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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 30ºN (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 (Mansfield 1967; Boulva and McLaren 1979; Katona *et al.* 1993; Gilbert and Guldager 1998; Baird 2001). Stanley *et al.* (1996) examined worldwide patterns in harbor seal mitochondrial DNA, which indicate that western and eastern North Atlantic harbor seal populations are highly differentiated. Further, they suggested 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 U.S. 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, to New Jersey coasts from September through late May (Schneider and Payne 1983; Barlas 1999; Schroeder 2000; deHart 2002). Scattered sightings and strandings have been recorded as far south as Florida (NMFS unpublished data).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; Jacobs and Terhune 2000). 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; deHart 2002). While earlier research identified no pupping areas southern New England (Payne and Schneider 1984; Barlas 1999), more recent information suggests that some pupping is occurring at high-use haulout sites off Manomet, Massachusetts (B. Rubinstein, pers. comm., New England Aquarium). The overall geographic range throughout coastal New England has not changed significantly during the last century (Payne and Selzer 1989).

Prior to the spring 2001 live-capture and radio-tagging of adult harbor seals, it was believed that the majority of seals moving into southern New England and mid-Atlantic waters were subadults and juveniles (Whitman and Payne 1990; Katona *et al.* 1993). The 2001 study established that adult animals also made this migration. Seventy-five percent (9/12) of the seals tagged in March in Chatham Harbor seals were detected at least once during the May/June 2001 abundance survey along the Maine coast (Gilbert *et al.* 2005; Waring *et al.* 2006).

POPULATION SIZE

Since passage of the MMPA in 1972, the observed count of seals along the New England coast has been increasing. Coast-wide aerial surveys along the Maine coast were conducted in May/June 1981, 1986, 1993, 1997, and 2001 during pupping (Gilbert and Stein 1981; Gilbert and Wynne 1983; 1984; Kenney 1994; Gilbert and Guldager 1998; Gilbert *et al.* 2005). However, estimates older than eight years are deemed unreliable (Wade and Angliss 1997), and should not be used for PBR determinations. Therefore, only the 2001 estimate is useful for population assessment. The 2001 survey, conducted in May/June, included replicate surveys and radio tagged seals to obtain a correction factor for animals not hauled out. The corrected estimate for 2001 is 99,340 (23,722). The 2001 observed count of 38,014 is 28.7% greater than the 1997 count. Increased abundance of seals in the Northeast region has also been documented during aerial and boat surveys of overwintering haul-out sites from the Maine/New Hampshire border to eastern Long Island and New Jersey (Payne and Selzer 1989; Rough 1995; Barlas 1999; Schroeder 2000; deHart 2002) .

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. The Sable Island population was the largest in eastern Canada in the late 1980s, however recently the number has drastically declined (Baird 2001). Similarly, pup production declined on Sable Island from 600 in 1989 to around a dozen pups or fewer by 2002 (Baird 2001; Bowen *et al.* 2003). A decline in the number of juveniles and adults did not occur immediately, but a decline was observed in these age classes as a result of the reduced number of pups moving into the older age classes (Bowen *et al.* 2003). Possible reasons for this decline may be increased use of the island by

gray seals and increased predation by sharks (Stobo and Lucas 2000; Bowen *et al*. 2003). Helicopter surveys have also been flown to count hauled-out animals along the coast and around small islands in parts of the Gulf of St. Lawrence and the St Lawrence estuary. In the estuary, surveys were flown in June 1995, 1996, and 1997, and in August 1994, 1995, 1996 and 1997; different portions of the Gulf were surveyed in June 1996 and 2001 (Robillard *et al.* 2005). Changes in counts over time in sectors that were flown under similar conditions were examined at nine sites that were surveyed in June and in August. Although all slopes were positive, only one was significant, indicating numbers are likely stable or increasing slowly. Overall, the June surveys resulted in an average of 469 (SD=60, N=3) hauled-out animals, which is lower than a count of 621 (SD=41, N=3) hauled-out animals flown under similar conditions in August. Aerial surveys in the Gulf of St. Lawrence resulted in counts of 467 animals in 1996 and 423 animals in 2001 for a different area (Robillard et al. 2005).

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_{best}) and coefficient of variation (CV).

Month/Year	**Area**	**N_{best}** [a]	**CV**
May/June 2001	Maine coast	99,340 (23,722) [b]	CV=.097

[a] Pup counts are in brackets

[b] Corrected estimate based on uncorrected count of 38,011 (9,278)

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 harbor seals is 99,340 (CV=.097). The minimum population estimate is 91,546 based on corrected total counts along the Maine coast in 2001.

