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 breeding site (Bonner 1990; Lavigne and Kovacs 1988). The largest stock is located off eastern Canada and is divided into two breeding herds which breed on the pack ice. 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 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 the 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; Stevick and Fernald 1998; McAlpine 1999; Lacoste and Stenson 2000, B. Rubinstein, pers. comm., New England Aquarium). 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 was subsequently been updated in Shelton *et al.* (1992), Stenson 1993), Shelton *et al.* (1996), and Warren *et al.* 1997. The 2000 total population estimate was 5.5 million seals (95% CI= 4.5-6.4 million, Healey and Stenson 2000) which was not significantly different from the 2004 estimate of 5.9 million (95% CI=4.6-72. million, DFO 2005) (Table 1).

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	5.9 million	(95% CI 4.6-7.2 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 5.9 million (SE = 660,000)(DFO 2005). The minimum population estimate based on the 2004 pup survey results is 5.3 million 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; Bowen and Sergeant 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; therefore, an F_R of 0.5 may be appropriate. Using the lower F_R results in a “PBR” of 160,500 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 2000-2004, the total estimated human caused mortality and serious injury to harp seals was 4,06.686. This is derived from three components: 1) an average catch of 406,600 seals from 2000-2004 by Canada (Table 2a); and 2) 81 seals (CV=0.29) from the observed U.S. fisheries (Table 2b) and 3) 5 from average 2000-2004 stranding mortalities resulting from human interactions (NMFS unpublished data).

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

Fishery	**2000**	**2001**	**2002**	**2003**	**2004**	**Average**
Commercial catches[a]	92,055	226,493	312,367	289,512	365,971	**257,280**
Commercial catch struck and lost[b]	7,762	16,607	22,190	18,678	23,887	**17,825**
Greenland subsistence catch[c]	101,941	89,617	69,895	68,499	67,064	**79,403**
Canadian Arctic[d]	280	405	715	715	715	**566**
Greenland and Canadian Arctic struck and lost[e]	51,111	45,011	35,305	34,607	33,889	**39,985**
Newfoundland lumpfish[f]	11,323	19,400	9,329	5,367	12,290	**11,542**
Total	**264,472**	**397,533**	**449,801**	**417,378**	**503,816**	**406,600**

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. Anonymous 2003, DFO 2005; Stenson unpublished data
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).
f. DFO 2005; Stenson unpublished data

Fishery Information

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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 19 harp seal mortalities observed in the Northeast sink gillnet fishery between 2000 and 2004. Estimated annual mortalities (CV in parentheses) from this fishery during 2000-2004 were: 24 in 2000 (1.57), 26 in 2001 (1.04), 0 during 2002-2003, and 303(0.30) in 2004 (Table 2b). There were also 5, 8, 2, 2, and 9 unidentified seals observed during 2000 through 2004 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 2000-2004 was 71 harp seals (CV=0.29) (Table 2). The stratification design used for this species is the same as that for harbor porpoise (Bravington and Bisack 1996). 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.

Mid-Atlantic Gillnet

No harp seals were taken in observed trips during 1993-1997, and 1999-2004. One harp seal was observed taken in 1998. Observed effort from 1993-2004 was scattered between New York and North Carolina from 1 to 50 miles off the beach. All bycatches were documented during January to April. Using the observed takes, the estimated annual mortality (CV in parentheses) attributed to this fishery was 0 in 1995-1997, 17 in 1998 (1.02) and 0 in 1999-2004. 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 2000-2004 was zero harp seals.

Northeast Bottom Trawl

The fishery is active in New England waters in all seasons. One mortality was observed between 2000 and 2004. 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. Average annual estimated fishery-related mortality attributable to this fishery between 2000 and 2004 was 10 harp seals (CV=1.10) (Table 2b).

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
Northeast Sink Gillnet	00-04	301	Obs. Data Weighout, Logbooks	.06, .04, .02, .03, .06	3, 1, 0, 0, 15	24, 26, 0, 0, 303	1.57, 1.04, 0, 0, .30	71 (0.29)
Northeast Bottom Trawl	00-04	TBD	Obs. Data Weighout	.01, .01, .03, .04, .05	0, 1, 0, 0, 0	0, 49, 0, 0, 0	0, 1.10, 0, 0, 0	10 (1.10)
TOTAL								81 (0.29)

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 coverage for the Northeast sink gillnet fishery and the mid-Atlantic coastal sink gillnet fisheries are measured in tons of fish landed. North Atlantic bottom trawl fishery coverage is measured in 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 - 2004, respectively, 2, 1, 0, 0, 4 takes were observed in nets with pingers. In 2000 – 2004, respectively, 1, 0, 0, 0, 11 takes were observed in nets without pingers.

