October 2007

SPERM WHALE (*Physeter macrocephalus*): North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The distribution of the sperm whale in the U.S. Exclusive Economic Zone (EEZ) occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions (Figure 1). Waring *et al.* (1993, 2001) suggest that this offshore distribution is more commonly associated with the Gulf Stream edge and other features. However, the sperm whales that occur in the eastern U.S. Atlantic EEZ likely represent only a fraction of the total stock. The nature of linkages of the U.S. habitat with those to the south, north, and offshore is unknown. Historical whaling records compiled by Schmidly (1981) suggested an offshore distribution off the southeast U.S., over the Blake Plateau, and into deep ocean waters. In the southeast Caribbean, both large and small adults, as well as calves and juveniles of different sizes are reported (Watkins *et al.* 1985). Whether the northwestern Atlantic population is discrete from northeastern Atlantic is currently unresolved. The International Whaling Commission recognizes one stock for the North Atlantic. Based on reviews of many types of stock studies, (i.e., tagging, genetics, catch data, mark-recapture, biochemical markers, etc.) Reeves and Whitehead (1997) and Dufault *et al.* (1999) suggest that sperm whale populations have no clear geographic structure. Recent ocean wide genetic studies (Lyrholm and Gyllensten 1998; Lyrholm *et al.* 1999) indicate low genetic diversity, but strong differentiation between potential social (matrilineally related) groups. Further, the ocean-wide findings, combined with observations from other studies, indicate stable social groups, site fidelity, and latitudinal range limitations in groups of females and juveniles (Whitehead 2002). In contrast, males migrate to polar regions to feed and return to more tropical waters to breed. There exists one tag return of a male tagged off Browns Bank (Nova Scotia) in 1966 and returned from Spain in 1973 (Mitchell 1975). Another male taken off northern Denmark in August 1981 had been wounded the previous summer by whalers off the Azores (Reeves and Whitehead 1997). In the U.S. Atlantic EEZ waters, there appears to be a distinct seasonal cycle (CETAP 1982; Scott and Sadove 1997). In winter, sperm whales are concentrated east and northeast of Cape Hatteras. In spring, the center of distribution shifts northward to east of Delaware and Virginia, and is widespread throughout the central portion of the mid-Atlantic bight and the southern portion of Georges Bank. In summer, the distribution is similar but now also includes the area east and north of Georges Bank and into the Northeast Channel region, as well as the continental shelf (inshore of the 100 m isobath) south of New England. In the fall, sperm whale occurrence south of New England on the continental shelf is at its highest level, and there remains a continental shelf edge occurrence in the mid-Atlantic bight. Similar inshore (<200 m) observations have been made on the southwestern (Kenney, pers. comm) and eastern Scotian Shelf, particularly in the region of "the Gully" (Whitehead *et al.* 1991).

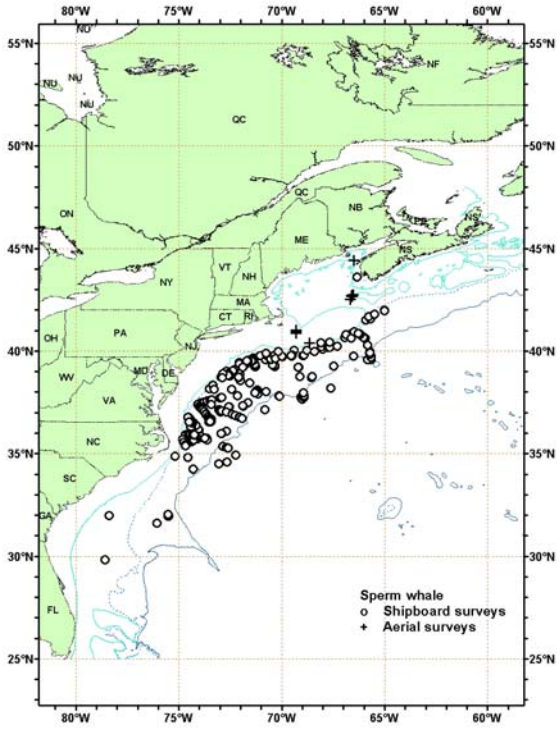

Figure 1. *Distribution of sperm whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summer in 1998, 1999, 2002, 2004 and 2006. Isobaths are the 100m, 1,000m, and 4,000m depth contours.*

