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HARBOR SEAL (*Phoca vitulina*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The harbor seal is found in all nearshore waters of the Atlantic Ocean and adjoining seas above about 30 degrees latitude (Katona *et al.* 1993). In the western North Atlantic, they are distributed from the eastern Canadian Arctic and Greenland south to southern New England and New York, and occasionally to the Carolinas (Boulva and McLaren 1979; Katona *et al*. 1993; Gilbert and Guldager 1998). Stanley *et al.* (1996) examined worldwide patterns in harbor seal mitochondrial DNA, which indicate that western and eastern North Atlantic harbor seals populations are highly differentiated. Further, they suggest that harbor seal females are only regionally philopatric, thus population or management units are on the scale of a few hundred kilometers. Although the stock structure of the western North Atlantic population is unknown, it is thought that harbor seals found along the eastern USA and Canadian coasts represent one population (Temte *et al*. 1991). In U.S. waters, breeding and pupping normally occur in waters north of the New Hampshire/Maine border, although breeding occurred as far south as Cape Cod in the early part of the twentieth century (Temte *et al.* 1991; Katona *et al*. 1993).

Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Katona *et al*. 1993), and occur seasonally along the southern New England and New York coasts from September through late May (Schneider and Payne 1983). In recent years, their seasonal interval along the southern New England to New Jersey coasts has increased (Barlas 1999; Hoover *et al*. 1999; Slocum *et al.* 1999). Scattered sightings and strandings have been recorded as far south as Florida (NMFS unpublished data). A general southward movement from the Bay of Fundy to southern New England waters occurs in autumn and early winter (Rosenfeld *et al.* 1988; Whitman and Payne 1990; Barlas 1999). A northward movement from southern New England to Maine and eastern Canada occurs prior to the pupping season, which takes place from mid-May through June along the Maine Coast (Richardson 1976; Wilson 1978; Whitman and Payne 1990; Kenney 1994). No pupping areas have been identified in southern New England (Payne and Schneider 1984; Barlas 1999). The overall geographic range throughout coastal New England has not changed significantly during the last century (Payne and Selzer 1989).

The majority of seals moving into southern New England and mid-Atlantic waters are subadults and juveniles (Whitman and Payne 1990; Katona *et al*. 1993; Slocum *et al.* 1999). Whitman and Payne (1990) suggest that the age-related dispersal may reflect the higher energy requirements of younger animals.

POPULATION SIZE

Since passage of the MMPA in 1972, the number of seals along the New England coast has increased nearly five-fold. Coast-wide aerial surveys along the Maine coast have been conducted in May/June during pupping in 1981, 1982, 1986, 1993, and 1997 (Table 1; Gilbert and Stein 1981; Gilbert and Wynne 1983, 1984; Kenney 1994; and Gilbert and Guldager 1998). The following numbers are considered to be a minimum abundance estimate because they are uncorrected for animals in the water or outside the survey area. A coast-wide survey, which included replicate surveys and radio tagged seals to obtain a correction factor, was conducted in May/June 2001. Data are presently under analysis. Increased abundance of seals in the northeast region has also been documented during aerial and boat surveys of overwintering haul-out sites in between the Maine/New Hampshire border to eastern Long Island and New Jersey (Payne and Selzer 1989; Rough 1995; Barlas 1999; Hoover *et al*. 1999; Slocum *et al.* 1999). Canadian scientists counted 3,500 harbor seals during an August 1992 aerial survey in the Bay of Fundy (Stobo and Fowler 1994), but noted that the survey was not designed to obtain a population estimate.

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

Month/Year	Area	N_{min}	CV
May/June 1997	Maine coast	30,990 (5,359)	None reported

[1]Pup counts are in brackets

Minimum Population Estimate

A minimum population estimate is 30,990 seals, based on uncorrected total counts along the Maine coast in 1997.

