HUMPBACK WHALE (*Megaptera novaeangliae*): Gulf of Maine Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the western North Atlantic, humpback whales feed during spring, summer and fall over a geographic range encompassing the eastern coast of the United States (including the Gulf of Maine), the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland (Katona and Beard 1990). Other North Atlantic feeding grounds occur off Iceland and northern Norway, including off Bear Island, Jan Mayen, and Franz Josef Land (Christensen *et al.* 1992; Palsbøll *et al.* 1997; M. Moore, WHOI, pers. comm.). These six regions represent relatively discrete subpopulations, fidelity to which is determined matrilineally (Clapham and Mayo 1987), which is supported by studies of the mitochondrial genome (Palsbøll *et al.* 1995; Palsbøll *et al.* 2001) and individual animal movements (Stevick *et al*. 2006). In early stock assessment reports, the North Atlantic humpback whale population was treated as a single stock for management purposes (Waring *et al.* 1999). Subsequently, a decision was made to reclassify the Gulf of Maine as a separate feeding stock (Waring *et al.* 2000) based upon the strong fidelity by individual whales to this region, and the attendant assumption that, were this subpopulation wiped out, repopulation by immigration from adjacent areas would not occur on any reasonable management timescale. During the 2002 Comprehensive Assessment of North Atlantic humpback whales, the International Whaling Commission acknowledged the evidence for treating the Gulf of Maine as a separate management unit (IWC 2002).

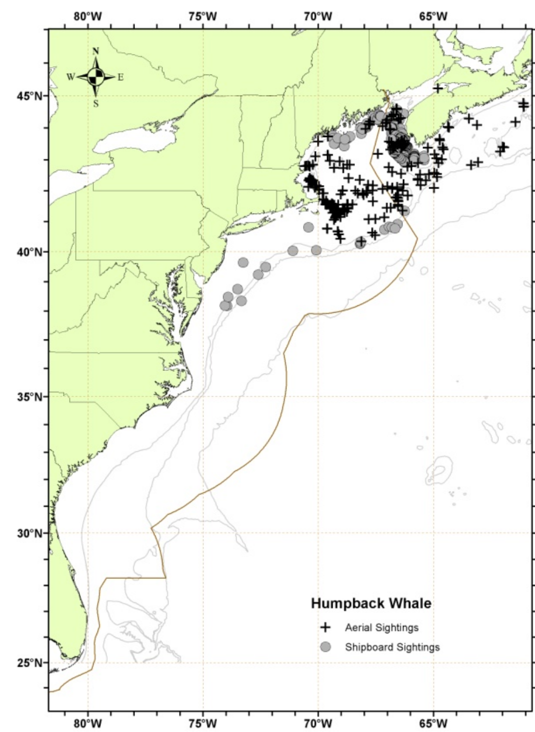

Figure 1. *Distribution of humpback whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010 and 2011. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

During the summers of 1998 and 1999, the Northeast Fisheries Science Center conducted surveys for humpback whales on the Scotian Shelf to establish the occurrence and population identity of the animals found in this region, which lies between the well-studied populations of the Gulf of Maine and Newfoundland. Photographs from both surveys were compared to both the overall North Atlantic Humpback Whale Catalogue and a large regional catalogue from the Gulf of Maine (maintained by the College of the Atlantic and the Provincetown Center for Coastal Studies, respectively); this work is summarized in Clapham *et al.* (2003). The match rate between the Scotian Shelf and the Gulf of Maine was 27% (14 of 52 Scotian Shelf individuals from both years). Comparable rates of exchange were obtained from the southern (28%, n=10 of 36 whales) and northern (27%, *n*=4 of 15 whales) ends of the Scotian Shelf, despite the additional distance of nearly 100 nautical miles (one whale was observed in both areas). In contrast, all of the 36 humpback whales identified by the same NMFS surveys elsewhere in the Gulf of Maine (including Georges Bank, southwestern Nova Scotia and the Bay of Fundy) had been previously observed in the Gulf of Maine region. The sighting histories of the 14 Scotian Shelf whales matched to the Gulf of Maine suggested that many of them were transient through the latter area. There were no matches between the Scotian Shelf and any other North Atlantic feeding ground, except the Gulf of Maine; however, instructive comparisons are compromised by the often low sampling effort in other regions in recent years. Overall, it appears that the northern range of many members of the Gulf of Maine stock does not extend onto the Scotian Shelf.

