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.

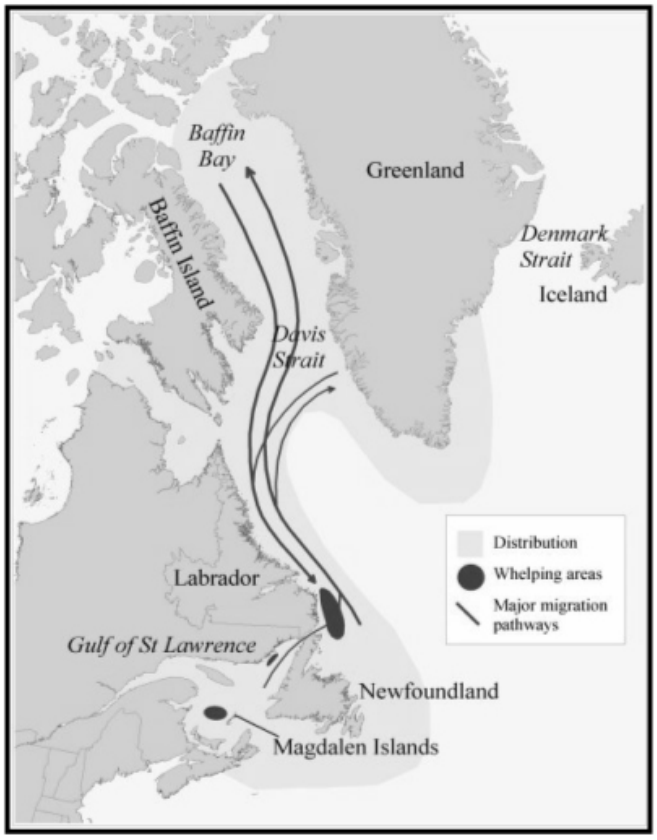

Figure 1: From: *Technical Briefing on the Harp Seal Hunt in Atlantic Canada*
http://www.dfo-mpo.gc.ca/misc/seal_briefing_e.htm

Harp seals are highly migratory (Sergeant 1965; Stenson and Sjare 1997). Breeding occurs at different times for each stock between late-February and April. Adults then assemble on suitable pack ice 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.

Since the early 1990s, 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 (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). A revised model assuming density-dependent population growth, carrying capacity of 12 million and annual reproductive rate data was fitted to the 2008 survey data (DFO 2011). The model estimated a total population 8.3 million (95% CI=7.5-8.9 million animals) increasing to 8.6 – 9.6 million (95% CI=7.8 to 10.8 million) animals in 2010. A population model was applied to 1952-2012 population estimates and the resultant total harp seal population size in 2012 was estimated to be 7.1 million animals (95% CI 5.9-8.3 million; Hammill *et al.* 2012). DFO flew a harp seal survey in 2012 and staff are completing counts of pups in the resultant imagery to estimate pup production and model population size.

Table 1. Summary of abundance estimates for western North Atlantic harp seals in Canadian waters. 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	8.3 million	(95% CI 7.5-8.9 million)
2010	Front and Gulf	8.6-9.6 million	(95% CI 7.8-10.8 million)
2012	Front and Gulf	7.1 million	(95% CI 5.9-8.3 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 7.1 million (95% CI 5.9-8.3 million; Hammill *et al.* 2012)). 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 suggested that the increase in pup production observed throughout the 1990s may have abated (Stenson *et al.* 2005). However, the 2008 revised estimate of pup production is 1,630,300 (CV=6.8%), based on photographic and visual aerial survey counts (DFO 2011), and indicates that pup production had increased in intervening years since 1999. Estimated pup production in 2012 was 1.5 million animals (Hammill *et al.* 2012).

The status of the population in U.S. waters is unknown. Recent increases in strandings may not be indicative of population size.

