Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985–1992

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Marine mammal strandings are a result of, or result in, mortality that may be attributed to natural or anthropogenic factors. As such, stranding data can provide insight on spatial distribution, seasonal movements, and mortality factors pertaining to marine mammal populations (Woodhouse, 1991; Mead[1]).

The general distribution and migratory movements of humpback whales, *Megaptera novaeangliae*, in the western North Atlantic are well known from numerous studies based on the identification of individual animals and on other techniques. Humpbacks feed in high latitude areas during the summer months, including waters of the Gulf of Maine, eastern Canada, West Greenland, and Iceland (Hain et al., 1982; Martin et al., 1984; Perkins et al., 1984; Katona and Beard 1990). In the winter, whales from all populations migrate to breeding grounds in the West Indies (Balcomb and Nichols, 1982; Mattila and Clapham, 1989; Mattila et al., 1989; Katona and Beard 1990). Between these migratory end points, little is known of the distribution of the species. In recent years, however, there has been an apparent increase in the frequency of sightings of humpback whales off the mid-Atlantic coast of the United States (Swingle et al., 1993). Furthermore, a considerable number of strandings have been documented along the mid-Atlantic and southeast coasts, many in midwinter, a time when the majority of humpbacks are thought to be located in tropical waters. In this paper, we analyze data from these strandings, discuss implications regarding distribution and possible spatial segregation by age class, and examine apparent causes of mortality.

Methods

Study area and period

The study covers the coastal area of eastern North America extending from New Jersey(40°28'5N, 74°00'0W) to southern Florida (25°12'N, 80°13'W), consisting of 2,319 km of coastline (Fig. 1). The eight-year period from 1 January 1985 through 31 December 1992 was investigated. Stranding data were obtained from the United States Museum of Natural History, Smithsonian Institution's Marine Mammal Events Program (MMEP). This information was confirmed and augmented by comparison with data from stranding response personnel involved with the Northeast and Southeast Regional Stranding Networks and with data published in newspaper reports. Organizations involved in the regional stranding networks operate under a permit issued by the National Marine Fisheries Service. The names and organizations of investigators responding to specific stranding events are on file.

Analyses

The following data were recorded for each stranding: date, location, sex, body length, and the presence or absence of body markings that may indicate a possible anthropogenic cause of mortality (e.g. ship strike or fishery interaction).

Stranding incidents among states were compared by using a ratio of the number of strandings in the state to

[1] Mead, J. G. 1979. An analysis of cetacean strandings along the eastern coast of the United States. *In* J. R. Geraci and D. J. St. Aubin (eds.), Biology of marine mammals: insights through strandings, p. 54–68. Report to U.S. Marine Mammal Comm. Contract MM7AC020. U.S. Dep. of Commer., Natl. Tech. Info. Serv. PB-293 890.

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the length of coastline along the state. This is referred to as the stranding incidence ratio (SIR). Length of coastline was calculated from Ringold and Clark (1980).