Geographic distribution of sperm whales may be linked to their social structure and their low reproductive rate and both of these factors have management implications. Several basic groupings or social units are generally recognized — nursery schools, harem or mixed schools, juvenile or immature schools, bachelor schools, bull schools or pairs, and solitary bulls (Best 1979; Whitehead *et al.* 1991; Christal *et al.* 1998). These groupings have a distinct geographical distribution, with females and juveniles generally based in tropical and subtropical waters, and males more wide-ranging and occurring in higher latitudes. Male sperm whales are present off and sometimes on the

continental shelf along the entire east coast of Canada south of Hudson Strait, whereas, females rarely migrate north of the southern limit of the Canadian EEZ (Reeves and Whitehead 1997; Whitehead 2002). Off the northeast U.S., CETAP and NMFS/NEFSC sightings in shelf-edge and off-shelf waters included many social groups with calves/juveniles (CETAP 1982; Waring *et al.* 1992, 1993). The basic social unit of the sperm whale appears to be the mixed school of adult females plus their calves and some juveniles of both sexes, normally numbering 20-40 animals in all. There is evidence that some social bonds persist for many years (Christal *et al.* 1998).

POPULATION SIZE

Total numbers of sperm whales off the U.S. or Canadian Atlantic coast are unknown, although several estimates from selected regions of the habitat do exist for select time periods. Sightings were almost exclusively in the continental shelf edge and continental slope areas (Figure 1). The best recent abundance estimate for sperm whales is the sum of the estimates from the two 2004 U.S. Atlantic surveys, 4,804 (CV =0.38), where the estimate from the northern U.S. Atlantic is 2,607 (CV =0.57), and from the southern U.S. Atlantic is 2,197 (CV =0.47). This joint estimate is considered best because together these two surveys have the most complete coverage of the species' habitat. Because all the sperm whale estimates presented here were not corrected for dive-time, they are likely downwardly biased and an underestimate of actual abundance. The average dive-time of sperm whales is approximately 30 - 60 min (Whitehead *et al.* 1991; Watkins *et al.* 1993; Amano and Yoshioka 2003; Watwood *et al.* 2006), therefore, the proportion of time that they are at the surface and available to visual observers is assumed to be low.

Although the stratification schemes used in the 1990-2004 surveys did not always sample the same areas or encompass the entire sperm whale habitat, they did focus on segments of known or suspected high-use habitats off the northeastern U.S. coast. The collective 1990- 2004 data suggest that, seasonally, at least several thousand sperm whales are occupying these waters. Sperm whale abundance may increase offshore, particularly in association with Gulf Stream and warm-core ring features; however, at present there is no reliable estimate of total sperm whale abundance in the western North Atlantic.