Current Population Trend

Between 1981 and 2001, the uncorrected counts of seals increased from 10,543 to 38,014, an annual rate of 6.6 percent (Gilbert et al. 2005).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this population. Based on uncorrected haulout counts over the 1981 to 2001 survey period, the harbor seal population is growing at approximately 6.6% (Gilbert et al. 2005). However, a population grows at the maximum growth rate (R_{max}) only when it is at a very low level; thus the 6.6% growth rate is not considered to be a reliable estimate of (R_{max}). 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 (½ of 12%), and a "recovery" factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 91,546. The recovery factor (F_R) for this stock is 0.5, the value for stocks of unknown status. PBR for U.S. waters is 2,746.

ANNUAL HUMAN-CAUSED MORTALITY

For the period 2002-2006 the total human caused mortality and serious injury to harbor seals is estimated to be 621 per year. The average was derived from two components: 1) 611 (CV=0.15); Table 2) from the 2002-2006 observed fishery; and 2) 10 from average 2002-2006 non-fishery related, human interaction stranding mortalities (NMFS unpublished data).

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, no data are available to determine

whether shooting still takes place.

Fishery Information

Detailed Fishery information is given in Appendix III.

U.S.

Northeast Sink Gillnet:

Annual estimates of harbor seal bycatch in the Northeast sink gillnet fishery reflect seasonal distribution of the species and of fishing effort. The fishery has been observed in the Gulf of Maine and in southern New England (Williams 1999; NMFS unpublished data). There were 545 harbor seal mortalities observed in the Northeast sink gillnet fishery between 1990 and 2006, excluding three animals taken in the 1994 pinger experiment (NMFS unpublished data). Williams (1999) aged 261 harbor seals caught in this fishery from 1991 to 1997, and 93% were juveniles (e.g. less than four years old). Estimated annual mortalities (CV in parentheses) from this fishery were 332 (0.33) in 1998, 1,446 (0.34) in 1999, 917 (0.43) in 2000, 1,471 (0.38) in 2001, 787 (0.32) in 2002, 542 (0.28) in 2003, 792 (0.34) in 2004, 719 (0.20) in 2005, and 87 (.58) in 2006 (Table 2). The stratification design used is the same as that for harbor porpoise (Bravington and Bisack 1996). There were 2, 2, 9, 14, and 8 unidentified seals observed during 2002-2006, respectively. Since 1997, unidentified seals have not been prorated to a species. This is consistent with the treatment of other unidentified mammals that do not get prorated to a specific species. Average annual estimated fishery-related mortality and serious injury to this stock attributable to this fishery during 2002-2006 was 585 harbor seals (CV=0.15) (Table 2).

Mid-Atlantic Gillnet

No harbor seals were taken in observed trips during 1993-1997, or 1999-2003. Two harbor seals were observed taken in 1998, one in 2004, two in 2005, and one in 2006. Using the observed takes, the estimated annual mortality (CV in parentheses) attributed to this fishery was 0 in 1995-1997 and 1999-2003, 11 in 1998 (0.77), 15 (0.86) in 2004, 63 (0.67) in 2005, and 26 (.98) in 2006. In 2002, 65% of observer coverage was concentrated in one area and not distributed proportionally across the fishery. Therefore observed mortality is considered unknown in 2002. Average annual estimated fishery-related mortality attributable to this fishery during 2002-2006 was 26 (CV=0.49) harbor seals (Table 2).

Northeast Bottom Trawl

Two harbor seal mortalities were observed between 2001 and 2006, one in 2002 and one in 2005. (Table 2). The estimated annual fishery-related mortality and serious injury attributable to this fishery has not been generated.

Gulf of Maine Atlantic Herring Purse Seine Fishery

The Gulf of Maine Atlantic Herring Purse Seine Fishery is a Category III fishery. This fishery was not observed until 2003. No mortalities have been observed, but 11 harbor seals were captured and released alive in 2004 and 4 in 2005. In addition, 5 seals of unknown species were captured and released alive in 2004 and 2 in 2005. This fishery was not observed in 2006.

CANADA

Currently, scant data are available on bycatch in Atlantic Canada fisheries due to a lack of observer programs (Baird 2001). 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; Cairns *et al.* 2000). Furthermore, some of these mortalities (e.g., seals trapped in herring weirs) are the result of direct shooting.