During winter, whales from most North Atlantic feeding areas (including the Gulf of Maine) mate and calve in the West Indies, where spatial and genetic mixing among feeding groups occurs (Katona and Beard 1990; Clapham *et al.* 1993; Palsbøll *et al.* 1997; Stevick *et al.* 1998). A few whales likely using eastern North Atlantic feeding areas migrate to the Cape Verde Islands (Reiner *et al.* 1996; Wenzel *et al.* 2009). In the West Indies, the majority of whales are found in the waters of the Dominican Republic, notably on Silver Bank and Navidad Bank, and in Samana Bay (Balcomb and Nichols 1982; Whitehead and Moore 1982; Mattila *et al.* 1989; Mattila *et al.* 1994). Humpback whales are also found at much lower densities throughout the remainder of the Antillean arc, from Puerto Rico to the coast of Venezuela (Winn *et al.* 1975; Levenson and Leapley 1978; Price 1985; Mattila and Clapham 1989). Although recognition of 2 breeding areas for North Atlantic humpbacks is the prevailing model, several observations suggest that our knowledge of breeding season distribution is far from complete (see Smith and Pike 2009).

All whales from this stock may not migrate to the West Indies every winter, because significant numbers of animals may be found in mid- and high-latitude regions at this time (Clapham *et al.* 1993; Swingle *et al.* 1993) and some individuals have been resighted across a winter season (Clapham *et al.* 1993; Robbins 2007). Acoustic recordings made in Stellwagen Bank National Marine Sanctuary in 2006 and 2008 detected humpback song in almost all months, including throughout the winter (Vu *et al*. 2012). This confirms the presence of male humpback whales in the area (a mid-latitude feeding ground) through the winter in these years. In addition, photographic records from Newfoundland have shown a number of adult humpbacks remain there year-round, particularly on the island's north coast. In collaboration with colleagues in the French islands of St. Pierre and Miquelon, a new photographic catalogue and concurrent matching effort is being undertaken for this region (J. Lawson, DFO, pers. comm.).

An increased number of sightings of humpback whales in the vicinity of the Chesapeake and Delaware Bays occurred in 1992 (Swingle *et al.* 1993). Wiley *et al.* (1995) reported that 38 humpback whale strandings occurred during 1985–1992 in the U.S. mid-Atlantic and southeastern states. Humpback whale strandings increased, particularly along the Virginia and North Carolina coasts, and most stranded animals were sexually immature; in addition, the small size of many of these whales strongly suggested that they had only recently separated from their mothers. Wiley *et al.* (1995) concluded that these areas were becoming an increasingly important habitat for juvenile humpback whales and that anthropogenic factors may negatively impact whales in this area. There have also been a number of wintertime humpback sightings in coastal waters of the southeastern U.S. Whether the increased numbers of sightings represent a distributional change, or are simply due to an increase in sighting effort and/or whale abundance, is unknown.

A key question with regard to humpback whales off the southeastern and mid-Atlantic states is their population identity. This topic was investigated using fluke photographs of living and dead whales observed in the region (Barco *et al.* 2002). In this study, photographs of 40 whales (alive or dead) were of sufficient quality to be compared to catalogs from the Gulf of Maine (i.e., the closest feeding ground) and other areas in the North Atlantic. Of 21 live whales, 9 (43%) matched to the Gulf of Maine, 4 (19%) to Newfoundland, and 1 (4.8%) to the Gulf of St Lawrence. Of 19 dead humpbacks, 6 (31.6%) were known Gulf of Maine whales. Although the population composition of the mid-Atlantic is apparently dominated by Gulf of Maine whales, lack of photographic effort in Newfoundland makes it likely that the observed match rates under-represent the true presence of Canadian whales in the region. A new photographic catalog and concurrent matching effort is being undertaken for this region which may improve knowledge in this regard. Barco *et al.* (2002) suggested that the mid-Atlantic region primarily represents a supplemental winter feeding ground used by humpbacks.

In New England waters, feeding is the principal activity of humpback whales, and their distribution in this region has been largely correlated to abundance of prey species, although behavior and bathymetry are factors influencing foraging strategy (Payne *et al.* 1986, 1990). Humpback whales are frequently piscivorous when in New England waters, feeding on herring (*Clupea harengus*), sand lance (*Ammodytes* spp.), and other small fishes. In the northern Gulf of Maine, euphausiids are also frequently taken (Paquet *et al.* 1997). Commercial depletion of herring and mackerel led to an increase in sand lance in the southwestern Gulf of Maine in the mid-1970s, with a concurrent decrease in humpback whale abundance in the northern Gulf of Maine. Humpback whales were densest over the sandy shoals in the southwestern Gulf of Maine favored by the sand lance during much of the late 1970s and early 1980s, and humpback distribution appeared to have shifted to this area (Payne *et al.* 1986). An apparent reversal began in the mid-1980s, and herring and mackerel increased as sand lance again decreased (Fogarty *et al.* 1991). Humpback whale abundance in the northern Gulf of Maine increased markedly during 1992–1993, along with a major influx of herring (P. Stevick, pers. comm.). Humpback whales were few in nearshore Massachusetts waters in the 1992–1993 summer seasons. They were more abundant in the offshore waters of Cultivator Shoal and on the Northeast Peak on Georges Bank and on Jeffreys Ledge; these latter areas are traditional locations of herring occurrence. In 1996 and 1997, sand lance and therefore humpback whales were once again abundant in the

