NORTH ATLANTIC RIGHT WHALE (*Eubalaena glacialis*): Western Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

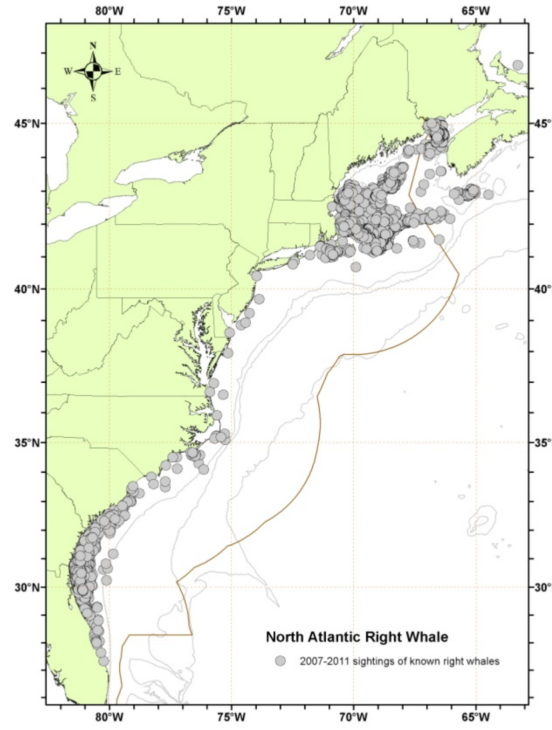

Figure 1. *Distribution of sightings of known North Atlantic right whales, 2007-2011. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

The western North Atlantic right whale population ranges primarily from calving grounds in coastal waters of the southeastern United States to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence. Mellinger *et al.* (2011) reported acoustic detections of right whales near the nineteenth-century whaling grounds east of southern Greenland, but the number of whales and their origin is unknown. However, Knowlton *et al.* (1992) reported several long-distance movements as far north as Newfoundland, the Labrador Basin, and southeast of Greenland. In addition, resightings of photographically identified individuals have been made off Iceland, in the old Cape Farewell whaling ground east of Greenland (Hamilton *et al.* 2007), northern Norway (Jacobsen *et al.* 2004), and the Azores (Silva *et al.* 2012). The September 1999 Norwegian sighting represents one of only two published sightings in the 20th century of a right whale in Norwegian waters, and the first since 1926. Together, these long-range matches indicate an extended range for at least some individuals and perhaps the existence of important habitat areas not presently well described. A few published records from the Gulf of Mexico (Moore and Clark 1963; Schmidly *et al.* 1972; Ward-Geiger *et al.* 2011) likely represent occasional wanderings of individual female and calf pairs beyond the sole known calving and wintering ground in the waters of the southeastern United States. Whatever the case, the location of much of the population is unknown during the winter. Surveys flown in an area from 17 to 86 miles from the shoreline off northeastern Florida and southeastern Georgia from 1996 to 2001 had 3 sightings in 1996, 1 in 1997, 13 in 1998, 6 in 1999, 11 in 2000, and 6 in 2001 (within each year, some were repeat sightings of previously recorded individuals). All but 1 of the sightings occurred within 49 miles of the shoreline –the remaining sighting occurred ~75 miles offshore (search effort was unevenly distributed). An offshore survey in March 2010 observed the birth of a right whale in waters 40 miles off Jacksonville, Florida (Foley *et al.* 2011). Several years of aerial survey counts for calves and adults were the lowest recorded since comprehensive surveys began in the Southeast calving grounds. Although habitat models predict right whales are not likely to occur further than 49 miles from the shoreline (Gowan and Ortega-Ortiz, 2015), the frequency with which right whales occur in offshore waters in the southeastern United States remains unclear.

