October 2008

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.

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; B. Rubinstein, pers. comm., New England Aquarium; 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).

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
2000	Front and Gulf	5.5 million	(95% CI 4.5-6.4 million)
2004	Front and Gulf	5.5 million	(95% CI 3.8-7.1 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 5.5 million (SE = 856,645; DFO 2007). The minimum population estimate based on the 2004 pup survey results is 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) suggests that the increase in pup production observed throughout the 1990s may have abated (Stenson *et al.* 2005).

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 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). 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 2002-2006 the total estimated annual human caused mortality and serious injury to harp seals was 443,299. This is derived from three components: 1) an average catch of 443,216 seals from 2002-2006 by Canada (Table 2a); 2) 80 harp seals (CV=0.31) from the observed U.S. fisheries (Table 2b); and 3) three harp seals from average 2002-2006 non-fishery related, human interaction stranding mortalities (NMFS unpublished data). 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	2002	2003	2004	2005	2006		Average
Commercial catches[a]	312,367	289,512	365,971	329,829	354,867		**330,509**
Commercial catch struck and lost[b]	30,275	24,084	31,026	23,071	26,674		**27,026**
Greenland subsistence catch[c]	69,895	68,499	70,585	91,361			**75,085**
Canadian Arctic[d]	715	715	715	715[d]			**715**
Greenland and Canadian Arctic struck and lost[e]	70,610	69,214	71,300	91,361			**75,621**
Newfoundland lumpfish[f]	9,329	5,367	12,290	11,597[f]			**8,995**
Total	**493,191**	**457,391**	**551,887**	**535,622**	**381,541**		**443,216**

a. (DFO 2003; Hammill and Stenson 2003; Stenson unpublished data; DFO 2005)

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; Stenson unpublished data; 2002-2004 average used for 2005; DFO 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; 2002-2004 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 143 harp seal mortalities observed in the Northeast sink gillnet fishery between 1990 and 2006. The bycatch occurred principally in winter (January-May) and was mainly in waters between Cape Ann and New Hampshire. 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, and 65 (0.66) in 2006 (Table 2b). There were also 2, 2, 9, 14, and 8 unidentified seals observed during 2002 through 2006 respectively. Since 1997, unidentified seals have not been prorated to a species. This is consistent with the treatment of other unidentified mammals that do not get prorated to a specific species. Average annual estimated fishery-related mortality and serious injury to this stock attributable to this fishery during 2002-2006 was 80 harp seals (CV=0.31) (Table 2b).

Mid-Atlantic Gillnet:

No harp seals were taken in observed trips during 1993-1997, and 1999-2006. One harp seal was observed taken in 1998. Observed effort from 1993 to 2006 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) and 0 in 1999-2006. In 2002, 65% of observer coverage was concentrated in one area and not distributed proportionally across the fishery. Therefore observed mortality is considered unknown in 2002. Average annual estimated fishery-related mortality attributable to this fishery during 2002-2006 was zero harp seals.

Northeast Bottom Trawl

Three mortalities were observed in the Northeast bottom trawl fishery between 2002 and 2006. 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 between 2002 and 2004, and in 2006. 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			Observer Coverage [b]	Observed Mortality[c]			Mean Annual Mortality
Northeast Sink Gillnet	02-06	unk	Obs. Data Weighout, Logbooks	.02, .03, .06, .07, .04	0, 0, 15, 3, 3	0, 0, 303, 35, 65	0, 0, .30, .68, .66	80 (0.31)
Northeast Bottom Trawl	02-06	unk	Obs. Data Weighout	.03, .04 .05, .12, .06	0, 0, 0, 3, 0	0, 0, 0, unk, 0	0, 0, 0, unk, 0	unk
TOTAL								80 (0.31)

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 - 2006, respectively, 2, 1, 0, 0, 4, 0, and 3 takes were observed in nets with pingers. In 2000 - 2006, respectively, 1, 0, 0, 0, 11, 3, and 0 takes were observed in nets without pingers.
d. Bycatch estimates attributed to the Northeast bottom trawl fishery have not been generated.

Other Mortality

U.S.: From 2002 to 2006, 456 harp seal stranding mortalities were reported (Table 3; NMFS unpublished data). Thirteen (2.8%) of the mortalities during this five-year period showed signs of human interaction (2 in 2002, 2 in 2003, 2 in 2004, 5 in 2005, and 2 in 2006), with 1 having some sign of fishery interaction (1 in 2005). Harris and Gupta (2006) analyzed NMFS 1996-2002 stranding data and suggest that the distribution of harp seal stranding 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 (2002-2006)[a].

State	2002	2003	2004	2005	2006	Total
ME	11	7	30	10	14	72
NH				2		2
MA	50	23	85	44	24	226
RI	5	3	7	9	6	30
CT	5	0	2	3	4	14
NY	15	5	20	41	15	96
NJ	1		6	12	3	22
DE		1	0	2		3

MD				2		2
VA	1		1	4		6
NC					1	1
Total	**83**	**37**	**142**	**129**	**65**	**456**
Unspecified seals (all states)	35	27	33	59	46	200

a. Some of the data reported in this table differ from that reported in previous years. We have reviewed the records and made an effort to standardize reporting. Live releases and rehabbed animals have been eliminated. 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 2001. Report of the Eminent Panel on Seal Management. Canadian Department of Fisheries and Oceans, Ottawa, Ontario, Canada, K1A 0E6. 145 pp.

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

DFO 2005. Stock assessment of Northwest Atlantic harp seals (*Pagophilus groenlandicus*). Dept. Of Fisheries and Oceans. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/037. http://www.dfo-mpo.gc.ca/csas.

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

Hammill, M. O. and G. B. Stenson 2003. Harvest simulations for 2003-2006 harp seal management plan. Can. Sci. Advisory Sec. Res. Doc. 2003/068.

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 2003. Report of the ICES/NAFO working group on harp and hooded seals, Arkhangelsk, Russia, ICES [International Council for the Exploration of the Sea], 2-6 September 2003. ICES CM 2004/ACFM:06.

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.

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.

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.