Stellwagen Bank area. However, unlike previous cycles, when an increase in sand lance corresponded to a decrease in herring, herring remained relatively abundant in the northern Gulf of Maine, and humpbacks correspondingly continued to occupy this portion of the habitat, where they also fed on euphausiids (Wienrich *et al.* 1997). Diel patterns in humpback foraging behavior have been shown to correlate with diel patterns in sand lance behavior (Friedlaender *et al.* 2009).

In early 1992, a major research program known as the Years of the North Atlantic Humpback (YONAH) (Smith *et al.* 1999) was initiated. This was a large-scale, intensive study of humpback whales throughout almost their entire North Atlantic range, from the West Indies to the Arctic. During two primary years of field work, photographs for individual identification and biopsy samples for genetic analysis were collected from summer feeding areas and from the breeding grounds in the West Indies. Additional samples were collected from certain areas in other years. Results pertaining to the estimation of abundance and to genetic population structure are summarized below.

POPULATION SIZE

North Atlantic Population

The overall North Atlantic population (including the Gulf of Maine), derived from genetic tagging data collected by the YONAH project on the breeding grounds, was estimated to be 4,894 males (95% CI=3,374-7,123) and 2,804 females (95% CI=1,776-4,463) (Palsbøll *et al.* 1997). Because the sex ratio in this population is known to be even (Palsbøll *et al.* 1997), the excess of males is presumed a result of sampling bias, lower rates of migration among females, or sex-specific habitat partitioning in the West Indies; whatever the reason, the combined total is an underestimate of overall population size. Photographic mark-recapture analyses from the YONAH project provided an ocean-basin-wide estimate of 11,570 animals during 1992/1993 (CV=0.068, Stevick *et al.* 2003), and an additional genotype-based analysis yielded a similar but less precise estimate of 10,400 whales (CV=0.138, 95% CI=8,000 to 13,600) (Smith *et al.* 1999).

Gulf of Maine stock - earlier estimates

Please see Appendix IV for earlier estimates. As recommended in the GAMMS Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable and should not be used for PBR determinations.

Gulf of Maine Stock - Recent surveys and abundance estimates

An abundance estimate of 847 animals (CV=0.55) was derived from a line-transect sighting survey conducted during August 2006, which covered 10,676 km of trackline from the 2000-m depth contour on the southern edge of Georges Bank to the upper Bay of Fundy and to the Gulf of St. Lawrence (Table 1; Palka pers. comm.). Photo-identification evidence indicates a 25% exchange rate between whales on the Scotian Shelf and the catalogued Gulf of Maine population (Clapham *et al.* 2003), which suggest that a 25% correction factor should be applied to the humpback population estimate from the Scotian Shelf stratum. Because the Scotian Shelf was surveyed during 2006, the 25% correction factor was applied to only the 2006 abundance estimate. In contrast to 2006, a line-transect based abundance estimate for humpbacks on the Scotian Shelf based on the 2007 Canadian component of the Trans-North Atlantic Sighting Survey (TNASS) survey was 2,612 (CV=0.26) whales (Lawson and Gosselin 2011).

An abundance of 335 (CV=0.42) humpback whales was estimated from a line-transect survey conducted during June-August 2011 by ship and plane (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey and shallower than the 100-m depth contour through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ. Both sighting platforms used a two-simultaneous-team data collection procedure, which allows estimation of abundance corrected for perception bias (Laake and Borchers, 2004). Estimation of abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). This estimate did not include the portion of the Scotian Shelf that is known to be part of the range used by Gulf of Maine humpback whales. These various line-transect surveys lack consistency in geographic coverage, and because of the mobility of humpback whales, pooling stratum estimates across years to produce a single estimate is not advisable. However, similar to an estimate that appeared in Clapham *et al.* (2003), J. Robbins (Provincetown Center for Coastal Studies, Pers comm.) used photo-id evidence of presence (see Robbins 2009, 2010, 2011 for data description) to calculate the minimum number alive of catalogued individuals seen during the 2008 feeding season within the Gulf of Maine, or seen both before and after 2008, plus whales seen for the first time as non-calves in 2009. That procedure placed the minimum number alive in 2008 at 823 animals.