Current Population Trend

The average increase in counts over the 1981-1997 survey period (e.g., 1981, 1982, 1986, 1993 and 1997) has been 4.2 % (Gilbert and Guldager 1998), about 50% of the 8.9 percent annual increase estimated by Kenney (1994) from counts through 1993. This suggests that population increase may have slowed. Similarly, the number of pups along the Maine coast has increased at an annual rate of 12.9% over the 1981-1997 period (Gilbert and Guldager 1998). Possible factors contributing to harbor seal population increase include MMPA protection, increased prey, and fishery management regulations (e.g., closed areas, fishing effort reduction) designed to rebuild groundfish stocks.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.12. This value is based on theoretical modeling showing that pinniped populations may not grow at rates much greater than 12% 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 30,990. The maximum productivity rate is 0.12, the default value for pinnipeds. The recovery factor (F_R) for this stock is 1.0, the value for stocks of unknown status, but is known to be increasing. PBR for USA waters is 1,859.

ANNUAL HUMAN-CAUSED MORTALITY

For the period 1996-2000, the total estimated human caused mortality and serious injury to harbor seals is estimated to be 857 per year. The average is derived from two components: 1) 843 (CV=0.17; Table 2) from the 1995-1999 observed fishery; and 2) 14 from average 1997-2000 stranding mortalities resulting from boat strikes, power plant entrainments, shooting, and other sources.

Researchers and fishery observers have documented incidental mortality in several fisheries, particularly within the Gulf of Maine (see below). An unknown level of mortality also occurred in the mariculture industry (*i.e.*, salmon farming), and by deliberate shooting (NMFS unpublished data). However, there are no recent data to indicate that shooting around aquaculture sites still takes place.

Fishery Information

USA

Data on current incidental takes in USA fisheries are available from several sources. In 1986, NMFS established a mandatory self-reported fisheries information system for large pelagic fisheries. Data files are maintained at the Southeast Fisheries Science Center (SEFSC). The Northeast Fisheries Science Center (NEFSC) Sea Sampling Observer Program was initiated in 1989, and since that year several fisheries have been covered by the program. In late 1992 and in 1993, the SEFSC provided observer coverage of pelagic longline vessels fishing off the Grand Banks (Tail of the Banks) and provides observer coverage of vessels fishing south of Cape Hatteras.

Incidental takes of harbor seals have been recorded in groundfish gillnet, herring purse seine, halibut tub trawl, and lobster fisheries (Gilbert and Wynne, 1985 and 1987). A study conducted by the University of Maine reported a combined average of 22 seals entangled annually by 17 groundfish gillnetters off the coast of Maine (Gilbert and Wynne 1987). All seals were young of the year and were caught from late June through August and in early October. Interviews with a limited number of mackerel gillnetters indicated only one harbor seal entanglement and a negligible loss of fish to seals. Net damage and fish robbing were not reported to be a major economic concern to gillnetters interviewed (Gilbert and Wynne 1987).

Herring purse seiners have reported accidentally entrapping seals off the mid-coast of Maine, but indicated that the seals were rarely drowned before the seine was emptied (Gilbert and Wynne 1985). Capture of seals by

halibut tub trawls are rare. One vessel captain indicated that he took one or two seals a year. These seals were all hooked through the skin and released alive, indicating they were snagged as they followed baited hooks. Infrequent reports suggest seals may rob bait off longlines, although this loss is considered negligible (Gilbert and Wynne 1985).

Incidental takes in lobster traps in inshore waters off Maine are reportedly rare. Captures of approximately two seal pups per port per year were recorded by mid-coastal lobstermen off Maine (Gilbert and Wynne 1985). Seals have been reported to rob bait from inshore lobster traps, especially in the spring, when fresh bait is used. These incidents may involve only a few individual animals. Lobstermen claim that seals consume shedding lobsters.