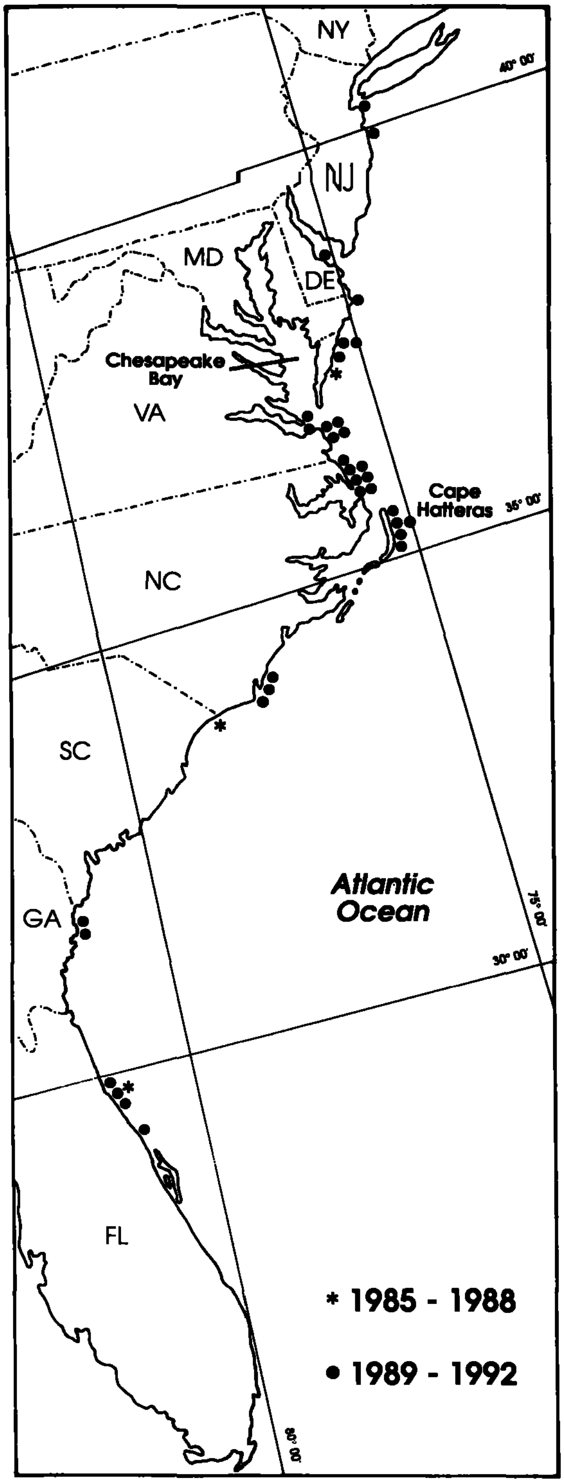

Figure 1

Locations of humpback whale, *Megaptera novaeangliae*, strandings from New Jersey to southern Florida, 1985 through 1992.

Reproductive class was inferred from body-length data. Animals of less than 8 m in length were considered to be dependent, nursing calves (Nishiwaki, 1959; Rice, 1963). We considered newly independent calves to be animals greater than 8.0 m but less than 9.9 m (calculated from Katona et al., 1983[2]). Males between 9.9 m and 11.6 m and females between 9.9 m and 12.0 m were considered sexually immature but not newly independent. Animals greater than 11.6 m (males) and 12.0 m (females) were considered sexually mature (Nishiwaki, 1959; Rice, 1963).

The Mann-Whitney U-test (Sokal and Rohlf, 1981) was used to test for differences between the number of strandings that occurred in the period 1985–88 versus 1989–92. Time periods were chosen to coincide with reported changes in observations of live animals in the same region (Swingle et al., 1993). The hypothesis that strandings occurred randomly throughout the study area was tested by chi-square analysis in a 2×2 contingency table (Sokal and Rohlf, 1981). The hypothesis that stranding events were not influenced by season was tested by chi-square analysis. Seasons were winter (January–March), spring (April–June), summer (July–September) and fall (October–December). Seasonal groupings were constructed so that the winter season would approximately coincide with the period of peak humpback occupancy of the breeding grounds, as reported by Mattila and Clapham (1989). The hypothesis that stranding occurrence was not influenced by sex was tested by chi-square analysis in a 2×2 contingency table.

Factors relating to mortality were taken from the written reports of on-site stranding response personnel from the Northeast and Southeast Regional Stranding Networks or, when not available, from the synthesis of such reports contained in the MMEP. The experience of stranding network response personnel is variable, and factors contributing to death or interpretation of bodily injury can be subject to debate. If on-site investigators recorded references to rope marks, propeller marks, broken bones, large gashes, etc., or directly suggested ship strike or entanglement as a potential cause of death, we attributed the death to possible anthropogenic causes. All mortality not suggesting anthropogenic trauma were grouped into a "natural" mortality category. This included animals that were euthanized but showed no other indications of human interaction. If a necropsy was conducted and no mention was made of body trauma, we assumed natural mortality. Carcasses that were reported to be in advanced stages of decomposition were eliminated from consideration.

