HARBOR SEAL (*Phoca vitulina concolor*): 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).

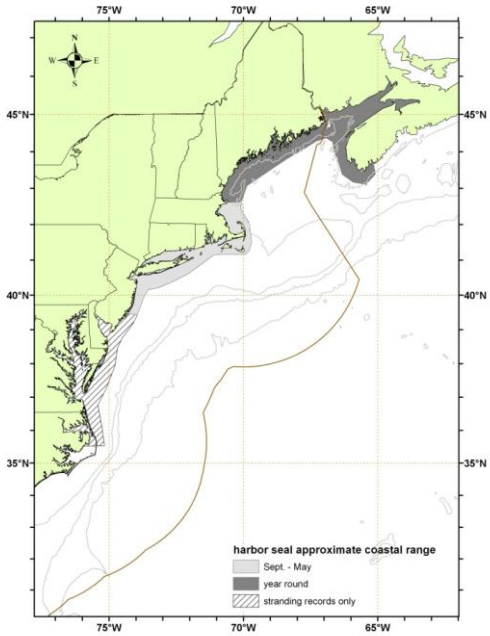

Figure 1. *Approximate coastal range of harbor seals. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.*

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 Scattered sightings and strandings have been recorded as far south as Florida (NMFS unpublished data).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 (Rubenstein pers. comm.). 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, there is no current abundance estimate for harbor seals. ~~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 (pups in parenthesis) 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 1980's, 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

Present data are insufficient to calculate a minimum population estimate for this stock.

~~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

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

~~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 was ~~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 the western North Atlantic stock of harbor seals is un~~known~~determined. ~~PBR for U.S. waters is 2,746.~~

ANNUAL HUMAN-CAUSED MORTALITY

For the period 2004-2008 ~~2003-2007~~ the total human caused mortality and serious injury to harbor seals is estimated to be 44~~0~~34 ~~477~~ per year. The average was derived from two components: 1) 4~~31~~25 (CV=0.16) ~~467 (CV=0.14)~~; Table 2) from the 2004-2008 ~~2003-2007~~ observed fishery; and 2) 9.4~~10~~ from average 2004-2008 ~~2003-2007~~ 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.~~Between 2004 and 2008, there are 6 records of harbors seals and 3 of unidentified seals with evidence of gunshot wounds in the Northeast Regional Office Marine Mammal Stranding Network database.

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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 560~~551~~ harbor seal mortalities observed in the Northeast sink gillnet fishery between 1990 and 2008~~2007~~, 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, 87 (0.58) in 2006, ~~and~~ 92 in 2007, and 2~~78~~43 (0.41) in 2008 (Table 2). The stratification design used is the same as that for harbor porpoise (Bravington and Bisack 1996). There were 2, 9, 14, 8, ~~and~~ 14, and 6 unidentified seals observed during 2003-2008~~2007~~, 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 200~~3~~4-2008~~2007~~ was 3~~93~~87 ~~446~~ harbor seals (CV=0.17~~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, one in 2006, ~~and~~ none in 2007, and two in 2008. 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, 26 (0.98) in 2006, ~~and~~ 0 in 2007, and 88 (0.74) in 2008. Average annual estimated fishery-related mortality attributable to this fishery during 200~~3~~4-2008~~2007~~ was ~~21~~38 (CV = 0.43~~0.49~~) harbor seals (Table 2).

Northeast Bottom Trawl

Seven harbor seal mortalities were observed between 2001 and 2007, one in 2002, one in 2005, ~~and~~ three in 2007, and none in 2008. (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, 2 in 2005, ~~and~~ one in 2007, and one in 2008. 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]	~~03-07~~	~~unk~~[d]	~~Obs. Data, Weighout, Logbooks~~	~~.03, .06, .07, .04, .07~~	~~21, 45, 70, 3, 6~~	~~542, 792, 719, 87, 92~~	~~.28, .34, .20, .58, .48~~	~~446 (0.15)~~
~~Mid-Atlantic Gillnet~~	~~03-07~~	~~unk~~[d]	~~Obs. Data, Weighout~~	~~.01, .02, .03, .04, .05~~	~~0, 1, 2, 1, 0~~	~~0, 15, 63, 26, 0~~	~~0, .86, .67, .98, 0~~	~~21 (0.49)~~[e]
~~Northeast Bottom Trawl~~	~~03-07~~	~~unk~~[d]	~~Obs. Data, Weighout~~	~~.04 .05, .12, .06, .06~~	~~0, 0, 1, 0, 3~~	~~0, 0, unk~~[e]~~, 0, unk~~[e]	~~0, 0, unk~~[e]~~, 0, unk~~[e]	~~unk~~[e]
~~TOTAL~~								~~467 (0.14)~~

~~[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 2003 – 2007, respectively, 0, 8, 3, 3, and 2 takes were observed in nets with~~

~~pingers. In 2003 – 2007, respectively, 21, 37, 67, 0, and 4 takes were observed in nets without pingers.~~

[a] ~~Number of vessels is not known.~~

[e] ~~Analysis of bycatch mortality attributed to the Northeast bottom trawl fishery for the years 2003-2007 has not been generated.~~

Table 2. Summary of the incidental mortality of harbor seals (*Phoca vitulina concolor*) 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	Data Type [a]	Observer Coverage [b]	Observed Mortality	Estimated Mortality	Estimated CVs	Mean Annual Mortality
Northeast [c] Sink Gillnet	04-08	Obs. Data, Weighout, Logbooks	.06, .07, .04, .07, .05	45, 70, 3, 6, 9	792, 719, 87, 92, 243	.34, .20, .58, .48, .41	39~~93~~87 (0.17)
Mid-Atlantic Gillnet	04-08	Obs. Data, Weighout	.02, .03, .04, .06, .03	1, 2, 1, 0, 2	15, 63, 26, 0, 88	.86, .67, .98, 0, .74	38 (0.43)
Northeast Bottom Trawl	04-08	Obs. Data, Weighout	.05, .12, .06, .05, .08	0, 1, 0, 3, 0	0, unk [ed], 0, unk [ed], 0	0, unk [ed], 0, unk [ed], 0	unk [ed]
TOTAL							43~~31~~25 (0.16)

[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 northeast 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 2004 - 2008, respectively, 8, 3, 3, 2, and 0 takes were observed in nets with pingers. In 2004 – 2008, respectively, 37, 67, 0, 4, and 11 takes were observed in nets without pingers.

[d] ~~Number of vessels is not known.~~

[ed] Analysis of bycatch mortality attributed to the Northeast bottom trawl fishery for the years 2004-2008 has not been generated.

Other Mortality

Canada: Aquaculture operations in eastern Canada are licensed to shoot nuisance seals, but the number of seals killed is unknown (Jacobs and Terhune 2000; Baird 2001). Small numbers of harbor seals are taken in subsistence hunting in northern Canada, and Canada also issues personal hunting licenses which allow the holder to take six seals annually (DFO 2008).

U.S.: 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; Lelli *et al.*, 2009). 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, 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 2004 to 2008~~2003 to 2007~~, 1,823~~1871~~ harbor seal stranding mortalities were reported in all states between Maine and Florida (Table 3; NMFS unpublished data). Sixty-eight

~~Seventy three (3.9%)~~ (3.7%) of the seals stranded during this five year period showed signs of human interaction (~~15 in 2003,~~ 15 in 2004, 14 in 2005, 8 in 2006, ~~and~~ 21 in 2007, and 10 in 2008), with 21 ~~24~~ having some sign of fishery interaction ~~8 in 2003,~~ 3 in 2004, 0 in 2005, 8 in 2006, ~~and~~ 5 in 2007, and 5 in 2008). 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 (2003-2007)[a]:~~

~~State~~	~~2003[b]~~	~~2004[b]~~	~~2005~~	~~2006[b]~~	~~2007[b]~~	~~Total~~
~~ME~~	~~169~~	~~348~~	~~121~~	~~371~~	~~106~~	~~1115~~
~~NH~~	~~15~~	~~21~~	~~31~~	~~28~~	~~6~~	~~101~~
~~MA~~	~~88~~	~~150~~	~~101~~	~~94~~	~~51~~	~~484~~
~~RI~~	~~8~~	~~11~~	~~3~~	~~6~~	~~8~~	~~36~~
~~CT~~	~~0~~	~~1~~	~~2~~	~~1~~	~~3~~	~~7~~
~~NY~~	~~7~~	~~12~~	~~22~~	~~11~~	~~11~~	~~63~~
~~NJ~~	~~7~~	~~5~~	~~1~~	~~7~~	~~6~~	~~26~~
~~DE~~	~~1~~	~~0~~	~~3~~	~~2~~	~~0~~	~~6~~
~~MD~~	~~0~~	~~0~~	~~2~~	~~0~~	~~0~~	~~2~~
~~VA~~	~~0~~	~~2~~	~~3~~	~~2~~	~~0~~	~~7~~
~~NC~~	~~8~~	~~2~~	~~8~~	~~4~~	~~0~~	~~22~~
~~FL~~	~~1~~	~~0~~	~~0~~	~~1~~	~~0~~	~~2~~
~~Total~~	~~304~~	~~552~~	~~297~~	~~527~~	~~191~~	~~1871~~
~~Unspecified seals (all states)~~	~~27~~	~~33~~	~~59~~	~~46~~	~~34~~	~~199~~

~~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. Records of live releases and rehabbed animals have been eliminated. Mortalities include animals found dead and animals that were euthanized, died during handling, or died in the transfer to, or upon arrival at, rehab facilities.~~

~~b. Unusual Mortality Event (UME) declared for harbor seals in northern Gulf of Maine waters during 2003-2004, and again in 2006-2007.~~

Table 3. Harbor seal (*Phoca vitulina concolor*) stranding mortalities along the U.S. Atlantic coast (2004-2008) with subtotals of animals recorded as pups in parentheses.[a].