Northeast Multispecies Sink Gillnet:

In 1993, there were approximately 349 full and part-time vessels in the Northeast multispecies sink gillnet fishery, which covered the Gulf of Maine and southern New England (Table 2). An additional 187 vessels were reported to occasionally fish in the Gulf of Maine with gillnets for bait or personal use; however, these vessels were not covered by the observer program (Walden 1996) and their fishing effort was not used in estimating mortality. In 1998, there were approximately 301 vessels in this fishery (NMFS unpublished data). Observer coverage in terms of trips has been 1%, 6%, 7%, 5%, 7%, 5%, 4%, 6%, 5%, 6%, and 6% for 1990 to 2000, respectively. The fishery has been observed in the Gulf of Maine and in Southern New England. There were 362 harbor seal mortalities, excluding three animals taken in the 1994 pinger experiment (NMFS unpublished data), observed in the Northeast multispecies sink gillnet fishery between 1990 and 2000. Annual estimates of harbor seal bycatch in the Northeast multispecies sink gillnet fishery reflect seasonal distribution of the species and of fishing effort. Estimated annual mortalities (CV in parentheses) from this fishery during 1990- 2000 were 602 in 1990 (0.68), 231 in 1991 (0.22), 373 in 1992 (0.23), 698 in 1993 (0.19), 1,330 in 1994 (0.25), 1,179 in 1995 (0.21), 911 in 1996 (0.27), 598 in 1997 (0.26), 332 in 1998 (0.33), 1446 in 1999 (0.34), and 917 (0.43) in 2000. The 1994 and 1995 bycatches, respectively, include 14 and 179 animals from the estimated number of unknown seals (based on observed mortalities of seals that could not be identified to species). The unknown seals were prorated, based on spatial/temporal patterns of bycatch of harbor seals, gray seals, harp seals, and hooded seals. Average annual estimated fishery-related mortality and serious injury to this stock attributable to this fishery during 1996-2000 was 843 harbor seals (CV= 0.17). The stratification design used is the same as that for harbor porpoise (Bravington and Bisack 1996). The bycatch occurred in Massachusetts Bay, south of Cape Ann and west of Stellwagen Bank during January-March. Bycatch locations became more dispersed during April-June from Casco Bay to Cape Ann, along the 30 fathom contour out to Jeffreys Ledge, with one take location near Cultivator Shoal and one off southern New England near Block Island. Incidental takes occurred from Frenchman's Bay to Massachusetts Bay during July-September. In inshore waters, the takes were aggregated while offshore takes were more dispersed. Incidental takes were confined from Cape Elizabeth out to Jeffreys Ledge and south to Nantucket Sound during October-December.

Mid-Atlantic Coastal Gillnet

Observer coverage of the USA Atlantic coastal gillnet fishery was initiated by the NEFSC Sea Sampling program in July, 1993; and from July to December 1993, 20 trips were observed. During 1994 and 1995, 221 and 382 trips were observed, respectively. This fishery, which extends from North Carolina to New York, is actually a combination of small vessel fisheries that target a variety of fish species, some of which operate right off the beach. The number of vessels in this fishery is unknown, because records which are held by both state and federal agencies have not been centralized and standardized. Observer coverage, expressed as percent of tons of fish landed, was 5%, 4%, 3%, 5%, 2%, and 2% for 1995, 1996, 1997, 1998, 1999, and 2000, respectively (Table 2).

No harbor seals were taken in observed trips during 1993-1997, and 1999-2000. Two harbor seals were observed taken in 1998 (Table 2). Observed effort was concentrated off NJ and scattered between DE and NC from 1 to 50 miles off the beach. All bycatches were documented during January to April. Using the observed takes, the estimated annual mortality (CV in parentheses) attributed to this fishery was 0 in 1995-1997 and 1999-2000 and 11 in 1998 (0.77). Average annual estimated fishery-related mortality attributable to this fishery during 1996-2000 was 2 harbor seals (CV=0.77).

CANADA

An unknown number of harbor seals have been taken in Newfoundland, Labrador, Gulf of St. Lawrence and Bay of Fundy groundfish gillnets, Atlantic Canada and Greenland salmon gillnets, Atlantic Canada cod traps, and in Bay of Fundy herring weirs (Read 1994). Furthermore, some of these mortalities (e.g., seals trapped in herring weirs) are the result of direct shooting.

There were 3,121 cod traps operating in Newfoundland and Labrador during 1979, and about 7,500 in 1980 (Read 1994). This fishery was closed at the end of 1993 due to collapse of Canadian groundfish resources.

Herring weirs are also distributed throughout the Bay of Fundy; it has been reported that 180 weirs were operating in the Bay of Fundy in 1990 (Read 1994).