Minimum Population Estimate

For statistically-based estimates, the minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The most recent line-transect survey, which did not include the Scotian Shelf portion of the stock, produced an estimate of abundance for Gulf of Maine humpback whales of 331 animals (CV=0.48) with a resultant minimum population estimate for this stock of 228 animals. The line-transect based Nmin is unrealistic because at least 500 uniquely identifiable individual whales from the GOM stock were seen during the calendar year of that survey and the actual population would have been larger because re-sighting rates of GOM humpbacks have historically been <1 (Robbins 2007). Using the minimum count from at least 2 years prior to the year of a stock assessment report allows time to resight whales known to be alive prior to and after the focal year. Thus, the minimum population estimate is set to the 2008 mark-recapture based count of 823.

Table 1. Summary of abundance estimates for Gulf of Maine humpback whales with month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV). Note that the second row represents the results from an analysis of resights of individually identified animals.

Month/Year	Type	N_{best}	CV
Aug 2006	S. Gulf of Maine to upper Bay of Fundy to Gulf of St. Lawrence	847	0.55
Jun-Oct 2008	Gulf of Maine and Bay of Fundy	823	0
Jun-Aug 2011	Virginia to lower Bay of Fundy	335	0.42

Current Population Trend

As detailed below, the most recent available data suggest that the Gulf of Maine humpback whale stock is characterized by a positive trend in size. This is consistent with an estimated average trend of 3.1% (SE=0.005) in the North Atlantic population overall for the period 1979-1993 (Stevick *et al.* 2003), although there are no feeding-area-specific estimates.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Zerbini *et al.* (2010) reviewed various estimates of maximum productivity rates for humpback whale populations, and, based on simulation studies, they proposed that 11.8% be considered as the maximum rate at which the species could grow. Barlow and Clapham (1997), applying an interbirth interval model to photographic mark-recapture data, estimated the population growth rate of the Gulf of Maine humpback whale stock at 6.5% (CV=0.012). Maximum net productivity is unknown for this population, although a theoretical maximum for any humpback population can be calculated using known values for biological parameters (Brandão *et al.* 2000; Clapham *et al.* 2001). For the Gulf of Maine stock, data supplied by Barlow and Clapham (1997) and Clapham *et al.* (1995) give values of 0.96 for survival rate, 6 years as mean age at first parturition, 0.5 as the proportion of females, and 0.42 for annual pregnancy rate. From this, a maximum population growth rate of 0.072 is obtained according to the method described by Brandão *et al.* (2000). This suggests that the observed rate of 6.5% (Barlow and Clapham 1997) is close to the maximum for this stock.

Clapham *et al.* (2003) updated the Barlow and Clapham (1997) analysis using data from the period 1992 to 2000. The population growth estimate was either 0% (for a calf survival rate of 0.51) or 4.0% (for a calf survival rate of 0.875). Although confidence limits were not provided (because maturation parameters could not be estimated), both estimates of population growth rate are outside the 95% confidence intervals of the previous estimate of 6.5% for the period 1979 to 1991 (Barlow and Clapham 1997). More recent work by Robbins (2007) places apparent survival of calves at 0.664 (95% CI: 0.517-0.784), a value intermediate between those used by Barlow and Clapham (1997).

Despite the uncertainty accompanying the more recent estimates of observed population growth rate for the Gulf of Maine stock, the maximum net productivity rate was assumed to be 6.5% calculated by Barlow and

Clapham (1997) because it represents an observation greater than the default of 0.04 for cetaceans (Barlow *et al.* 1995) but is conservative in that it is well below the results of Zerbini *et al.* (2010).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for the Gulf of Maine stock is 823 whales. The maximum productivity rate is 0.065. The recovery factor, which accounts for endangered, depleted, or threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP) is assumed to be 0.10 because this stock is listed as an endangered species under the Endangered Species Act. PBR for the Gulf of Maine humpback whale stock is 2.7 whales.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2008 through 2012, the minimum annual rate of human-caused mortality and serious injury to the Gulf of Maine humpback whale stock averaged 10.3 animals per year. This value includes incidental fishery interaction records, 8.90; and records of vessel collisions, 1.4 (Table 2; Henry *et al.* 2014, Cole and Henry 2015).