[2] Calculated as length at birth, 4.5 m; growth rate, 45 cm per month; 12 month growth period = 9.9 m.

Results

A total of 38 stranded humpback whales were recorded between 1 January 1985 and 31 December 1992 (Table 1). One animal (4/14/85) was not included in the analyses because body condition ("mummification") indicated death or stranding, or both, occurred prior to the study period. The number of strandings by year was as follows: 0 in 1985, 2 in 1986, 0 in 1987, 1 in 1988, 3 in 1989, 8 in 1990, 7 in 1991, and 16 in 1992. Significantly more animals stranded during the period 1989 to 1992 (n=34), than from 1985 to 1988 (n=3) (Mann-Whitney U: Z=–2.32, P=0.02). Of the strandings recorded in our database, 92% (34/37) occurred after January 1989.

Significantly more strandings occurred along 170 km of coastline between Chesapeake Bay, Virginia, and Cape Hatteras, North Carolina (χ^2=70.67, df=1, P<0.01), than occurred in the rest of the study area. In this region, which represents 7.3% (170 km/2,319 km) of the coastline within the study area, 43% (16/37) of all strandings occurred. A second cluster of strandings occurred along the coast of northern Florida; however, this grouping was not found to be significant (χ^2=5.98, df=1, P=0.25). The region, which represents 4.7% (110 km/2319 km) of the study area's coastline, contained 13.5% (5/37) of all strandings.

The number of strandings per state was highly variable (Table 2). Numerically, the highest number of strandings occurred in North Carolina (n=15), but the incidence of strandings (strandings per kilometer of coastline) was greatest in Virginia (SIR=0.055, n=10), followed by North Carolina (SIR=0.031). South Carolina had the lowest incidence of strandings (SIR=0.003, n=1). The stranding incidence ratio for the entire study area was 0.016. All states recorded at least one stranding.

There were no significant differences in stranding occurrence by season (χ^2=4.22, df=3, P=0.24) (Fig. 2). However, only 8% (3/37) of all strandings occurred during the summer (July-September). Strandings occurred with the greatest frequency in April (n=6) followed by February, March, and October (n=5 each), and least in July and August (n=0 each). In 1992 (the most recent year of the study), strandings were spread over a greater number of months than any of the seven previous years.

Data on body length were available for 25 animals. Body length indicated all animals were sexually immature but none were dependent calves. Sixty-eight percent (17/25) of the animals were considered newly independent calves. Information on gender was available for 26 animals. Fifty percent (13/26) were female and 50% (13/26) were male.

Mortality

Of the 37 animals, an advanced stage of decomposition eliminated 13 from analysis for potential cause of death. Four additional animals were insufficiently examined or information was inadequately reported to determine a cause of death or the presence or absence of injury or scars. Of the 20 remaining animals, 30% (6/20) had major injuries potentially attributable to a ship strike and 25% (5/20) had injuries consistent with possible entanglement in fishing gear. One animal exhibited scars consistent with past entanglement or ship strike, or both, and was emaciated at the time of stranding. Thus, up to 60% (12/20) of the sufficiently inspected animals showed signs that anthropogenic factors may have contributed to or been directly responsible for their death. However, the possibility that some animals sustained body trauma after death can not be ruled out. Unfortunately, few animals were sufficiently necropsied to establish an unequivocal cause of death.

Discussion

These results suggest that stranding of humpback whales along the mid-Atlantic and southeast coastal areas of the United States has increased. All stranded animals were sexually immature and males and females stranded with equal frequency. However, natural mortality may show a gender bias that has been obscured by the high number of deaths potentially due to anthropogenic factors. Strandings occurred throughout the fall, winter, and spring seasons, but few strandings occurred during the summer months.

