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

STOCK DEFINITION AND GEOGRAPHIC RANGE

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 animals 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. Offshore (greater than 30 miles) surveys flown off the coast of 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). 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 of the years that offshore surveys were flown were some of the lowest count years for calves and for numbers of right whales in the Southeast recorded since comprehensive surveys began in the calving grounds. Therefore, the frequency with which right whales occur in offshore waters in the southeastern U.S. remains unclear.

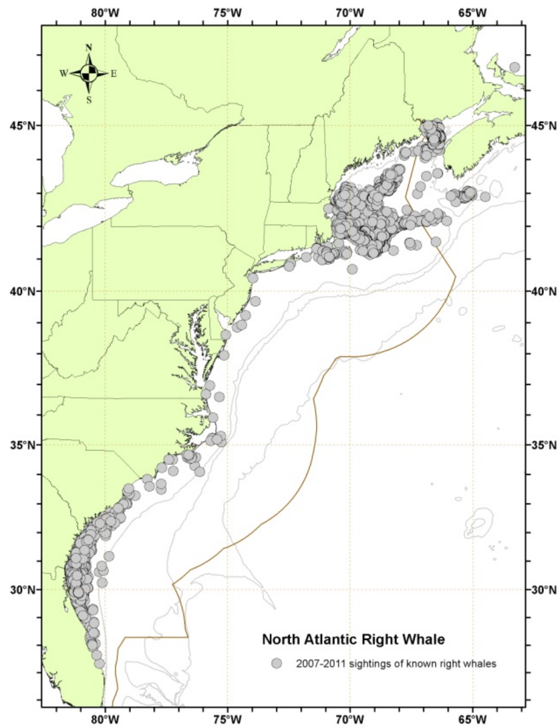

Figure 1. *Distribution of sightings of known North Atlantic right whales, 2007-2011. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

Surveys have demonstrated the existence of seven areas where western North Atlantic right whales congregate seasonally: the coastal waters of the southeastern United States; the Great South Channel; Jordan Basin (Cole *et al.* 2013); 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. However, 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 eleven 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 tags 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 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. Four of the 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 (McLellan *et al.* 2003). 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 recently detected in Cape Cod Bay.

New England waters are important feeding habitats for right whales, which feed in this area primarily on copepods (largely of the genera *Calanus* and *Pseudocalanus*). Research suggests that 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. 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 Provincetown 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). The consistency with which right whales occur in such locations is relatively high, but these studies also highlight the high interannual variability in right whale use of some habitats (Pendleton *et al.* 2009). 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). Acoustic detections demonstrate that right whales are present more than aerial survey observations indicate. Comparisons between detections from passive acoustic recorders with 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). Passive acoustic monitoring is demonstrating 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 hetroplasmy 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. Additional work comparing modern and historic genetic population structure, using DNA extracted from museum and archaeological specimens of baleen and bone, has 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 and not right whales (Rastogi *et al.* 2004) 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 and 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 habitats of potentially significant use that remain unknown.

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 25 October 2013 indicated that 465 individually recognized whales in the catalog were known to be alive during 2011. This number represents a minimum population size. This is a direct count and has no associated coefficient of variation.

Previous estimates using the same method with the added assumption that whales seen within the previous seven years were still alive have resulted in counts of 295 animals in 1992 (Knowlton *et al.* 1994) and 299 animals in 1998 (Kraus *et al.* 2001). An International Whaling Commission (IWC) workshop on status and trends of western North Atlantic right whales gave a minimum direct-count estimate of 263 right whales alive in 1996 and noted that the true population was unlikely to be substantially greater than this (Best *et al.* 2001).

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; Reeves *et al.* 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 465 individuals in 2011 (457 cataloged whales plus 8 not cataloged calves at the time the data were received) based on a census of individual whales identified using photo-identification techniques. This value is a minimum, and does not include animals that were alive prior to 2008 but not recorded in the individual sightings database as seen during 1 December 2008 to 25 October 2013 (note that matching of photos taken during 2011-2013 was not considered complete at the time these data were received, P. Hamilton, New England Aquarium, pers. com).

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 showing signs of slow recovery, 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, no one examined the early part of the recapture series for excessive retrospective recaptures which had the potential to positively bias survival as the catalog was being developed.

