GRAY SEAL (*Halichoerus grypus atlantica*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The gray seal (*Halichoerus grypus*) is found on both sides of the North Atlantic, with three major populations: Northeast Atlantic, Northwest Atlantic and the Baltic Sea (Haug *et al.* 2007). The Northeast Atlantic and the Northwest Atlantic populations are classified as the subspecies *H. g. atlantica* (Olsen *et al.* 2016). The Northwest Atlantic population includes the western North Atlantic stock ranges from New Jersey to Labrador (Figure 1; Davies 1957, Mansfield 1966, Katona *et al.* 1993, Lesage and Hammill 2001). This stock is separated from the northeastern Atlantic stocks by geography, differences in the breeding season, and mitochondrial and nuclear DNA variation (Bonner 1981, Boskovic *et al.* 1996, Lesage and Hammill 2001, Klimova *et al.* 2014). There are three breeding aggregations in eastern Canada: Sable Island, Gulf of St. Lawrence, and at sites along the coast of Nova Scotia (Laviguer and Hammill 1993). Animals from these aggregations mix outside the breeding season (Lavigueur and Hammill 1993; Harvey *et al.* 2008; Breed *et al.* 2006, 2009) and they are considered a single population based on genetic similarity (Boskovic *et al.* 1996, Wood *et al.* 2011).

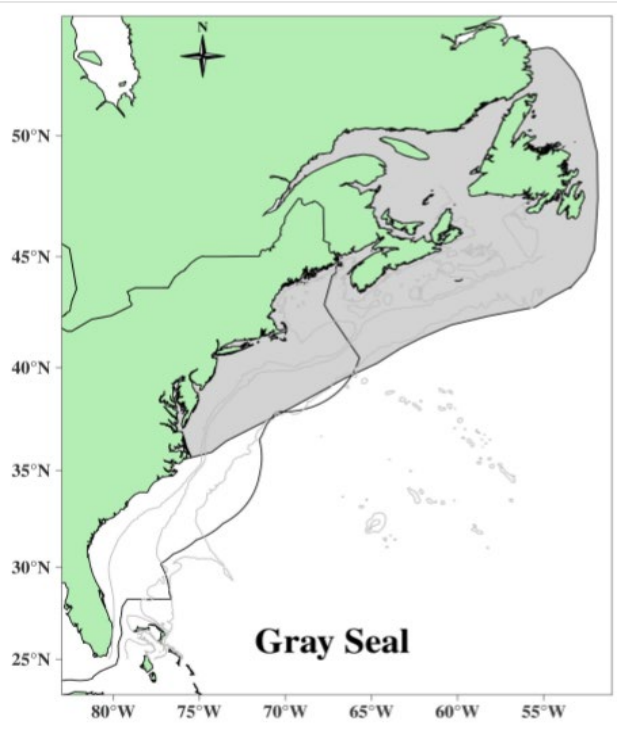

Figure 1: Approximate range of the Western North Atlantic stock of gray seals (Halichoerus grypus atlantica).

After near extirpation due to bounties, which ended in the 1960s, small numbers of animals and pups were observed on several isolated islands along the Maine coast and in Nantucket-Vineyard Sound, Massachusetts (Katona *et al.* 1993, Rough 1995, Gilbert *et al*. 2005). In December 2001, NMFS initiated aerial surveys to monitor gray seal pup production on Muskeget Island and adjacent sites in Nantucket Sound, and Green and Seal Islands off the coast of Maine (Wood *et al.* 2007). Tissue samples collected from Canadian and U.S. populations were examined for genetic variation using mitochondrial and nuclear DNA (Wood *et al.* 2011). All individuals were identified as belonging to one population, confirming that the new U.S. population was recolonized by Canadian gray seals. The genetic evidence (Boskovic *et al.* 1996, Wood *et al.* 2011) provides a high degree of certainty that the western North Atlantic stock of gray seals comprise a single stock. Further supporting evidence comes from sightings of seals in the U.S. that had been branded on Sable Island, resights of tagged animals, and satellite tracks of tagged animals (Puryear *et al.* 2016). However, the percentage of time that individuals are resident in U.S. waters is unknown.