Visual and acoustic surveys have demonstrated the existence of seven areas where western North Atlantic right whales aggregate seasonally: the coastal waters of the southeastern United States; the Great South Channel; Jordan Basin; Georges Basin along the northeastern edge of Georges Bank; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Roseway Basin on the Scotian Shelf (Brown *et al*. 2001; Cole *et al.* 2013). Passive acoustic studies of right whales have demonstrated their year-round presence in the Gulf of Maine (Morano *et al.* 2012; Bort *et al.* 2015), New Jersey (Whitt *et al.* 2013)), and Virginia (Salisbury *et al*. 2015). Additionally, right whales were acoustically detected off Georgia and North Carolina in 7 of 11 months monitored (Hodge *et al*. 2015),). All of this work further demonstrates the highly mobile nature of right whales. Movements within and between habitats are extensive and the area off the mid-Atlantic states is an important migratory corridor. In 2000, one whale was photographed in Florida waters on 12 January, then again 11 days later (23 January) in Cape Cod Bay, less than a month later off Georgia (16 February), and back in Cape Cod Bay on 23 March, effectively making the round-trip migration to the Southeast and back at least twice during the winter season (Brown and Marx 2000). Results from satellite tagging studies clearly indicate that sightings separated by perhaps two weeks should not necessarily be assumed to indicate a stationary or resident animal. Instead, telemetry data have shown rather lengthy and somewhat distant excursions, including into deep water off the continental shelf (Mate *et al.* 1997; Baumgartner and Mate 2005). Systematic visual surveys conducted off the coast of North Carolina during the winters of 2001 and 2002 sighted 8 calves, suggesting the calving grounds may extend as far north as Cape Fear (McLelland, et al., 2008, Contract report available from SE regional Office, NMFS). Four of those calves were not sighted by surveys conducted further south. One of the females photographed was new to researchers, having effectively eluded identification over the period of its maturation. In 2016 the Southeastern U.S. Calving Area Critical Habitat was expanded north to Cape Fear, North Carolina. There is also at least one recent case of a calf apparently being born in the Gulf of Maine (Patrician *et al*. 2009) and another newborn was detected in Cape Cod Bay in 2013.

New England waters are important feeding habitats for right whales, where they feed primarily on copepods (largely of the genera *Calanus* and *Pseudocalanus*). Right whales must locate and exploit extremely dense patches of zooplankton to feed efficiently (Mayo and Marx 1990). These dense zooplankton patches are likely a primary characteristic of the spring, summer, and fall right whale habitats (Kenney *et al.* 1986, 1995). While feeding in the coastal waters off Massachusetts has been better studied than in other areas, right whale feeding has also been observed on the margins of Georges Bank, in the Great South Channel, in the Gulf of Maine, in the Bay of Fundy, and over the Scotian Shelf (Baumgartner *et al.* 2007). The characteristics of acceptable prey distribution in these areas are beginning to emerge (Baumgartner *et al.* 2003; Baumgartner and Mate 2003). NMFS (National Marine Fisheries Service) and Center for Coastal Studies aerial surveys during springs of 1999–2006 found right whales along the Northern Edge of Georges Bank, in the Great South Channel, in Georges Basin, and in various locations in the Gulf of Maine including Cashes Ledge, Platts Bank, and Wilkinson Basin. Analysis of the sightings data has shown that utilization of these areas has a strong seasonal component (Pace and Merrick 2008). Although right whales are consistently found in these locations, studies also highlight the high interannual variability in right whale use of some habitats (Pendleton *et al.* 2009). In 2016, the Northeastern U.S. Foraging Area Critical Habitat was expanded to include all U.S. waters of the Gulf of Maine. In the most recent years (2012–2015), surveys have detected fewer individuals in the Great South Channel and the Bay of Fundy, indicating an important shift in habitat use patterns.

Right whale calls have been detected by autonomous passive acoustic sensors deployed between 2005 and 2010 at three sites (Massachusetts Bay, Stellwagen Bank, and Jeffreys Ledge) in the southern Gulf of Maine (Morano *et al*. 2012, Mussoline *et al*. 2012). Comparisons between detections from passive acoustic recorders and observations from aerial surveys in Cape Cod Bay between 2001 and 2005 demonstrated that aerial surveys found whales on approximately two-thirds of the days during which acoustic monitoring detected whales (Clark *et al*. 2010). These data suggest that the current understanding of the distribution and movements of right whales in the Gulf of Maine and surrounding waters is incomplete.

Genetic analyses based upon direct sequencing of mitochondrial DNA (mtDNA) have identified 7 mtDNA haplotypes in the western North Atlantic right whale, including heteroplasmy that led to the declaration of the 7th haplotype (Malik *et al.* 1999, McLeod and White 2010). Schaeff *et al.* (1997) compared the genetic variability of North Atlantic and southern right whales (*E. australis*), and found the former to be significantly less diverse, a finding broadly replicated by Malik *et al.* (2000). The low diversity in North Atlantic right whales might be indicative of inbreeding, but no definitive conclusion can be reached using current data. Modern and historic genetic population structures were compared using DNA extracted from museum and archaeological specimens of baleen and bone. This work suggested that the eastern and western North Atlantic populations were not genetically distinct (Rosenbaum *et al.* 1997, 2000). However, the virtual extirpation of the eastern stock and its lack of recovery in the last hundred years strongly suggest population subdivision over a protracted (but not evolutionary) timescale. Genetic studies concluded that the principal loss of genetic diversity occurred prior to the 18th century (Waldick *et al.* 2002). However, revised conclusions that nearly all the remains in the North American Basque whaling archaeological sites were bowhead whales (*Balaena mysticetus*) and not right whales (Rastogi *et al.* 2004; McLeod *et al.* 2008) contradict the previously held belief that Basque whaling during the 16th and 17th centuries was principally responsible for the loss of genetic diversity.