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 the population is increasing. PBR for the western North Atlantic harp seal in U.S. waters is unknown. The PBR for the stock in U.S. waters is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2007–2011 the total estimated annual human caused mortality and serious injury to harp seals was 306,082. This is derived from three components: 1) an average catch of 305,804 seals from 2007-2011 by Canada and Greenland, including bycatch in the lumpfish fishery (Table 2a); 2) 271 harp seals (CV=0.19) from the observed U.S. fisheries (Table 2b); and 3) an average of 7 stranded seals from 2007-2011 that showed signs of non-fishing human interaction.

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

Fishery	**2007**	**2008**	**2009**	**2010**	**2011**	**Average**
Commercial catches[a]	224,745	217,850	76,688	69,101	40,370	**125,751**
Commercial catch struck and lost[b]	14,914	11,736	4,035	4,060	2,078	**7,365**
Greenland subsistence catch[c]	82,836	80,556	71,046	83,669	77,800	**79,181**
Canadian Arctic[d]	1,000	1,000	1,000	1,000	1,000	**1,000**
Greenland and Canadian Arctic struck and lost[e]	83,836	81,556	72,046	84,669	78,800	**80,181**
Newfoundland lumpfish[f]	12,330	12,330	12,330	12,330	12,330	**12,330**
Total	**419,661**	**405,028**	**237,125**	**254,829**	**212,378**	**305,804**

a. Hammill and Stenson 2003, DFO 2003, DFO 2005, DFO 2010; ICES 2011; Hammill *et al.* 2012

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, 2011 DFO 2005, 2010; Hammill *et al.* 2012

d. Hammill and Stenson 2003; Hammill *et al.* 2012

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).

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998; Andersen *et al*. 2008; NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

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 212 harp seal mortalities observed in the Northeast sink gillnet fishery between 1990 and 2011. The bycatch occurred principally in winter (January-May) and was mainly in waters from New Hampshire south to the shelf and shelf-edge waters southwest 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, 119 (0.35) in 2007, 238 (0.38) in 2008, 415 (0.27) in 2009, 253 (0.61) in 2010, and 14 (0.46) in 2011 (Table 2b; Orphanides 2013). There were also 2, 9, 14, 8, 18, 6, 8, 5, and 9 unidentified seals observed during 2003 through 2011 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 2007-2011 was 208 harp seals (CV=0.21) (Table 2b).

A study on the effects of two different hanging ratios in the bottom set monkfish gillnet fishery on the bycatch of cetaceans and pinnipeds was conducted by NEFSC in 2009 and 2010. Commercial fishing vessels from Massachusetts and New Jersey were used for the study which took place south of the Harbor Porpoise Take Reduction Team Cape Cod South Management Area (south of 40° 40´) in February, March and April. One hundred fifty-nine hauls with eight research strings each were completed during the course of the study. Results showed that while a 0.33 mesh performed better at catching commercially important finfish than a 0.50 mesh, there was no statistical difference in cetacean or pinniped bycatch rates between the two hanging ratios. Nine harp seals were caught in this project during 2009 and one during 2010 (A.I.S. Inc 2010). These animals are included in the observed interactions and added to the total estimates (Table 2b), though these interactions and their associated fishing effort were not included in bycatch rate calculations.

Mid-Atlantic Gillnet:

No harp seals were taken in observed trips during 1993-1997 or 1999-2006. One harp seal was observed taken in both 1998 and 2007, 4 were taken in 2008, 3 in 2009, 1 in 2010 and 0 in 2011. 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 38 in 2007, 176 (0.74) in 2008, 70 (0.67) in 2009, 32 (0.96) in 2010, and 0 in 2011 (Table 2b; Orphanides 2013). Average annual estimated fishery-related mortality attributable to this fishery during 2007-2011 was 63 harp seals (CV=0.46) (Table 2b).

Northeast Bottom Trawl

Five mortalities were observed in the Northeast bottom trawl fishery between 2002 and 2011. 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 2006–2008, and 2010. Estimates have not been generated for 2009 or 2011.