There are several possible explanations for the apparent increase in strandings, including changes

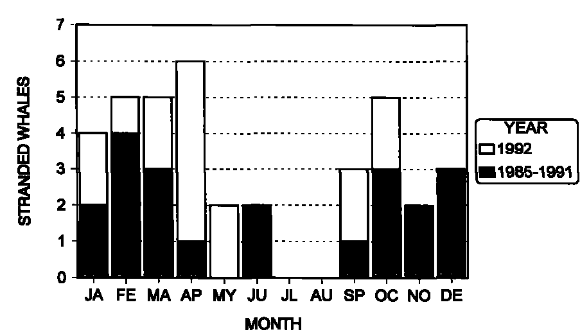

Figure 2

Humpback whale, *Megaptera novaeangliae*, strandings by month, 1985 through 1992.

Table 1

Humpback whale, *Megaptera novaeangliae*, strandings, New Jersey to south Florida, 1985–1992. unk = unknown; est = estimated.

Date	Location	Sex	Length	Necropsy	Carcass analyses	Potential cause of death
14 Apr 85	Carolina Beach, NC 34°02'--" N 078°53'--" W	unk	unk	no	old carcass (mummy or skeleton) not included in analyses	unknown
15 Feb 86	Cobb Island, VA 37°2-'--" N 075°4-'--" W	F	10.8 m	partial	fresh, no obvious sign of external trauma or disease	natural
07 Mar 86	N. Myrtle Beach, SC 33°48'--" N 078°44'--" W	F	11.7 m	yes	live stranding; euthanized	natural
08 Dec 88	St. Johns, FL 29°54'--" N 081°20'--" W (est)	unk	7.8 m (est)	no	advanced decomposition	unknown
14 Jan 89	St. Augustine, FL 29°55'3-" N 081°17'3" W	F	7.6 m (est)	unknown	advanced decomposition	unknown
18 Sep 89	Monmouth Beach, NJ 40°19'55" N 073°57'17" W	unk	8.0 m (est)	no	entangled in gear, apparently anchored by gear to bottom	entanglement
18 Dec 89	Assateague Island, VA 37°50'--" N 075°20'--" W	F	8.7 m[1]	yes	live stranding, no external injuries noted	natural
27 Jan 90	New Smyrna Beach, FL 29°00'0-" N 080°52'2-" W	M	7.9 m	yes	advanced decomposition	unknown
05 Feb 90	Nags Head, NC 35°56'5-" N 075°36'5-" W	unk[2]	11.1 m	partial	broken jaw bone, head damaged[3]	ship strike
24 Feb 90	Corolla Beach, NC 36°15'--" N 075°46'--" W	unk	9.0 m (est)	unknown	fresh, insufficient information	unknown
24 Mar 90	Sanderling, NC 36°11'5-" N 075°45'2-" W	unk	7.6 m – 8 m (est)	no	advanced decomposition	unknown
01 Apr 90	Virginia Beach, VA 36°4-'--" N 075°5-'--" W	F	9.6 m	yes	fresh, net/line marks on tail stock, right half of fluke had line marks	entanglement
19 Jun 90[4]	Virginia Beach, VA 36°56'15" N 076°03'30" W	F	8.3 m	yes	fresh, no evidence of scars or injuries	natural
20 Jun 90	Virginia Beach, VA 36°45'15" N 075°56'30" W	F	8.2 m	yes	live stranding; euthanized, rope marks on flukes, emaciated	entanglement

Table 1 (continued)

