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

STOCK DEFINITION AND GEOGRAPHIC RANGE

The harbor seal (*Phoca vitulina*) is widespread 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 Virginia from September through late May (Schneider and Payne 1983; Schroeder 2000; Rees *et al*. 2016; Toth *et al*. 2018). Scattered sightings and strandings have been recorded as far south as Florida (NOAA National Marine Mammal Health and Stranding Response Database, accessed 23 October 2018). A general southward movement from the Bay of Fundy to southern New England and mid-Atlantic waters occurs in autumn and early winter (Rosenfeld *et al.* 1988; Whitman and Payne 1990; Jacobs and Terhune 2000). A northward movement to Maine and eastern Canada occurs prior to the pupping season, which takes place from early May through early June primarily along the Maine coast (Gilbert *et al.* 2005; Skinner 2006). The amount of pupping that occurs in Canadian waters is currently unknown.

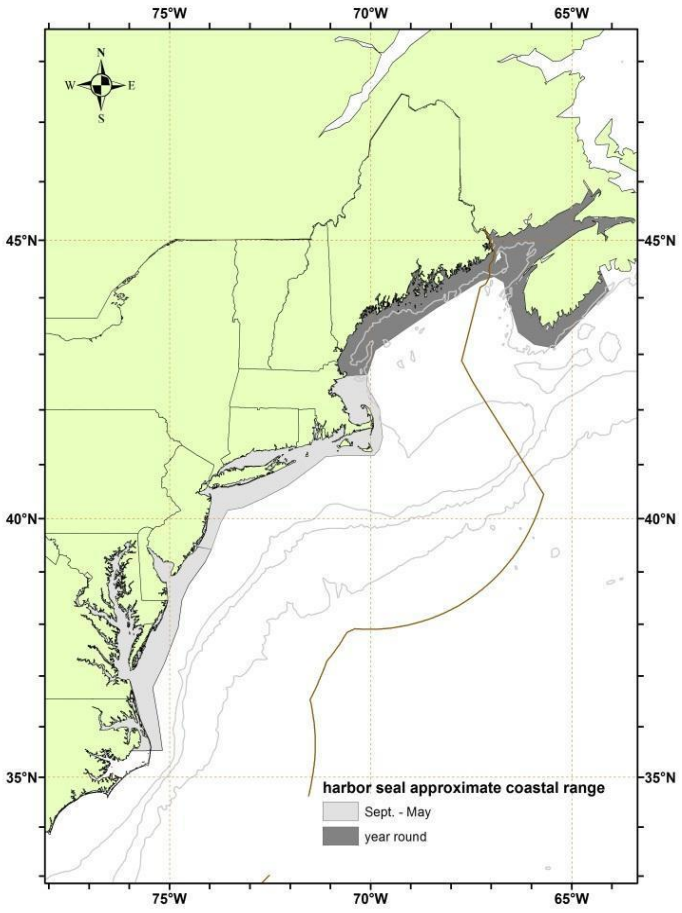

Figure 1. Approximate coastal range of harbor seals. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.

Tagging studies of adult harbor seals demonstrate that adults can make long-distance migrations through the mid-Atlantic and Gulf of Maine (Waring *et al.* 2006; Ampela *et al.* 2018). Prior to these studies, 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 more recent studies demonstrate that various age classes utilize habitat along the eastern seaboard throughout the year. 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 estimate of harbor seal abundance in U.S. waters is 61,336 (CV=0.08) for 2018, the last year surveyed, based on a Bayesian hierarchical analysis of abundance trends from 1993 to 2018 (Sigourney *et al.* 2021). Estimates of abundance are based on surveys conducted during the pupping season, when most of the population is assumed to be congregated along the Maine coast. Abundance estimates do not reflect the portion of the stock that might pup in Canadian waters. Survey specific correction factors, a means to adjust the survey counts to account for the number of seals in the water at the time of the survey, were not available for most years in the analysis including 2018. Therefore, multiple sources of information on harbor seal haul-out behavior were used to adjust observed counts to estimate total abundance. The 2018 estimate is an average of 2 abundance estimates [70,663 (CV=0.11) and 51,878 (CV=0.10)] derived using different correction factors applied to the estimated number of seals hauled out under ideal conditions.

The 2018 harbor seal pupping survey was designed to survey ledges of known historic occupancy in U.S. waters. If new areas are being populated, they need to be incorporated into future surveys for abundance. Reconnaissance flights for pupping south of Maine would help confirm the extent of the current pupping range and help ensure that some portion of the population is not missed during the survey.

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_{est}) and coefficient of variation (CV).

Month/Year	Area	N_{est}	CV
May/June 2018	Maine coast	61,336	0.08
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% credible interval about the median of the posterior abundance estimates using the methods of Sigourney *et al*. 2021. This is roughly equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The minimum population estimate is 57,637 based on corrected available counts along the Maine coast in 2018.