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 Serious Injury[f]	Observed Mortality[c]	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Annual Mortality
Northeast Sink Gillnet[e]	07-11	Obs. Data, Trip Logbook, Allocated Dealer Data	.07, .05, .04, .17, .19	0, 0, 0, 0, 0	11, 14, 32, 8, 4	0, 0, 0, 0, 0	119, 238, 415, 253, 14	119, 238, 415, 253, 14	.35, .38, .27, .61, .46	208 (0.21)
Mid-Atlantic Gillnet	07-11	Obs. Data, Trip Logbook, Allocated Dealer Data	.05, .03, .03, .04, .02	0, 0, 0, 0, 0	1, 4, 3, 1, 0	0, 0, 0, 0, 0	38, 176, 70, 32, 0	38, 176, 70, 32, 0	0.9, .74, .67, .96, 0	63 (0.46)
Northeast Bottom Trawl[d]	07-11	Obs. Data Weighout	.06, .08, .09, .16, .26	0, 0, 0, 0, 0	0, 0, 1, 0, 1	0, 0, 0, 0, 0	0, 0, unk, 0, unk	0, 0, unk, 0, unk	0, 0, unk, 0, unk	0.4 (na) [d]
TOTAL										271 (0.19)

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. The 2010 and 2011 observer coverage in the NE sink gillnet fishery includes the At Sea Monitoring Program coverage.
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 2000-2011, respectively, 2, 1, 0, 0, 4, 0, 3, 0, 3, 4, 1 and 4takes were observed in nets with pingers. In 2000-2011, respectively, 1, 0, 0, 0, 11, 3, 0, 12, 15, 28, 6, and 0 takes were observed in nets without pingers.
d. Bycatch estimates attributed to the Northeast bottom trawl fishery have not been generated. Unexpanded values are provisionally provided.
e. Nine harp seals in 2009 and 1 in 2010 were incidentally caught as part of a NEFSC hanging ratio study to examine the impact of gillnet hanging ratio on harbor porpoise bycatch. These animals were included in the observed interactions and added to the total estimates, though these interactions and their associated fishing effort were not included in bycatch rate calculations.
f. Serious injuries were evaluated for the 2007–2011 period using new guidelines (Waring *et al.* in prep.)

Other Mortality

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 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). In 2009 the TAC was 280,000, it was increased to 330,000 in 2010, and to 400,000 in 2011 (DFO 2011)..

U.S.: From 2007 to 2011, 555 harp seal stranding mortalities were reported (Table 3; NMFS unpublished data). Thirty-seven (6.7%) of the mortalities during this five-year period showed signs of human interaction (6 in 2007, 3 in 2008, 6 in 2009, 15 in 2010 and 7 in 2011), 4 of which with some sign of fishery interaction (1each in 2007 and 2008 and 2 in 2009, and 2 in 2010). However, the cause of death of stranded animals is not being evaluated (interactions may be non-fatal or even post-mortem). Harris and Gupta (2006) analyzed NMFS 1996-2002 stranding data and suggested that the distribution of harp seal strandings in the Gulf of Maine was consistent with the species' seasonal migratory patterns in this region.

Table 3. Harp seal (*Pagophilus groenlandicus*) stranding mortalities [a] along the U.S. Atlantic coast (2007–2011) with subtotals of animals recorded as pups in parentheses.

State	2007	2008	2009	2010	2011	Total
Maine	8	15	9	13	6	51
New Hampshire	1	1	4	1	0	7
Massachusetts	51 (2)	51	59 (2)	45	51 (1)	96
Rhode Island	2	5	9	5	7	28
Connecticut	1	2	3	5	4	15
New York	19 (1)	8	29	22	38 (1)	59
New Jersey	3	12	5	9	16	45
Delaware	2	0	0	1	1	2
Maryland	4	1	2	2	2	3
Virginia	5	3	1	2	2	5
North Carolina	0	0	0	0	0	3
Total	**96**	**98**	**121**	**105**	**135**	**555**
Unspecified seals (all states)	34	51	34	22	11	152

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

Harp seals are not listed as threatened or endangered under the Endangered Species Act and the western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act.The level of human-caused mortality and serious injury in the U.S. Atlantic EEZ is low relative to the total stock size. 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 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.

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