An increase in mortality in 2004 and 2005 was cause for serious concern (Kraus *et al.* 2005). 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). 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. 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 has continued to grow since that apparent interval of decline (Figure 1).

Examination of the minimum number alive population index calculated from the individual sightings database, as it existed on 25 October 2013, for the years 1990-2010 (Figure 1) suggests a positive and slowly accelerating trend in population size. These data reveal a significant increase in the number of catalogued whales with a geometric mean growth rate for the period of 2.6%.

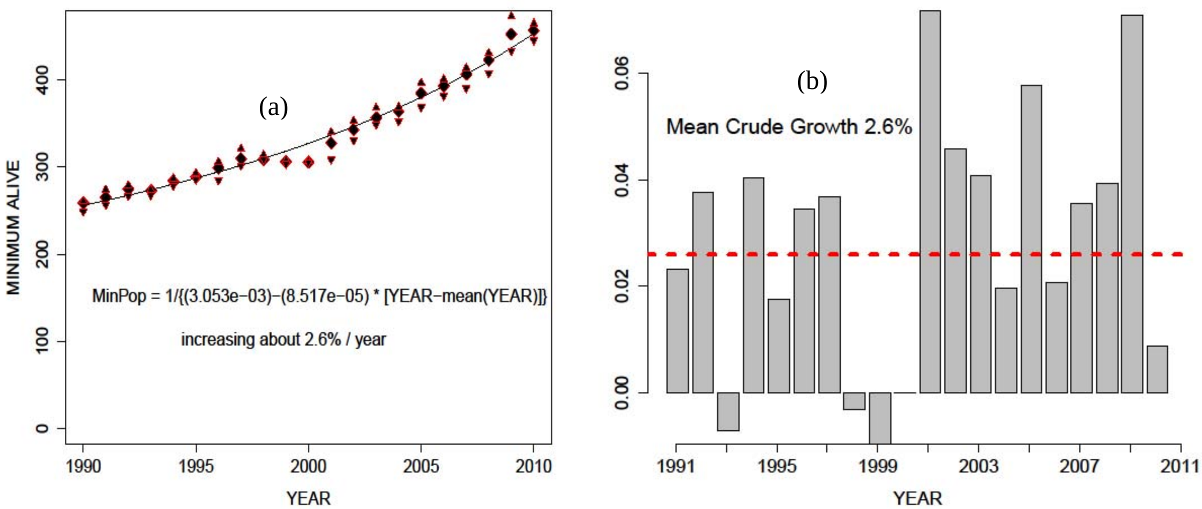

Figure 1. Minimum number alive (a) and crude annual growth rate (b) for cataloged North Atlantic right whales. Minimum number (N) of cataloged individuals known to be alive in any given year includes all whales known to be alive prior to that year and seen in that year or subsequently plus all whales 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. Mean crude growth rate (dashed line) is the exponentiated mean of $\log_e [(N_{t+1}-N_t)/N_t]$ *for each year (t).*

The minimum number alive may increase slightly in later years as analysis of the backlog of unmatched but high-quality photographs proceeds. For example, the minimum number alive for 2002 was calculated to be 313 from a 15 June 2006 data set and revised to 325 using the 30 May 2007 data set.

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 (Table 1).

Total reported calf production and calf mortalities from 1993 to 2012 are shown below in Table 1. The mean calf production for this 20-year period was 17.25. During the 2004 and 2005 calving seasons three adult females were found dead with near-term fetuses.

An updated analysis of calving intervals through the 1997/1998 season suggested that the mean calving interval increased since 1992 from 3.67 years to more than 5 years, a significant trend (Kraus *et al.* 2001). This conclusion was supported by modeling work reviewed by the IWC workshop on status and trends in this population (Best *et al.* 2001); the workshop agreed that calving intervals had indeed increased and further that the reproductive rate was approximately half that reported from studied populations of southern right whales, *E. australis*. A workshop on possible causes of reproductive failure was held in April 2000 (Reeves *et al.* 2001). Factors considered included contaminants, biotoxins, nutrition/food limitation, disease, and inbreeding problems. Analyses completed since that workshop found that in the early part of this century, calving intervals were closer to 3 years (Kraus *et al.* 2007).

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 suggested 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 senescence 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 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).