High-resolution (i.e., using 35 microsatellite loci) genetic profiling has been completed for 66% of all North Atlantic right whales identified through 2001. This work has improved our understanding of genetic variability, number of reproductively active individuals, reproductive fitness, parentage, and relatedness of individuals (Frasier *et al.* 2007).

One emerging result of the genetic studies is the importance of obtaining biopsy samples from calves on the calving grounds. Only 60% of all known calves are seen with their mothers in summering areas, when their callosity patterns are stable enough to reliably make a photo-ID match later in life. The remaining 40% are not seen on a known summering ground. Because the calf's genetic profile is the only reliable way to establish parentage, if the calf is not sampled when associated with its mother early on, then it is not possible to link it with a calving event or to its mother, and information such as age and familial relationships is lost. From 1980 to 2001, there were 64 calves born that were not sighted later with their mothers and thus unavailable to provide age-specific mortality information (Frasier *et al.* 2007). An additional interpretation of paternity analyses is that the population size may be larger than was previously thought. Fathers for only 45% of known calves have been genetically determined. However, genetic profiles were available for 69% of all photo-identified males (Frasier 2005). The conclusion was that the majority of these calves must have different fathers that cannot be accounted for by the unsampled males, therefore the population of males must be larger (Frasier 2005). This inference of additional animals that have never been captured photographically and/or genetically suggests the existence of potentially important habitats that remain to be described.

POPULATION SIZE

The western North Atlantic minimum stock size is based on a census of individual whales identified using photo-identification techniques. A review of the photo-ID recapture database as it existed on 17 November 2015 indicated that 440 individually recognized whales in the catalog were known to be alive during 2012. This number represents a minimum population size. This is a direct count and has no associated coefficient of variation.

Historical Abundance

An estimate of pre-exploitation population size is not available. Basque whalers were thought to have taken right whales during the 1500s in the Strait of Belle Isle region (Aguilar 1986), however, genetic analysis has shown that nearly all of the remains found in that area are, in fact, those of bowhead whales (Rastogi *et al.* 2004; Frasier *et al.* 2007). The stock of right whales may have already been substantially reduced by the time whaling was begun by colonists in the Plymouth area in the 1600s (Reeves *et al.* 2001, 2007). A modest but persistent whaling effort along the coast of the eastern U.S. lasted three centuries, and the records include one report of 29 whales killed in Cape Cod Bay in a single day during January 1700. Reeves *et al.* (2007) calculated that a minimum of 5500 right whales were taken in the western North Atlantic between 1634 and 1950, with nearly 80% taken in a 50-year period between 1680 and 1730. They concluded "there were at least a few thousand whales present in the mid-1600s." The authors cautioned, however, that the record of removals is incomplete, the results were preliminary, and refinements are required. Based on back calculations using the present population size and growth rate, the population may have numbered fewer than 100 individuals by 1935 when international protection for right whales came into effect (Hain 1975; Reeves *et al.* 1992; Kenney *et al.* 1995). However, little is known about the population dynamics of right whales in the intervening years.

Minimum Population Estimate

The western North Atlantic population size was estimated to be at least 440 individuals in 2012.

Current Population Trend

The population growth rate reported for the period 1986–1992 by Knowlton *et al.* (1994) was 2.5% (CV=0.12), suggesting that the stock was recovering slowly, but that number may have been influenced by discovery phenomenon as existing whales were recruited to the catalog. Work by Caswell *et al.* (1999) suggested that crude survival probability declined from about 0.99 in the early 1980s to about 0.94 in the late 1990s. The decline was statistically significant. Additional work conducted in 1999 was reviewed by the IWC workshop on status and trends in this population (Best *et al.* 2001); the workshop concluded based on several analytical approaches that survival had indeed declined in the 1990s. Although capture heterogeneity could negatively bias survival estimates, the workshop concluded that this factor could not account for the entire observed decline, which appeared to be particularly marked in adult females. Another workshop was convened by NMFS in September 2002, and it reached similar conclusions regarding the decline in the population (Clapham 2002). At the time, the early part of the recapture series had not been examined for excessive retrospective recaptures which had the potential to positively bias survival as the catalog was being developed.