Earlier abundance estimates

An abundance of 219 (CV=0.36) sperm whales was estimated from an aerial survey program conducted from 1978 to 1982 on the continental shelf and shelf edge waters between Cape Hatteras, North Carolina and Nova Scotia (CETAP 1982). An abundance of 338 (CV=0.31) sperm whales was estimated from an August 1990 shipboard line transect sighting survey, conducted principally along the Gulf Stream north wall between Cape Hatteras and Georges Bank (NMFS 1990; Waring *et al.* 1992). An abundance of 736 (CV=0.33) sperm whales was estimated from a June and July 1991 shipboard line- transect sighting survey conducted primarily between the 200 and 2,000m isobaths from Cape Hatteras to Georges Bank (Waring *et al.* 1992; Waring 1998). An abundance of 705 (CV=0.66) and 337 (CV=0.50) sperm whales was estimated from line transect aerial surveys conducted from August to September 1991 using the Twin Otter and AT-11, respectively (NMFS 1991). An abundance of 116 (CV=0.40) sperm whales was estimated from a June and July 1993 shipboard line-transect sighting survey conducted principally between the 200 and 2,000m isobaths from the southern edge of Georges Bank, across the Northeast Channel to the southeastern edge of the Scotian Shelf (NMFS 1993). An abundance of 623 (CV=0.52) sperm whales was estimated from an August 1994 shipboard line transect survey conducted within a Gulf Stream warm-core ring located in continental slope waters southeast of Georges Bank (NMFS 1994). An abundance of 2,698 (CV=0.67) sperm whales was estimated from a July to September 1995 sighting survey conducted by two ships and an airplane that covered waters from Virginia to the mouth of the Gulf of St. Lawrence (Palka 1996). An abundance of 2,848 (CV=0.49) sperm whales was estimated from a line-transect sighting survey conducted during 6 July to 6 September 1998 by a ship and plane that surveyed 15,900 km of track line in waters north of Maryland (38ºN). An abundance of 1,181 (CV=0.51) sperm whales was estimated from a shipboard line-transect sighting survey conducted between 8 July and 17 August 1998 that surveyed 4,163 km of track line in waters south of Maryland (38ºN) (Mullin and Fulling 2003). As recommended in the GAMMS Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable, therefore should not be used for PBR determinations. Further, due to changes in survey methodology these data should not be used to make comparisons to more current estimates.

Recent surveys and abundance estimates

An abundance of 2,607 (CV=0.57) for sperm whales was estimated from a line-transect sighting survey conducted during 12 June to 4 August 2004 by a ship and plane that surveyed 10,761 km of track line in waters north of Maryland (about 38ºN) to the Bay of Fundy (about 45ºN) (Table 1; Palka 2006). Shipboard data were collected

using the two independent team line transect method and analyzed using the modified direct duplicate method (Palka 1995) accounting for biases due to school size and other potential covariates, reactive movements (Palka and Hammond 2001), and *g(0)*, the probability of detecting a group on the track line. Aerial data were collected using the Hiby circle-back line transect method (Hiby 1999) and analyzed accounting for *g(0)* and biases due to school size and other potential covariates (Palka 2005).

A survey of the U.S. Atlantic outer continental shelf and continental slope (water depths > 50m) between Florida and Maryland (27.5 and 38ºN) was conducted during June-August, 2004. The survey employed two independent visual teams searching with 50x bigeye binoculars. Survey effort was stratified to include increased effort along the continental shelf break and Gulf Stream front in the mid-Atlantic. The survey included 5,659 km of trackline, and there were a total of 473 cetacean sightings. Sightings were most frequent in waters north of Cape Hatteras, North Carolina along the shelf break. Data were analyzed to correct for visibility bias (*g(0)*) and group-size bias employing line transect distance analysis and the direct duplicate estimator (Palka 1995; Buckland *et al.*, 2001). The resulting abundance estimate for sperm whales between Florida and Maryland was 2,197 (CV =0.47)(Table 1).

Table 1. Summary of abundance estimates for the western North Atlantic sperm whale. Month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun-Aug 2004	Maryland to the Bay of Fundy	2,607	0.57
Jun-Aug 2004	Florida to Maryland	2,197	0.47
Jun-Aug 2004	Bay of Fundy to Florida (COMBINED)	4,804	0.38

Minimum Population Estimate

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 best estimate of abundance for sperm whales is 4,804 (CV =0.38). The minimum population estimate for the western North Atlantic sperm whale is 3,539.