POPULATION SIZE

The size of the Northwest Atlantic gray seal population is estimated separately for the portion of the population in Canada versus the U.S., and mainly reflects the size of the breeding population in each respective country (Table 1). Currently there is a lack of information on the rate of exchange between animals in the U.S. and Canada, which influences seasonal changes in abundance throughout the range of this transboundary stock as well as life history parameters in population models. Total pup production in 2016 at breeding colonies in Canada was estimated to be 98,650 pups (CV=0.10; den Heyer 2017, DFO 2017). Production at Sable Island, Gulf of St. Lawrence, and Coastal Nova Scotia colonies accounted for 85%, 11% and 4%, respectively, of the estimated total number of pups born.

Population models, incorporating estimates of age-specific reproductive rates and removals, are fit to these pup production estimates to estimate total population levels in Canada. The total Canadian gray seal population in 2016 was estimated to be 424,300 (95%CI: 263,600–578,300; DFO 2017). Uncertainties in the population estimate derive from uncertainties in life history parameters such as mortality rates and sex ratios (DFO 2017).

In U.S. waters, the number of pupping sites has increased from one in 1988 to nine in 2019, and are located in Maine and Massachusetts (Wood *et al*. 2019). Although white-coated pups have stranded on eastern Long Island beaches in New York, no pupping colonies have been detected in that region. A minimum of 6,308 pups were born in 2016 at U.S. breeding colonies (Wood *et al*. 2019), approximately 6% of the total pup production over the entire range of the population (denHeyer *et al.* 2017). The percentage of pup production in the U.S. is considered a minimum because pup counts are single day counts that have not been adjusted to account for pups born after the survey, or that left the colony prior to the survey. Mean rates of increase in the number of pups born at various times since 1988 at four of the more frequently surveyed pupping sites (Muskeget, Monomoy, Seal, and Green Islands) ranged from -0.2% (95%CI: -2.3–1.9%) to 26.3% (95%CI: 21.6–31.4%; Wood *et al.* 2019). These high rates of increase provide further support that seals from other areas are continually supplementing the breeding population in U.S. waters.

The number of pups born at U.S. breeding colonies can be used to approximate the total size (pups and adults) of the gray seal population in U.S. waters, based on the ratio of total population size to pups in Canadian waters (4.3:1; den Heyer *et al.* 2017, DFO 2017). Although not yet measured for U.S. waters, this ratio falls within the range of other adult to pup ratios suggested for pinniped populations (Harwood and Prime 1978, Thomas *et al.* 2019). Using this approach, the population estimate in U.S. waters is 27,131 (CV=0.19; 95%: 18,768–39,221) animals. The CV and CI around this estimate are based on CVs and CIs from Canadian population estimates, rather than using a default CV when the variance is unknown (Wade and Angliss 1997). There is further uncertainty in this abundance level in the U.S. because life history parameters that influence the ratio of pups to total individuals in this portion of the population are unknown. It also does not reflect seasonal changes in stock abundance in the Northeast region for a transboundary stock. For example, roughly 24,000 seals were observed in southeastern Massachusetts alone in 2015 (Pace *et al.* 2019), yet 28,000–40,000 gray seals were estimated to be in this region in 2015 using correction factors applied to seal counts obtained from Google Earth imagery (Moxley *et al.* 2017).

Table 1. Summary of recent abundance estimates for the western North Atlantic gray seal (Halichoerus grypus atlantica) by year, and area covered, resulting total abundance estimate (N_{est}) and 95% confidence interval (95%CI).

Year	Area	N_{est} [a]	95%CI
2012[b]	Gulf of St Lawrence + Nova Scotia Eastern Shore + Sable Island	331,000	263,000–458,000
2014[c]	Gulf of St Lawrence + Nova Scotia Eastern Shore + Sable Island	505,000	329,000–682,000
2016[d]	Gulf of St Lawrence + Nova Scotia Eastern Shore + Sable Island	424,300	263,600–578,300
2016	U.S	27,131[e]	18,768–39,221

a. These are model-based estimates derived from pup surveys.
b. DFO 2013
c. DFO 2014
d. DFO 2017
e. This is derived from total population size to pup ratios in Canada, applied to U.S. pup counts.

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). Based on an estimated U.S. population in 2016 of 27,131 (CV=0.19), the minimum population estimate in U.S. waters is 23,153 (Table 2). Similar to the best abundance estimate, there is uncertainty in this minimum abundance level in the U.S. because life history parameters that influence the ratio of pups to total individuals in this population are unknown.