In contrast to stock assessment reports before 2007, these averages include humpback mortalities and serious injuries that occurred in the southeastern and mid-Atlantic states that could not be confirmed as involving members of the Gulf of Maine stock. In past reports, only events involving whales confirmed to be members of the Gulf of Maine stock were counted against the PBR. Starting in the 2007 report, we assumed whales were from the Gulf of Maine unless they were identified as members of another stock. At the time of this writing, no whale was identified as a member of another stock. These determinations may change with the availability of new information. Canadian records from the southern side of Nova Scotia were incorporated into the mortality and serious injury rates, to reflect the effective range of this stock as described above. For the purposes of this report, discussion is primarily limited to those records considered to be confirmed human-caused mortalities or serious injuries.

To better assess human impacts (both vessel collision and gear entanglement) there needs to be greater emphasis on the timely recovery of carcasses and complete necropsies. The literature and review of records described here suggest that there are significant human impacts beyond those recorded in the data assessed for serious injury and mortality. For example, a study of entanglement-related scarring on the caudal peduncle of 134 individual humpback whales in the Gulf of Maine suggested that between 48% and 65% had experienced entanglements (Robbins and Mattila 2001). Decomposed and/or unexamined animals (e.g., carcasses reported but not retrieved or no necropsy performed) represent 'lost data', some of which may relate to human impacts.

Background

As with right whales, human impacts (vessel collisions and entanglements) may be slowing recovery of the humpback whale population. Van der Hoop *et al.* (2012) reviewed 1762 mortalities and serious injuries recorded for 8 species of large whales in the Northwest Atlantic for the 40 years 1970–2009. Of 473 records of humpback whales, cause of death could be attributed for 203. Of the 203, 116 (57%) mortalities were caused by entanglements in fishing gear, and 31 (15%) were attributable to vessel strikes.

Robbins and Mattila (2001) reported that males were more likely to be entangled than females. Annually updated inferences made from scar prevalence and multistate models of GOM humpback whales that (1) younger animals are more likely to become entangled than adults, (2) juvenile scarring rates may be trending up, (3) maybe less than 10% of humpback entanglements are ever reported, and (4) 3 % of the population maybe dying annually as the result of entanglements (Robbins 2009, 2010, 2011, 2012). Humpback whale entanglements also occur in relatively high numbers in Canadian waters. Reports of interactions with fixed fishing gear set for groundfish around Newfoundland averaged 365 annually from 1979 to 1987 (range 174-813). An average of 50 humpback whale entanglements (range 26-66) was reported annually between 1979 and 1988, and 12 of 66 humpback whales entangled in 1988 died (Lien *et al.* 1988). A total of 965 humpbacks was reported entangled in fishing gear in Newfoundland and Labrador from 1979 to 2008 (Benjamins *et al.* 2012). Volgenau *et al.* (1995) reported that in Newfoundland and Labrador, cod traps caused the most entanglements and entanglement mortalities (21%) of humpbacks between 1979 and 1992. They also reported that gillnets were the primary cause of entanglements and entanglement mortalities (20%) of humpbacks in the Gulf of Maine between 1975 and 1990. In more recent times, following the collapse of the cod fishery, groundfish gillnets for other fish species and crab pot lines have been the most common sources of humpback entanglement in Newfoundland. Since the crab pot fishery is primarily an offshore activity on the Grand Banks, these entanglements are hard to respond to and are likely underreported. One humpback whale was reported released alive (status unknown) from a herring weir off Grand Manan in 2009 (H. Koopman, UNC Wilmington, pers. comm.).

Wiley *et al.* (1995) reported that serious injuries attributable to ship strikes are more common and probably more serious than those from entanglements, but this claim is not supported by more recent analysis (van der Hoop *et al.* 2012). Furthermore, in the NMFS records for 2008 through 2012, there are 7 reports of serious injuries and mortalities as a result of collision with a vessel and 41 serious injuries and mortalities attributed to entanglement. Because it has never been shown that serious injuries and mortalities related to ships or to fisheries interactions are equally detectable, it is unclear as to which human source of mortality is more prevalent. A major aspect of vessel collision that will be cryptic as a serious injury is blunt trauma, where when lethal it is usually undetectable from an external exam (Moore *et al.* 2013). No whale involved in the recorded vessel collisions had been identified as a member of a stock other than the Gulf of Maine stock at the time of this writing (Cole and Henry 2015; Henry *et al.* 2014).