State	2004[b]	2005	2006[b]	2007[b]	2008	Total
ME	348	121(94)	371 (220)	106 (80)	178 (152)	1124
NH	21	31 (25)	28 (19)	6 (5)	3 (2)	89
MA	150	101(45)	94 (35)	51 (17)	50 (4)	446
RI	11	3	6 (3)	8 (1)	6 (4)	34
CT	1	2 (1)	1 (1)	3	-	7
NY	12	22 (2)	11	11 (7)	5 (1)	61

NJ	5	1 (1)	7	6	7	26
DE	-	3 (1)	2	-	-	5
MD	-	2	-	-	-	2
VA	2	3	2	-	1	8
NC	2	8 (3)	4	-	6 (2)	20
FL	-	-	1	-	-	1
Total	552	297	527	191	256	1823
Unspecified seals (all states)	33	59	46	34	51	223

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. Records of live releases and rehabbed animals have been eliminated. Mortalities include animals found dead and animals that were euthanized, died during handling, or died in the transfer to, or upon arrival at, rehab facilities.

b. Unusual Mortality Event (UME) declared for harbor seals in northern Gulf of Maine waters during 2003-2004, and again in 2006-2007.

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 believed to be low relative to the population size in U.S. waters but cannot ~~not less than 10% of the calculated PBR and, therefore, cannot~~ be considered to be approaching zero mortality and serious injury rate. Although PBR cannot be determined for this stock, the level of human-caused mortality and serious injury in the U.S. Atlantic EEZ is believed to be low relative to the total stock size; therefore, this is not a strategic stock.~~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 University, 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. 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.

DFO. 2008. Atlantic Seal Hunt: 2006-2010 management plan. Department of Fisheries and Oceans. Fisheries Resource Management – Atlantic, Ottawa, Ontario, Canada, K1A 0E6 34 pp. Available at: http://www.dfo-mpo.gc.ca/reports-rapports-eng.htm#n1.

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 University, Boston, MA. 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. Final Report

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.

Annual report 35 pp.
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 pp.
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. Third annual report 52 pp.
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. 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.
Lelli, B., D.E. Harris, and A-M Aboueissa. 2009. Seal bounties in Maine and Massachusetts, 1888 to 1962. Northeast. Nat. 16(2): 239-254.
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. http://www.mmc.gov/reports/annual/pdf/2005annualreport.pdf
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*: W. F. Perrin, G. P. Donovan and J. Barlow, (eds.) 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 pp.
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. University of Rhode Island, Kingston, RI. 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. University of Maine, Orono, ME. 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. Final Report

~~January~~March 2010 ~~December 2009~~

GRAY SEAL (*Halichoerus grypus grypus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The gray seal is found on both sides of the North Atlantic, with three major populations: eastern Canada, northwestern Europe and the Baltic Sea (Katona *et al.* 1993). The western North Atlantic stock is equivalent to the eastern Canada population, and ranges from New York to Labrador (Davies 1957; Mansfield 1966; Katona *et al.* 1993; Lesage and Hammill 2001). This stock is separated by geography, differences in the breeding season, and mitochondrial DNA variation from the northeastern Atlantic stock (Bonner 1981; Boskovic *et al.* 1996; Lesage and Hammill 2001). There are two breeding concentrations in eastern Canada; one at Sable Island, and one that breeds on the pack ice in the Gulf of St. Lawrence (Laviguer and Hammill 1993). Tagging studies indicate that there is little intermixing between the two breeding groups (Zwanenberg and Bowen 1990) and, for management purposes, they are treated by the Canadian DFO as separate stocks (Mohn and Bowen 1996). In the mid 1980s, small numbers of animals and pupping were observed on several isolated islands along the Maine coast and in Nantucket-Vineyard Sound, Massachusetts (Katona *et al.* 1993; J. R. Gilbert, pers. comm., University of Maine, Orono, ME; Rough 1995). In the late 1990's, a year-round breeding population of approximately 400+ animals was documented on outer Cape Cod and Muskeget Island (D. Murley, pers. comm., Mass. Audubon Society, Wellfleet, MA). In December 2001, NMFS initiated aerial surveys to monitor gray seal pup production on Muskeget Island and adjacent sites in Nantucket Sound, and Green and Seal Islands off the coast of Maine (Wood *et al.* 2007)

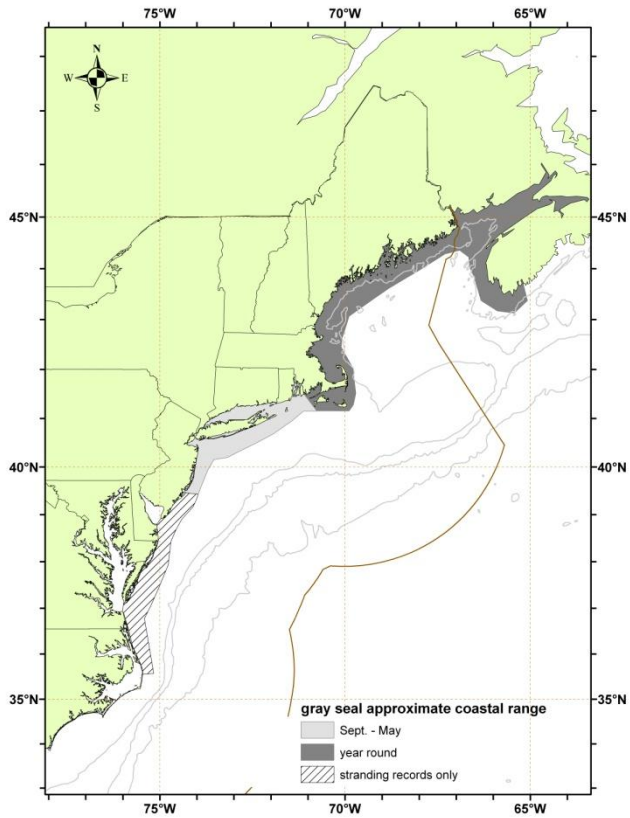

Figure 1. Approximate coastal range of gray seals. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.

POPULATION SIZE

Current estimates of the total western Atlantic gray seal population are not available; although estimates of portions of the stock are available for select time periods. The size of the Canadian population from 1993 to 2004 has been estimated from three ~~-~~surveys. A 1993 survey estimated the population at 144,000 animals (Mohn and Bowen 1996; DFO 2003) a 1997 survey estimated 195,000 (DFO 2003), and a 2004 survey obtained estimates ranging between 208,720 (SE=29,730) and 223,220 (SE=17,376) depending upon the model used (Trzcinski *et al.* 2005). The population at Sable Island had been increasing by approximately 13% per year for nearly 40 years (Bowen *et al.* 2003), but the most recent (2004) survey results indicate this population increase has declined to 7% (Trzcinski *et al.* 2005; Bowen *et al.* 2007). The non-Sable Island (Gulf of St Lawrence and Eastern Shore) abundance has increased from 20,900 (SE=200) in 1970 to 52,500 (SE=7,800) in 2004 (Hammill 2005). ~~The population in US waters is also increasing. Maine coast-wide surveys conducted during summer (all other surveys were conducted January-May) revealed 597 and 1,731 gray seals in 1993 and 2001, respectively (Gilbert *et al.* 2005).~~ In U.S. waters, gray seals currently pup at three established colonies: Muskeget Island, MA, Green Island, ME, and Seal Island, ME. They have been observed using the historic pupping site on Muskeget Island in Massachusetts since 1990. Pupping has taken place on Seal and Green Islands in Maine since at least the mid

1990's. Aerial survey data of these sites indicate that pup production is increasing. A minimum of 2,620 pups (Muskeget= 2,095, Green= 59, Seal= 466) was born in the U.S. in 2008 (Wood LaFond 2009). Table 2 summarizes singe day pup counts from the three U.S. pupping colonies from 2001/2002 to 2007/2008 pupping period. The decrease in pup counts in some years is an artifact of survey date and not indicative of true declines in those years. In recent years NMFS monitoring surveys have detected an occasional mother/pup (white coats) pair on both Monomoy Island (MA) and Noman's Land (MA). Some of the local breeders have been observed with brands and tags indicating they had been born on Sable Island, Canada (Rough 1995). The increase in the number of gray seals observed in the U.S. is probably due to both natural increase and immigration.