An increase in carcass detections in 2004 and 2005 was cause for serious concern (Kraus *et al.* 2005). Of those mortalities, six were adult females, three of which were carrying near-term fetuses. Furthermore, four of these females were just starting to bear calves, losing their complete lifetime reproduction potential. Calculations based on demographic data through 1999 (Fujiwara and Caswell 2001) indicated that this mortality rate increase would reduce population growth by approximately 10% per year (Kraus *et al.* 2005). Strong evidence for flat or negative growth exists in the time series of minimum number alive during 1998-2000, which coincided with very low calf production in 2004. However, the population continued to grow since that apparent interval of decline until the most recent year included in this analysis (Figure 2).

Examination of the minimum number alive calculated from the individual sightings database, as it existed on 27 October 2015, for the years 1990–2012 (Figure 2) suggests that abundance has declined. As noted above, there seems 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. This apparent change in habitat use has the effect that, despite relatively constant effort to find whales, the chance of seeing an individual that is alive has decreased. Some caution is advised in interpreting the apparent downward trend in abundance in 2012, but without evidence to the contrary, it is possible that this deflection represents a true population decline.

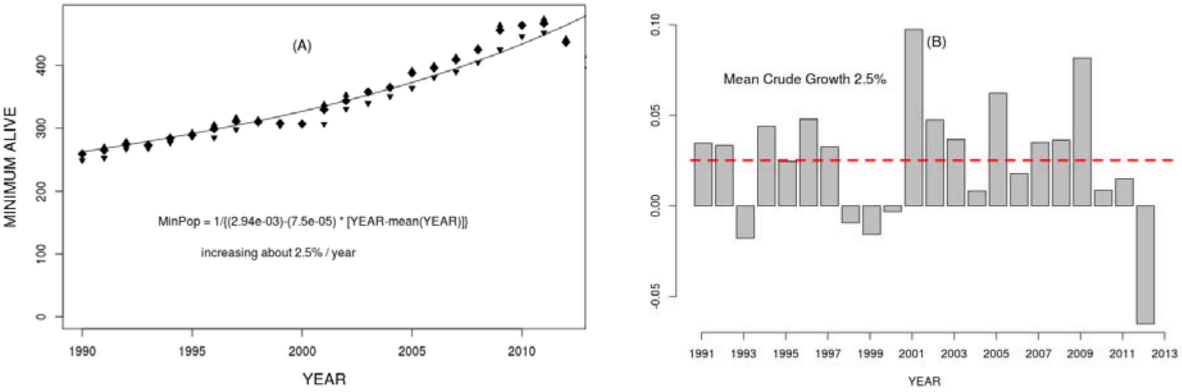

Figure 2. Minimum number alive (a) for North Atlantic right whales. Minimum number alive (diamonds) of cataloged individuals known to be alive in any given year includes all whales known to be alive prior to that year and seen in that year or subsequently plus all whales newly cataloged that year. Cataloged whales may include some but not all calves produced each year. Bracketing the minimum number of cataloged whales is the number without calves (below) and that plus calves above, the latter which yields Nmin for purposes of stock assessment. (b) Crude annual growth rates from the minimum number alive values. Mean crude growth rate (dashed line) is the exponentiated mean of $\log_e [(N_{t+1}-N_t)/N_t]$ *for each year (t), where* N_t *is the max of the accounting procedure and the estimated abundance for year t.*

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

During 1980–1992, at least 145 calves were born to 65 identified females. The number of calves born annually ranged from 5 to 17, with a mean of 11.2 (SE=0.90). The reproductively active female pool was static at approximately 51 individuals during 1987–1992. Mean calving interval, based on 86 records, was 3.67 years. There was an indication that calving intervals may have been increasing over time, although the trend was not statistically significant (P=0.083) (Knowlton *et al.* 1994). Since 1993, calf production has been more variable than a simple stochastic model would predict.

During 1990–2014, at least 411 calves were born into the population. The number of calves born annually ranged from 1 to 39, and averaged 16.4 but was highly variable (SD=9.2). The fluctuating abundance observed from 1990 to 2014 makes interpreting a count of calves by year less clear than measuring population productivity, which we index by the number of calves detected/Nmin. Productivity for this stock has been highly variable over time and has been characterized by periodic swings in per capita birth rates (Figure 3). Notwithstanding the high variability observed, which might be expected from a small population, productivity in North Atlantic right whales lacks a definitive trend.

