*	Calving Grounds SMA	Yes	Yes	0	3
01/05/93*	Calving Grounds SMA	Yes	Yes	0	1
12/06/93*	Chesapeake Bay SMA	Yes	No	2.6 / 4.8	Unk
01/30/96*	Calving Grounds SMA	Yes	Yes	0	3
03/09/96*	Cape Cod Bay SMA	Yes	Yes	0	Unk
04/20/99*	Cape Cod Bay SMA	Yes	Yes	0	3
03/17/01*	Delaware Bay SMA	Yes	No	36 / 66.7	3
06/18/01	New York Harbor MA	No	Yes	0	3
08/22/02	Delaware Bay SMA	No	No	15.4 / 28.5	4
02/07/04*	Chesapeake Bay SMA	Yes	Yes	0	3
11/17/04*	Chesapeake Bay SMA	Yes	Yes	0	3
01/12/05*	Calving Grounds SMA	Yes	Yes	0	2
04/28/05*	Outer Cape Cod SMA	Yes	No	5.9 / 10.9	3
01/10/06*	Calving Grounds SMA	Yes	Yes	0	2
12/30/06*	Calving Grounds SMA	Yes	Yes	0	3
After 8 December 2008 Rule Effective Date					
07/02/10	Great South Channel SMA	Yes	No	112 / 207	3
03/27/11	Chesapeake Bay SMA	Yes	No	47 / 86	4

771
772

773 Table 2. Date and distance from Seasonal Management Areas (SMAs) of all North Atlantic right
774 whale carcasses attributed to unknown causes possibly including ship strikes along the U.S.
775 East Coast: 1 January 1990 – 8 December 2013. (* = carcass found in or within 45 nmi
776 (74 km) of SMA boundaries during active time frames; Decomposition codes: 1 = alive, 2
777 = fresh, 3 = moderate decomposition, 4 = advanced decomposition, Unk = unknown
778 condition).
779

Date	Nearest SMA	Inside SMA Dates?	Inside SMA Boundary?	Distance from SMA (in nmi/km)	Decomp. Code
Before 8 December 2008 Rule Effective Date					
01/15/93	Calving Grounds SMA	Yes	No	62 / 115	Unk
12/06/93*	Chesapeake Bay SMA	Yes	No	1.2 / 2.2	Unk
02/08/96*	Calving Grounds SMA	Yes	Yes	0	4
02/19/96*	Calving Grounds SMA	Yes	Yes	0	3
10/07/98	Chesapeake Bay SMA	No	No	8.5 / 15.7	4
01/19/00*	Block Island Sound SMA	Yes	Yes	0	Unk
01/27/01*	Calving Grounds SMA	Yes	No	15 / 28	Unk
03/17/01*	NC-Georgia Coast SMA	Yes	No	3 / 5.6	4
06/10/02*	Great South Channel SMA	Yes	Yes	0	4
09/03/02	Chesapeake Bay SMA	No	No	38 / 70.3	3
09/06/02	Chesapeake Bay SMA	No	No	65 / 120.3	4
12/09/04	Great South Channel SMA	No	No	38 / 70.3	Unk
01/09/05	Great South Channel SMA	No	No	21 / 38.9	4
02/14/08*	Calving Grounds SMA	Yes	Yes	0	4
After 8 December 2008 Rule Effective Date					
02/17/09*	Calving Grounds SMA	Yes	Yes	0	3
02/25/09	Great South Channel SMA	No	Yes	0	3
08/18/09	New York Harbor SMA	No	No	44 / 81.5	4
12/19/09	Great South Channel SMA	No	No	6.1 / 11.3	2
02/19/11*	NC-GA SMA	Yes	No	34 / 63.0	4
03/17/11*	Delaware Bay SMA	Yes	No	40 / 74.1	3
03/02/12*	Race Point SMA	Yes	No	24 / 44.5	3