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 Injuries and Mortalities

A description of fisheries is provided in Appendix III. Two mortalities were observed in the pelagic drift gillnet fishery, one in 1993 and the other in 1995. In winter 1993, a juvenile humpback was observed entangled and dead in a pelagic drift gillnet along the 200-m isobath northeast of Cape Hatteras. In early summer 1995, a humpback was entangled and found dead in a pelagic drift gillnet on southwestern Georges Bank. Additional reports of mortality and serious injury, as well as description of total human impacts, are contained in records maintained by NMFS. A number of these records (11 entanglements involving lobster pot/trap gear) from the 1990–1994 period were the basis used to reclassify the lobster fishery (62 FR 33, Jan. 2, 1997). Large whale entanglements are rarely observed during fisheries sampling operations. However, during 2008, 3 humpback whales were observed as incidental bycatch: 2 in gillnet gear (1 no serious injury; 1 undetermined) and 1 in a purse seine (released alive) , in 2011 a humpback was caught on an observed gillnet trip (disentangled and released free of gear; Cole and Henry 2015), and in 2012 there was an observed interaction with a humpback whale in mid-Atlantic gillnet gear (non-serious injury). A recent review (Cassoff *et al*. 2011) describes in detail the types of injuries that baleen whales, including humpbacks, suffer as a result of entanglement in fishing gear.

For this report, the records of dead, injured, and/or entangled humpbacks (found either stranded or at sea) for the period 2008 through 2012 were reviewed. With no evidence to the contrary, all events were assumed to involve members of the Gulf of Maine stock. While these records are not statistically quantifiable in the same way as observer fishery records, they provide some indication of the minimum frequency of entanglements. Specifically to this stock, if the calculations of Robbins (2011 and 2012) are reasonable then the 3% mortality due to entanglement that they calculate equates to a minimum average rate of 25, which is nearly 10 times PBR.

Table 2. Confirmed human-caused mortality and serious injury records of Humpback Whales (*Megaptera novaeangliae*) 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
1/6/2008	Serious Injury	-	off Cape Lookout, NC	EN	1	XU	NR	Line cutting into right pectoral flipper in several places. Moderate cyamid load and appears emaciated.
1/10/08	Prorated Injury	-	off Wilmington,	EN	0.75	US	H/MF	Entanglement configuration

			NC					unknown.
5/7/2008	Prorated Injury	Brillo	off Provincetown, MA	EN	0.75	XU	NR	Extent of entanglement unclear--previously embedded wrap on body appears to have shifted aft. Thin and has some cyamids, however moving around actively in a feeding group during last sighting.
5/30/2008	Mortality	-	Georges Bank	EN	1	XU	NR	Constricting body and head wrap. Open wound on right pectoral.
6/9/2008	Mortality	-	Georges Bank	EN	1	US	PT	Constricting body wrap.
7/8/2008	Serious Injury	Estuary	off Wellfleet, MA	EN	1	US	GU	Anchored. Cuts were made, but no gear was removed. Animal was emaciated and had moderate cyamid coverage. Deep wounds in fluke blades from gear. Hunched over position maintained after cuts were made to the gear.
7/2008	Prorated Injury	-	off Chatham, MA	EN	0.75	US	GN	Left pectoral pinned. Partial disentanglement. Remaining configuration unknown.
7/13/2008	Prorated Injury	-	off Monomoy Point, MA	EN	0.75	XU	NR	Entanglement configuration unknown.
8/13/2008	Serious Injury	-	off Montauk, NY	EN	1	XU	NR	Wraps around tail, polyball attached, but full entanglement configuration unknown. Partial disentanglement. Whale

								emaciated, lethargic and with heavy cyamid load.
8/21/2008	Serious Injury	-	off Chatham, MA	EN	1	XU	NR	No wraps or weighted gear. Sloughing skin & extensive scuffing indicate health decline. Therefore SI.
9/20/2008	Prorated Injury	Cranny	off Brier Island, Nova Scotia	EN	0.75	XC	NR	Full extent of entanglement unclear--at least 4 non-constricting body wraps around midsection and peduncle.
11/4/2008	Mortality	-	Assateague, MD	VS	1	US	-	Cranial fractures w/ associated hemorrhaging.
11/8/2008	Prorated Injury	-	Nova Scotia	EN	0.75	XC	NR	Disentangled by fishermen. No photos or description of entanglement. Unknown if all gear removed.
2/8/2009	Mortality	-	Cape Fear, NC	EN	1	XU	NP	Evidence of entanglement at mouthline, peduncle, & pectoral w/ associated hemorrhaging. Emaciated.
2/16/2009	Mortality	-	Nags Head, NC	EN	1	XU	NP	Evidence of entanglement involving anchoring or heavily weighted gear w/ associated hemorrhaging.
2/25/2009	Serious Injury	-	off Sandy Hook, NJ	EN	1	US	NR	Anchored. Disentangled but SI due to deformed body position that did not substantially improve after disentanglement.
4/9/2009	Prorated	-	off	EN	0.75	XU	NR	Full