In 1996, observers recorded seven harbor seals (one released alive) in Spanish deep water trawl fishing on the southern edge of the Grand Bank (NAFO Areas 3) (Lens, 1997). Seal bycatches occurred year-round, but interactions were highest during April-June. Many of the seals that died during fishing activities were unidentified. The proportion of sets with mortality (all seals) was 2.7 per 1,000 hauls (0.003).

Table 2. Summary of the incidental mortality of harbor seals (*Phoca vitulina*) by commercial fishery including the years sampled (Years), the number of vessels active within the fishery (Vessels), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the mortalities recorded by on-board observers (Observed Mortality), the estimated annual mortality (Estimated Mortality), the estimated CV of the annual mortality (Estimated CVs) and the mean annual mortality (CV in parentheses).

Fishery	Years	Vessels	Data Type [1]	Observer Coverage [2]	Observed Mortality	Estimated Mortality	Estimated CVs	Mean Annual Mortality
Northeast [3] Multispecies Sink Gillnet	96-00	301	Obs. Data Weighout, Logbooks	.04, .06, .05, .06, .06	36, 48, 15, 49, 26	911, 598, 332, 1446, 917	.27, .26, .33, .34, .43	841 (0.17)
mid-Atlantic Coastal Sink Gillnet	96-00	Unk[4]	Obs. Data Weighout	.04, .03, .05, .02, .02	0, 0, 2, 0, 0	0, 0, 11, 0, 0	0, 0, .77, 0, 0	2 (.77)
TOTAL								843 (0.17)

[1] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Science Center (NEFSC) Sea Sampling Program. NEFSC collects landings data (Weighout), and total landings are used as a measure of total effort for the sink gillnet fishery. Mandatory logbook (Logbook) data are used to determine the spatial distribution of fishing effort in the Northeast multispecies sink gillnet fishery.

[2] The effort for the Northeast multispecies sink gillnet fishery is measured in trips. Observer coverage of the mid-Atlantic coastal gillnet fishery is measured in tons of fish landed.

[3] In 1996, 1997, 1998, 1999, and 2000 respectively, observed mortality on "marine mammal trips" was 37, 14, 13, 45, and 26 animals. Only these mortalities were used to estimate total harbor seal bycatch. See Bisack (1997) for "trip" type definitions. In 1996 to 2000, 3, 1, 2, 4, and 3 harbor seals were observed on dedicated fish sampling trips. In 1996 to 2000, 2, 14, 1, 5, and 8 harbor seals were observed taken in nets equipped with pingers.

[4] Number of vessels is not known.

Other Mortality

Harbor seals were bounty hunted in New England waters until the mid- 1960's. This hunt may have caused the demise of this stock in USA waters (Katona *et al*. 1993).

Annually, small numbers of harbor seals regularly strand throughout their migratory range. Most reported strandings, however, occur during the winter period in southern New England and mid-Atlantic regions (NMFS unpublished data). Sources of mortality include human interactions (boat strikes and fishing gear, power plant intake (12-20 per year; NMFS unpublished data), oil, shooting (around salmon aquaculture sites and fixed fishing gear), storms, abandonment by the mother, and disease (Katona *et al*. 1993; NMFS unpublished data). Interactions with Maine salmon aquaculture operations appears to be increasing, although the magnitude of interactions and seal mortalities has not been quantified (Anon 1996). In 1980, more than 350 seals were found dead in the Cape Cod area from an influenza outbreak (Geraci *et al*. 1981).

The 1992-1996 harbor seal strandings data are currently under review. In 1995 one stranding was in South Carolina. Reported harbor seal strandings during 1997-2000 were: 1997 (153),1998 (256), 1999 (150), and 2000 (219). Strandings were reported in all states between Maine and North Carolina, and in 1997 one each was reported in Georgia and Florida. Maine (350/778), Massachusetts (190/778), New York (78/778) and New Jersey (46/778) accounted for most of the strandings, reflecting both long coastlines and habitat use. Fifty five (7%) of the stranded animals during this four year period showed signs of human interactions: fishery (14), vessel strike (4), power plant (22), and other (15). Further, many live strandings are euthanized due to condition of the animals. Some sick and injured seals are transported to rehabilitation facilities.