Current Population Trend

In the U.S., the mean rate of increase in the number of pups born differs across the pupping. From 1988–2019, the estimated mean rate of increase in the number of pups born was 12.8% on Muskeget Island, 26.3% on Monomoy Island, 11.5% on Seal Island, and -0.2% on Green Island (Wood *et al*. 2019). These rates only reflect new recruits to the population and do not reflect changes in total population growth resulting from Canadian seals migrating to the region.

The total population of gray seals in Canada was estimated to be increasing by 4.4% per year from 1960–2016 (Hammill *et al*. 2017), primarily due to increases at Sable Island. Pup production on Sable Island increased exponentially at a rate of 12.8% per year between the 1970s and 1997 (Bowen *et al.* 2003). Pupping also occurs on Hay Island off Nova Scotia, in colonies off southwestern Nova Scotia, and in the Gulf of St. Lawrence. Since 1997, the rate of increase has slowed (Bowen *et al.* 2011, den Heyer *et al.* 2017), supporting the hypothesis that density-dependent changes in vital rates may be limiting population growth. While slowing, pup production is still increasing on Sable Island and in southwest Nova Scotia, and stabilizing on Hay Island in the Gulf of St. Lawrence (DFO 2017, den Heyer *et al.* 2017). In the Gulf of St. Lawrence, the proportion of pups born on the ice has declined from 100% in 2004 to 1% in 2016 due to a decline in winter ice cover in the area, and seals have responded by pupping on nearby islands (DFO 2017).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For the 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 for the portion of the stock residing in U.S. waters is 23,153. The maximum productivity rate is 0.12, the default value for pinnipeds. The recovery factor (F_r) for this stock is 1.0, the value for stocks of unknown status, but which are known to be increasing. PBR for the western North Atlantic stock of gray seals residing in U.S. waters is 1,389 animals (Table 2). Uncertainty in the PBR level arises from the same sources of uncertainty in calculating a minimum abundance estimate in U.S. waters.

Table 2. Best (N_{est}) and minimum abundance (N_{min}) estimates for the western North Atlantic gray seal (Halichoerus grypus atlantica) with Maximum Productivity Rate (R_{max}), Recovery Factor (F_r) and PBR.

N_{est}	CV	N_{min}	Fr	Rmax	PBR
27,131	0.19	23,153	1	0.12	1,389

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2014–2018, the average annual estimated human-caused mortality and serious injury to gray seals in the U.S. and Canada was 4,729 (953 U.S./3,776 Canada) per year. 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 gray seal (Halichoerus grypus atlantica).

Years	Source	Annual Avg.	CV
2014–2018	U.S. fisheries using observer data	946	0.11
2014–2018	U.S. non-fishery human interaction stranding mortalities	6.2	
2014–2018	U.S. research mortalities	1.2	
2014–2018	Canadian commercial harvest	636	
2014–2018	DFO Canada scientific collections	62	
2014–2018	Canadian removals of nuisance animals	3,078	
Total		**4,729**	

Some human-caused mortality or serious injury may not be able to be quantified. Observed serious injury rates are lower than would be expected from the anecdotally observed numbers of gray seals living with ongoing entanglements. Estimated rates of entanglement in gillnet gear, for example, may be biased low because 100% of observed animals are dead when they come aboard the vessel (Josephson *et al.* 2021); therefore, rates do not reflect the number of live animals that may have broken free of the gear and are living with entanglements. For example, mean prevalence of live entangled gray seals ranged from roughly 1 to 4% at haul-out sites in Massachusetts and Isle of Shoals (Iruzun Martins *et al.* 2019). Reports of seal shootings and other non-fishery-related human interactions are minimum counts.

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 2014–2018 was 199 animals, and the average annual estimated total mortality was 896 (CV=0.11; Hatch and Orphanides 2016; Orphanides and Hatch 2017; Orphanides 2019, 2020, 2021). 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 2014–2018 was <1 animal, and the average annual total mortality was 8.8 (CV=0.67; Hatch and Orphanides 2016; Orphanides and Hatch 2017; Orphanides 2019, 2020, 2021). 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.