	Injury		Provincetown, MA					configuration unknown.
4/11/2009	Prorated Injury	-	off Gloucester, MA	EN	0.75	XU	NR	Configuration unclear--unknown if body wrap is loose or constricting. No photos.
5/23/2009	Prorated Injury	-	off Provincetown, MA	EN	0.75	XU	NR	Entanglement configuration unknown.
6/9/2009	Serious Injury	Inukshuk	off Provincetown, MA	EN	1	US	NR	Constricting body wrap.
9/12/2009	Prorated Injury	2008 Calf of Touchdown	off White Island, Nova Scotia	EN	0.75	CN	WE	Swam out of entrapment in weir, but carrying some gear in an unknown configuration.
9/16/2009	Prorated Injury	-	off Halifax, Nova Scotia	EN	0.75	XC	NR	Entanglement configuration unknown.
10/20/2009	Serious Injury	-	off Halifax, Nova Scotia	EN	1	CN	GN	Disentangled, but in poor condition: emaciated, heavy cyamid load, lethargic.
11/20/2009	Prorated Injury	-	off Goat Island, NC	EN	0.75	XU	NR	Entanglement configuration unknown.
3/7/2010	Serious Injury	-	off Ponte Vedra Beach, FL	EN	1	XU	NR	Constricting body & flipper wraps. May have shed some or all of gear, but severe health decline--emaciated, heavy cyamid load.
3/13/2010	Mortality	-	Ocean City Inlet, MD	VS	1	US	-	Skull fractures w/ associated hemorrhaging
5/5/2010	Serious Injury	-	off Northampton, VA	EN	1	XU	NR	Wrap around fluke blades near insertion and trailing gear. Young/small whale and gear likely to become constricting.

5/8/2010	Mortality	-	off Point Judith, RI	EN	1	US	GN	Evidence of constricting gear w/ associated hemorrhaging. Fluid filled lungs.
5/15/2010	Mortality	-	Hatteras Inlet, NC	EN	1	XU	NP	Live stranding - euthanized. Necrotic infected wounds at base of flukes and chronic abrasions on head.
5/28/2010	Mortality	-	off Martha's Vineyard, MA	EN	1	XU	GU	Evidence of entanglement w/ associated bruising & edema.
6/10/2010	Mortality	-	Jones Beach State Park, NY	VS	1	US	-	Extensive hemorrhage & edema on right dorsal lateral surface.
7/4/2010	Mortality	-	off Ocean City Inlet, MD	VS	1	US	-	Extensive hemorrhage & edema to left lateral area.
7/26/2010	Prorated Injury	-	off Chatham, MA	EN	0.75	XU	NR	Configuration and extent of entanglement unknown.
8/13/2010	Serious Injury	-	off Orleans, MA	EN	1	US	PT	Partial disentanglement, but remaining head wrap likely to become constricting.
8/20/2010	Serious Injury	Chili	off Provincetown, MA	EN	1	XU	NR	Embedded wraps, skinny, moderate cyamids indicating health decline.
9/10/2010	Prorated Injury	-	off White Head Island, Nova Scotia	EN	0.75	XC	NR	Configuration of entanglement unknown.
10/2/2010	Prorated Injury	-	off Provincetown, MA	EN	0.75	XU	NR	Entanglement configuration unknown. Unable to confirm if a resight of 8/20/10 event.
11/27/2010	Mortality	-	off Grand	EN	1	XC	NR	Evidence of

			Manan Island, New Brunswick					constricting wraps on fluke, peduncle, & pectoral
12/23/2010	Serious Injury	-	off Port Everglades Inlet, FL	EN	1	XU	NP	Evidence of recent constricting entanglement and severe health decline.
1/7/2011	Serious Injury	-	off Oregon Inlet, NC	EN	1	US	NR	Extensive entanglement with netting covering majority of body including head and blowholes. Anchored.
2/1/2011	Serious Injury	EKG	off Bar Harbor, ME	EN	1	US	NR	Anchored. Cuts were made to gear but whale still anchored.
3/7/2011	Mortality	-	Thorofare Bay, NC	VS	1	US	-	Live stranded with 8 deep lacerations across back. Euthanized.
4/11/2011	Prorated Injury	-	off Rockport, MA	EN	0.75	XU	NR	Entanglement configuration unknown.
5/5/2011	Mortality	-	Little Compton, RI	VS	1	US	-	Hemorrhaging at left jaw associated w/ blunt trauma.
5/27/2011	Mortality	-	Island Beach State Park, NJ	VS	1	US	-	5 broken vertebral processes along left side w/ associated hemorrhaging.
5/30/2011	Prorated Injury	-	off Orleans, MA	EN	0.75	XU	NR	Entanglement configuration unknown.
7/2/2011	Serious Injury	-	off Provincetown, MA	EN	1	XU	NP	Young whale. Missing flukes attributed to chronic entanglement. Laceration due to VS appears minor. Significant health decline, emaciated.