Gray seals are also observed in New England outside of the pupping season. In April-May 1994 a maximum count of 2,010 was obtained for Muskeget Island and Monomoy combined (Rough 1995). Maine coast-wide surveys conducted during summer revealed 597 and 1,731 gray seals in 1993 and 2001, respectively (Gilbert *et al.* 2005). ~~In 2002, the maximum counts of two breeding colonies in Maine, with number of pups in parentheses, were 193 (9) on Seal Island and 74 (31) on Green Island (S. Wood, pers. comm., University of Massachusetts, Boston, MA). Gray seal numbers are increasing in coastal waters between southern Massachusetts and eastern Long Island. Pup counts on Muskeget have increased from 0 in 1989 to 1,023 in 2002 (Rough 1995, S. Wood, pers. comm.). Gray seal numbers increase in this region in the spring (April May) when molting occurs. In April May 1994 a maximum count of 2,010 was obtained for Muskeget Island and Monomoy combined (Rough 1995).~~ In March 1999 a maximum count of 5,611 was obtained in the region south of Maine (between Isles of Shoals, Maine and Woods Hole, Massachusetts) (Barlas 1999). No gray seals were recorded at haul out sites between Newport, Rhode Island and Montauk Pt., New York (Barlas 1999), although, more recently several hundred ~~small numbers of~~ gray seals have been recorded in surveys conducted ~~in~~ off eastern Long Island ~~this region (deHart 2002;~~ (R. DiGiovanni, pers. comm., The Riverhead Foundation, Riverhead, NY). ~~Recently, a small number of gray seals have maintained a winter presence in the Woods Hole region (Vineyard Sound) (deHart 2002).~~

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

Month/Year	**Area**	**Nbest**	**CV**
~~May 2001[a]~~	~~Maine coast~~	~~1,731~~	~~NA~~
January 2004~~[b]~~[a]	Gulf of St Lawrence + Nova Scotia Eastern Shore	52,500	0.15
January 2004~~[b]~~[a]	Sable Island	208,720 216,490223,220	0.14 0.11 0.08

~~[a] These counts pertain to animals seen in U.S. waters, and the stock relationship to animals in Canadian waters is unknown.~~

~~[b]~~[a]These are model based estimates derived from pup surveys.

Table 2. The number of pups observed on Muskeget, Seal and Green Islands 2002-2008. Data are from aerial surveys. These are single day counts, not an estimate of total pup production. (Wood LaFond 2009)

Pupping Season	Muskeget Island	Seal Island	Green Island
2001-2	883	No data	34
2002-3	509	147	No data
2003-4	824	150	26
2004-5	992	365	33
2005-6	868	239	43
2006-7	1704	364	57
2007-8	2095	466	59

Minimum Population Estimate

Depending on the model used, the N_{min} for the Canadian gray seal population was estimated to range between 125,541 and 169,064 (Trzcinski et al. 2005) Present data are insufficient to calculate the minimum population estimate for U.S. waters.

Current Population Trend

Gray seal abundance is likely increasing in the U.S. Atlantic Exclusive Economic Zone (EEZ), but the rate of increase is unknown. The population in eastern Canada was greatly reduced by hunting and bounty programs, and in the 1950s the gray seal was considered rare (Lesage and Hammill 2001). The Sable Island population was less affected and has been increasing for several decades. Pup production on Sable Island, Nova Scotia, has increased exponentially at a rate of 12.8% annually for more than 40 years (Stobo and Zwanenburg 1990; Mohn and Bowen 1996; Bowen *et al.* 2003; Trzcinski *et al.* 2005; Bowen *et al.* 2007), but has declined to 7% in 2004 (Trzcinski *et al.* 2005; Bowen *et al.* 2007). The non Sable Island population increased from 6,900 in the mid-1980s to a peak of 11,100 (SE=1,300) animals in 1996 (Hammill and Gosselin 2005). Pup production declined to 6,100 (SE=900) in 2000, then increased to 15,900 (SE=1,200) in 2004 (Hammill and Gosselin 2005). Approximately 57% of the western North Atlantic population is from the Sable Island stock. In recent years pupping has been established on Hay Island, off the Cape Breton coast (Lesage and Hammill 2001).

Surveys of ~~W~~winter breeding colonies in Maine and on Muskeget Island may provide some measure of gray seal population trends and expansion in distribution. Sightings in New England increased during the 1980's as the gray seal population and range expanded in eastern Canada. Five pups were born at Muskeget in 1988. The number of pups increased to 12 in 1992, 30 in 1993, and 59 in 1994 (Rough 1995). In January 2002, ~~between 900 and 1,000~~ 883 pups were counted on Muskeget Island and surrounding shoals (~~S.~~ Wood Lafond 200~~, pers. comm9.~~). In recent years NMFS monitoring surveys have detected an occasional mother/pup (white coats) pair on both Monomoy Island and Nomans Land. These observations continue the increasing trend in pup production reported by Rough (1995). The change in gray seal counts at Muskeget and Monomoy from 2,010 in spring 1994 to 5,611 in spring 1999 represents an annual increase rate of 20.5%, however, it has not been determined what proportion of the increase represents growth or immigration. For example, a few gray seals branded as pups on Sable Island in the 1970s (Stobo and Zwanenburg 1990) are typically sighted in the Cape Cod region during winter.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. A recent study estimated the current annual rate of increase at 7% on Sable Island (Trzcinski *et al.* 2005; Bowen *et al.* 2007), which represents a 45% decline from previous estimates (Mohn and Bowen 1996; Bowen *et al.* 2003). 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 unknown. 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 the western North Atlantic gray seals in U.S. waters is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2004-2008~~2003-2007~~, the total estimated human caused mortality and serious injury to gray seals was 1,139~~1,160.4~~ per year. The average was derived from three components: 1) 585~~503(CV=0.16)~~ (0.15) (Table ~~2~~3) from the 2004-2008~~2003-2007~~ U.S. observed fishery; 2) ~~2.4~~ 4.8 from average 2004-2008 ~~2003-2007~~ non-fishery related, human interaction stranding mortalities (NMFS unpublished data); and 3) ~~655~~ 549 from average 2004-2008~~2003-2007~~ kill in the Canadian hunt.

Fishery Information

Detailed fishery information is given in Appendix III.

U.S.

Northeast Sink Gillnet

Annual estimates of gray seal bycatch in the Northeast sink gillnet fishery reflect seasonal distribution of the species and of fishing effort. There were 216~~185~~ gray seal mortalities observed in the Northeast sink gillnet fishery between 1993 and 2008~~2007~~. Estimated annual mortalities (CV in parentheses) from this fishery were 0 in 1990-1992, 18 in 1993 (1.00), 19 in 1994 (0.95), 117 in 1995 (0.42), 49 in 1996 (0.49), 131 in 1997 (0.50),61 in 1998 (0.98), 155 in 1999 (0.51), 193 in 2000 (0.55), 117 in 2001 (0.59), 0 in 2002, 242 (0.47) in 2003, 504 (0.34) in 2004, 574 (0.44) in 2005, 314 (0.22) in 2006, ~~and~~ 886 (0.24) in 2007, and 6~~43~~18 (0.23) in 200~~7~~8 (Table ~~2~~3). There were 2, 9, 14, 8, ~~and~~ 14, and 6 unidentified seals observed during 2004-2008~~2003-2007~~, 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 2004-2008~~2003-2007~~ was 5~~71~~66~~490~~ gray seals (CV= 0.15~~0.16~~) (Table 3~~2~~). The stratification design used is the same as that for harbor porpoise (Bravington and Bisack 1996).

Mid-Atlantic Coastal Gillnet

No gray seals were taken in observed trips during 1998-2000, 2003, or 2006-2008~~, and 2007~~. One gray seal was observed taken in both 2001and 2004 (Table ~~2~~3). In 2001 the gray seal was taken in April off the coast of New Jersey near Hudson Canyon in 81 m of water. The 2004 take was off Virginia in April. Observed effort was scattered between New Jersey and North Carolina from 1 to 90 km off the beach. In 2002, 65% of sampling 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 and serious injury to this stock attributable to this fishery during 2004-2008~~2003-2007~~ was 14~~13~~ gray seals (CV= 0.92~~0.92~~) (Table ~~2~~3).

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, and was not observed in 2006. No mortalities have been observed, but 15 gray seals were captured and released alive in 2004, 19 in 2005, ~~and~~ 0 in 2007, and 6 in 2008. In addition, 5 seals of unknown species were captured and released alive in 2004, ~~,~~ 2 in 2005, ~~and~~ 1 in 2007, and none in 2008.