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 [a]	Observer Coverage [b]	Observed Mortality	Estimated Mortality	Estimated CVs	Mean Annual Mortality
Northeast Sink Gillnet [c]	02-06	unk [d]	Obs. Data, Weighout, Logbooks	.02, .03, .06, .07, .04	12, 21, 45, 70, 3	787, 542, 792, 719, 87	.32, .28, .34, .20, .58	585 (0.15)
Mid-Atlantic Gillnet	02-06	unk [d]	Obs. Data, Weighout	.01, .01, .02, .03, .04	unk [e], 0, 1, 2, 1	unk [e], 0, 15, 63, 26	unk [e], 0, .86, .67, .98	26 (0.49) [e]
Northeast Bottom Trawl	02-06	unk [d]	Obs. Data, Weighout	.03, .04 .05, .12, .06	1, 0, 0, 1, 0	unk [f], 0, 0, unk [f], 0	unk [f], 0, 0, unk [f], 0	unk [f]
TOTAL								611 (0.15)

[a] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer 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 sink gillnet fishery.

[b] The observer coverages for the Northeast sink gillnet fishery and the mid-Atlantic gillnet fisheries are ratios based on tons of fish landed and coverages for the northease bottom trawl are ratios based on trips.

[c] Since 1998, takes from pingered and non-pingered nets within a marine mammal time/area closure that required pingers, and takes from pingered and non-pingered nets not within a marine mammal time/area closure were pooled. The pooled bycatch rate was weighted by the total number of samples taken from the stratum and used to estimate the mortality. In 2002 - 2006, respectively, 3, 0, 8, 3, and 3 takes were observed in nets with pingers. In 2002 – 2006, respectively, 9, 21, 37, 67, and 0 takes were observed in nets without pingers.

[d] Number of vessels is not known.

[e] Sixty-five percent of sampling in the mid-Atlantic coastal gillnet by the NEFSC fisheries observer program was concentrated in one area off the coast of Virginia. Because of the low level of sampling that was not distributed proportionately throughout the mid-Atlantic region observed mortality is considered unknown in 2002. The four year average (2003- 2006) estimated mortality was applied as the best representative estimate.

[f] Analysis of bycatch mortality attributed to the Northeast bottom trawl fishery for the years 2002-2006 has not been generated.

Other Mortality

Historically, harbor seals were bounty hunted in New England waters, which may have caused a severe decline of this stock in U.S. waters (Katona *et al.* 1993). Bounty hunting ended in the mid-1960s.

Currently, aquaculture operations in eastern Canada are licensed to shoot nuisance seals, but the number of seals killed is unknown (Baird 2001). Other sources of harbor seal mortality include human interactions, storms, abandonment by the mother, disease, and predation (Katona *et al.* 1993; NMFS unpublished data; Jacobs and Terhune 2000). Mortalities caused by human interactions include boat strikes, fishing gear interactions, power plant entrainment, oil spill/exposure, harassment, and shooting.

Small numbers of harbor seals strand each year throughout their migratory range. Stranding data provide insight into some of these sources of mortality. From 2002 to 2006, 2162 harbor seal stranding mortalities were reported in all states between Maine and Florida (Table 3; NMFS unpublished data). Seventy-one (3.2%) of the seals stranded during this five year period showed signs of human interaction (18 in 2002, 2 in 2003, 15 in 2004, 24 in 2005, and 12 in 2006), with 21 having some sign of fishery interaction (9 in 2002, 0 in 2003, 3 in 2004, 4 in 2005, and 5 in 2006). An Unusual Mortality Event (UME) was declared for harbor seals in northern Gulf of Maine waters in 2003 and continued into 2004. No consistent cause of death could be determined. The UME was declared over in spring 2005 (MMC [Marine Mammal Commission] 2006). NMFS declared another UME in the Gulf of Maine in autumn

2006 based on infectious disease.

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% in 1980-1993, approximately 25% in 1994-1995, and increased to 45% in 1996. Also, shark predation on adults was selective towards mature females. The decline in the Sable Island population appears to result from a combination of shark-inflicted mortality, on both pups and adult females and inter-specific competition with the much more abundant gray seal for food resources (Stobo and Lucas 2000; Bowen *et al.* 2003).

Table 3. Harbor seal (*Phoca vitulina*) stranding mortalities along the U.S. Atlantic coast (2002-2006)[a].

State	2002	2003[b]	2004[b]	2005	2006[c]	Total
ME	149	212	358	148	448	1315
NH	2	15	21	31	31	100
MA	90	98	146	112	99	545
RI	4	12	11	4	8	39
CT		1	3	2	2	8
NY	8	10	14	23	15	70
NJ	6	15	5	4	10	40
DE		2		4	1	7
MD		1	1	3		5
VA	1	2	1	3	3	10
NC	2	8		7	4	21
FL		1			1	2
Total	262	377	560	341	622	2162
Unspecified seals (all states)	35	27	33	59	46	200

a. Some of the data reported in this table differ from that reported in previous years. We have reviewed the records and made an effort to standardize reporting. Live releases and rehabbed animals have been eliminated

b. Unusual Mortality Event (UME) declared for harbor seals in northern Gulf of Maine waters during 2003-2004.

c. Unusual Mortality Event (UME) declared for harbor seals in the Gulf of Maine in 2006.