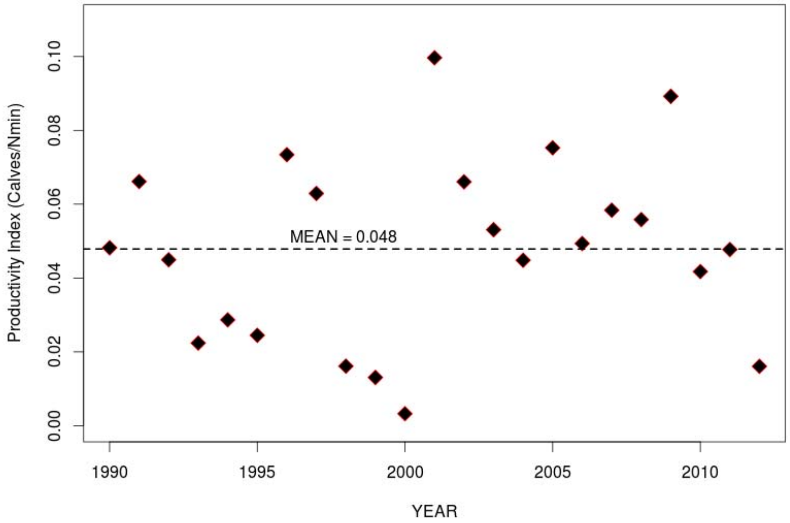

Figure 3. Productivity in the North Atlantic right whale population as characterized by calves detected/(N_{min}). Note that because Nmin is likely biased somewhat low, the values shown in the graph likely overstate actual per capita production.

North Atlantic right whales have thinner blubber than southern right whales off South Africa (Miller *et al.* 2011). Blubber thickness of male North Atlantic right whales (males were selected to avoid the effects of pregnancy and lactation) varied with *Calanus* abundance in the Gulf of Maine (Miller *et al.* 2011). Sightings of North Atlantic right whales correlated with satellite-derived sea-surface chlorophyll concentration (as a proxy for productivity), and calving rates correlated with chlorophyll concentration prior to gestation (Hlista *et al.* 2009). On a regional scale, observations of North Atlantic right whales correlate well with copepod concentrations (Pendleton *et al*. 2009). The available evidence suggests that at least some of the observed variability in the calving rates of North Atlantic right whales is related to variability in nutrition.

An analysis of the age structure of this population suggests that it contains a smaller proportion of juvenile whales than expected (Hamilton *et al.* 1998; Best *et al.* 2001), which may reflect lowered recruitment and/or high juvenile mortality. Calf and perinatal mortality was estimated by Browning *et al.* (2010) to be between 17 and 45 animals during the period 1989 and 2003. In addition, it is possible that the apparently low reproductive rate is due in part to an unstable age structure or to reproductive dysfunction in some females. However, few data are available on either factor and senescence has not been documented for any baleen whale.

The maximum net productivity rate is unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be the default value of 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is the product of minimum population size, one-half the maximum net productivity rate and a recovery factor for endangered, depleted, threatened stocks, or stocks of unknown status relative to OSP (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The recovery factor for right whales is 0.10 because this species is listed as endangered under the Endangered Species Act (ESA). The minimum population size is 440. The maximum productivity rate is 0.04, the default value for cetaceans. PBR for the Western Atlantic stock of the North Atlantic right whale is 1.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2010 through 2014, the minimum rate of annual human-caused mortality and serious injury to right whales averaged 5.66 per year. This is derived from two components: 1) incidental fishery entanglement records at 4.65 per year, and 2) vessel strike records at 1.01 per year. Early analyses of the effectiveness of the ship strike rule were reported by Silber and Bettridge (2012). Recently, van der Hoop *et al.* (2015) concluded that large whale mortalities due to vessel strikes decreased inside active SMAs and increased outside inactive SMAs. Analysis by Laist *et al.* (2014) incorporated an adjustment for drift around areas regulated under the ship strike rule and produced weak evidence that the rule was effective inside the SMAs.

Beginning with the 2001 Stock Assessment Report, Canadian records have been incorporated into the mortality and serious injury rates to reflect the effective range of this stock. It is also important to stress that serious injury determinations are made based upon the best available information; these determinations may change with the availability of new information (Henry *et al.* 2016). For the purposes of this report, discussion is primarily limited to those records considered confirmed human-caused mortalities or serious injuries. Annual rates calculated from detected mortalities should not be considered an unbiased estimate of human-caused mortality, but they represent a definitive lower bound. Detections are haphazard, incomplete, and not the result of a designed sampling scheme. As such they represent a minimum estimate of human-caused mortality, which is biased low.