Other Mortality

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From 1999 to 2004, 1,482 strandings were recorded (116 in 1999, 145 in 2000, 495 in 2001, 188 in 2002, 101 in 2003, and 332 in 2004) in all states between Maine and North Carolina (NMFS unpublished data). Factors contributing to a dramatic increase in strandings in 2001 are unknown (Harris *et al.* 2002). Twenty-three (1.6%) of the stranded animals during this five- year period showed signs of human interaction as a direct cause of mortality. Mortalities caused by human interaction include boat strikes, fishing gear interactions, power plant entrainment, oil spills, harassment, and shooting.

The total number of harp seal strandings in 2004 was 332, of which 7 were healthy and did not require rehabilitation. Sixteen animals were rehabilitated and released. The remaining animals were either found dead or died in rehabilitation.

Table 3. Harp seal (*Pagophilus groenlandicus*) reported along the U.S. Atlantic coast (2002-2004).

State	2002	2003	2004[a]	Total
Maine	35	21	112	168
New Hampshire	1	1	2	4
Massachusetts	67	31	104	202
Rhode Island	10	6	14	30
Connecticut	12	1	2	15
New York	48	28	66	142
New Jersey	13	9	22	44
Delaware	0	1	5	6
Maryland	0	1	0	1
Virginia	1	0	4	5
North Carolina	1	2	1	4
Total	188	101	332	621

a. During 2004, one harp seal had signs of human interaction as the cause of mortality.

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

Anonymous. 2003. Report of the ICES/NAFO Working Group on Harp and Hooded Seals. 2-6 September 2003, Arkhangelsk, Russia. ICES CM 2004/ACFM:06. 57 pp.

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

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

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.

CAFSAC. 1992. Update on population estimates of Harp seal in the Northwest Atlantic. Canadian Atlantic Fisheries Scientific Advisory Committee, CAFSAC Adv. Doc. 92/8.

DFO [Dept. Of Fisheries and Oceans]. 2000. Northwest Atlantic harp seals. DFO Science Stock Status Report E1-01. Available at http://www.dfo-mpo.gc.ca/csas/Csas/status/2000/.

DFO [Dept. Of Fisheries and Oceans]. 2001. Report on the Eminent Panel on Seal Management. Available from Canadian Department of Fisheries and Oceans, Ottawa, Ontario, Canada, K1A 0E6, Communication Branch. 145 pp.

DFO [Dept. Of Fisheries and Oceans]. 2003. Atlantic Seal Hunt: 2003-2005 Management Plan. Available from Canadian Department of Fisheries and Oceans, Ottawa, Ontario, Canada, K1A 0E6, Fisheries Resource Management – Atlantic. 34 pp.

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

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.

Harris, D.E., B. Lelli, and G. Jakush. 2002. Harp seal records from the southern Gulf of Maine: 1997-2001. Northeastern Naturalist 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.

Johnston, D.W., P. Meisenheimer, and D.M. Lavigne. 2000. An evaluation of management objectives for Canada's commercial harp seal hunt, 1996-1998. Conserv. 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. Mammal Sci. 15:906-911.

McAlpine, D.F. and R.H. Walker. 1990. Extralimital records of the harp seal, *Phoca groenlandica*, from the western North Atlantic: a review. Mar. Mammal Sci. 6:243-247.

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, 359 pp.

Rubinstein, B. 1994. An apparent shift in distribution of ice seals, *Phoca groenlandica*, *Cystophora cristata*, and *Phoca hispida*, toward the east coast of the United States. M.A. Thesis, Boston University, Boston, MA, 45 pp.

Sergeant, D.E. 1965. Migrations of harp seal *Pagophilus groenlandicus* (Erxleben) in the Northwest Atlantic. J. Fish. Res. Bd. 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. 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., M.O. Hammill, J. Lawson, J.F. Gosselin, and T. Haug. 2005. 2004 pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic. Available at: http://www.dfo-mpo.gc.ca./csas/ . 34 pp

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. Mammal. Sci. 19:141-160.

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., 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.

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

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. U.S. Dep. Commer., 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.