HARBOR SEAL (*Phoca vitulina vitulina*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The harbor seal (*Phoca vitulina*) is found in all nearshore waters of the North Atlantic and North Pacific Oceans and adjoining seas above about 30ºN (Burns 2009; Desportes *et al*. 2010).

Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Katona *et al*. 1993), and occur seasonally along the coasts from southern New England to New Jersey from September through late May (Schneider and Payne 1983; Schroeder 2000). Scattered sightings and strandings have been recorded as far south as Florida (NOAA National Marine Mammal Health and Stranding Response Database, accessed 08 October 2015). 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; 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; Waring *et al*. 2006). Earlier research identified no pupping areas in southern New England (Payne and Schneider 1984); however, more recent anecdotal reports suggest that some pupping is occurring at high-use haulout sites off Manomet, Massachusetts and the Isles of Shoals, Maine.

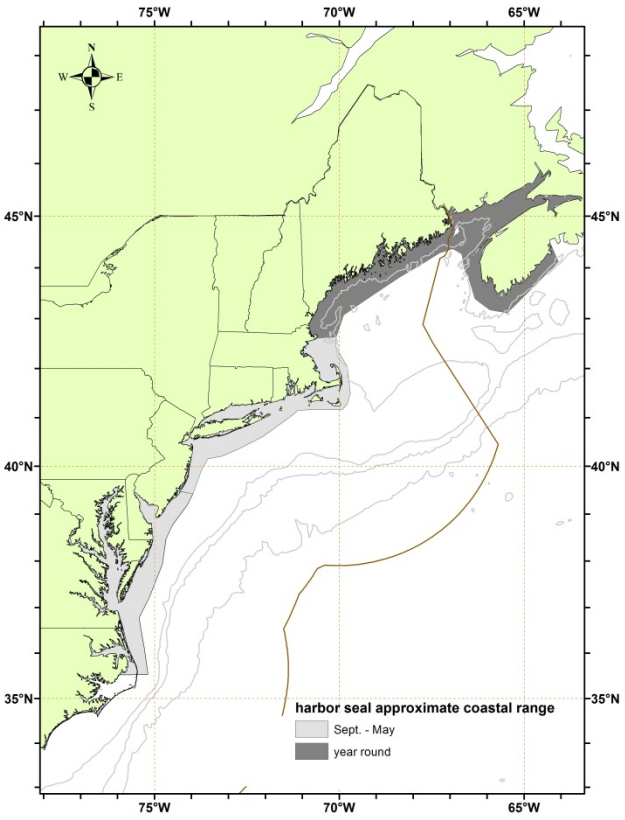

Figure 1. Approximate coastal range of harbor seals. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.

Prior to the spring 2001 live-capture and radio-tagging of adult harbor seals (Waring *et al.* 2006), 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 were detected at least once during the May/June 2001 abundance survey along the Maine coast (Gilbert *et al.* 2005; Waring *et al.* 2006). Similar findings were made in spring 2011 and 2012 (Waring *et al.* 2015).

Although the stock structure of western North Atlantic harbor seals is unknown, it is thought that harbor seals found along the eastern U.S. and Canadian coasts represent one population (Temte *et al.* 1991; Andersen and Olsen 2010). However, uncertainty in the single stock designation is suggested by multiple sources, both in this population and by inference from other populations. Stanley *et al.* (1996) demonstrated some genetic differentiation in Atlantic Canada harbor seal samples. Gilbert *et al.* (2005) noted regional differences in pup count trends along the coast of Maine. Goodman (1998) observed high degrees of philopatry in eastern North Atlantic populations. In addition, multiple lines of evidence have suggested fine-scaled sub-structure in Northeast Pacific harbor seals (Westlake and O'Corry-Crowe 2002; O'Corry-Crowe *et al.* 2003, Huber *et al*. 2010).

POPULATION SIZE

The best current abundance estimate of harbor seals is 75,834 (CV=0.15) which is from a 2012 survey (Waring *et al.* 2015). Aerial photographic surveys and radio tracking of harbor seals on ledges along the Maine coast were conducted during the pupping period in late May 2012. Twenty-nine harbor seals (20 adults and 9 juveniles) were captured and radio-tagged prior to the aerial survey. Of these, 18 animals were available during the survey to develop a correction factor for the fraction of seals not observed. A key uncertainty is that the area from which the samples were drawn in 2012 may not have included the area the entire population occupied in late May and early June. Additionally, since the most current estimate dates from a survey done in 2012, the ability for that estimate to accurately represent the present population size has become increasingly uncertain.

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

Month/Year	Area	N_{best}	CV
May/June 2012	Maine coast	75,834	0.15

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for harbor seals is 75,834 (CV=0.15). The minimum population estimate is 66,884 based on corrected available counts along the Maine coast in 2012.