Background

The details of a particular mortality or serious injury record often require a degree of interpretation (Moore *et al.* 2005). The assigned cause is based on the best judgment of the available data; additional information may result in revisions. When reviewing Table 1 below, several factors should be considered: 1) a vessel strike or entanglement may have occurred at some distance from the location where the animal is detected/reported; 2) the mortality or injury may involve multiple factors; for example, whales that have been both vessel struck and entangled are not uncommon; 3) the actual vessel or gear type/source is often uncertain; and 4) in entanglements, several types of gear may be involved.

Further, the small population size and low annual reproductive rate of right whales suggest that human sources of mortality may have a greater effect relative to population growth rates than for other whales. The principal factors believed to be retarding growth and recovery of the population are vessel strikes and entanglement with fishing gear. Between 1970 and 1999, a total of 45 right whale mortalities was recorded (IWC 1999; Knowlton and Kraus 2001; Glass *et al.* 2009). Of these, 13 (28.9%) were neonates that were believed to have died from perinatal complications or other natural causes. Of the remainder, 16 (35.6%) resulted from vessel strikes, 3 (6.7%) were related to entanglement in fishing gear (in two cases lobster gear, and one gillnet gear), and 13 (28.9%) were of unknown cause. At a minimum, therefore, 42.2% of the observed total for the period and 50% of the 32 non-calf deaths was attributable to human impacts (calves accounted for three deaths from ship strikes). Young animals, ages 0-4 years, are apparently the most impacted portion of the population (Kraus 1990).

Finally, entanglement or 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 injurySerious injury determinations for large whales commonly include animals carrying gear when these entanglements are constricting or appear to interfere with foraging (Henry *et al*. 2016).

Fishery-Related Mortality and Serious Injury

Reports of mortality and serious injury relative to PBR as well as total human impacts are contained in records maintained by the New England Aquarium and the NMFS Northeast and Southeast Regional Offices (Table 1). From 2010 through 2014, 24 records of mortality or serious injury (including records from both U.S. and Canadian waters, pro-rated to 23.25 using serious injury guidelines) involved entanglement or fishery interactions. For this time frame, the average reported mortality and serious injury to right whales due to fishery entanglement was 4.65 whales per year. Information from an entanglement event often does not include the detail necessary to assign the entanglements to a particular fishery or location.

Although disentanglement is often unsuccessful or not possible for many cases, there are several documented cases of entanglements for which the intervention of disentanglement teams averted a likely serious-injury determination. Four serious injuries were prevented by intervention during 2010–2014 (Henry *et al.* 2016). Sometimes, even with disentanglement, an animal may die of injuries sustained from fishing gear. A female yearling right whale, #3107, was first sighted with gear wrapping its caudal peduncle on 6 July 2002 near Briar Island, Nova Scotia. Although the gear was removed on 1 September by the New England Aquarium disentanglement team, and the animal seen alive during an aerial survey on 1 October, its carcass washed ashore at Nantucket on 12 October 2002 with deep entanglement injuries on the caudal peduncle. Additionally, but infrequently, a whale listed as seriously injured becomes gear-free without a disentanglement effort and is seen later in reasonable health. Such was the case for whale #1980, listed as a serious injury in 2008 but seen gear-free and apparently healthy in 2011.

The only bycatch of a right whale observed by the Northeast Fisheries Observer Program was in the pelagic drift gillnet fishery in 1993. No mortalities or serious injuries have been documented by fisheries observers in any of the other fisheries monitored by NMFS.

Whales often free themselves of gear following an entanglement event, and as such scarring may be a better indicator of fisheries interaction than entanglement records. A review of scars detected on identified individual right whales over a period of 30 years (1980–2009) documented 1032 definite, unique entanglement events on the 626 individual whales identified (Knowlton *et al.* 2012). Most individual whales (83%) were entangled at least once, and almost half of them (306 of 626) were entangled more than once. About a quarter of the individuals identified in each year (26%) were entangled in that year. Juveniles and calves were entangled at higher rates than were adults. Scarring rates suggest that entanglements are occurring at about an order of magnitude greater than that detected from observations of whales with gear on them. More recently, analyses of whales carrying entangling gear also suggest that entanglement wounds have become more severe since 1990, possibly due to increased use of stronger lines in fixed fishing gear (Knowlton *et al*. 2015).