Current Population Trend

Aerial surveys of harbor seals during the pupping season in Maine have been conducted periodically since 1981 (Gilbert *et al.* 2005; Waring *et al*. 2015; Sigourney *et al*. 2021) and some of these surveys have been used to estimate trends in abundance. Trend in the population from 1993–2018 was estimated for non-pups and pups using a Bayesian hierarchical model to account for missing data both within and between survey years (Sigourney *et al*. 2021). The estimated mean change in non-pup harbor seal abundance per year was positive from 2001 to 2004, but close to zero or negative between 2005 and 2018 (Figure 1a). However, these mean percent changes each year were not statistically significant as evidenced by 95% credible intervals. The estimated mean change in pup abundance was significantly positive from 2001 to 2005. After 2005, mean change in pup abundance was steady or declining until 2018 but these changes were not significant (Figure 1b).

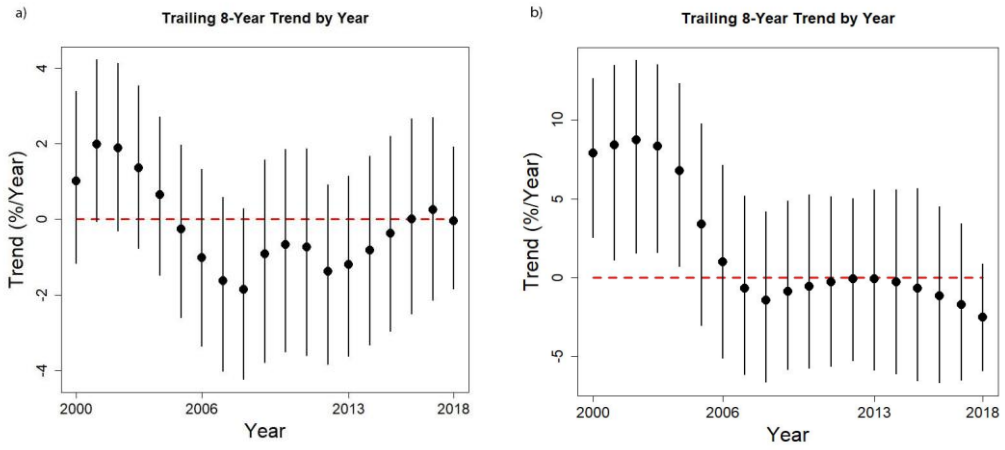

Figure 1. Estimates of average percent change in non-pup (a) and pup (b) harbor seal abundance with 95% Bayesian credible intervals (vertical lines) around the posterior mean over a trailing 8-year moving window starting from 1993.

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 57,637 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 portion of the western North Atlantic stock of harbor seals in U.S. waters is 1,729.

Table 2. Best and minimum abundance estimates for the Western North Atlantic harbor seal (Phoca vitulina vitulina) with Maximum Productivity Rate (R_{max}), Recovery Factor (F_R) and PBR.

N_{est}	CV	N_{min}	F_R	R_{max}	PBR
61,336	0.08	57,637	0.5	0.12	1,729

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2015–2019, the annual average annual estimated human-caused mortality and serious injury to harbor seals in the U.S. is 339 (Table 3). Mortality in U.S. fisheries is explained in further detail below.

Table 3. The total annual estimated average human-caused mortality and serious injury for the Western North Atlantic harbor seal (Phoca vitulina vitulina).

Years	Source	Annual Avg.	CV
2015–2019	U.S. fisheries using observer data	334	0.09
2015–2019	Non-fishery human interaction stranding mortalities	4.6	-

2015–2019	Research mortalities	0	-
TOTAL		339	-

Fishery Information

Detailed fishery information is given in Appendix III.

United States

Northeast Sink Gillnet

The Northeast sink gillnet fishery is a Category I fishery. The average annual observed mortality from 2015–2019 was 53 animals, and the average annual total mortality was 304 (CV=0.10; Orphanides and Hatch 2017; Orphanides 2019, 2020, 2021; Precoda and Orphanides 2022; Josephson *et al.* 2022). See Table 4 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Gillnet

The Mid-Atlantic sink gillnet fishery is a Category I fishery. The average annual observed mortality from 2015–2019 was 3 animals, and the average annual total mortality was 22 (CV=0.30; Orphanides and Hatch 2017; Orphanides 2019, 2020, 2021; Precoda and Orhanides 2022; Josephson *et al.* 2022). See Table 4 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Bottom Trawl

The Northeast bottom trawl fishery is a Category II fishery. The average annual observed mortality from 2015–2019 was <1 animal, and the average annual total mortality was 3 (CV=0.68; Lyssikatos and Chavez-Rosales 2022). See Table 4 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

The Mid-Atlantic bottom trawl fishery is a Category II fishery. The average annual observed mortality from 2015–2019 was <1 animal, and the average annual total mortality was 4 (CV=0.56; Lyssikatos and Chavez-Rosales 2022). See Table 4 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)

The Northeast mid-water and pair trawl fisheries are Category II fisheries. The average annual observed mortality from 2015–2019 was <1 animal. An expanded bycatch estimate has not been calculated for the current 5-year period. See Table 4 for observed mortality and serious injury during the current 5-year period, and Appendix V for historical bycatch information.