Current Population Trend

A trend analysis has not been possible for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV>0.30) remains below 80% (alpha=0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

Although the 2012 population estimate was lower than the previous estimate of 99,340 obtained from a survey in 2001 (Gilbert *et al.* 2005), Waring *et al.* (2015) did not consider the population to be declining because the two estimates were not significantly different and there was uncertainty over whether some fraction of the population was not in the survey area. This was due to the fact that 31.4% of the count was pups, a percentage that is biologically unlikely. The estimated number of harbor seal pups did not differ significantly between 2001 and 2012. In 2001, there were an estimated 23,722 (CV=0.096) pups in the study area (Gilbert *et al.* 2005); in 2012 there were an estimated 23,830 (CV=0.159) pups in the study area. Therefore some non-pups in the population may not have been available to be counted because they were outside the study area of Coastal Maine. Some seals could have remained farther south in New England, more northerly in Canada, or offshore.

Johnston *et al.* (2015) document a decline in stranding and bycatch rates of harbor seals, providing support for an apparent decline in abundance. However, there has been very little systematic research conducted on fine-scale changes in habitat use, particularly in relation to the sympatric population of gray seals. Therefore, a decline in the apparent abundance of harbor seals could be explained by changing distributions and survey designs.

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). Key uncertainties about the maximum net productivity rate are due to the limited understanding of the stock-specific life history parameters; thus the default value was used.

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 66,884 animals. The maximum productivity rate is 0.12, the default value for pinnipeds. The recovery factor (F_R) is 0.5, the default value for stocks of unknown status relative to optimum sustainable population (OSP) and with the CV of the average mortality estimate less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic stock of harbor seals is 2,006.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2012-2016 the total human caused mortality and serious injury to harbor seals is estimated to be 345 per year. The average was derived from two components: 1) 333 (CV=0.12; Table 2) from 2012–2016 observed fisheries; 2) 11.6 from 2012–2016 non-fishery-related, human interaction stranding and direct interaction mortalities (NOAA National Marine Mammal Health and Stranding Response Database, accessed 03 November 2017, and 3) 0.2 from U.S. research mortalities.

Analysis of bycatch rates from fisheries observer program records likely underestimates lethal (Lyle and Willcox 2008), and greatly under-represents sub-lethal, fishery interactions. Reports of seal shootings and other non-fishery-related human interactions are minimums.

Fishery Information

Detailed fishery information is given in Appendix III.

U.S.

Northeast Sink Gillnet:

Harbor seal bycatch is observed year-round, most frequently in the summer in groundfish trips occurring between Boston, Massachusetts, and Maine in coastal Gulf of Maine waters. Williams (1999) aged 261 harbor seals caught in this fishery from 1991 to 1997, and 93% were juveniles (i.e., less than four years old). Revised serious injury guidelines were applied for this period (Josephson *et al.* 2019). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information. Analysis methodology and results can be found in Orphanides (2013, 2019), Hatch and Orphanides (2014, 2015, 2016), and Orphanides and Hatch (2017).

Mid-Atlantic Gillnet

Harbor seal bycatch has been observed in this fishery in waters off Massachusetts and New Jersey and rarely further south. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information. Analysis methodology and results can be found in Orphanides (2013, 2019), Hatch and Orphanides (2014, 2015, 2016), and Orphanides and Hatch (2017).

Northeast Bottom Trawl

Harbor seals are occasionally observed taken in this fishery. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Bottom Trawl

Harbor seals are rarely observed taken in this fishery. Annual harbor seal mortalities were estimated using annual stratified ratio-estimator methods (Chavez *et al*. 2018). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Mid-water Trawl Fishery (Including Pair Trawl)

Harbor seals are occasionally observed taken in this fishery. An extended bycatch rate has not been calculated for the current 5-year period. Until this bycatch estimate can be developed, the average annual fishery-related mortality and serious injury for 2012–2016 is calculated as 1.0 animal (5 animals/5 years). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

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 1 harbor seal was captured and released alive in 2012, 1 in 2013, and 0 in 2014– 2016. In addition, 0 seals of unknown species were captured and released alive in 2012–2014, 2 in 2015, and 1 in 2016. None of the seals captured alive herring purse seine during 2012-2016 were designated as serious injuries (Josephson *et al.* 2019).

CANADA

Currently, scant data are available on bycatch in Atlantic Canada fisheries due to limited 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 under nuisance permits.