Knowlton *et al.* (2012) concluded from their analysis of entanglement scarring rates over time that efforts made since 1997 to reduce right whale entanglement had not worked. Working from a completely different data source (observed mortalities of eight large whale species, 1970–-2009), van der Hoop *et al*. (2012) arrived at a similar conclusion. Vessel strikes and entanglements were the two leading causes of death for known mortalities of right whales for which a cause of death could be determined. Across all 8 species of large whales, there was no detectable change in causes of anthropogenic mortality over time (van der Hoop *et al*. 2012). Pace *et al.* (2015) analyzed entanglement rates and serious injuries due to entanglement during 1999-2009 and found no support that mitigation measures that were implemented prior to 2009 were effective at reducing takes due to commercial fishing.

Incidents of entanglements in waters of Atlantic Canada and the U.S. east coast were summarized by Read (1994) and Johnson *et al.* (2005). In six records of right whales that were entangled in groundfish gillnet gear in the Bay of Fundy and Gulf of Maine between 1975 and 1990, the whales were either released or escaped on their own, although several whales were observed carrying net or line fragments. A right whale mother and calf were released alive from a herring weir in the Bay of Fundy in 1976. Gillnet gear entanglements in the U.S. can also be fatal. A calf died in 2006, apparently victim of a gillnet entanglement, and other whales initially detected in gillnet gear have subsequently not been seen alive (NMFS unpub. data).

For all areas, specific details of right whale entanglement in fishing gear are often lacking. When direct or indirect mortality occurs, some carcasses come ashore and are subsequently examined, or are reported as "floaters" at sea. The number of unreported and unexamined carcasses is unknown, but may be significant in the case of floaters. More information is needed about fisheries interactions and where they occur.

Other Mortality

Vessel strikes are a major cause of mortality and injury to right whales (Kraus 1990; Knowlton and Kraus 2001, van der Hoop *et al.* 2012). Records from 2010 through 2014 have been summarized in Table 1. For this time frame, the average reported mortality and serious injury to right whales due to vessel strikes was 1.01 whales per year.

Table 1. Confirmed human-caused mortality and serious injury records of North Atlantic right whales (*Eubalaena glacialis*) where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2010-2014 [a]								
Date[b]	Injury Determination	ID	Location[b]	Asigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
6/27/2010	Mortality	1124	off Cape May, NJ	EN	1	XU	NR	Evidence of constricting rostrum, mouth & pectoral wraps w/associated hemorrhage & bone damage.
7/2/2010	Mortality	3901	off Great Wass Island, ME	VS	1	XU	-	2 large lacerations from dorsal to ventral surface.
8/12/2010	Mortality	1113	Digby Neck, NS	EN	1	XC	NP	Evidence of entanglement w/associated hemorrhaging around right pectoral.
9/10/2010	Serious Injury	1503	Jeffreys Ledge, NH	EN	1	XU	NR	Constricting wrap on rostrum. Poor health.

12/25/2010	Mortality	3911	off Jacksonville Beach, FL	EN	1	XU	GU	Constricting wraps w/ severe health decline. Sedation & partial disentanglement. Carcass recovered w/ embedded line on flipper & in mouth.
1/20/2011	Serious Injury	3853	off Edisto Island, SC	VS	1	US	-	Sixteen deep lacerations across back, potentially penetrating body cavity.
2/13/2011	Serious Injury	3993	off Tybee Island, GA	EN	1	XU	NR	Right pectoral compromised, likely necrotic. Emaciated & poor skin condition.
3/16/2011	Mortality	-	Cape Romain, SC	EN	1	XU	GU	Multiple wraps embedded in right pectoral bones.
3/27/2011	Mortality	1308	Nags Head, NC	VS	1	US	-	Fractured right skull.
3/27/2011	Serious Injury	2011 Calf of 1308	Nags Head, NC	VS	1	US	-	Dependent calf of mom that was killed by ship strike.
4/22/2011	Serious Injury	3302	off Martha's Vineyard, MA	EN	1	XU	NR	Constricting wrap on head.

9/3/2011	Serious Injury	2660	Gaspe Bay, QC	EN	1	XC	NP	Evidence of extensive, constricting entanglement. Significant health decline: cyamids, sloughing skin. Right blow hole not functional.
9/18/2011	Prorated Injury	4090	Jeffreys Ledge, NH	EN	0.75	XU	NR	Full configuration unknown.
9/27/2011	Prorated Injury	3111	off Grand Manan Island, NB	EN	0.75	XC	NR	Constricting wrap on left flipper. Disentanglement attempted, but unsure if any cuts made. Final entanglement configuration unknown. Resight in 2012 did not confirm configuration or if still entangled, but health apparently improved.
2/15/2012	Serious Injury	3996	off Provincetown, MA	EN	1	XU	NR	Constricting gear across head and health decline.
7/19/2012	Mortality	-	Clam Bay, NS	EN	1	XC	GU	Multiple constricting wraps on peduncle; COD - peracute underwater entrapment.
9/24/2012	Serious Injury	3610	Bay of Fundy	EN	1	XC	NP	New significant raw & healing entanglement wounds on head, dorsal & ventral peduncle, and leading fluke edges. Health decline: moderate cyamid load, thin.