Northeast Bottom Trawl

Vessels in the North Atlantic bottom trawl fishery, a Category III fishery under MMPA, were observed in order to meet fishery management, rather than marine mammal management needs. No mortalities were observed prior to 2005, when four mortalities were attributed to this fishery. No mortalities were observed in 2006. The estimated annual fishery-related mortality and serious injury attributable to this fishery was 0 between 2001 and 2004, and for 2006. Nine gray seal mortalities were attributed to this fishery in 2007, and 4 in 2008. Estimates have not been generated for 2005, ~~or~~ 2007 or 2008.

CANADA

An unknown number of gray seals have been taken in Newfoundland and 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). In addition to incidental catches, some mortalities (e.g., seals trapped in herring weirs) were the result of direct shooting, and there were culls of about 1,700 animals annually during the

1970's and early 1980's on Sable Island (Anonymous 1986).

In 1996, observers recorded 3 gray seals (1 released alive) in Spanish deep-water trawl fishing on the southern edge of the Grand Banks (NAFO Areas 3) (Lens 1997). Seal bycatch 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 gray seal (*Halichoerus grypus*) 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]	~~03-07~~	~~unk~~	~~Obs. Data, Weighout, Logbooks~~	~~.03, .06, .07, .04, .07~~	~~5, 21, 33, 9, 80~~	~~0, 242, 504 , 574, 248, 886~~	~~.47, .34 , .44, .47, .24~~	~~490 (0.16)~~
~~Mid-Atlantic Gillnet~~	~~03-07~~	~~unk~~	~~Obs. Data, Weighout~~	~~.01, .02 , .03, .04, .05~~	~~0, 1 , 0, 0, 0~~	~~0, 69 , 0, 0, 0~~	~~0, .92 , 0, 0, 0~~	~~13 (0.92)~~
~~Northeast Bottom Trawl~~	~~03-06~~	~~unk~~	~~Obs. Data, Weighout~~	~~.04, .05, .12, .06, .06~~	~~0, 0, 4, 0, 9~~	~~0, 0, 0, unk~~ [f] ~~, unk~~ [f]	~~0, 0, 0, unk~~ [f] ~~, unk~~ [f]	~~unk~~ [d]
~~TOTAL~~								~~503 (0.16)~~

~~a. Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. The Northeast Fisheries Observer Program 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.~~

~~b. The observer coverages for the Northeast sink gillnet fishery and the mid-Atlantic gillnet fisheries are ratios based on tons of fish landed.~~

~~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 1998, 1 take was observed in a net without a pinger that was within a marine mammal closure that required pingers. In 2003 - 2007, respectively, 1, 1, 1, , 1 and 8 takes were observed in nets with pingers. In 2003 – 2007, respectively, 0, 4, 20, 32, 8, and 72 takes were observed in nets without pingers.~~

~~d. Analysis of bycatch mortality attributed to the Northeast bottom trawl fishery has not been generated.~~

Table 3. Summary of the incidental mortality of gray seal (*Halichoerus grypus*) 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	Data Type [a]	Observer Coverage [b]	Observed Mortality	Estimated Mortality	Estimated CVs	Mean Annual Mortality

Northeast Sink Gillnet[c]	04-08	Obs. Data, Weighout, Logbooks	.06, .07, .04, .07, .05	21, 33, 9, 80, 31	504, 574, 248, 886, 64~~3~~18	.34, .44, .47, .24, .23	5~~71~~66 (0.15)
Mid-Atlantic Gillnet	04-08	Obs. Data, Weighout	.02, .03, .04, .05, .03	1, 0, 0, 0, 0	69, 0, 0, 0, 0	.92, 0, 0, 0, 0	14 (0.92)
Northeast Bottom Trawl	04-08	Obs. Data, Weighout	.05, .12, .06, .06, .08	0, 4, 0, 9, 4	0, 0, unk[d], unk[d], unk[d]	0, 0, unk[d], unk[d], unk[d]	unk[d]
TOTAL							58~~5~~0 (0.15)

a. Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. The Northeast Fisheries Observer Program 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.

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

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 2004 - 2008, respectively, 1, 1, 1 8, and 4 takes were observed in nets with pingers. In 2004 – 2008, respectively, 4, 20, 32, 8, 72, and 27 takes were observed in nets without pingers.

d. Analysis of bycatch mortality attributed to the Northeast bottom trawl fishery has not been generated.

Other Mortality

Canada: In Canada, gray seals were hunted for several centuries by indigenous people and European settlers in the Gulf of St. Lawrence and along the Nova Scotia eastern shore, and were locally extirpated (Laviguer and Hammill 1993). Between 1999 and 200~~7~~8 the annual kill of gray seals by hunters in Canada was: 1999 (98), 2000 (342), 2001 (76), 2002 (126), 2003 (6), 2004 (0), 2005 (579), 2006 (1,804) ~~and~~ 2007 (887), ~~and~~ 2008 (1,472), and 259 (2009). (DFO 2003; 2008; 2009; M. Hammill pers. comm.). The traditional hunt of a few hundred animals is expected to continue off the Magdalen Islands and in other areas, except Sable Island where commercial hunting is not permitted (DFO 2003). DFO established a 2008 total allowable catch (TAC) ~~n annual (2006-2010) TAC~~ of 12,000: ~~2,100 gray seals in the Gulf of St. Lawrence, and 8,300 on the Scotian Shelf.~~ 2,000 in the Gulf and 10,000 on the Scotian Shelf. Since 2007, a small commercial hunt has taken place on Hay Island in Nova Scotia (http://www.dfo-mpo.gc.ca/fm-gp/seal-phoque/faq-eng.htm)~~–~~. The hunting of gr~~e~~ay seals will continue to be prohibited on Sable Island (http://www.dfo-mpo.gc.ca/seal-phoque/index_e.htm).

Canada also issues personal hunting licenses which allow the holder to take six gray seals annually (Lesage and Hammill 2001). Hunting is not permitted during the breeding season and some additional seasonal/spatial restrictions are in effect (Lesage and Hammill 2001).

U.S: Gray seals, like harbor seals, were hunted for bounty in New England waters until the late 1960s (Katona, *et al*. 1993; Lelli, *et al*. 2009). This hunt may have severely depleted this stock in U.S. waters (Rough 1995; Lelli, *et al*. 2009). Other sources of mortality include human interactions, storms, abandonment by the mother, disease, and predation. Mortalities caused by human interactions include boat strikes, fishing gear interactions, power plant entrainment, oil spill/exposure, harassment, and shooting. The Cape Cod stranding network has documented gray seals entangled in netting or plastic debris around the Cape Cod/Nantucket area, and in recent years have made successful disentanglement attempts.

From 2004-2008 305 ~~2003-2007, 305~~ gray seal stranding mortalities were recorded, extending from Maine to North Carolina (Table ~~3~~4; NMFS unpublished data). Most stranding mortalities were in Massachusetts, which is the center of gray seal abundance in U.S. waters. Fifty-three ~~Thirty-nine (12.8%)~~ (17.4%) of the total stranding mortalities showed signs of human interaction (~~7 in 2003,~~ 16 in 2004, 3 in 2005, and 5 in 2006, ~~and~~ 8 in 2007, and 21 in 2008), with 29 ~~27~~ having some indication of fishery interaction (~~5 in 2003,~~ 11 in 2004, 1 in 2005, 5 in 2006, ~~and~~ 5 in 2007, and 7 in 2008).

~~Table 3. Gray seal (*Halichoerus grypus*) stranding mortalities along the U.S. Atlantic coast (2003-2007)[a].~~

~~State~~	~~2003~~	~~2004~~	~~2005~~	~~2006~~	~~2007~~	~~Total~~
~~ME~~	~~2~~	~~3~~	~~4~~	~~3~~	~~5~~	~~17~~
~~NH~~	~~1~~	~~-~~	~~-~~	~~-~~	~~1~~	~~2~~
~~MA~~	~~58~~	~~33~~	~~26~~	~~29~~	~~50~~	~~196~~
~~RI~~	~~6~~	~~8~~	~~2~~	~~2~~	~~5~~	~~23~~
~~CT~~	~~-~~	~~2~~	~~-~~	~~-~~	~~-~~	~~2~~
~~NY~~	~~5~~	~~2~~	~~7~~	~~6~~	~~21~~	~~41~~
~~NJ~~	~~2~~	~~-~~	~~2~~	~~1~~	~~5~~	~~10~~
~~DE~~	~~-~~	~~1~~	~~-~~	~~-~~		~~1~~
~~MD~~	~~-~~	~~1~~	~~3~~	~~-~~	~~1~~	~~5~~
~~VA~~	~~1~~	~~2~~	~~1~~	~~-~~	~~1~~	~~5~~
~~NC~~	~~-~~	~~-~~	~~-~~	~~2~~	~~1~~	~~3~~
~~Total~~	~~75~~	~~52~~	~~45~~	~~43~~	~~90~~	~~305~~
~~Unspecified seals (all states)~~	~~27~~	~~33~~	~~59~~	~~46~~	~~34~~	~~199~~

~~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. Mortalities include those which stranded dead, died at site, were euthanized, died during transport, or died soon after transfer to rehab.~~

Table 4. Gray seal (*Halichoerus grypus*) stranding mortalities [a] along the U.S. Atlantic coast (2004-2008) with subtotals of animals recorded as pups in parentheses.