780
781

782 Table 3. Date and distance from Seasonal Management Areas (SMAs) of all humpback whale
783 carcasses attributed to ship strikes along the U.S. East Coast: 1 January 1990 – 8 June
784 2011. (* = carcass found in or within 45 nmi (74 km) of SMA boundaries during active
785 time frames; Decomposition codes: 1 = alive, 2 = fresh, 3 = moderate decomposition, 4 =
786 advanced decomposition, Unk = unknown condition).
787

Date	Nearest SMA	Inside SMA Dates?	Inside SMA Boundary?	Distance from SMA (in nmi/km)	Decomp. Code
Before 8 December 2008 Rule Effective Date					
11/08/91*	New York Harbor SMA	Yes	No	22.6 / 41.9	Unk
02/14/92*	Chesapeake Bay SMA	Yes	Yes	0	3
04/16/92*	Delaware Bay SMA	Yes	No	22.7 / 42.0	4
06/04/95	Chesapeake Bay SMA	No	No	0.1 / 0.2	3
05/09/96	Delaware Bay SMA	No	No	0.5 / 0.9	3
11/03/96*	Chesapeake Bay SMA	Yes	No	42.9 / 79.5	3
12/10/97*	Morehead City SMA	Yes	Yes	0	3
12/04/00*	Morehead City SMA	Yes	Yes	0	
01/25/01	Chesapeake Bay SMA	Yes	No	51.6 / 95.6	2
04/08/01*	NC-GA Coast SMA	Yes	Yes	0	2
07/29/01	New York Harbor SMA	No	No	6.8 / 12.6	3
08/18/01	Delaware Bay SMA	No	No	22.5 / 41.7	2
10/01/01	Cape Cod Bay SMA	No	Yes	0	3
02/08/02*	Chesapeake Bay SMA	Yes	No	4.8 / 8.9	Unk
05/30/02	Race Point SMA	No	No	51.7 / 95.7	3
08/01/02	New York Harbor SMA	No	No	0	4
06/06/03	Chesapeake Bay SMA	No	No	4.6 / 8.5	2-3
12/19/04*	Delaware Bay SMA	Yes	Yes	0	3
01/09/06*	NC-GA Coast SMA	Yes	Yes	0	3
03/17/06*	Chesapeake Bay SMA	Yes	No	1.5 / 2.8	3
09/27/06	Delaware Bay SMA	No	Yes	0	4
10/15/06	Delaware Bay SMA	No	No	6.2 / 11.5	4
05/10/07	Chesapeake Bay SMA	No	No	21.6 / 40.0	4
05/13/07	Race Point SMA	No	No	9.2 / 17.0	4
06/24/07	Race Point SMA	No	Yes	0	3
11/04/08*	Delaware Bay SMA	Yes	No	20.1 / 37.2	2
After 8 December 2008 Rule Effective Date					
07/27/09	New York Harbor SMA	No	Yes	0	3
03/13/10*	Delaware Bay SMA	Yes	No	12.8 / 23.7	3
06/10/10	New York Harbor SMA	No	No	0.1 / 0.2	3
07/04/10	Delaware Bay SMA	No	No	12.0 / 22.2	4
03/07/11*	Morehead City SMA	Yes	No	15 / 27.8	1
05/28/11	New York Harbor	No	No	23.9 / 44.3	4

788

Table 4. Number of known right whale and humpback whale deaths along the U.S. East Coast attributed to ship strikes and unknown causes possibly including ship strikes found inside or within 45 nmi of active Seasonal Management Area (SMA) boundaries or beyond 45 nmi of SMA boundaries before and after the SMA implementation on 8 December 2008. (i.e., 8 December 1990 through 8 December 2013 for right whales and through 8 June 2011 for humpback whales).