Table 1. North Atlantic right whale calf production and mortality, 1993-2012.

Year[a]	Reported calf production	Reported calf mortalities
1993	8	2
1994	9	0
1995	7	0
1996	22	3
1997	20	1
1998	6	1
1999	4	0
2000	1	0
2001	31	4
2002	21	2
2003	19	0
2004	17	1
2005	28	0
2006	19	2
2007	23	2
2008	23	2
2009	39	1
2010	19	0
2011	22	0
2012	7	1

[a] includes December of the previous year

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 465. 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 0.9.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2008 through 2012, the minimum rate of annual human-caused mortality and serious injury to right whales averaged 4.55 per year. This is derived from two components: 1) incidental fishery entanglement records at 3.65 per year, and 2) ship strike records at 0.9 per year. Of the 12.75 reported fisheries entanglements first reported in U.S. waters during this 5-year time period that were classified as serious injury or mortality, 2 were reported before the Atlantic Large Whale Take Reduction Plan's sinking-groundline rule went into effect in April 2009, and 10.75 were reported after enactment of the rule. All 5 of the reported ship strike serious injury and mortalities from U.S. waters during this 5-year time period were after the speed limit rule which went into effect in December 2008, although all were found more than 45 nmi from regulated areas or involved vessels smaller than those subject to regulation. Some analyses of the effectiveness of the ship strike rule were reported by Silber and Bettridge (2012). Beginning with the 2001 Stock Assessment Report, Canadian records have been incorporated into the mortality and serious injury rates of this report 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 (Cole and Henry 2015.). 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. The assigned cause is based on the best judgment of the available data; additional information may result in revisions. When reviewing Table 2 below, several factors should be considered: 1) a ship strike or entanglement may occur 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 ship 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.

The total minimum detected annual average human-induced mortality and serious injury incurred by this stock (including fishery and non-fishery related causes) for the period 2008-2012 was 4.55 right whales per year. As with entanglements, some injury or mortality due to ship strikes is almost certainly undetected, particularly in offshore waters. Decomposed and/or unexamined animals (e.g., carcasses reported but not retrieved or necropsied) represent lost data, some of which may relate to human impacts. For these reasons, the estimate of 4.55 right whales per year must be regarded as a minimum count.

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 ship 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 ship 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 injury. Such was apparently the case with the two-year-old right whale killed by a ship off Amelia Island, Florida in March 1991 after having carried gillnet gear wrapped around its tail region since the previous summer (Kenney and Kraus 1993). A similar fate befell right whale #2220, found dead on Cape Cod in 1996.

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998; Andersen *et al.* 2008; NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality.*" All injury determinations for this stock assessment were performed under the new guidelines. The new process involves proration of serious injury determinations where there is uncertainty regarding the severity or cause.

Fishery-Related Serious Injury and Mortality

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 2). From 2008 through 2012, 19 records of mortality or serious injury (including records from both U.S. and Canadian waters, pro-rated to 18.25 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 3.65 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. An adult female, #2029, first sighted entangled in the Great South Channel on 9 March 2007, may have avoided serious injury due to being partially disentangled on 18 September 2007 by researchers in the Bay of Fundy, Canada. On 8 December 2008, #3294 was successfully disentangled. 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 on 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. Three whales freed from probably fatal entanglements are known to have birthed calves at least once after their disentanglement, including 2 disentangled during the period 2008–2012.

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 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 definitely 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.

Knowlton *et al* (2012) concluded from their analysis of entanglement scar rates over time that efforts made since 1997 to reduce right whale entanglement have 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 strike 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).

Incidents of entanglements in groundfish gillnet gear, cod traps, and herring weirs in waters of Atlantic Canada and the U.S. east coast were summarized by Read (1994). 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.

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

Ship 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 2008 through 2012 have been summarized in Table 2. For this time frame, the average reported mortality and serious injury to right whales due to ship strikes was 0.9 whales per year.