Date	Location	Sex	Length	Necropsy	Carcass analyses	Potential cause of death
19 Nov 90	Norfolk, VA 36°56'00" N 076°11'30" W	M	9.5 m	no	various rope burns, abrasions on tail stock, rope scars on left flipper	entanglement
05 Feb 91	St. Johns, FL 29°59'06" N 081°18'48" W	M	9.4 m	partial	moderately decomposed, no external injuries noted	natural
02 Mar 91	Bald Head Island, NC 33°55'0-" N 077°56'4-" W	M	8.5 m	no	inaccessible	unknown
15 Oct 91	Kill Devil Hills, NC 36°01'--" N 075°39'--" W	unk[5]	9.3 m[6]	partial	no external injuries noted	natural
25 Oct 91	Nags Head, NC 35°56'5-" N 075°37'0-"	M	9.1 m (est)	no	no external injuries noted	natural
27 Oct 91	Bodie Island, NC 35°46'0-" N 075°29'1-" W	unk	10.0 m	no	advanced decomposition	unknown
08 Nov 91	Island Beach State Park, NJ 39°50'00" N 074°05'12" W	M	9.0 m	yes	four propeller cuts, one through the occipital condyle, were cause of death	vessel strike
25 Dec 91	Carolina Beach, NC 34°01'--" N 077°54'--" W	F	9.9 m	no	insufficient information	unknown
03 Jan 92	Salvo, NC 35°20'9-" N 075°21'8-" W	M	10.4 m	no	no external injuries noted	natural
30 Jan 92	Oregon Inlet, NC 35°46'5-" N 075°31'9-" W	unk	unk	no	inaccessible	unknown
14 Feb 92	Virginia Beach, VA 37°01'--" N 076°07'--" W (est)	M	8.5 m[1]	yes	left eye socket and left mandible fractured, signs of healing from injuries at point of fractures	vessel strike
10 Mar 92	Avon, NC 35°20'--" N 075°21'--" W	F	10.7 m	partial	left fluke "scalloped" possibly due to ship strike or entanglement, evidence of healed rope/net scars on caudal peduncle	past entanglement or ship strike
19 Mar 92	North Core Banks, NC 35°01'1-" N 076°06'0-" W	M	11.0 m	no	advanced decomposition	unknown

Table 1 (continued)

Date	Location	Sex	Length	Necropsy	Carcass analyses	Potential cause of death
14 Apr 92	St. Johns, FL 29°45'--" N 081°10'--" W (est)	unk	8.6 m existing length	no	advanced decomposition	unknown
16 Apr 92	Assateague Island, MD 38°12'--" N 075°08'--" W	F	8.9 m	yes	no external trauma, but skull disarticulated, blunt trauma to left side	vessel strike
18 Apr 92	Southport, NC 33°42'8-" N 77°55'4-" W	M	9.5 m	no	advanced decomposition	unknown
22 Apr 92	Hatteras, NC 35°11'4-" N 075°46'3-" W	F	8.9 m	yes	no external trauma, but extensive skeletal damage, "probably struck by boat"	vessel strike
30 Apr 92	Nags Head, NC 35°22'--" N 075°29'--" W	unk	9.2 m (est)	no	advanced decomposition inaccessible	unknown
16 May 92	Ossabaw Island, GA 31°45'7-" N 081°05'0-" W	M	> 7.2 m	no	advanced decomposition	unknown
17 May 92	St. Catherines Island, GA 31°38'2-" N 081°08'2-" W	unk	unk	partial	advanced decomposition	unknown
22 Sep 92	Prime Hook National Wildlife Refuge, DE 38°55'--" N 075°05'--" W	F	8.3 m (est)	yes	advanced decomposition	unknown
28 Sep 92	Assateague Island, VA 37°53'--" N 075°22'--" W	M	8.9 m (est)- part of head buried	yes	advanced decomposition	unknown
09 Oct 92	Metompkin Island, VA 37°46'--" N 075°32'--" W	F	8.7 m	yes	"probably boat strike," 3 areas of hemorrhage noted	vessel strike
22 Oct 92	Virginia Beach, VA 36°46'15" N 075°57'02" W	M	9.1 m	yes	"obvious entaglement scars" on leading edge of fluke and around caudal peduncle	entanglement

[1] Animal towed prior to measurement, therefore measured length may be greater than actual length.

[2] Discrepancy in reported gender. Original stranding report stated female. MMEP reported male.

[3] Discrepancy in reported body condition. Original stranding report stated broken jaw bone and head damage. MMEP had no report of body condition.