	Pre rule	Post rule
Right Whales - Ship Strikes		
Inside or within 45 nmi of SMA boundaries	13	0
Beyond 45 nmi of nearest SMA	2	2
Right Whales - Unknown Cause		
Inside or within 45 nmi of SMA boundaries	8	4
Beyond 45 nmi of nearest SMA	6	3
Humpback Whales - Ship Strikes		
Inside or within 45 nmi of SMA boundaries	12	2
Beyond 45 nmi of nearest SMA	14	4

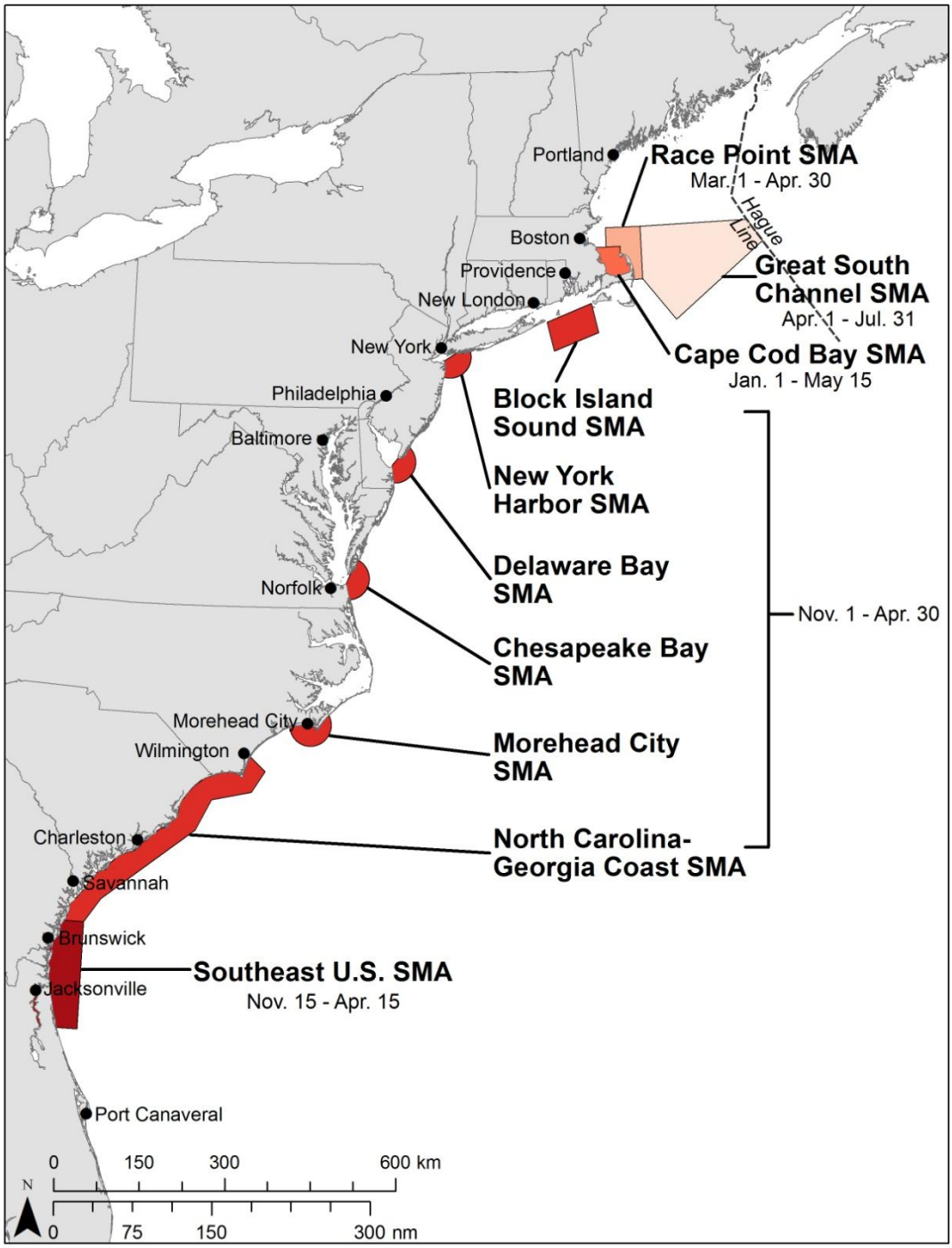


Figure 1. Locations and effective dates of Seasonal Management Areas (SMAs) requiring 10-knot ship speed limits after 8 December 2008 to protect North Atlantic right whales.