STATUS OF STOCK

The status of the western North Atlantic harbor seal stock, relative to OSP, in the U.S. Atlantic EEZ is unknown. The species is not listed as threatened or endangered under the Endangered Species Act. 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 CITED

Baird, R. W. 2001. Status of harbor seals, *Phoca vitulina*, in Canada. Can. Field-Nat. 115: 663-675.

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. M.A. thesis. Graduate School of Arts and Sciences. Boston, MA, Boston University. 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. NOAA Tech. Memo. NMFS-OPR-6. 73 pp.

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.

Bowen, W. D., S. L. Ellis, S. J. Iverson and D. J. Boness 2003. Maternal and newborn life-history traits during periods of contrasting population trends: implications for explaining the decline of harbour sels (*Phoca vitulina*), on Sable Island. J. Zool., London 261: 155-163.

Bravington, M. V. and K. D. Bisack 1996. Estimates of harbour porpoise bycatch in the Gulf of Maine sink gillnet fishery, 1990-1993. Rep. Int. Whal. Comm. 46: 567-574.

Cairns, D. K., D. M. Keen, P-Y. Daoust, D. J. Gillis and M. Hammill 2000. Conflicts between seals and fishing gear on Prince Edward Island. Canadian technical report of fisheries and aquatic sciences. 2333. 39 pp.

deHart, P. A. P. 2002. The distribution and abundance of harbor seals (*Phoca vitulina concolor)* in the Woods Hole region. M.A. thesis. Graduate School of Arts and Sciences. Boston, MA, Boston University. 88 pp.

Gilbert, J. R. and N. Guldager 1998. Status of harbor and gray seal populations in northern New England, NMFS, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA. NMFS/NER Cooperative Agreement 14-16-009-1557.

Gilbert, J. R. and J. L. Stein 1981. Harbor seal populations and marine mammal fisheries interactions, 1981, NMFS, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA. Contract NA-80-FA-C-00029**:** 35.

Gilbert, J. R., G. T. Waring, K. M. Wynne and N. Guldager 2005. Changes in abundance and distribution of harbor seals in Maine, 1981-2001. Mar. Mamm. Sci. 21: 519-535.

Gilbert, J. R. and K. M. Wynne 1983. Harbor seal populations and marine mammal-fisheries interactions, 1982, NMFS. NA80FAC00029**:** 43.

Gilbert, J. R. and K. M. Wynne 1984. Harbor seal populations and marine mammal fisheries interactions, 1983, NMFS, Northeast Fisheries Science Center, 166 Water St, Woods Hole, MA. Contract NA-80-FA-C-00029**:** 52.

Jacobs, S. R. and J. M. Terhune 2000. Harbor seal (*Phoca vitulina*) numbers along the New Brunswick coast of the Bay of Fundy in autumn in relation to aquaculture. Northeast. Nat. 7(3): 289-296.

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

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

Mansfield, A. W. 1967. Distribution of the harbor seal, *Phoca vitulina Linnaeus*, in Canadian Arctic waters. J. Mamm. 48(2): 249-257.

MMC [Marine Mammal Commission] 2006. US Marine Mammal Commission Annual Report to Congress, 2005. M. M. Commission, Bethesda, MD. Vi+163 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. 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. Mamm. Sci. 5(2): 173-192.

Read, A. J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the northwest Atlantic. *Pages* 133-147 *in*: Read, A. J., (ed.) Gillnets and cetaceans. Reports of the International Whaling Commission. (Special Issue) 15.

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

Robillard, A., V. Lesage and M. O. Hammill 2005. Distribution and abundance of harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) in the estuary and Gulf of St Lawrence, 1994-2001. Can. Tech. Rep. Fish. Aquat. Sci. 2613: 152.

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.

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.

Schroeder, C. L. 2000. Population status and distribution of the harbor seal in Rhode Island waters. M.S. thesis. Kingston, RI, University of Rhode Island. 197 pp.

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.

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., London 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., London 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. NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Waring, G. T., J. R. Gilbert, J. Loftin and N. Cabana 2006. Short-term movements of radio-tagged harbor seals in New England. Northeast. Nat. 13(1): 1–14.

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.

Williams, A. S. 1999. Prey selection by harbor seals in relation to fish taken by the Gulf of Maine sink gillnet fishery. M.S. thesis. Orono, ME, University of Maine. 62 pp.

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