Stranding data probably underestimate the extent of fishery-related mortality and serious injury because not all of the marine mammals which die or are seriously injured may wash ashore, nor will all of those that do wash ashore necessarily show signs of entanglement or other fishery-interaction.

Stobo and Lucas (2000) have documented shark predation as an important source of natural mortality at Sable Island, Nova Scotia. They suggest that shark-inflicted mortality in pups, as a proportion of total production, was less than 10% (1980-1993), approximately 25% (1994-1995), and increasing to 45% in 1996. Also, shark predation on adults was selective towards mature females. They suggest that the combined predation mortality is likely impacting the Sable Island population growth, and may be contributing to the observed population decline.

STATUS OF STOCK

The status of harbor seals, relative to OSP, in the US Atlantic EEZ is unknown, but the population is increasing. The species is not listed as threatened or endangered under the Endangered Species Act. Gilbert and Guldager (1998) estimated a 4.4% annual rate of increase of this stock in Maine coastal waters based on 1981, 1982, 1986, 1993, 1997 surveys conducted along the Maine coast. The population is increasing despite the known fishery-related and other human sources of mortality. Total fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be approaching zero mortality and serious injury rate. This is not a strategic stock because fishery-related mortality and serious injury does not exceed PBR.

REFERENCES

Anon. 1996. Report of the Gulf of Maine Aquaculture-Pinniped Interaction task Force. Available from NMFS, Office of Protected Resources. Silver Spring, MD. 70 pp.

Barlas, M. E. 1999. The distribution and abundance of harbor seals (*Phoca vitulina concolor*) and gray seals (*Halichoerus grypus*) in southern New England, winter 1998- summer 1999. MA Thesis, Boston University, Graduate School of Arts and Sciences., Boston, MA. 52 pp.

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.

Bisack, K. D. 1997. Harbor porpoise bycatch estimates in the New England multispecies sink gillnet fishery: 1994 and 1995. *Rep. int Whal. Commn*. 47:705-14.

Boulva, J. and I. A. McLaren. 1979. Biology of the harbor seal, *Phoca vitulina*, in eastern Canada. *Bull. Fish. Res. Bd. Can.* 200:1-24.

Bravington, M. V. and K. D. Bisack. 1996. Estimates of harbor porpoise bycatch in the Gulf of Maine sink gillnet fishery, 1990-93. *Rep. int Whal. Commn.* 46:567-574.

Geraci, R., D. J. St. Aubin and I. K. Barker. 1981. Mass mortality of harbor seals: pneumonia associated with influenza A virus. *Science* 215: 1129-1131.

Gilbert, J. R. and J. L. Stein. 1981. Harbor seal populations and marine mammal fisheries interactions, 1981. Annual report to Northeast Fisheries Science Center. Contract NA-80-FA-C-00029. 35p.

Gilbert, J. R. and K. M. Wynne. 1983. Harbor seal populations and marine mammal fisheries interactions, 1982. Second annual report. Northeast Fisheries Science Center. Contract NA-80-FA-C-00029. 43p.

Gilbert, J. R. and K. M. Wynne. 1984. Harbor seal populations and marine mammal fisheries interactions, 1983. Third annual report. Northeast Fisheries Science Center. Contract NA-80-FA-C-00029. 52p.

Gilbert, J. R. and K. M. Wynne. 1985. Harbor seal populations and fisheries interactions with marine mammals in New England, 1984. Interim Rep., NOAA NA-84-EAC-00070, NMFS, NEFSC, Woods Hole, MA, 15 pp.

Gilbert, J. R. and K. M. Wynne. 1987. Marine mammal interactions with New England gillnet fisheries. Final Report Contract No. NA-84-EAC-00070, NOAA, NMFS, NEFSC, Woods Hole, MA. 21 pp.

Gilbert, J. R. and N. Guldager. 1998. Status of harbor and gray seal populations in northern New England. Final Report to: National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA. Under NMFS/NER Cooperative Agreement 14-16-009-1557. 13 pp.