State	2004	2005	2006	2007	2008	Total
ME	3 (2)	4 (1)	3	5 (1)	6 (1)	21
NH	-	-	-	1 (1)	-	1
MA	33 (7)	26 (6)	29 (5)	50 (9)	53 (4)	191
RI	8 (3)	2 (1)	2 (2)	5 (1)	7	24
CT	2 (1)	-	-	-	-	2
NY	2 (1)	7	6 (4)	21 (17)	2 (2)	38
NJ	-	2 (2)	1 (1)	5 (2)	3	11
DE	1	-	-		1 (1)	2
MD	1 (1)	3 (2)	-	1	1	6
VA	2	1	-	1	1	5
NC	-	-	2	1 (1)	1 (1)	4
Total	52 (15)	45 (12)	43 (12)	90 (32)	75 (9)	305 (80)
Unspecified seals (all states)	33	59	46	34	51	223

a. Mortalities include those which stranded dead, died at site, were euthanized, died during transport, or died soon after transfer to rehab.

STATUS OF STOCK

The status of the gray seal population relative to OSP in U.S. Atlantic EEZ waters is unknown, but the stock's abundance appears to be increasing in Canadian and U.S. waters. The species is not listed as threatened or

endangered under the Endangered Species Act. The total U.S. fishery-related mortality and serious injury for this stock is low relative to the stock size in Canadian and U.S. waters and can be considered insignificant and approaching zero mortality and serious injury rate. The level of human-caused mortality and serious injury in the U.S. Atlantic EEZ is unknown, but believed to be very low relative to the total stock size; therefore, this is not a strategic stock.

REFERENCES CITED

Anonymous 1986. Seals and sealing in Canada. Rep. of the Royal Commission on Seals and Sealing, Vol. 1. Canadian Government Publishing Centre, Ottawa, Ontario, Canada, 65 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. M.A. thesis. Graduate School of Arts and Sciences Boston University, 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. NOAA Tech. Memo. NMFS-OPR-6. 73 pp.

Bonner, W.N. 1981. Grey seal *Halichoerus grypus Fabricus*, 1791. Pages 111-144 *in*: S. H. Ridgway and R. J. Harrison, (eds.) Handbook of marine mammals, Vol. 2: Seals. Academic Press, London.

Boskovic, R., K.M. Kovacs, M.O. Hammill and B.N. White. 1996. Geographic distribution of mitochondrial DNA haplotypes in grey seals (*Halichoerus grypus*). Can. J. Zool. 74: 1787-1796.

Bowen, W.D., J. McMillan and R. Mohn. 2003. Sustained exponential population growth of grey seals at Sable Island, Nova Scotia. ICES J. Mar. Sci. 60: 1265-1274.

Bowen, W.D., J.I. McMillan and W. Blanchard. 2007. Reduced population growth of gray seals at Sable Island: Evidence from pup production and age of primiparity. Mar. Mamm. Sci. 23: 48-64.

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.

Davies, J.L. 1957. The geography of the gray seal. J. Mamm. 38: 297-310.

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 University, Boston, MA. 88 pp.

DFO. 2003. Atlantic Seal Hunt: 2003-2005 management plan. Department of Fisheries and Oceans. Fisheries Resource Management – Atlantic, Ottawa, Ontario, Canada, K1A 0E6 34 pp.

DFO. 2008. ~~—~~Atlantic Seal Hunt: 2006-2010 management plan. Department of Fisheries and Oceans. Fisheries Resource Management – Atlantic, Ottawa, Ontario, Canada, K1A 0E6 34 pp. ~~accessed on 17 November, 2008, from~~ Available at: http://www.dfo-mpo.gc.ca/seal-phoque/faq_e.htm#2.

DFO, 2009. Frequently asked questions about Canada's seal hunt. Department of Fisheries and Oceans. Available at: http://www.dfo-mpo.gc.ca/fm-gp/seal-phoque/faq-eng.htm

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.

Hammill, M.O. 2005. Abundance of Northwest Atlantic grey seals in the Gulf of St. Lawrence and along the Nova Scotia Eastern Shore. Canadian Department of Fisheries and Oceans. Ottawa, Ontario. DFO~~–~~ Research Document 2005/036. 11 pp.
http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2005/2005_036_e.

Hammill, M.O. and J.F. Gosselin. 2005. Pup production of non-Sable Island grey seals in 2004. Canadian Department of Fisheries and Oceans. Ottawa, Ontario. DFO Research Document 2005/036. 20 pp. http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2005/2005_033_e.htm

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.

Laviguer, L. and M.O. Hammill. ~~–~~1993. Distribution and seasonal movements of grey seals, *Halichoerus grypus*, born in the Gulf of St. Lawrence and eastern Nova Scotia shore. Can. Field-Nat. 107: 329-340.

Lens, S. 1997. Interactions between marine mammals and deep water trawlers in the NAFO regulatory area. ICES [Int. Counc. Explor. Sea] C.M. 1997/Q:08:-10.

Lesage, V. and M.O. Hammill. 2001. The status of the grey seal, *Halichoerus grypus*, in the Northwest Atlantic. Can. Field-Nat. 115(4): 653-662.

Lelli, B., D.E. Harris, and A-M Aboueissa. 2009. Seal bounties in Maine and Massachusetts, 1888 to 1962. Northeast. Nat. 16(2): 239-254.

Mansfield, A.W. 1966. The grey seal in eastern Canadian waters. Can. Audubon Mag. 28: 161-166.

Mohn, R. and W.D. Bowen. 1996. Grey seal predation on the eastern Scotian Shelf: Modeling the impact on Atlantic cod. Can. J. Fish. Aquat. Sci 53: 2722-2738.

Read, A.J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the northwest Atlantic. Pages 133-147 *in*: W. F. Perrin, G. P. Donovan and J. Barlow, (eds.) –Gillnets and cetaceans. Reports of the International Whaling Commission. (Special Issue) 15.

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

Stobo, W.T. and K.C.T. Zwanenburg. 1990. Grey seal (*Halichoerus grypus*) pup production on Sable Island and estimates of recent production in the northwest Atlantic. Pages 171-184 *in*: W. D. Bowen, (ed.) Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. Can. Bull. Fish. and Aq. Sci. 222.

Trzcinski, M.K., R. Mohn and W.D. Bowen. 2005. Estimation of grey seal population size and trends at Sable Island. Canadian Department of Fisheries and Oceans. Ottowa, Ontario. DFO Research Document 2005/067. 10 pp. http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2005/2005_067_e.htm

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.

Wood LaFond, S. 2009. Dynamics of Recolonization: a Study of the Gray Seal (*Halichoerus grypus*) in the Northeast U.S. Ph.D. Dissertation. University of Massachusetts, Boston. 83 p.

Wood, S.A., S. Brault and J.R. Gilbert. 2007. 2002 Aerial survey of grey seals in the Northeastern United States. Pages 117-121 *in*: T. Haug, M. Hammill and D. Ólafsdóttir, (eds.) –Grey seals in the North Atlantic and Baltic. NAMMCO Sci. Pub. 6, Tromsø, Norway.

Zwanenberg, K.C.T. and W.D. Bowen. – 1990. Population trends of the grey seal (*Halichoerus grypus*) in eastern Canada. Pages 185-197 *in*: W. D. Bowen, (ed.) –Population biology of sealworm (Pseudoterranova decipiens) in relation to its intermediate and seal hosts. Can. Bull. Fish. and Aq. Sci. 222.

~~January~~March 2010~~December 2009~~

HARP SEAL (*Pagophilus groenlandicus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The harp seal occurs throughout much of the North Atlantic and Arctic Oceans (Ronald and Healey 1981; Lavigne and Kovacs 1988). The world's harp seal population is divided into three separate stocks, each identified with a specific pupping site on the pack ice (Lavigne and Kovacs 1988; Bonner 1990). The largest stock is located off eastern Canada and is divided into two breeding herds. The Front herd breeds off the coast of Newfoundland and Labrador, and the Gulf herd breeds near the Magdalen Islands in the middle of the Gulf of St. Lawrence (Sergeant 1965; Lavigne and Kovacs 1988). The second stock breeds on the West Ice off eastern Greenland (Lavigne and Kovacs 1988), and the third stock breeds on the ice in the White Sea off the coast of Russia. The Front/Gulf stock is equivalent to western North Atlantic stock.

Harp seals are highly migratory (Sergeant 1965; Stenson and Sjare 1997). Breeding occurs at different times for each stock between mid-February and April. Adults then assemble north of their whelping patches to undergo the annual molt. The migration then continues north to Arctic summer feeding grounds. In late September, after a summer of feeding, nearly all adults and some of the immature animals of the western North Atlantic stock migrate southward along the Labrador coast, usually reaching the entrance to the Gulf of St. Lawrence by early winter. There they split into two groups, one moving into the Gulf and the other remaining off the coast of Newfoundland. The southern limit of the harp seal's habitat extends into the U.S. Atlantic Exclusive Economic Zone (EEZ) during winter and spring.