Current Population Trend

There are insufficient data to determine the population trends for this species.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. While more is probably known about sperm whale life history in other areas, some life history and vital rates information is available for the northwest Atlantic. These include: calving interval is 4-6 years; lactation period is 24 months; gestation period is 14.5-16.5 months; births occur mainly in July to November; length at birth is 4.0 m; length at sexual maturity 11.0-12.5 m for males and 8.3-9.2 m for females; mean age at sexual maturity is 19 years for males and 9 years for females; and mean age at physical maturity is 45 years for males and 30 years for females (Best 1974; Best *et al.* 1984; Lockyer 1981; Rice 1989).

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).

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 is 3,539. The maximum productivity rate is 0.04, the default value for cetaceans. The "recovery" factor, which accounts for endangered, depleted, threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP) is assumed to be 0.10 because the sperm whale is listed as endangered under the Endangered Species Act (ESA). PBR for the western North Atlantic sperm whale is 7.1.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

During 2001-2005, human caused mortality was 0.2 sperm whales per year (CV=unknown). This is derived from two components: 0 sperm whales per year (CV=unknown) from U.S. fisheries using observer data and 0.2 sperm whales per year from ship strikes.

Fishery Information

Detailed fishery information is reported in Appendix III.

Earlier Interactions

Several sperm whale entanglements have been documented. In July 1990, a sperm whale was entangled and subsequently released (injured) from the now prohibited pelagic drift gillnet near the continental shelf edge on southern Georges Bank. This resulted in an estimated annual fishery-related mortality and serious injury of 4.4 (CV=1.77) for 1990. In August 1993, a dead sperm whale, with longline gear wound tightly around the jaw, was found floating about 20 miles off Mt Desert Rock. In October 1994, a sperm whale was successfully disentangled from a fine- mesh gillnet in Birch Harbor, Maine. During June 1995, one sperm whale was entangled with "gear in/around several body parts" then released injured from a pelagic drift gillnet haul located on the shelf edge between Oceanographer and Hydrographer Canyons on Georges Bank. In May 1997, a sperm whale entangled in net with three buoys trailing was sighted 130 nm northwest of Bermuda. No information on the status of the animal was provided.

Other Mortality

Four hundred twenty-four sperm whales were harvested in the Newfoundland-Labrador area between 1904 and 1972 and 109 male and no female sperm whales were taken near Nova Scotia in 1964-1972 (Mitchell and Kozicki 1984) in a Canadian whaling fishery. There was also a well-documented sperm whale fishery based on the west coast of Iceland. Other sperm whale catches occurred near West Greenland, the Azores, Madeira, Spain, Spanish Morocco, Norway (coastal and pelagic), the Faroes, and Britain. At present, because of their general offshore distribution, sperm whales are less likely to be impacted by humans and those impacts that do occur are less likely to be recorded. There has been no complete analysis and reporting of existing data on this topic for the western North Atlantic.

During 1994-2000, eighteen sperm whale strandings have been documented along the U.S. Atlantic coast between Maine and Miami, Florida (NMFS unpublished data). One 1998 and one 2000 stranding off Florida showed signs of human interactions. The 1998 animal's head was severed, but it is unknown if it occurred pre- or post-mortem. The 2000 animal had fishing gear in the blowhole. In October 1999, a live sperm whale calf stranded on eastern Long Island, and was subsequently euthanized. Also, a dead calf was found in the surf off Florida in 2000.

During 2001 to 2005, fifteen sperm whale strandings were documented along the U.S. Atlantic coast and in Puerto Rico and the EEZ according the NER and SER strandings databases (Table 2). Except for the sperm whale struck by a naval vessel in the EEZ in 2001, there were no confirmed documented signs of human interactions on the other animals.

Table 2. Sperm Whale (*Physeter macrocephalus*) reported strandings along the U.S. Atlantic coast, 2001-2005.