Hoover, K., S. Sadove and P. Forestell. 1999. Trends of harbor seal, *Phoca vitulina*, abundance from aerial surveys in New York waters: 1985-1999. Proceedings of the 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Hawaii, Nov. 28 - Dec. 3, 1999. (Abstract).

Katona, S. K., V. Rough and D. T. Richardson. 1993. A field guide to whales, porpoises, and seals from Cape Cod to Newfoundland. *Smithsonian Institution Press*: Washington, DC, 316 pp.

Kenney, M. K. 1994. Harbor seal population trends and habitat use in Maine. M.S. Thesis. University of Maine, Orono, ME. 55 pp.

Kenney, M. K. and J. R. Gilbert. 1994. Increase in harbor and gray seal populations in Maine. Final Report Contract No. 50-EANF-2-00064. NOAA, NMFS, NEFSC, Woods Hole, MA. 19 pp.

Lens, S. 1997. Interactions between marine mammals and deep water trawlers in the NAFO regulatory area. *ICES C.M. 8/Q. 10 pp.*

Payne. P. M. and D. C. Schneider. 1984. Yearly changes in abundance of harbor seals, *Phoca vitulina*, at a winter haul-out site in Massachusetts. *Fish. Bull., U.S.* 82: 440-442.

Payne, P. M. and L. A. Selzer. 1989. The distribution, abundance and selected prey of the harbor seal, *Phoca vitulina concolor*, in southern New England. *Mar. Mammal Sci.* 5(2): 173-192.

Read, A. J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the northwest Atlantic. *Rep. int Whal. Commn*. Special Issue 15: 133-147.

Richardson, D. T. 1976. Assessment of harbor and gray seal populations in Maine 1974-1975. Final report to Marine Mammal Commission. Contract No. MM4AC009.

Rosenfeld M., M. George and J. M. Terhune. 1988. Evidence of autumnal harbour seal, *Phoca vitulina*, movement from Canada to the United States. *Can. Field-Nat.* 102(3): 527-529.

Rough, V. 1995. Gray seals in Nantucket Sound, Massachusetts, winter and spring, 1994. Final report to Marine Mammal Commission, Contract T10155615, 28 pp. NTIS Pub. PB95-191391.

Schneider, D. C. and P. M. Payne. 1983. Factors affecting haul-out of harbor seals at a site in southeastern Massachusetts. *J. Mamm.* 64(3): 518-520.

Slocum, C.J., R. Schoelkopf, S. Tulevech, M. Stevens, S. Evert and M. Moyer. 1999. Seal populations wintering in New Jersey (USA) have increased in abundance and diversity. Proceedings of the 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Hawaii, Nov. 28 - Dec. 3, 1999. (Abstract).

Stanley, H. F., S. Casey, J. M. Carnahan, S. Goodman, J. Harwood, and R. K. Wayne. 1996. Worldwide patterns of mitochondrial DNA differentiation in the harbor seal (*Phoca vitulina*). *Mol. Biol. Evol*. 13: 368-382.

Stobo, W. T. and G. M. Fowler. 1994. Aerial surveys of seals in the Bay of Fundy and off southwest Nova Scotia. *Can. Tech. Rep. Fish. Aquat. Sci.* 1943:57 pp.

Stobo, W. T. and Z. Lucas. 2000. Shark-inflicted mortality on a population of harbour seals (*Phoca vitulina*) at Sable Island, Nova Scotia. *J. Zool. Lond*. 252: 405-414.

Temte, J. L., M. A. Bigg and O. Wiig. 1991. Clines revisited: the timing of pupping in the harbour seal (*Phoca vitulina*). *J. Zool. Lond*. 224: 617-632.

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.

Walden, J. 1996. The New England gillnet effort survey. NOAA-NMFS-NEFSC Ref. Doc. 99-10. 38 pp. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Whitman, A. A. and P. M. Payne. 1990. Age of harbour seals, *Phoca vitulina concolor*, wintering in southern New England. *Can. Field-Nat.* 104(4): 579-582.

Wilson, S. C. 1978. Social organization and behavior of harbor seals, *Phoca concolor*, in Maine. Final Report to Marine Mammal Commission, Contract MM6ACO13, GPO-PB-280-188.