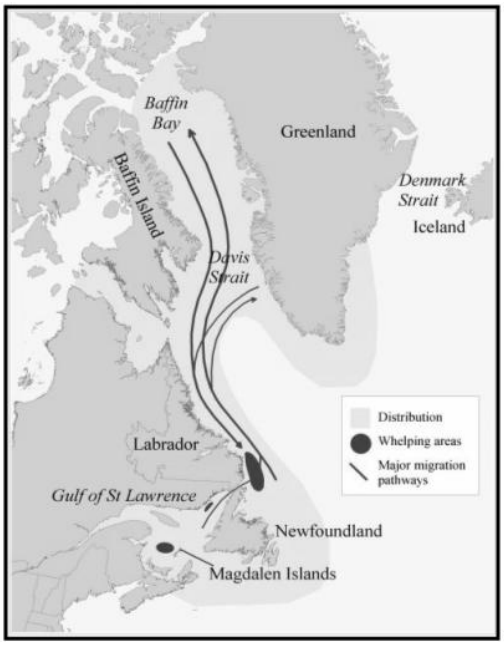

Figure 1: From: *Technical Briefing on the Harp Seal Hunt in Atlantic Canada*
http://www.dfo-mpo.gc.ca/misc/seal_briefing_e.htm

Since the early 1990s, ~~In recent years,~~ numbers of sightings and strandings have been increasing off the east coast of the United States from Maine to New Jersey (Katona *et al.* 1993; Rubinstein 1994; Stevick and Fernald 1998; McAlpine 1999; Lacoste and Stenson 2000). These extralimital appearances usually occur in January-May (Harris *et al.* 2002), when the western North Atlantic stock of harp seals is at its most southern point of migration. Concomitantly, a southward shift in winter distribution off Newfoundland was observed during the mid-1990s, which was attributed to abnormal environmental conditions (Lacoste and Stenson 2000).

POPULATION SIZE

Abundance estimates for the western North Atlantic stock are available which use a variety of methods including aerial surveys and mark-recapture (Table 1). These methods involve surveying the whelping concentrations and estimating total population adult numbers from pup production. Roff and Bowen (1983) developed an estimation model to provide a more precise estimate of total abundance. This technique incorporates recent pregnancy rates and estimates of age-specific hunting mortality (CAFSAC 1992). This model has subsequently been updated in Shelton *et al.* (1992), Stenson (1993), Shelton *et al.* (1996), and Warren *et al.* (1997). The revised 2000 population estimate was 5.5 million ~~seals~~ (95% CI= 4.5-6.4 million) harp seals. (Healey and Stenson 2000). The estimate based on the 2004 survey was calculated at 5.82 million (95% CI=4.1-7.6 million;

Hammill and Stenson 2005) but has been subsequently revised to 5.5 million (95% CI=3.8 - 7.1 million; Table 1; DFO 2007). The 2008 and 2009 estimates, respectively, based on the 2008 survey of the Gulf and Front were 6.5 million (95% CI=5.7 to 7.3 million) and 6.9 million (95% CI=6.0 to 7.7 million; Table 1; DFO 2010).

Table 1. Summary of abundance estimates for western North Atlantic harp seals. Year and area covered during each abundance survey, resulting abundance estimate (N_{best}) and confidence interval (CI).

Month/Year	Area	N_{best}	CI
2004	Front and Gulf	5.5 million	(95% CI 3.8-7.1 million)
2008	Front and Gulf	6.5 million	(95% CI 5.7-7.3 million)
2009	Front and Gulf	6.9 million	(95% CI 6.0-7.7 million)

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 western North Atlantic harp seals is 6.9 million (95% CI 6.0-7.7 million; DFO 2010)~~5.5 million (SE = 856,645; DFO 2007)~~. The minimum population estimate based on the ~~2004~~ 2008 pup survey results is 6.5 million (CV=0.06) ~~288,000~~ seals. Data are insufficient to calculate the minimum population estimate for U.S. waters.

Current population trend

Harp seal pup production in the 1950s was estimated at 645,000, but had decreased to 225,000 by 1970 (Sergeant 1975). Estimated number then began to increase and have continued to increase through the late 1990s, reaching 478,000 in 1979 (Bowen and Sergeant 1983; 1985), 577,900 (CV=0.07) in 1990 (Stenson *et al.* 1993), 708,400 (CV=0.10) in 1994 (Stenson *et al.* 2002), and 998,000 (CV=0.10) in 1999 (Stenson *et al.* 2003). The 2004 estimate of 991,000 pups (CV=0.06) was not significantly different from the 1999 estimate, which ~~suggests~~ suggested that the increase in pup production observed throughout the 1990s may have abated (Stenson *et al.* 2005). The 2008 estimated of 1,076,600 pups (CV=0.06) is based on the visual aerial survey counts (DFO 2010).

The population appears to be increasing in U.S. waters, judging from the increased number of stranded harp seals, but the magnitude of the suspected increase is unknown~~. In Canada the 2004 pup production estimate suggests that the increase in pup production observed throughout the 1990s has likely stopped (Stenson *et al.* 2005).~~

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 in U.S. waters is unknown. The maximum productivity rate is 0.12, the default value for pinnipeds. The "recovery" factor, which accounts for endangered, depleted, threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP) was set at 1.0 because it was believed that harp seals are within OSP. PBR for the western North Atlantic harp seal in U.S. waters is unknown. Applying the formula to the minimum population estimate for Canadian waters results in a "PBR" of ~~321,000~~289,220 harp seals. ~~However, Johnston *et al.* (2000) suggests that catch statistics from the Canadian hunt are negatively biased due to under reporting. Because of this, and because of biases in the current abundance estimate, a more conservative F_R of 0.5 may be appropriate. Using the lower F_R results in a "PBR" of 160,000 harp seals. The Canadian model predicts~~

~~replacement yields between 522,000 and 541,000 (Healey and Stenson 2000).~~ However, the PBR for the stock in US waters is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2004-2008~~2003-2007~~ the total estimated annual human caused mortality and serious injury to harp seals was 500,27~~20433,221~~. This is derived from two components: 1) an average catch of 500,075~~433,221~~ seals from 2004-2008~~2003-2007~~ by Canada (Table 2a); and 2) 19~~75111~~ harp seals (CV=0.20~~0.20~~) from the observed U.S. fisheries (Table 2b. Harp seal harvests are summarized in the table below.

~~Table 2a. Summary of the Canadian directed catch and bycatch incidental mortality of harp seal (*Pagophilus groenlandicus*) by year.~~

~~Fishery~~	~~2003~~	~~2004~~	~~2005~~	~~2006~~	~~2007~~	~~Average~~
~~Commercial catches[a]~~	~~289,512~~	~~365,971~~	~~323,826~~	~~354,867~~	~~224,745~~	~~217850 311,881~~
~~Commercial catch struck and lost[b]~~	~~24,084~~	~~31,026~~	~~21,495~~	~~26,674~~	~~14,914~~	~~24,745~~
~~Greenland subsistence catch[c]~~	~~66,149~~	~~70,586~~	~~91,696~~	~~92,210~~	~~82778~~81,447	~~8064878,137~~
~~Canadian Arctic[d]~~	~~1,000~~	~~-~~	~~-~~	~~-~~	~~-~~	~~1000 1,000~~
~~Greenland and Canadian Arctic struck and lost[e]~~	~~67,149~~	~~70,586~~	~~91,696~~	~~92,210~~	~~81,447~~	~~78,470~~
~~Newfoundland lumpfish[f]~~	~~5,367~~	~~12,290~~	~~12,290~~	~~12,290~~	~~12,290~~	~~12290 10,643~~
~~Total~~	~~453,261~~	~~550,458~~	~~541,002~~	~~578,251~~	~~414,842~~	~~504,209~~

~~a. Hammill and Stenson 2003, DFO 2003, DFO 2005; Stenson 2005, Stenson 2008~~

~~b. Struck and lost is calculated for the commercial harvest assuming that the rate is 5% for young of the year, and 50% for animals one year of age and older (DFO 2001, Stenson unpublished data).~~

~~c. ICES 2003, DFO 2005; Stenson unpublished data; 2002-2004 average used for 2005.~~

~~d. Hammill and Stenson 2003; Stenson unpublished data;~~

~~e. The Canadian Arctic and Greenland struck and lost rate is calculated assuming the rate is 50% for all age classes (DFO 2001; Stenson unpublished data); 2002-2004 average used for 2005.~~

~~f. DFO 2005; Stenson unpublished data; 2001-2004 average used for 2005.~~

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Table 2a. Summary of the Canadian directed catch and bycatch incidental mortality of harp seal (*Pagophilus groenlandicus*) by year.