STATE	**2001**	**2002**	**2003**	**2004**	**2005**	**TOTAL**
Massachusetts	1	1				2
North Carolina			2	1		3
South Carolina		1				1
Florida		2	2	1	1	6
EEZ	1[1]					1
Puerto Rico				1	1	2
TOTAL	**2**	**4**	**4**	**3**	**2**	**15**

[1] U.S. Navy reported ship strike

In eastern Canada, 6 dead strandings were reported in Newfoundland/Labrador in 1987-2005; 20 dead strandings along Nova Scotia in 1988-2005; 9 dead strandings on Prince Edward Island in 1988-2005; 2 dead strandings in Quebec in 1992; 5 dead strandings in New Brunswick in 2005; and 13 animals in 8 stranding events on Sable Island, Nova Scotia in 1970-1998 (Reeves and Whitehead 1997; Hooker *et al.* 1997; Lucas and Hooker 2000).

Sex was recorded for 11 of the 13 Sable island animals, and all were male, which is consistent with sperm whale distribution patterns (Lucas and Hooker 2000).

Recent mass strandings have been reported in the North Sea, including; winter 1994/1995 (21); winter 1995/1996 (16); and winter 1997/1998 (20). Reasons for the strandings are unknown, although multiple causes (e.g., unfavorable North Sea topography, ship strikes, global changes in water temperature and prey distribution, and pollution) have been suggested (Holsbeek *et al.* 1999).

Ship strikes are another source of human- induced mortality. In May 1994 a ship-struck sperm whale was observed south of Nova Scotia (Reeves and Whitehead 1997) and in May 2000 a merchant ship reported a strike in Block Canyon (NMFS, unpublished data). In spring, Block Canyon is a major pathway for sperm whales entering southern New England continental shelf waters in pursuit of migrating squid (CETAP 1982; Scott and Sadove 1997).

A potential human-caused source of mortality is from accumulation of stable pollutants (e.g., polychlorobiphenyls (PCBs), chlorinated pesticides (DDT, DDE, dieldrin, etc.), polycyclic aromatic hydrocarbons (PAHs), and heavy metals) in long lived, high -trophic level animals. Analysis of tissue samples obtained from 21 sperm whales that mass -stranded in the North Sea in 1994/1995 indicated that mercury, PCB, DDE, and PAH levels were low and similar to levels reported for other marine mammals (Holsbeek *et al.* 1999). Cadmium levels were high and double reported levels in North Pacific sperm whales. Although the 1994/1995 strandings were not attributable to contaminant burdens, Holsbeek *et al.* (1999) suggest that the stable pollutants might affect the health or behavior of North Atlantic sperm whales.

Using stranding and entanglement data, during 2001-2005, one sperm whale was confirmed struck by a ship, thus, there is an annual average of 0.2 sperm whales per year struck by ships. No sperm whale stranding mortalitiesduring this period were confirmed fishery interactions.

STATUS OF STOCK

The status of this stock relative to OSP in U.S. Atlantic EEZ is unknown, but the species is listed as endangered under the ESA. There are insufficient data to determine population trends. The current stock abundance estimate was based upon a small portion of the known stock range. Total U.S. fishery-related mortality and serious injury for this stock is less than 10% of the calculated PBR, and therefore can be considered to be insignificant and approaching a zero mortality and serious injury rate. This is a strategic stock because the species is listed as endangered under the ESA. A Draft Recovery Plan for sperm whales has been prepared and is available for review (NMFS 2006).

REFERENCES CITED

Amano M. and M. Yoshioka. 2003. Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. Mar. Ecol. Prog. Ser. 258:291-295.

Barlow, J., S. L. Swartz, T. C. Eagle, and P. R. Wade. 1995. U.S. Marine Mammal Stock Assessments: Guidelines for Preparation, Background, and a Summary of the 1995 Assessments. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-6, 73 pp.

Best, P. B. 1974. Biology of the sperm whale. Pages 53-81. *In:* W. E. Schevill (ed), The whale problem: A status report. Harvard University Press, Cambridge, Massachusetts, 419 pp.

Best, P. B. 1979. Social organization in sperm whales, *Physeter macrocephalus*. Pages 227-289. *In:* H. E. Winn and B. L. Olla (eds), Behavior of marine animals, Vol. 3: Cetaceans. Plenum Press, New York.