Gulf of Maine Atlantic Herring Purse Seine Fishery

The Gulf of Maine Atlantic Herring Purse Seine Fishery is a Category III fishery. No mortalities have been observed in this fishery, during the current 5-year period, however, two gray seals were captured and released alive in 2014, zero in 2015, five in 2016, zero in 2017 and one in 2018. In addition, two seals of unknown species were captured and released alive in 2015 and one in 2016 (Josephson *et al.* 2021).

Northeast Bottom Trawl

The Northeast bottom trawl fishery is a Category II fishery. The average annual observed mortality from 2014–2018 was three animals, and the average annual total mortality was 18 (CV=0.22; Lyssikatos *et al.* 2021). 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 2014–2018 was two animals, and the average annual total mortality was 23 (CV=0.33; Lyssikatos *et al.* 2021). 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 and Pair Trawl

The Northeast mid-water trawl and pair trawl fisheries are Category II fisheries. Only one gray seal was observed in these fisheries from 2014–2018 and an expanded bycatch estimate has not been generated. See Table 4 for observed mortality and serious injury for during the current 5-year period, and Appendix V for historical bycatch information.

Canada

There is limited information on Canadian fishery bycatch (DFO 2017). Historically, an unknown number of gray seals have been taken in Newfoundland and Labrador, Gulf of St. Lawrence, and Bay of Fundy groundfish gillnets; Atlantic Canada and Greenland salmon gillnets; Atlantic Canada cod traps, and Bay of Fundy herring weirs (Read 1994).

Table 4. Summary of the incidental serious injury and mortality of gray seals (Halichoerus grypus atlantica) by commercial fishery including the years sampled, 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 combined mortality (CV in parentheses).

Fishery	Years	Data Type [a]	Observer Coverage[b]	Observed Serious Injury[c]	Observed Mortality	Est. Serious Injury	Est. Mortality	Est. Comb. Mortality	Est. CVs	Mean Annual Combined Mortality
Northeast Sink Gillnet	2014	Obs. Data, Weighout, Logbook	0.18	0	159	0	917	917	0.14	896 (0.11)
	2015		0.14	0	131	0	1021	1021	0.25	
	2016		0.10	0	43	0	498	498	0.33	
	2017		0.12	0	158	0	930	930	0.16	
	2018		0.11	0	103	0	1113	1113	0.32	
Mid-Atlantic Gillnet	2014	Obs. Data, Logbook, Allocated Dealer Data	0.05	0	1	0	22	22	1.09	8.8 (0.67)
	2015		0.06	0	1	0	15	15	1.04	
	2016		0.08	0	1	0	7	7	0.93	
	2017		0.09	0	0	0	0	0	0	
	2018		0.09	0	0	0	0	0	0	
Northeast Bottom Trawl	2014	Obs. Data, Logbook	0.19	0	4	0	19	19	0.45	18 (0.22)
	2015		0.19	0	4	0	23	23	0.46	
	2016		0.12	0	0	0	0	0	0	
	2017		0.12	0	2	0	16	16	0.24	
	2018		0.12	0	5	0	32	32	0.42	
Mid-Atlantic Bottom Trawl	2014	Obs. Data, Logbook	0.09	0	1	0	7	7	0.96	23 (0.33)
	2015		0.09	0	0	0	0	0	0	
	2016		0.10	0	3	0	26	26	0.57	
	2017		0.14	0	5	0	26	26	0.40	
	2018		0.12	0	7	0	56	56	0.58	
Northeast Mid-water Trawl – Incl. Pair Trawl	2014	Obs. Data, Logbook	0.42	0	0	0	0	0	0	0.2 (na) [d]
	2015		0.08	0	0	0	0	0	0	
	2016		0.27	0	0	0	0	0	0	
	2017		0.16	0	0	0	0	0	0	
	2018		0.14	0	1	0	na	na	na	
Total										**946 (0.11)**

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 multispecies 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. North Atlantic bottom trawl, mid-Atlantic bottom trawl, and mid-Atlantic mid-water trawl fishery coverages are ratios based on trips. Total observer coverage reported for bottom trawl gear and gillnet gear includes traditional fisheries observers in addition to fishery monitors through the Northeast Fisheries Observer Program (NEFOP).

c. Serious injuries were evaluated for the 2014–2018 period (Josephson *et al.* 2021).

d. Unextrapolated number from observed data.