Fishery	**2004**	**2005**	**2006**	**2007**	**2008**	**Average**
Commercial catches[a]	365,971	323,826	354,867	224,745	217,850	**297,452**
Commercial catch struck and lost[b]	31,026	21,495	26,674	14,914	11,724	**21,167**
Greenland subsistence catch[c]	70,586	91,696	92,210	82,778	80,648	**83,583**
Canadian Arctic[d]	1,000	1,000	1,000	1,000	1,000	**1,000**
Greenland and Canadian Arctic struck and lost[e]	71,586	92,696	93,210	83,778	81,648	**84,583**
Newfoundland lumpfish[f]	12,290	12,290	12,290	12,290	12,290	**12,290**
Total	**552,458**	**543,002**	**580,251**	**419,505**	**405,160**	**500,075**

a. Hammill and Stenson 2003, DFO 2003, DFO 2005; Stenson unpublished data

b. Struck and lost is calculated for the commercial harvest assuming that the rate is 5% for young of the year, and 50% for animals one year of age and older (DFO 2001, Stenson unpublished data).

c. ICES 2003, DFO 2005; Stenson unpublished data; 2002-2004 average used for 2005.

d. Hammill and Stenson 2003; Stenson unpublished data;~~2002-2004 average for Yr - Yr - check papers for years~~

e. The Canadian Arctic and Greenland struck and lost rate is calculated assuming the rate is 50% for all age classes (DFO 2001; Stenson unpublished data); 2002-2004 average used for 2005.

f. DFO 2005; Stenson unpublished data; 2001-2004 average used for 2005.

Fishery Information

U.S.

Detailed fishery information is reported in the Appendix III.

Northeast Sink Gillnet:

Annual estimates of harp seal bycatch in the Northeast sink gillnet fishery reflect seasonal distribution of the species and of fishing effort. There were 168 154 harp seal mortalities observed in the Northeast sink gillnet fishery between 1990 and 2008 2007. The bycatch occurred principally in winter (January-May) and was mainly in waters between Cape Ann and New Hampshire. In addition, bycatch was also observed in shelf and shelf-edge waters southwest of Cape Cod. One observed winter mortality was in waters south of Cape Cod. The stratification design used for this species is the same as that for harbor porpoise (Bravington and Bisack 1996). Estimated annual mortalities (CV in parentheses) from this fishery were: 81 (0.78) in 1999, 24 (1.57) in 2000, 26 (1.04) in 2001, 0 during 2002-2003, 303 (0.30) in 2004, 35 (0.68) in 2005, 65 (0.66) in 2006, and 119 (0.35) in 2007, and 25 50 38 (0.37 8) in 2008 (Table 2b). There were also 2, 9, 14, 8, and 18, and 6 unidentified seals observed during 2004 2003 through 2008 2007 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 2004-2008 2003-2007 was 15 42 104 harp seals (CV= 0.19 0.21) (Table 2b).

Mid-Atlantic Gillnet:

No harp seals were taken in observed trips during 1993-1997, and or 1999-2006. One harp seal was observed taken in both 1998, and and one in 2007, and four were taken in 2008. Observed effort from 1993 to 2008 2007 was scattered between New York and North Carolina from 1 to 9 km 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, 17 in 1998 (1.02), 0 in 1999-2006 and 38 in 2007, and 176 (0.74) in 2008. 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 2004-2008 2003-2007 was 43 7 harp seals (CV=).63 0.90) (Table 2b).

Northeast Bottom Trawl

Three mortalities were observed in the Northeast bottom trawl fishery between 2002 and 2008 2007. The estimated annual fishery-related mortality and serious injury attributable to this fishery (CV in parentheses) was 0 between 1991 and 2000, 49 (CV=1.10) in 2001, and 0 in 2002 - 2004, and 0 in and 2006 - 2007 2008. Estimates have not been generated for 2005.

Table 2b. Summary of the incidental mortality of harp seal (*Pagophilus groenlandicus*) 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 [c]	Estimated Mortality	Estimated CVs	Mean Annual Mortality

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~~Northeast Sink Gill net~~	~~03-07~~	~~unk~~	~~Obs. Data, Trip Logbook, Allocated Dealer Data~~	~~.06, .07, .04, .07~~	~~0, 15, 3, 3, 11~~	~~0, 303, 35, 65, 119~~	~~0, .30, .68, .66, .35~~	~~104 (0.21)~~
~~Mid-Atlantic Gill net~~	~~03-07~~							

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Northeast Bottom Trawl	03-07	unk						
TOTAL								111 (0.20)

a. Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. The Northeast Fisheries Observer Program 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 coastal sink gillnet fisheries are ratios based on tons of fish landed. North Atlantic bottom trawl fishery coverages 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 2000 – 2007, respectively, 2, 1, 0, 0, 4, 0, 3, and 0 takes were observed in nets with pingers. In 2000 – 2007, respectively, 1, 0, 0, 0, 11, 3, 0, and 12 takes were observed in nets without pingers.

d. Bycatch estimates attributed to the Northeast bottom trawl fishery have not been generated.

Table 2b. Summary of the incidental mortality of harp seal (Pagophilus groenlandicus) by commercial fishery including the years sampled (Years), 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	Data Type [a]	Observer Coverage [b]	Observed Mortality[c]	Estimated Mortality	Estimated CVs	Mean Annual Mortality
Northeast Sink Gillnet	04-08	Obs. Data, Trip Logbook, Allocated Dealer Data	.06, .07, .04, .07, .05	15, 3, 3, 11, 14	303, 35, 65, 119, 238	.30, .68, .66, .35, .38	152 (0.19)

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Mid-Atlantic Gillnet	04-08	Obs. Data, Trip Logbook, Allocated Dealer Data	.02, .03, .04, .05, .03	0, 0, 0, 1, 4	0, 0, 0, 38, 176	0, 0, 0, 0.9, .74	43 (0.63)
Northeast Bottom Trawl	04-08	Obs. Data Weighout	.05, .12, .06, .06, .08	0, 3, 0, 0, 0	0, unk, 0, 0	0, unk, 0, 0, 0	unk
TOTAL							195 (0.20)

a. Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. The Northeast Fisheries Observer Program 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 coastal sink gillnet fisheries are ratios based on tons of fish landed. North Atlantic bottom trawl fishery coverages 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 2000-2008, respectively, 2, 1, 0, 0, 4, 0, 3, 0, and 3 takes were observed in nets with pingers. In 2000-2008, respectively, 1, 0, 0, 0, 11, 3, 0, 12, and 15 takes were observed in nets without pingers.
d. Bycatch estimates attributed to the Northeast bottom trawl fishery have not been generated.

Other Mortality

Field Code Changed

Canada: Harp seals have been commercially hunted since the mid-1800s in the Canadian Atlantic (Stenson 1993). A total allowable catch (TAC) of 200,000 harp seals was set for the large vessel hunt in 1971. The TAC varied until 1982 when it was set at 186,000 seals and remained at this level through 1995 (Stenson 1993; ICES 1998). The TAC was increased to 250,000 and 275,000, respectively, in 1996 and 1997 (ICES 1998). The 1997 TAC remained in effect through 2002. In 2003, a three-year TAC was set at 975,000 with a maximum of 350,000 allowed in the first ~~tow~~ two years (ICES 2008). As a result of catches in the first two years the 2005 TAC was set at 319,517 (ICES 2008). The 2006 TAC was increased to 335,000 (325,000 commercial hunt, 6,000 Aboriginal initiative, and 2,000 allocation each for personal use and Arctic catches). The TAC was reduced to 270,000 in 2007 (263,140 commercial hunt, 4,860 for Aboriginal, and 2,000 for personal use) (ICES 2008). In 2008 the TAC was increased to 275,000 (268,050 commercial hunt, 4,950 for Aboriginal, and 2,000 for personal use). ~~).~~

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U.S.: From 2004 to 2008~~2003 to 2007~~, 541~~469~~ harp seal stranding mortalities were reported (Table 3; NMFS unpublished data). Eighteen~~Seventeen (3.6%)~~ (3.3%) of the mortalities during this five-year period showed signs of human interaction (~~2 in 2003,~~ 2 in 2004, 5 in 2005, 2 in 2006, ~~and~~ 6 in 2007, and 3 in 2008), with ~~2~~3 having some sign of fishery interaction (1each in 2005, 2007 and 2008) ~~and 1 in 2007~~). However, the cause of death of stranded animals is not being evaluated (interactions may be non-fatal or even post-mortem) and is not included in annual human-induced mortality estimates. Harris and Gupta (2006) analyzed NMFS 1996-2002 stranding data and suggest that the distribution of harp seal strandings in the Gulf of Maine is consistent with the species' seasonal migratory patterns in this region.