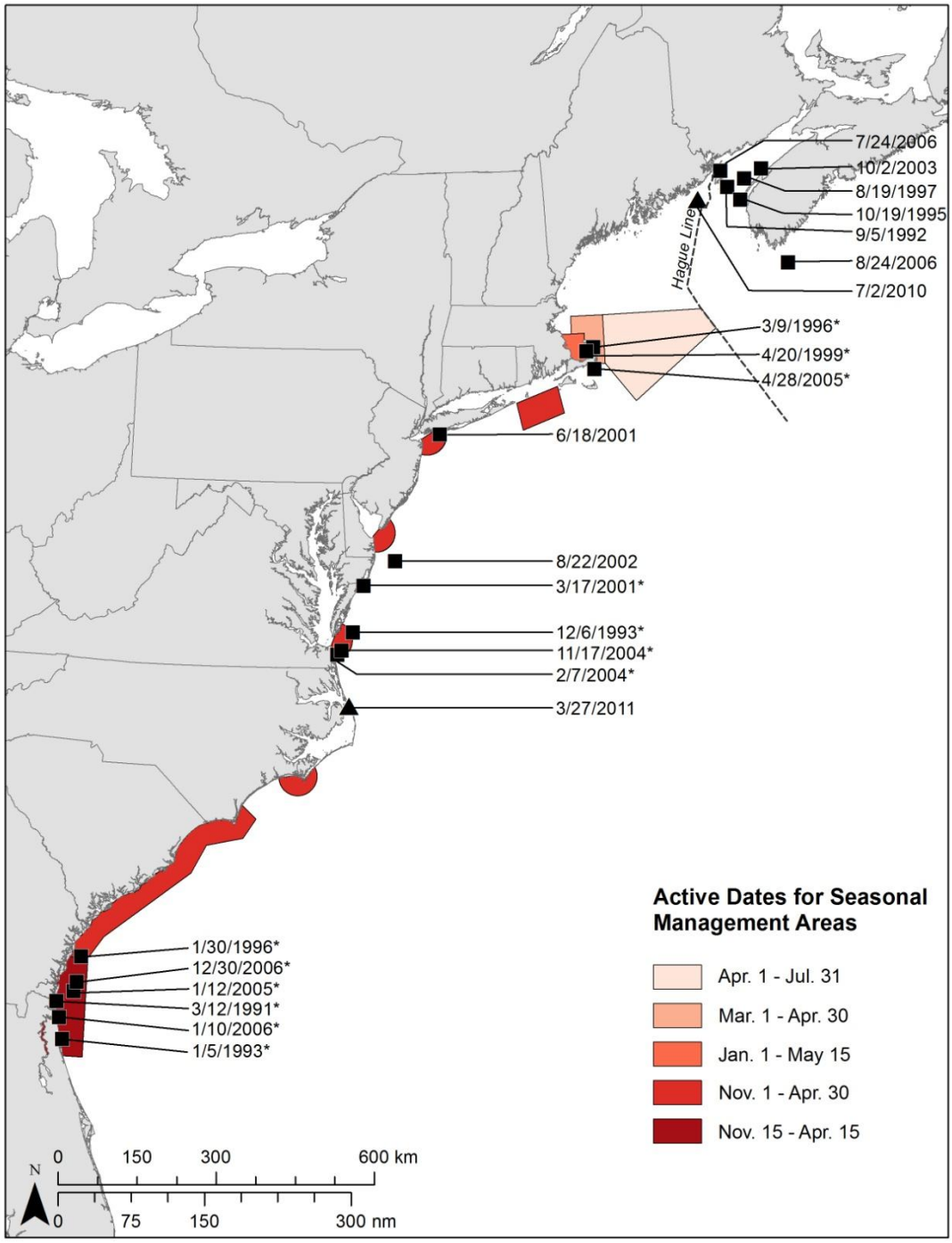


Figure 2. Locations and dates where all North Atlantic right whales killed by ships were found before and after Seasonal Management Areas (SMAs) were established on 8 December 2008 (* = carcass found in or within 45 nmi (74 km) of SMA boundaries during active time frames; ■ = carcass locations during pre-rule years 1990-2008; ▲ = carcass locations during post-rule years 9 December 2008 through 8 December 2013).