Best, P. B., P. A. S. Canham, and N. Macleod. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephlus*. Rep. int Whal. Commn (Special Issue) 8:51-79.

Buckland, S. T., D.R. Andersen, K.P Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling estimating abundance of biological populations. Oxford University Press, New York, 432 pp.

CETAP. 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf. Cetacean and Turtle Assessment Program, University of Rhode Island. Final Report #AA551-CT8-48 to the Bureau of Land Management, Washington, DC, 538 pp.

Christal, J., H. Whitehead, and E. Lettevall. 1998. Sperm whale social units: variation and change. Can. J. Zool., 76: 1431-1440.

Dufault, S., H. Whitehead, and M. Dillon. 1999. An examination of the current knowledge on the stock structure of sperm whales (*Physeter macrocephalus)* Worldwide. J. Cetacean Res. Manage. 1(1):1-10.

Hiby, L. 1999. The objective identification of duplicate sightings in aerial survey for porpoise. Pages 179-189 *in*:. G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson (eds). Marine Mammal Survey and Assessment Methods. Balkema, Rotterdam.

Holsbeek, L., C. R. Joiris, V. Debacker, I. B. Ali, P. Roose, J-P. Nellissen, S. Gobert, J-M. Bouquegneau, and M. Bossicart. 1999. Heavy metals, organochlorines and polycyclic aromatic hydrocarbons in sperm whales stranded in the southern North Sea during the 1994/1995 winter. Mar. Pollu. Bull. 38: 4 304-313.

Hooker, S. K., R. W. Baird, and M. A. Showell. 1997. Cetacean Strandings and bycatches in Nova Scotia, Eastern Canada, 1991-1996. Paper SC/49/05 presented to the IWC Scientific Committee, September 1997. 11 pp.

Lockyer, C. 1981. Estimates of growth and energy budget for the sperm whale. Pages 491-504 *in:* Mammals in the seas, III. FAO Fish. Ser. No. 5. FAO, Rome, 504 pp.

Lucas, Z. N. and S. K. Hooker. 2000. Cetacean strandings on Sable Island, Nova Scotia, 1970-1998. Can. Field Nat.114:45-61.

Lyrholm, T. and U. Gyllensten. 1998. Global matrilineal population structure in sperm whales as indicated by mitochondrial DNA sequences. Proc. R. Soc. Lond. B 265:1679-1684.

Lyrholm, T., O. Leimar, B. Johanneson, and U. Gyllensten. 1999. Sex-biased dispersal in sperm whales: contrasting mitochondrial and nuclear genetic structure of global populations. Proc. R. Soc. Lond. B 266: 347-354.

Mitchell, E. 1975. Progress report on whale research, Canada. Rep. int Whal. Commn 25:270-272.

Mitchell, E. and V. M. Kozicki. 1984. Reproductive condition of male sperm whales, *Physeter macrocephalus*, taken off Nova Scotia. Rep. int Whal. Commn. (Special Issue 6):243-252.

Mullin, K. D. and G. L. Fulling. 2003. Abundance of cetaceans in the southern U.S. Atlantic Ocean during summer 1998. Fish. Bull., U.S. 101:603-613.

NMFS [National Marine Fisheries Service]. 1990. Cruise results, NOAA Ship CHAPMAN, Cruise No. 90-05. Marine Mammal Sighting Survey. 5 pp. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

NMFS [National Marine Fisheries Service]. 1991. Northeast cetacean aerial survey and interplatform study. NOAA-NMFS-SEFSC and NEFSC. 4 pp. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

NMFS [National Marine Fisheries Service]. 1993. Cruise results, NOAA Ship DELAWARE II, Cruise No. DEL 93-06, Marine Mammal Survey. 5 pp. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

NMFS [National Marine Fisheries Service]. 1994. Cruise results, NOAA Ship RELENTLESS, Cruise No. RS 94-02, Marine Mammal Survey/Warm Core Ring Study. 8 pp. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

NMFS [National Marine Fisheries Service]. 2006. Draft recovery plan for the sperm whale (*Physeter macrocephalus*). National Marine Fisheries Service, Silver Spring, MD. (Available at http://www.nmfs.noaa.gov/pr/pdfs/recovery/draft_spermwhale.pdf)

Palka, D. 1995. Abundance estimate of the Gulf of Maine harbor porpoise. Rep. int Whal. Commn (Special Issue) 16:27-50.