[4] Discrepancy in reported date. Original stranding report stated 19 June 1990. MMEP reported 19 May 1990.

[5] Discrepancy in reported gender. Original stranding report stated female. MMEP reported as unknown.

[6] Discrepancy in reported body length. Original stranding report stated 9.3 m. MMEP reported an estimated length of 660 cm.

Table 2

Humpback whale, *Megaptera novaeangliae*, strandings by state; 1985 through 1992.

State	Number of strandings	Kilometers of coastline	SIR: Number of strandings / km of coastline
Virginia	10	180.6	0.055
North Carolina	15	485.5	0.031
Delaware	1	45.2	0.022
Maryland	1	50.0	0.020
Georgia	2	161.3	0.012
New Jersey	2	209.7	0.010
Florida	5	935.5	0.005
South Carolina	1	301.6	0.003

in observer effort, mortality factors, and whale distribution. That increased observer effort could account for the increase seems unlikely. The size of stranded humpback whales and both the public and media interest in such events results in few carcasses escaping notice. Additionally, strandings of finback whales, *Balaenoptera physalus*, over the same time period have remained relatively constant (1985 to 1988, n=10; 1989 to 1992, n=9)) (calculated from MMEP, Smithsonian Institution). An increase for this large baleen species might also be expected if the reported humpback change were due solely to increased observer effort.

If the reported increase in strandings is not an artifact of observer effort, it may be due to an increase in factors resulting in mortality, an increase in the number of animals inhabiting the study area, or both. While the tonnage of cargo moving through Atlantic ports in 1989 showed a 9% increase over the mean of the previous four years (calculated from Anon., 1991), the number of vessels using the Chesapeake Bay area, and probably the rest of the Atlantic coast, has decreased because ships capable of carrying greater tonnage are being used (Pringer[3]). While a decline in vessel traffic may result in a decreased risk to whales, it is possible that these larger, faster, deeper draft vessels pose a greater danger than the slower, shallower draft vessels of the past. In addition to commercial shipping, some areas, such as near Chesapeake Bay and northern Florida, are subject to substantial use by military vessels. However, data pertaining to trends in military vessel traffic were not available.

Evidence also indicates that as much as 25% of the reported mortality may be attributable to interaction with commercial fishing activity, such as gill netting. North Carolina's coastal sink gillnet fishery expanded dramatically during the 1980's (Ross[4]). South Carolina, the state with the lowest SIR, banned the commercial use of gill nets in 1987 (with the exception of a tended shad net fishery) (Moran[5]). However, fishing effort in the entire study area is inadequately monitored to determine trends (Read, in press; Bisack[6]).

While changes in shipping and commercial fishing activity may represent increased hazards to animals inhabiting the study area, they seem inadequate to account for the dramatic change in stranding levels reported. Each of these hazards existed prior to 1989, the period when strandings began to increase. The most likely explanation for the reported increase in mortality appears to be increased use of this area by juvenile humpback whales that are then exposed to such hazards.

Although few standardized marine mammal surveys consistently cover the study area, anecdotal and published observations point to a recent increase in live sightings of humpback whales in coastal waters of Florida and Georgia (Kraus[7]), North Carolina (Barrington[8]), Virginia (Swingle et al., 1993), and Maryland (Driscoll[9]). Although reliable estimation of the length of free-swimming whales is difficult, there is general agreement among observers that most, if not all, of the animals frequenting the area are small.

Changes in humpback whale distribution in relation to changes in prey composition and abundance have been demonstrated elsewhere (Payne et al., 1986; Piatt et al., 1989; Payne et al., 1990), and such a prey shift may account for or be an important fac-

[3] Pringer, Captain M. Association of Maryland Pilots, Baltimore, MD 21228. Personal commun., January 1993.

[4] Ross, J. L. 1989. Assessment of the sink net fishery along North Carolina's Outer Banks, fall 1982 through spring 1987, with notes on other coastal gill net fisheries. Special Sci. Rep. 50, North Carolina Dep. of Environ., Health and Nat. Resour., Moorehead City, NC, 54 p.