12/7/2012	Prorated Injury	-	off Wassaw Island, GA	VS	0.52	US	-	46' vessel, 12-13 kts struck whale. Animal not resighted but large expanding pool of blood at surface.
12/18/2012	Mortality	4193	off Palm Coast, FL	EN	1	US	PT	Constricting & embedded wraps w/ associated hemorrhaging at peduncle, mouthline, tongue, oral rete, rostrum & pectoral; malnourished.
7/12/2013	Prorated Injury	3123	off Virginia Beach, VA	EN	0.75	XU	NR	Constricting gear cutting into mouthline; Partially disentangled; final configuration unknown.
1/15/2014	Serious Injury	4394	off Ossabaw Island, GA	EN	1	XU	NR	Injuries indicating prior constricting gear on both pectorals and at fluke insertion. Injury to left ventral fluke. Evidence of health decline.
4/1/2014	Serious Injury	1142	off Atlantic City, NJ	EN	1	XU	NR	Constricting rostrum wrap with line trailing to at least mid-body.
4/2/2014	Serious Injury	3390	Cod Cape Bay	EN	1	XU	NP	Evidence of a rostrum wrap, body wrap just aft of blowholes, and damage to right pectoral, peduncle and leading fluke edges. Resights indicate health decline.

4/9/2014	Prorated Injury	-	Cape Cod Bay	VS	0.52	US	-	Animal surfaced underneath R/V Shearwater (39ft) while it was underway @ 9 kts. Small amount of blood and some lacerations of unknown depth on lower left flank.
6/29/2014	Serious Injury	1131	off Yarmouth, NS	EN	1	XC	NR	At least 1, possibly 2, embedded rostrum wraps. Remaining configuration unclear but extensive. Animal in extremely poor condition: emaciated, heavy cyamid coverage, overall pale skin.
9/4/2014	Serious Injury	4001	off Grand Manan, NB	EN	1	XC	NR	Free-swimming with constricting rostrum wrap.
9/4/2014	Mortality	-	off St. Pierre & Miquelon, NL	EN	1	XC	NR	No necropsy conducted, but evidence of extensive, constricting entanglement - constricting line around rostrum and body.
9/17/2014	Serious Injury	3279	off Grand Manan, NB	EN	1	XC	NR	Free-swimming with heavy, green line over head cutting into nares. In poor overall condition: heavy cyamids on head and blowholes. Left blowhole appears compromised.

9/27/2014	Mortality	-	off Nantucket, MA	EN	1	US	NR	No necropsy conducted, but fresh carcass with evidence of extensive, constricting entanglement - multiple line wraps around head, pectoral and peduncle.
12/18/2014	Serious Injury	3670	off Sapelo Sound, GA	EN	1	XU	NP	Portion of right lip torn away leaving an opening in mouth. Severe injuries to peduncle and leading & trailing fluke edges. Wrapping injuries on head and body. Possible damage to right pectoral. Resights indicate health decline.
Five-year averages		Vessel strike (US/CN/XU/XC)			1.01 (0.81/ 0.00/ 0.20/ 0.00)			
		Entanglement (US/CN/XU/XC)			4.65 (0.40/ 0.00/ 2.5/ 1.75)			
a. For more details on events please see Henry *et al.* 2016.								
b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.								
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)								
d. CN=Canada, US=United States, XC=Unassigned 1st sight in CN, XU=Unassigned 1st sight in US								
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir								

STATUS OF STOCK

The size of this stock is considered to be extremely low relative to OSP in the U.S. Atlantic EEZ, and this species is listed as endangered under the ESA. The North Atlantic right whale is considered one of the most critically endangered populations of large whales in the world (Clapham *et al.* 1999). Status review by the National Marine Fisheries Service affirms endangered status (NMFS Northeast Regional Office 2012). The total level of human-caused mortality and serious injury is unknown, but reported human-caused mortality and serious injury was a minimum of 5.65 right whales per year from 2010 through 2014. Given that PBR has been calculated as 1, any human-caused mortality or serious injury for this stock can be considered significant. This is a strategic stock because the average annual human-related mortality and serious injury exceeds PBR, and also because the North Atlantic right whale is an endangered species.

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