~~Table 3. Harp seal (*Pagophilus groenlandicus*) stranding mortalities along the U.S. Atlantic coast (2003-2007)[a].~~

~~State~~	~~2003~~	~~2004~~	~~2005~~	~~2006~~	~~2007~~	~~Total~~
~~ME~~	~~7~~	~~30~~	~~10~~	~~14~~	~~8~~	~~69~~
~~NH~~	~~-~~	~~-~~	~~2~~	~~-~~	~~1~~	~~3~~
~~MA~~	~~23~~	~~85~~	~~44~~	~~24~~	~~51~~	~~227~~

RI	3	7	9	6	2	27
CT	0	2	3	4	1	10
NY	5	20	41	15	19	100
NJ	-	6	12	3	3	24
DE	1	0	2	-	2	5
MD	-	-	2	-	4	6
VA	-	1	4	-	5	10
NC	-	-	-	1	-	1
Total	**37**	**142**	**129**	**65**	**96**	469
Unspecified seals (all states)	27	33	59	46	34	199

a. Mortalities include animals found dead and animals that were euthanized, died during handling, or died in the transfer to, or upon arrival at, rehab facilities.

Table 3. Harp seal (*Pagophilus groenlandicus*) stranding mortalities [a] along the U.S. Atlantic coast (2004-2008) with subtotals of animals recorded as pups in parentheses.

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State	2004	2005	2006	2007	2008	Total
ME	30	10	14	8	15	77
NH	-	2	-	1	1	4
MA	85	44	24	51 (2)	51	255
RI	7	9	6	2	5	29
CT	2	3	4	1	2	12
NY	20	41	15	19 (1)	8	103
NJ	6	12	3 (1)	3	12	36
DE	0	2 (1)	-	2	-	4
MD	-	2	-	4	1	7
VA	1	4	-	5	3	13
NC	-	-	1	-	-	1
Total	**151**	**129**	**67**	**96**	**98**	**541**
Unspecified seals (all states)	33	59	46	34	51	223

a. Mortalities include animals found dead and animals that were euthanized, died during handling, or died in the transfer to, or upon arrival at, rehab facilities.

STATUS OF STOCK

The status of the harp seal stock, relative to OSP, in the U.S. Atlantic EEZ is unknown, but the stock's abundance appears to have stabilized. The species is not listed as threatened or endangered under the Endangered Species Act. The total U.S. fishery-related mortality and serious injury for this stock is very low relative to the stock size and can be considered insignificant and approaching zero mortality and serious injury rate. The level of human-caused mortality and serious injury in the U.S. Atlantic EEZ is also low relative to the total stock size; therefore, this is not a strategic stock.

REFERENCES CITED

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.

Bonner, W. N. 1990. The natural history of seals. Facts on File, New York. 196 pp.

Bowen, W. D. and D. E. Sergeant. 1983. Mark-recapture estimates of harp seal pup (*Phoca groenlandica*) production in the northwest Atlantic. Can. J. Fish. Aquat. Sci 40: 728-742.

Bowen, W. D. and D. E. Sergeant. 1985. A mark-recapture estimate of 1983 harp seal pup production in the Northwest Atlantic. NAFO SCR Doc. 85/I/1.

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.

CAFSAC 1992. Update on population estimates of Harp seal in the Northwest Atlantic. Canadian Atlantic Fisheries Scientific Advisory Committee.

DFO 2007. A review of ice conditions and potential impact on harp seal neonatal mortality. Department of Fisheries and Oceans. DFO Can. Sci. Advis. Sec. Sci. Resp. 2007/008. http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ScR-RS/2007/ScR-RS2007_008_E.pdf

DFO 2010. Current status of Northwest Atlantic harp seals, (*Phagophilusa groenlandicus*). Department of Fisheries and Oceans. DFO Can. Sci. Advis. Sec. Sci. Resp. 2009/074.

Hammill, M. O. and G. B. Stenson. 2005. Abundance of Northwest Atlantic harp seals (1960-2005). Can. Sci. Advisory Sec. Res. Doc. 2005/090.

Harris, D. E. and S. Gupta. 2006. GIS-based analysis of ice-breeding seal strandings in the Gulf of Maine. Northeast. Nat. 13: 403-420.

Harris, D. E., B. Lelli and G. Jakush. 2002. Harp seal records from the southern Gulf of Maine: 1997-2001. Northeast. Nat. 9(3): 331-340.

Healey, B. P. and G. B. Stenson. 2000. Estimating pup production and population size of the northwest Atlantic harp seal (*Phoca groenlandica*). Can. Stock Assess. Sec. Res. Doc. 2000/081.

ICES 1998. Report of the joint ICES/NAFO working group on harp and hooded seals, Copenhagen, Denmark, ICES [International Council for the Exploration of the Sea], 28 August-3 September 1997. ICES CM 1998/Assess:3.

ICES 2008. Report of the working group on harp and hooded seals (WGHARP), Tromsø, Norway, ICES [International Council for the Exploration of the Sea], 30 August 2008. ICES CM 2008/ACOM:17.

ICES 2009. Report of the working group on harp and hooded seals (WGHARP), Copenhagen, Denmark [International Council for the Exploration of the Sea], 27 August 2009. ICES CM 2009/ACOM:17.

~~Johnston, D. W., P. Meisenheimer and D. M. Lavigne 2000. An evaluation of management objectives for Canada's commercial harp seal hunt, 1996-1998. Cons. Biol. 14: 729-737.~~

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.

Lacoste, K. N. and G. B. Stenson. 2000. Winter distribution of harp seals (*Phoca groenlandica*) off eastern Newfoundland and southern Labrador. Polar Biol. 23: 805-811.

Lavigne, D. M. and K. M. Kovacs. 1988. Harps and hoods: Ice breeding seals of the Northwest Atlantic. University of Waterloo Press, Waterloo, Ontario, Canada. 174 pp.

McAlpine, D. F. 1999. Increase in extralimital occurrences of ice-breeding seals in the northern Gulf of Maine region: more seals or fewer fish. Mar. Mamm. Sci. 15: 906-911.

Roff, D. A. and W. D. Bowen. 1983. Population dynamics and management of the Northwest Atlantic harp seal. Can. J. Fish. Aquat. Sci 40: 919-932.

Ronald, K. and P. J. Healey. 1981. Harp Seal. Pages 55-87 *in*: S. H. Ridgway and R. J. Harrison, (eds.) Handbook of marine mammals, Vol. 2: Seals. Academic Press, New York.

Rubinstein, B. 1994. An apparent shift in distrubution of ice seals, *Phoca groenlandica*, *Cystophora cristata*, and *Phoca hispida*, toward the east coast of the United States. MA thesis. Department of Biology. Boston, MA, Boston University.

Sergeant, D. E. 1965. Migrations of harp seal *Pagophilus groenlandicus* (Erxleben) in the Northwest Atlantic. J. Fish. Res. Board Can 22: 433-464.

Sergeant, D. E. 1975. Estimating numbers of harp seals. Rapp. P.-v. Reun. Cons. int Explor. Mer. 169(274-280).

Shelton, P. A., N. G. Caddigan and G. B. Stenson. 1992. Model estimates of harp seal population trajectories in the Northwest Atlantic. CAFSAC Res. Doc. 92/89. 23 pp.

Shelton, P. A., G. B. Stenson, B. Sjare and W. G. Warren. 1996. Model estimates of harp seal numbers-at-age for the Northwest Atlantic. NAFO Sci. Coun. Studies 26: 1-14.

Stenson, G. B. 1993. The status of pinnipeds in the Newfoundland region. NAFO SCR Doc. 93/34.

Stenson, G. B., M. O. Hammill, M. C. S. Kingsley, B. Sjare, W. G. Warren and R. A. Myers. 2002. Is there evidence of increased pup production in northwest Atlantic harp seals, *Pagophilus groenlandicus*? ICES J. Mar. Sci. 59: 81-92.

Stenson, G. B., M. O. Hammill, J. Lawson, J. F. Gosselin and T. Haug. 2005. 2004 pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic. Department of Fisheries and Oceans, Canada 34 pp. http://www.dfo-mpo.gc.ca./csas/

Stenson, G. B., R. A. Myers, M. O. Hammill, I.-H. Ni, W. G. Warren and M. S. Kingsley. 1993. Pup production of harp seals, *Phoca groenlandica*, in the Northwest Atlantic. Can. J. Fish. Aquat. Sci 50: 2429-2439.

Stenson, G. B., L. P. Rivest, M. O. Hammill, J. F. Gosselin and B. Sjare 2003. Estimating pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic. Mar. Mamm. Sci. 19(1): 141-160.

Stenson, G. B. and B. Sjare. 1997. Seasonal distribution of harp seals, *Phoca groenlandica*, in the Northwest Atlantic. ICES C.M. 1997/CC:10 (Biology and Behavior II). 23 pp.

Stenson, G. B. 2008. Recent catches of harp seals (*Pagophilus groenlandicus*) in the Northwest Atlantic DFO. Can. Sci. Advisory Sec. Res. Doc. 2008/080.

Stevick, P. T. and T. W. Fernald. 1998. Increase in extralimital records of harp seals in Maine. Northeast. Nat. 5(1): 75-82.

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.

Warren, W. G., P. A. Shelton and G. B. Stenson. 1997. Quantifying some of the major sources of uncertainty associated with estimates of harp seal prey consumption. Part 1: Uncertainty in the estimates of harp seal population size. J. Northwest Atl. Fish. Sci. 22: 289-302.