[5] Moran, J. South Carolina Wildlife and Marine Resource Department, Charleston, SC 29422. Personal commun., September 1993.

[6] Bisack, K. 1992. Sink gill net fishing activity in the North Atlantic as reflected in the NEFSC weightout database: 1982–1991. U.S Dep. Commer., NOAA, Natl. Mar. Fish.Serv. Northeast Fish. Sci Cent., Woods Hole, MA 02543. Unpubl. manuscr., 4 p.

[7] Kraus, S. New England Aquarium, Boston, MA 02110. Personal commun., March 1993.

[8] Barrington, P. North Carolina Aquarium, Fort Fisher, Kuri Beach, NC 28449. Personal commun., April, 1993.

[9] Driscoll, C. NMFS, Office of Protected Resources, Silver Spring, MD 20910. Personal commun., March 1993.

tor in the change in whale distribution suggested here. While data on changes in prey distribution were not available, the first observations of winter feeding humpbacks were documented in the nearshore waters of Maryland (deGroot[10]) and Virginia (Swingle et al., 1993), during the winters of 1991 and 1992.

An additional possibility is that the humpback whale population in the western North Atlantic may be increasing and expanding its range such that habitats historically occupied are being recolonized. Several authors (Katona and Beard, 1990; Sigurjonsson and Gunnlaugsson, 1990) have reported numerical increases for this population, although this may be due to increased effort resulting in more accurate estimates of abundance.

Humpback whales may have always been present during winter in offshore waters of the study area, but a shift in prey abundance or distribution, or both, may have brought them into areas where death would result in stranding, rather than have caused them to be lost at sea. However, offshore concentrations were not detected during 1978–82 aerial surveys (CeTAP[11]) or during 1980–88 ship board surveys (Payne et al.[12]).

While juvenile whales can be expected to exhibit higher mortality than adults (Sumich and Harvey, 1986; Kraus, 1990a), the absence of adult animals from the stranding record may provide support for the suggestions of Swingle et al. (1993) that winter or migratory segregation, or both, is occurring. Foraging opportunities on the breeding grounds are rare (Dawbin, 1966; Baraff et al., 1991), and it may be adaptive for some juvenile animals to remain and feed in mid-latitude areas, rather than to migrate with adults. If occupying the breeding grounds is the preferred behavior, individuals remaining in higher latitude areas may be those that failed to obtain sufficient resources during the feeding season. Such nutritionally stressed animals may be more susceptible to all forms of mortality, natural or anthropogenic. Nutritionally stressed juveniles and newly weaned calves in particular may be vulnerable to the effects of the parasitic nematode *Crassicauda boopis* (Lambertsen, 1992).

If winter foraging opportunities are sufficient, juveniles may delay their return to traditional feeding areas and may eventually occupy new habitat. This may be one mechanism by which a species establishes itself in new areas or reoccupies historic sites. This process may be reflected in the stranding record. There seems to be a progressive trend not only for an increased number of strandings but for strandings to take place in a greater variety of months.

A high percentage of animals exhibited signs that anthropogenic interactions could be implicated in their death. However, there are reasons to believe that mortality estimates based on available stranding data could under- or overestimate the impact of human interaction. For example, stranded animals on 16 and 22 April 1992 exhibited no external signs of trauma. However, necropsies indicated internal injuries consistent with a ship strike (McLellan[13]; Thayer[14]), suggesting that such injuries could have escaped notice during more cursory examinations. The lack of external body trauma on animals which thorough necropsy revealed to have been killed by a ship strike has also been noted for the northern right whale, *Eubalaena glacialis* (Kraus[15]).