Table 2. Summary of the incidental mortality of harbor seals (Phoca vitulina 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	Data Type [a]	Observer Coverage [b]	Observed Serious Injury [c]	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Annual Mortality
Northeast Sink Gillnet	2012	Obs. Data, Weighout, Logbooks	0.15	0	37	0	252	252	0.26	302 (0.13)
	2013		0.11	0	22	0	142	142	0.31	
	2014		0.18	0	59	0	390	390	0.39	
	2015		0.14	0	87	0	474	474	0.17	
	2016		0.1	0	36	0	245	245	0.29	
Mid-Atlantic Gillnet	2012	Obs. Data, Weighout	0.02	0	0	0	0	0	0	17 (0.43)
	2013		0.03	0	0	0	0	0	0	
	2014		0.05	0	1	0	19	19	1.06	
	2015		0.06	0	5	0	48	48	0.52	
	2016		0.08	0	2	0	18	18	0.95	
Northeast Bottom Trawl	2012	Obs. Data, Weighout	0.17	0	1	0	3	3	.81,	3.6 (.46)
	2013		0.15	0	1	0	4	4	0.89	
	2014		0.17	0	2	0	11	11	0.63	
	2015		0.19	0	0	0	0	0	0	
	2016		0.12	0	0	0	0	0	0	
Mid-Atlantic Bottom Trawl	2012	Obs. Data, Dealer	0.05	0	3	0	23	23	.96,	10 (.53)
	2013		0.06	0	1	0	11	11	0.96	
	2014		0.08	0	2	0	10	10	0.95	
	2015		0.09	0	1	0	7	7	1	
	2016		0.097	0	0	0	0	0	0	
Northeast Mid-water Trawl - Including Pair Trawl	2012	Obs. Data, Weighout, Trip Logbook	0.45	0	1	0	na	na	na	1.0 (na)
	2013		0.37	0	0	0	0	0	0	
	2014		0.42	0	1	0	na	na	na	
	2015		0.08	0	2	0	na	na	na	
	2016		0.27	0	1	0	na	na	na	
TOTAL	-	-	-	-	-	-	-	-	-	333 (0.12)

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 bottom and mid-water trawl fisheries are ratios based on trips. Total observer coverage reported for bottom trawl gear and gillnet gear in the years 2012-2016 includes samples collected from traditional fisheries observers in addition to fishery monitors through the Northeast Fisheries Observer Program (NEFOP).

c. Serious injuries were evaluated for the 2012–2016 period and include both at-sea monitor and traditional observer data (Josephson *et al.* 2019).

Other Mortality

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.

Other sources of harbor seal mortality include human interactions, storms, abandonment by the mother, disease (Anthony *et al.* 2012), and predation (Katona *et al.* 1993; NMFS unpublished data; Jacobs and Terhune 2000). Mortalities caused by human interactions include research mortalities, boat strikes, fishing gear interactions, oil spill/exposure, harassment, and shooting.

Harbor seals strand each year throughout their migratory range. Stranding data provide insight into some of these sources of mortality. From 2012 to 2016, 1,198 harbor seal stranding mortalities were reported between Maine and Florida (Table 3; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 03 November 2017). Sixty-nine (5.8%) of the dead harbor seals stranded during this five-year period showed signs of human interaction (9 in 2012, 15 in 2013, 11 in 2014, 18 in 2015, and 16 in 2016), with 11 (1.0%) having some sign of fishery interaction (2 in 2012, 3 in 2013, 2 in 2014, 2 in 2015, and 3 in 2016). Three harbor

seals during this period were reported as having been shot. Sixteen harbor seal mortalities were reported with indications of vessel strike. In an analysis of mortality causes of stranded marine mammals on Cape Cod and southeastern Massachusetts between 2000 and 2006, Bogomolni *et al.* (2010) reported that 13% of harbor seal stranding mortalities were attributed to human interaction.

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 2006). NMFS declared another UME in the Gulf of Maine in autumn 2006 based on infectious disease. A UME was declared in November of 2011 that involved 567 harbor seal stranding mortalities between June 2011 and October 2012 in Maine, New Hampshire, and Massachusetts. The UME was declared closed in February 2013.

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).

CANADA

Aquaculture operations in eastern Canada can be 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 (DFO 2011).

Table 3. Harbor seal (*Phoca vitulina vitulina*) stranding mortalities along the U.S. Atlantic coast (2012-2016) with subtotals of animals recorded as pups in parentheses.

State	2012	2013	2014	2015	2016	Total
Maine	131 (101)	99 (74)	127 (94)	73 (47)	76 (58)	506
New Hamphire	24 (18)	16 (6)	38 (22)	56 (43)	45 (27)	179
Massachusetts	54 (35)	95 (39)	58 (15)	81 (24)	55 (19)	343
Rhode Island	14 (0)	9 (3)	7 (1)	8 (0)	5 (1)	43
Connecticut	1 (1)	2 (1)	0	2 (1)	1	6
New York	14 (1)	11 (2)	13 (4)	21 (0)	1	60
New Jersey	7 (0)	4 (0)	2 (1)	9 (4)	4	26
Delaware	0	0	3 (0)	1 (0)	1 (1)	5
Maryland	0	1 (0)	2 (0)	0	0	3
Virginia	0	5 (0)	2 (0)	1 (0)	1	9
North Carolina	2 (0)	3 (0)	3 (1)	5 (2)	4 (2)	17
South Carolina	0	0	1 (0)	0	0	1
Total	**247**	**245**	**256**	**257**	**193**	**1198**

State	2012	2013	2014	2015	2016	Total
Unspecified seals (all states)	28	25	38	31	13	135

STATUS OF STOCK

Harbor 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 2012–2016 average annual human-caused mortality and serious injury does not exceed PBR. The status of the western North Atlantic harbor seal stock, relative to OSP, in the U.S. Atlantic EEZ is unknown. Total fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate.

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