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 4. Summary of the incidental mortality of harbor seals (Phoca vitulina vitulina) 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 [c]	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Annual Mortality
Northeast Sink Gillnet	2015 2016 2017 2018 2019	Obs. Data, Weighout, Logbooks	0.14 0.10 0.12 0.11 0.13	0 0 0 0 0	87 36 63 22 59	0 0 0 0 0	474 245 298 188 316	474 245 298 188 316	0.17 0.29 0.18 0.36 0.15	304 (0.1)
Mid-Atlantic Gillnet	2015 2016 2017 2018 2019	Obs. Data, Weighout	0.06 0.08 0.09 0.09 0.12	0 0 0 0 0	5 2 1 3 3	0 0 0 0 0	48 18 3 26 17	48 18 3 26 17	0.52 0.95 0.62 0.52 0.35	22 (0.3)
Northeast Bottom Trawl	2015 2016 2017 2018 2019	Obs. Data, Weighout	0.19 0.12 0.16 0.12 0.16	0 0 0 0 0	0 0 0 0 1	0 0 0 0 0	0 0 8 0 5	0 0 8 0 5	0 0 0.96 0 0.88	2.7 (0.68)
Mid-Atlantic Bottom Trawl	2015 2016 2017 2018 2019	Obs. Data, Dealer	0.09 0.10 0.14 0.12 0.12	0 0 0 0 0	1 0 0 1 1	0 0 0 0 0	7 0 0 6 7	7 0 0 6 7	1 0 0 0.94 0.93	4.0 (0.56)
Northeast Mid-water Trawl - Including Pair Trawl	2015 2016 2017 2018 2019	Obs. Data, Weighout, Trip Logbook	0.08 0.27 0.16 0.14 0.28	0 0 0 0 0	2 1 0 0 0	0 0 0 0 0	na na 0 0 0	na na 0 0 0	na na 0 0 0	0.6 (na)
TOTAL										334 (0.09)

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 2014–2018 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 2015–2019 period and include both at-sea monitor and traditional observer data (Josephson *et al.* 2022)

Other Mortality

United States

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.

Harbor seals strand each year throughout their migratory range. Stranding data provide insight into some of these sources of mortality. Tables 5 and 6 present summaries of harbor seal stranding mortalities as reported to the NOAA National Marine Mammal Health and Stranding Response Database (accessed 17 November 2020). 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.

Table 5. Harbor seal (Phoca vitulina vitulina) stranding mortalities along the U.S. Atlantic coast (2015–2019) with subtotals of animals recorded as pups in parentheses.

State	2015	2016	2017	2018	2019	Total
Maine	73 (47)	76 (58)	120 (84)	819 (75)	188 (59)	1,276 (323)
New Hampshire	56 (43)	45 (27)	26 (20)	113 (60)	26 (2)	266 (152)

Massachusetts	81 (24)	55 (19)	78 (29)	204 (58)	72 (12)	490 (142)
Rhode Island	8 (0)	5 (1)	9 (3)	9 (0)	10 (3)	41 (7)
Connecticut	2 (1)	1 (0)	2 (0)	2 (1)	2 (0)	9 (2)
New York	21 (0)	1 (0)	11 (0)	12 (1)	13 (0)	58 (1)
New Jersey	9 (4)	4 (0)	9 (3)	14 (2)	4 (0)	40 (9)
Delaware	1 (0)	1 (1)	1 (0)	2 (1)	3 (0)	8 (2)
Maryland	0	0	1 (0)	4 (0)	2 (0)	7 (0)
Virginia	1 (0)	1 (0)	2 (0)	1 (0)	4 (0)	9 (0)
North Carolina	5 (2)	4 (2)	4 (4)	7 (2)	2 (1)	22 (11)
Total	257 (121)	193 (108)	263 (143)	1,187 (200)	326 (77)	2,226 (649)
Unspecified seals (all states)	31	13	86	92	80	302

Table 6. Harbor seal (Phoca vitulina vitulina) human-interaction stranding mortalities along the U.S. Atlantic coast (2015–2019) by type of interaction.

Cause	2015	2016	2017	2018	2019	Total
Fishery Interaction	2	3	1	5	3	14
Boat Strike	1	5	3	2	0	11
Shot	0	0	0	0	0	0
HI - Other - possible contribution to death	4	1	1	5	1	12
HI - Other - not contributing to death, or unk	11	7	5	17	8	48
TOTAL	18	16	10	29	12	85

A number of Unusual Mortality Events (UMEs) have affected harbor seals over the past decade. The most recent was declared by the NMFS beginning in July 2018 due to increased numbers of harbor and gray seal strandings along the U.S. coasts of Maine, New Hampshire, and Massachusetts. Strandings remained elevated over the summer and the UME area was expanded to include nine states from Maine to Virginia with strandings continuing into 2019. From July 1, 2018 to March 13, 2020, 3,152 seals (including harbor and gray seals) stranded from Maine to Virginia. The preliminary cause of the UME was attributed to a phocine distemper outbreak (https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/2018-2020-pinniped-unusual-mortality-event-along).

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). Four animals were taken in 2019 for scientific research (Samuel Mongrain, pers comm.).

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 2015–2019 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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