7/9/2011	Prorated Injury	-	off Monomoy Island, MA	EN	0.75	XU	NR	Entanglement configuration unknown.
7/10/2011	Prorated Injury	-	off Monomoy Island, MA	EN	0.75	XU	NR	Report was of two entangled whales but could not confirm that both were entangled. Configuration of entanglement unknown.
7/21/2011	Prorated Injury	-	off Oregon Inlet, NC	EN	0.75	XU	NR	Entanglement configuration unknown.
10/10/2011	Serious Injury	Clutter	off Grand Manan Island, New Brunswick	EN	1	XC	NR	Constricting wraps embedded at fluke insertion.
4/29/2012	Serious Injury	-	off Chatham, MA	EN	1	US	NR	SI based on description of body position which indicates constriction
5/27/2012	Prorated Injury	-	off Louisberg, Nova Scotia	EN	0.75	CN	PT	Partial disentanglement. Original and final configurations unclear, likely not life-threatening, but description is insufficient
7/29/2012	Serious Injury	-	off Gloucester, MA	EN	1	XU	NR	Calf with line cutting into peduncle
8/4/2012	Serious Injury	Aphid	off Provincetown, MA	EN	1	XU	NR	Line exiting both sides of mouth, under flippers, twisting together aft of the dorsal fin and trailing 75 ft past flukes; no wraps. Health decline – thin with graying skin.
8/21/12	Prorated Injury	2011 Calf of Wizard	off Provincetown, MA	EN	0.75	XU	NR	Calf with monofilament trailing over left fluke. Point of attachment unknown. No

								resights.
8/24/2012	Serious Injury	Forceps	off Provincetown, MA	EN	1	US	NR	Closed, possibly weighted, bridle w/ large tangle of line just above left eye. SI due to odd behavior and apparent difficulty staying at the surface.
Five-year averages		Shipstrike (US/CN/XU/XC)			1.40 (1.40/ 0.00/ 0.00/ 0.00)			
		Entanglement (US/CN/XU/XC)			8.90 (2.3/ 0.50/5.1/ 1.00)			
a. For more details on events please see Cole and Henry 2015 and Henry *et al.* 2014.								
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								

Other Mortality

Between November 1987 and January 1988, at least 14 humpback whales died after consuming Atlantic mackerel containing a dinoflagellate saxitoxin (Geraci *et al.* 1989). The whales subsequently stranded or were recovered in the vicinity of Cape Cod Bay and Nantucket Sound, and it is highly likely that other unrecorded mortalities occurred during this event. During the first six months of 1990, seven dead juvenile (7.6 to 9.1 m long) humpback whales stranded between North Carolina and New Jersey. The significance of these strandings is unknown.

Between July and September 2003, an Unusual Mortality Event (UME) that included 16 humpback whales was invoked in offshore waters of coastal New England and the Gulf of Maine . Biotoxin analyses of samples taken from some of these whales found saxitoxin at very low/questionable levels and domoic acid at low levels, but neither were adequately documented and therefore no definitive conclusions could be drawn. Seven humpback whales were considered part of a large whale UME in New England in 2005. Twenty-one dead humpback whales found between 10 July and 31 December 2006 triggered a humpback whale UME declaration. Causes of these UME events have not been determined.

STATUS OF STOCK

NMFS has concluded a global humpback whale status review, the report of which is being finalized. NMFS will include the relevant results of this review in the SARs when they are available. The status of the North Atlantic humpback whale population was the topic of an International Whaling Commission Comprehensive Assessment in June 2001, and again in May 2002. These meetings conducted a detailed review of all aspects of the population and made recommendations for further research (IWC 2002). Although recent estimates of abundance indicate a stable or growing humpback whale population, the stock may be below OSP in the U.S. Atlantic EEZ. A Recovery Plan was published and is in effect (NMFS 1991). There are insufficient data to reliably determine current population trends for humpback whales in the North Atlantic overall. The average annual rate of population increase for this stock was estimated at 3.1% (SE=0.005, Stevick *et al.* 2003). An analysis of demographic parameters for the Gulf of Maine (Clapham *et al.* 2003) suggested a lower rate of increase than the 6.5% reported by Barlow and Clapham (1997), but results may have been confounded by distribution shifts. The total level of U.S. fishery-caused mortality and serious injury is unknown, but reported levels are more than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant or approaching a zero mortality and serious injury rate. This is a strategic stock because the average annual human-related mortality and serious injury exceeds PBR, and because the North Atlantic humpback whale is an endangered species.

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