	Table 2. Confirmed human-caused serious injury and mortality records of North Atlantic Right Whales (*Eubalaena glacialis*) where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2008-2012 a							
Date[b]	Injury Determination	ID	Location[b]	Assigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
9/24/2008	Serious Injury	2110	Jeffreys Ledge, NH	EN	1	XU	NP	In poor health with heavy cyamid load, swath lesions and rake marks. Presented old prop scars and fresh entanglement scars (no gear present). SI due to entanglement with ship strike as secondary cause. Images received in 2011 clearly show scoliosis. Spinal damage to peduncle similar to entanglement injury of right whale case reported on 27-Jan-09 off Cape Lookout NC
1/14/2009	Serious Injury	3311	off Brunswick, GA	EN	1	XU	GU	Line deeply embedded in rostrum and lip. Sedated & wrap on head cut and some gear removed. SI due to health decline (heavy cyamids, skin discoloration). No resights.
7/18/2009	Prorated Injury	1019	off Nantucket, MA	EN	0.75	XU	NR	Entanglement configuration unknown.
8/9/2009	Serious Injury	3930	Bay of Fundy	EN	1	XC	NP	Deep lacerations at fluke insertion potentially affecting arteries. Health decline including fluke

								deformation, increased cyamids & rake marks.
6/27/2010	Mortality	1124	off Cape May, NJ	EN	1	XU	NR	Evidence of constricting rostrum,mouth & pectoral wraps w/associated hemorrhage & bonedamage
7/2/2010	Mortality		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. No resights.
12/25/2010	Mortality	3911	off Jacksonville Beach, FL	EN	1	XU	GU	Embedded line on flipper & in mouth. Severe health decline. Partial disentanglement.
1/20/2011	Serious Injury	3853	off South Carolina	VS	1	US	-	Sixteen deep lacerations across back, potentially penetrating body cavity. No resights.
2/13/2011	Serious Injury	3993	off Tybee, GA	EN	1	XU	NR	Right pectoral compromised, likely necrotic. Emaciated and poor skin condition. No resights.
3/16/2011	Mortality		Cape Romain, SC	EN	1	XU	GU	Multiple wraps embedded inright pectoral bones; unknown rope
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.
7/19/2011	Serious Injury	4160	off Provincetown, MA	EN	1	XU	NP	Calf of the year with fresh entanglement wounds but no gear present. Mom not present. Abandoned dependent calf of seriously injured mother (see 9/3/11 event).
9/3/2011	Serious Injury	2660	Gaspe Bay	EN	1	XC	NP	No gear present but evidence of extensive, constricting entanglement. Significant health decline--cyamids, sloughing skin. Right blow hole not functional. Dependent calf absent (see 7/19/11 event).
9/18/2011	Prorated Injury	4090	Jeffreys Ledge, NH	EN	0.75	XU	NR	Entanglement configuration unknown. Could not confirm if anchored.
9/27/2011	Prorated Injury	3111	off Grand Manan Island, New Brunswick	EN	0.75	XC	NR	Constricting wrap on left flipper. Partial disentanglement. 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, Nova Scotia	EN	1	XC	NR	Multiple constricting wraps on peduncle; COD - peracute underwater entrapment.
9/24/2012	Serious Injury	3610	Bay of Fundy	EN	1	XC	NP	New significant 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 butlarge expanding pool of blood at surface.
12/18/2012	Mortality	4193	off Palm Coast, FL	EN	1	US	PT	Constricting and embedded wraps with associated hemorrhaging at peduncle, mouthline, tongue, oral rete, rostrum and pectoral; malnourished.
Five-year averages		Shipstrike (US/CN/XU/XC)			0.90 (0.70/ 0.00/ 0.20/ 0.00)			
		Entanglement (US/CN/XU/XC)			3.65 (0.20/ 0.00/ 2.30/ 1.15)			
a. For more details on events please see Henry *et al.* 2014 and Cole and Henry 2015.								
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). A Recovery Plan has been published for the North Atlantic right whale and is in effect (NMFS 2005). NMFS is presently engaged in evaluating the need for critical habitat designation for the North Atlantic right whale. Under a prior listing as northern right whale, three critical habitats, Cape Cod Bay/Massachusetts Bay, Great South Channel, and the Southeastern U.S., were designated by NMFS (59 FR 28793, June 3, 1994). Two additional critical habitat areas in Canadian waters, Grand Manan Basin and Roseway Basin, were identified in Canada's final recovery strategy for the North Atlantic right whale (Brown *et al.* 2009). 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 4.75 right whales per year from 2008 through 2012. Given that PBR has been set to 0.9, any 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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