Palka, D. 1996. Update on abundance of Gulf of Maine/Bay of Fundy harbor porpoises. NOAA/NMFS/NEFSC. Ref. Doc. 96-04; 37 pp. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Palka, D. and Hammond, P.S. 2001. Accounting for responsive movement in line transect estimates of abundance. Can. J. Fish. Aquat. Sci. 58: 777-787.

Palka, D. 2005. Aerial surveys in the northwest Atlantic: estimation of g(0). *In:* Proceedings of the workshop on estimation of g(0) in line-transect surveys of cetaceans, ed. F. Thomsen, F. Ugarte, and P.G.H. Evans. ECS Newletter No. 44 – Special Issue. April 2005. Pgs. 12-7.

Palka, D.L. 2006. Summer abundance estimates of cetaceans in US North Atlantic Navy Operating Areas. U.S. Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 06-03; 41 p. (http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0603/crd0603.pdf)

Reeves, R. R. and H. Whitehead. 1997. Status of sperm whale, *Physeter macrocephalus*, in Canada. Can. Field Nat. 111:293-307.

Rice, D. W. 1989. Sperm whale. *Physeter macrocephalus* Linnaeus, 1758. Pp. 177-233 *in:* Handbook of marine animals. Vol. 4. S. H. Ridgway and R Harrison (eds). Academic Press, London.

Scott, T. M. and S. S. Sadove. 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Mar. Mammal Sci. 13:317-321.

Schmidly, D. J. 1981. Marine mammals of the southeastern United States and the Gulf of Mexico. Department of the Interior, U.S. Fish and Wildlife Service Publication FWS/OBS-80/41, Washington, DC, 166 pp.

Wade P. R., and R. P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 pp. Available at: http://nmml.afsc.noaa.gov/library/gammsrep/gammsrep.htm.

Waring, G.T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker. 2001. Characterization of beaked whale (*Ziphiidae*) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. Mar. Mammal Sci. 17(4):703-717.

Waring, G. T., C. P. Fairfield, C. M. Ruhsam, and M. Sano. 1992. Cetaceans associated with Gulf Stream features off the northeastern USA shelf. ICES. C.M. 1992/N:12. 29 pp.

Waring, G. T., C. P. Fairfield, C. M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the northeastern USA shelf. Fish. Oceanogr. 2:101-105

Waring, G. T. 1998. Results of the summer 1991 R/V Chapman marine mammal sighting survey. NOAA-NMFS-NEFSC, Lab. Ref. Doc. No. 98-09, 21 pp. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Watkins, W. A., K. E. Moore, and P. Tyack. 1985. Sperm whale acoustic behavior in the southeast Caribbean. Cetology 49:1-15.

Watkins, W. A., M. A. Daher, K. M. Fristrup, and T. J. Howard, and G. Notarbatolo di Sciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Mar. Mammal Sci. 9:55-67.

Watwood, S.L., P.J.O. Miller, M. Johnson, P.T. Madsen, and P.L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales (Physeter macrocephalus). J. Anim. Ecol. 75:814-825.

Whitehead, H. 2002. Sperm whales social evolution in the ocean. The University of Chicago Press, Chicago, 431 pp.

Whitehead, H., S. Brennan, and D. Grover. 1991. Distribution and behavior of male sperm whales on the Scotian Shelf, Canada. Can. J. Zool. 70:912-918.