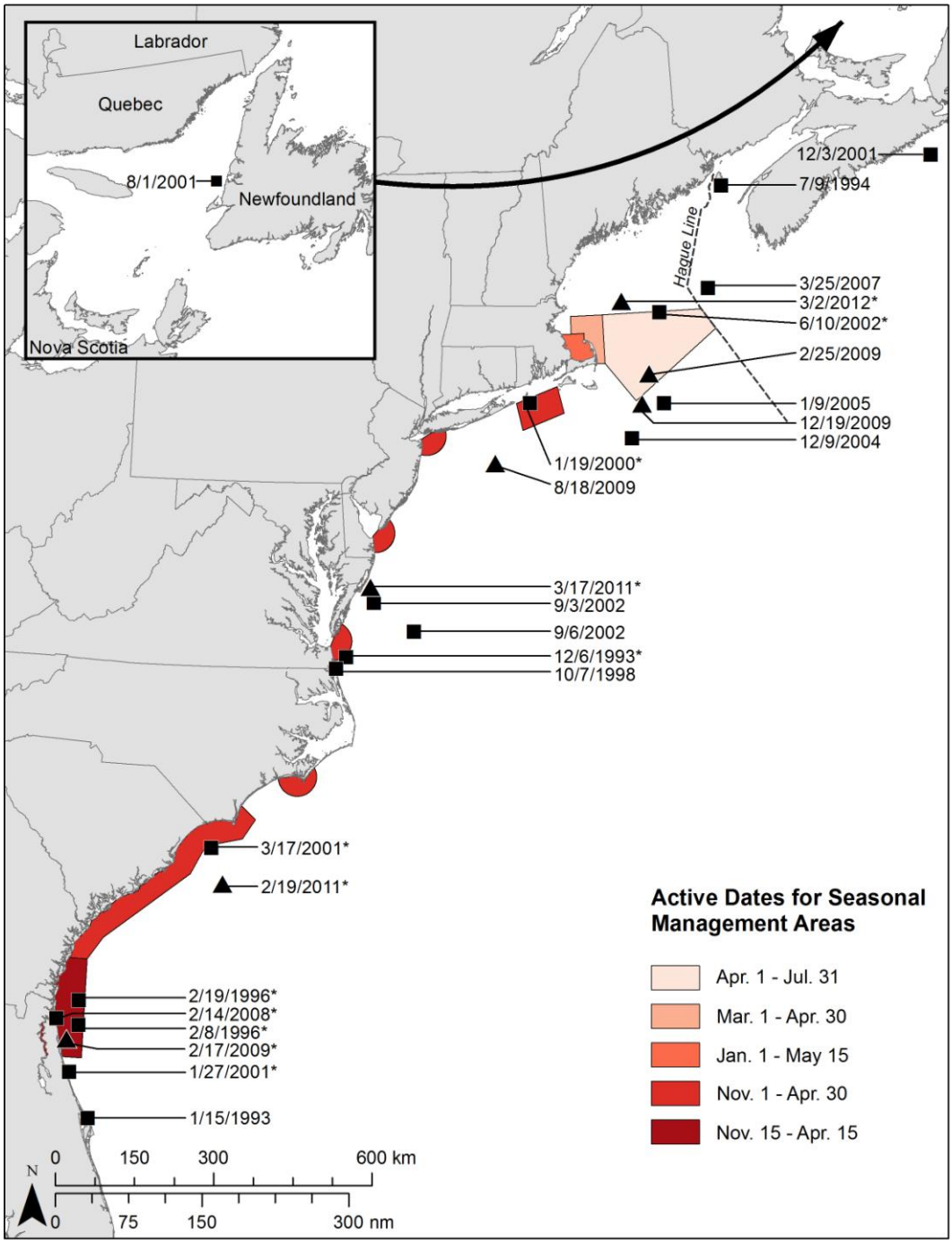


Figure 3. Locations and dates where all North Atlantic right whales killed by unknown causes possibly including ship-strikes were found before and after Seasonal Management Areas (SMAs) were established on 8 December 2008 (* = carcass found in or within 45 nmi (74 km) of SMA boundaries during active time frames; ■ = carcass locations during pre-rule years 1990-2008; ▲ = carcass locations during post-rule years 9 December 2008 through 8 December 2013).