Other Mortality

United States

Gray seals, like harbor seals, were hunted for bounty in New England waters until the late 1960s (Katona *et al.* 1993, Lelli *et al*. 2009). This hunt may have severely depleted this stock in U.S. waters (Rough 1995, Lelli *et al*. 2009). Other sources of mortality include human interactions, storms, abandonment by the mother, disease, and shark predation. Mortalities caused by human interactions include research mortalities, boat strikes, fishing gear interactions, power plant entrainment, oil spill/exposure, harassment, and shooting. Seals entangled in netting are common at haul-out sites in the Gulf of Maine and Southeastern Massachusetts.

Tables 5 and 6 present summaries of gray seal strandings as reported to the NOAA National Marine Mammal Health and Stranding Response Databaseaccessed 20 November 2019). Most stranding mortalities were in Massachusetts, which is the center of gray seal abundance in U.S. waters. 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 45% of gray seal stranding mortalities were attributed to human interaction.

A UME was declared in November of 2011 that involved at least 137 gray seal stranding mortalities between June 2011 and October 2012 in Maine, New Hampshire, and Massachusetts. The UME was declared closed in February 2013 (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events).

Canada

Between 2014 and 2018, the average annual human-caused mortality and serious injury to gray seals in Canadian waters from commercial harvest is 636 individuals, though up to 60,000 seals/year are permitted (http://www.dfo-mpo.gc.ca/decisions/fm-2015-gp/atl-001-eng.htm). This included: 82 in 2014, 1,381 in 2015, 1,588 in 2016, 64 in 2017, and 66 in 2018 (DFO 2017, Courtney D'Aoust pers. comm.). In addition, between 2014 and 2018, an average of 3,078 nuisance animals per year were killed. This included 3,732 annually in 2014–2017 (DFO 2017) and 461 in 2018 based on the total number of licenses that were issued (Courtney D'Aoust pers. comm). Lastly, DFO took 83 animals in 2014, 42 animals in 2015, 30 animals in 2016, 60 animals in 2017, and 96 animals in 2018 for scientific collections, for an annual average of 62 animals (DFO 2017, Samuel Mongrain pers. comm).

Table 5. Gray seal (Halichoerus grypus atlantica) stranding mortalities along the U.S. Atlantic coast (2014–2018) with subtotals of animals recorded as pups in parentheses.

State	2014	2015	2016	2017	2018	Total
ME	3 (1)	5	6(0)	14 (1)	25 (0)	53
NH	3 (2)	2	0	3 (0)	9 (3)	17
MA	62 (6)	77 (3)	54(0)	135 (21)	261 (29)	589
RI	8 (1)	7 (1)	4(0)	16 (5)	20 (3)	55
CT	0	0	0	3 (0)	1(0)	4
NY	12 (4)	10	1 (1)	57 (0)	25 (1)	105
NJ	7 (6)	7 (6)	3 (1)	4 (3)	14 (10)	35
DE	3 (3)	3 (3)	0	1 (0)	4 (2)	11
MD	1 (0)	0	0	0	1 (1)	2
VA	0	3	0	0	1 (1)	4
NC	2 (2)	0	0	0	5 (2)	7
Total	**101 (25)**	**114 (13)**	**68 (2)**	**192 (30)**	**346 (48)**	**882**
Unspecified seals (all states)	38	31	13	86	92	193

Table 6. Documented gray seal (Halichoerus grypus atlantica) human-interaction related stranding mortalities along the U.S. Atlantic coast (2014–2018) by type of interaction. "Fishery interactions" are subsumed in the total estimated mortality calculated from observer data.

Cause	2014	2015	2016	2017	2018	Total
Fishery Interaction	2	14	0	10	10	36
Boat Strike	3	3	0	4	2	12
Shot	0	1	1	0	0	2
Human Interaction - Other	3	2	0	3	9	17
Total	**8**	**20**	**1**	**17**	**21**	**67**

STATUS OF STOCK

Gray 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 average annual human-caused mortality and serious injury during 2014–2018 in U.S. waters does not exceed the PBR of the U.S. portion of the stocks. The status of the gray seal population relative to OSP in U.S. Atlantic EEZ waters is unknown, but the stock's abundance appears to be increasing in Canadian and U.S. waters. 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 the zero mortality and serious injury rate. Uncertainties described in the above sections could have an effect on the designation of the status of this stock in U.S. waters.

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