Alternatively, references to rope or net marks did not always specify whether such marks were of recent origin or due to past entanglement from which the animal escaped. Baleen whale entanglement does not always lead to immediate mortality (Kraus, 1990a); however, the effect of escaped entanglement on long-term survivorship or reproductive success, or both, is unknown. If rope or net marks noted in the stranding reports were of past origin, they may have been independent of the animal's death or the animal may have succumbed to the long-term effects of past entanglement. Reduced foraging efficiency during the entanglement period may be a factor influencing animals to engage in winter feeding behavior, such as that observed in the study area by Swingle et al. (1993).

The apparent high rate of interaction with commercial fishing and shipping, may be due, in part, to the age class inhabiting the area. Juvenile animals, and newly independent calves in particular, may be more susceptible to ship strikes or fishing gear entanglements, or both, owing to a lack of experience with either factor (Lien, in press). Commercial shipping and military traffic to and from the Chesapeake Bay passes by much of the area where strandings

[10] deGroot, G. 1992. A fluke of nature. The Annapolis Capital-Gazette. 10 March, p. 1.

[11] CeTAP. 1982. A characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U. S. outer continental shelf. Final Rep. to the Cetacean and Turtle Assessment Program, Univ. Rhode Island, Bur. Land Manage., Contract AA551-CT8-48. U.S. Dep. Int., Wash., DC, 450 p.

[12] Payne, P. M., W. Heinemann, and L. A. Selzer. 1992. A distributional assessment of cetaceans in shelf/shelf-edge and adjacent slope waters of the northeastern United States based on aerial and shipboard surveys, 1978–1988. Natl. Mar. Fish. Serv., Northeast Fish. Sci. Cent,, Woods Hole, MA 02543. Unpubl. manuscr., 108 p.

[13] McLellan, W. James Madison Univ., Harrisonburg, VA 22807. Personal commun., March 1993.

[14] Thayer, V. Natl. Mar. Fish. Serv., Beaufort, NC 28516. Personal commun., March 1993.

[15] Kraus, S. New England Aquarium, Boston, MA 02110. Personal commun., March 1993.

occur most frequently (Virginia and North Carolina), often in water depths of less than 20 m. In Florida, the concentration of strandings occurs in the vicinity of active commercial and military shipping and where ship strikes have been reported to represent a hazard to northern right whales (Kraus and Kenney, 1991).

Entanglement in commercial fishing gear has been the most frequently identified anthropogenic cause of injury and death in humpback whales; gillnet-type gear most often was implicated (O'Hara et al., 1986). Coastal gillnet fisheries exist in the study area on a year-round basis, but effort may peak in late winter/spring (NMFS, 1992; Swingle et al., 1993; Brooks[16]). Over 2,200 gillnet licenses have been issued for the mid-Atlantic coastal region. However, fishermen may hold more than one permit and some coastal fisheries do not require permits (NMFS, 1992). In the study area, coastal gill nets and whales concurrently occupy waters of less than 15 m in depth (observed by RAA and DPG), and whales have been observed trailing such gear (Swingle[17]). The association of young, inexperienced whales with gill nets in shallow waters may increase the potential for entanglement incidents. Since entanglement mortality is inversely related to body size (Lien et al., 1989; Kraus 1990b), juvenile humpbacks may be more susceptible to fatalities.

Data contained in this paper suggest that mid-Atlantic and southeast coastal areas of the United States are becoming increasingly important habitat for juvenile humpback whales and that anthropogenic factors may negatively impact these animals. However, there are a number of factors that suggest caution should be used in interpretation of these data. The site of stranding is not necessarily the site of death, as the body of a large whale can be carried considerable distances by wind and currents before beaching occurs. Cause of death in the stranded animals was rarely determined with certainty and in most cases was inferred from observations of the presence or absence of surface body trauma, not from thorough necropsy by experienced individuals. A greater emphasis should be placed on complete necropsies of stranded animals to determine not only the immediate cause of death but also whether there is an underlying factor in the fatality. This would allow a more reliable investigation into mortality and provide greater ability to evaluate and alleviate the impact of anthropogenic interactions. This is particularly important for an endangered species, such as the humpback whale.

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