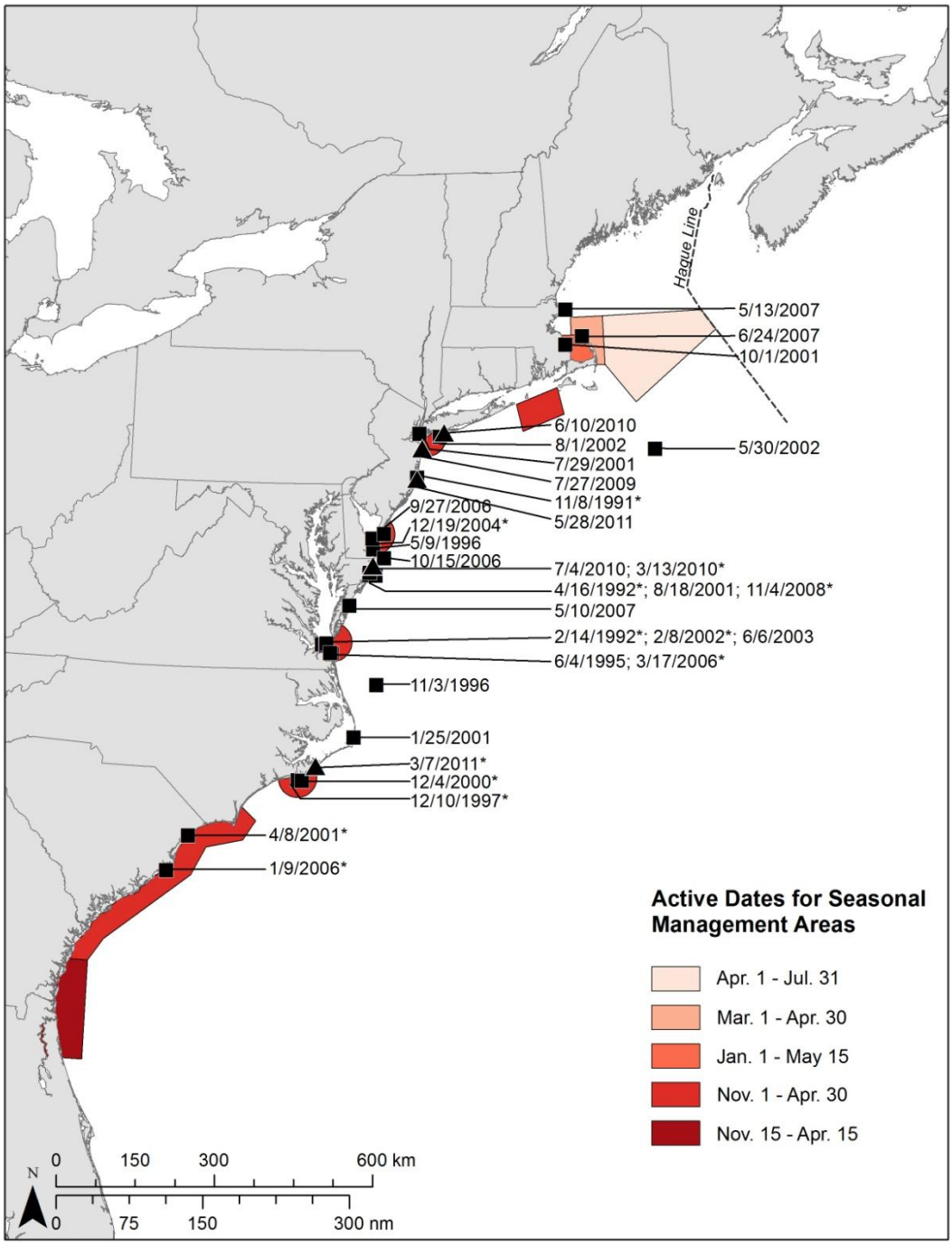
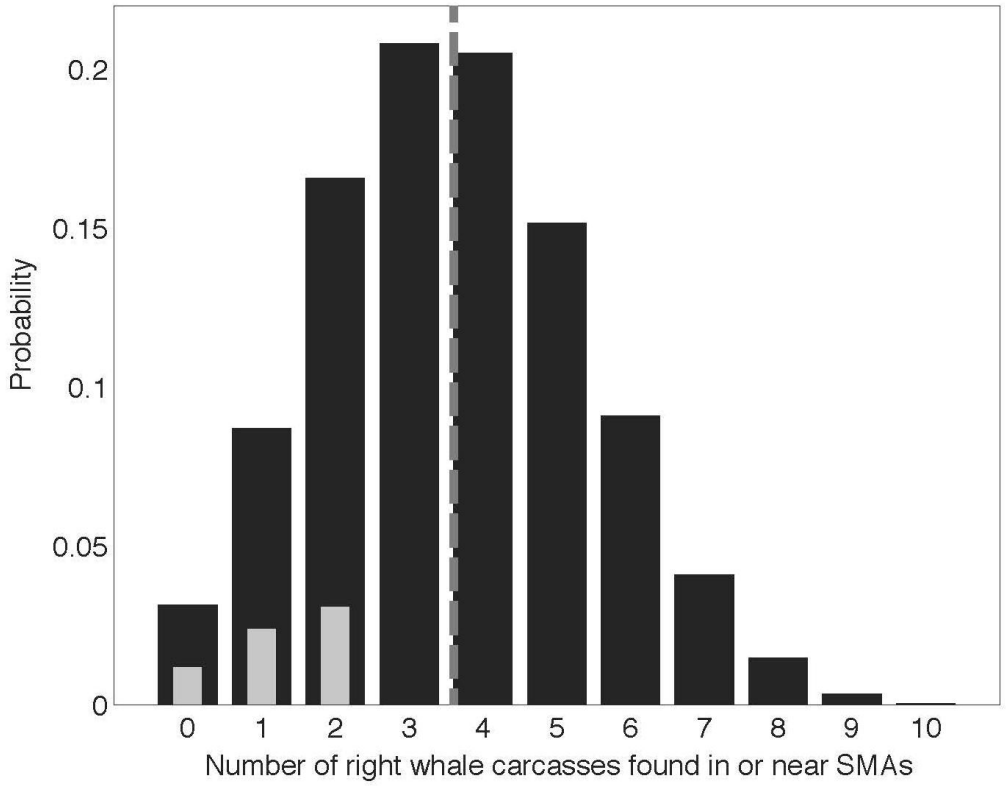


Figure 4. Locations and dates where all humpback whales killed by ships were found before and after Seasonal Management Areas (SMAs) were established on 8 December 2008 (* = carcass found in or within 45 nmi (74 km) of SMA boundaries during active time frames; ■ = carcass locations during pre-rule years 1990-2008; ▲ = carcass locations during post-rule years 9 December 2008 through 8 June 2013).

831



832
833 Figure 5. Eubalaena glacialis. Probabilities of finding 0 to 10 right whale carcasses in or near
834 Seasonal Management Areas (SMAs) over the 5 yr post-rule period (8 December 2008 to
835 8 December 2013) based on bootstrap resampling of discovery records during the 18 yr
836 pre-rule period (8 December 1990 to 7 December 2008). Dark gray bars show
837 probabilities of 5 yr totals assuming whales could be found in any year during the 5 yr
838 period; light gray bars show probabilities assuming no whales were found in Years 1 to 5
839 and 0, ≤1, or ≤2 whales were found in Year 6; gray dashed line shows the annual mean
840 pre-rule discovery rate of 0.72 (equivalent to 3.6 carcasses over 5 yr).
841
842