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

STOCK DEFINITION AND GEOGRAPHIC RANGE

The gray seal (*Halichoerus grypus atlantica*) 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 western North Atlantic stock is equivalent to the Northwest Atlantic population, and ranges from New Jersey to Labrador (Davies 1957; Mansfield 1966; Katona *et al.* 1993; Lesage and Hammill 2001). This stock is separated by geography, differences in the breeding season, and mitochondrial and nuclear DNA variation from the northeastern Atlantic stocks (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). Outside the breeding period, there is overlap in the distribution of animals from the three colonies (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). In the mid-1980s, small numbers of animals and pupping 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 recolonization by Canadian gray seals is the source of the U.S. population. 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) provide further evidence that there is movement of individuals between the U.S. and Canada. However, the percentage of time that individuals are resident in U.S. waters is unknown.

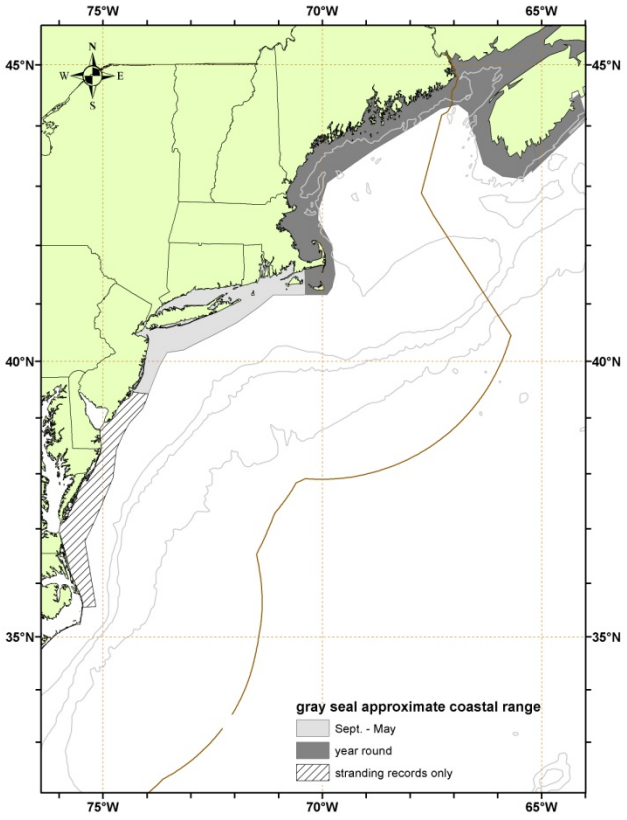

Figure 1. Approximate coastal range of gray seals. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.

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 is a single stock.

POPULATION SIZE

Current estimates of the total western Atlantic gray seal population are not available; although estimates of portions of the stock are available for select time periods. 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 to 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, gray seals primarily pup at four established colonies: Muskeget and Monomoy islands in Massachusetts, and Green and Seal islands in Maine. Since 2010 pupping has also been observed at Noman's Island in Massachusetts and Wooden Ball and Matinicus Rock in Maine. Although white-coated pups have stranded on eastern Long Island beaches in New York, no pupping colonies have been detected in that region. Gray seals have been observed using the historic pupping site on Muskeget Island in Massachusetts since 1988. Pupping has taken place on Seal and Green Islands in Maine since at least the mid-1990s. Aerial survey data from these sites indicate that pup production is increasing (Table 2), although aerial survey quality and coverage has varied significantly among surveys. Table 2 summarizes single-day pup counts from U.S. pupping colonies from 2001/2002 to 2015/2016 pupping periods. A minimum of 6,308 of pups were born in 2016 at U.S. breeding colonies, approximately 6% of the total pup production over the entire range of the stock. 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.

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 best population size to pups in Canadian waters (4.3:1). This ratio falls within the range of other adult to pup ratios suggested for pinniped populations (Harwood and Prime 1978). Using this approach, the population estimate in U.S. waters is 27,131 (CV=0.19, 95% CI: 18,768–39,221) animals. The CV and CI around this estimate is 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 28,000–40,000 gray seals were estimated in southeastern Massachusetts in 2015, using correction factors applied to seal counts visible in 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 and 95% confidence interval.

Month/Year	Area	N_{best} [a]	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.

Table 2. Single day pup counts from five U.S. pupping colonies during 2001-2016 from aerial surveys. 'CIP' = Counting in Progress. As single day pup counts, these counts do not represent the entire number of pups born in a pupping season.

	Massachusetts			Maine			
Pupping Season	Muskeget Island	Monomoy Island	Nomans Island	Seal Island	Green Island	Wooden Ball	Matinicus Rock
2001-02	883	Not surveyed	Not surveyed	No data	34	Not surveyed	Not surveyed
2002-03	509	Not surveyed	Not surveyed	147	No data	Not surveyed	Not surveyed
2003-04	824	Not surveyed	Not surveyed	150	26	Not surveyed	Not surveyed
2004-05	992	1	Not surveyed	365	33	Not surveyed	Not surveyed
2005-06	868	8	Not surveyed	239	43	Not surveyed	Not surveyed
2006-07	1704	9	Not surveyed	364	57	Not surveyed	Not surveyed
2007-08	2095	2	Not surveyed	466	59	Not surveyed	Not surveyed
2008-09	-1104	68	0	CIP	48	Not surveyed	Not surveyed
2009-10	1841	154	0	CIP	51	Not surveyed	Not surveyed
2010-11	3173	325	1	CIP	65	Not surveyed	112
2011-12	2831	80	8	CIP	41	2	57
2012-13	2750	633	4	CIP	Not surveyed	Not surveyed	CIP
2013-14	3073	507	16	CIP	30	Not surveyed	201
2014-15	1633	768	23	CIP	33	185	182
2015-16	3787	935	32	1043	34	284	193

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 of 27,131 (CV=0.19), the minimum population estimate in U.S. waters is 23,158. 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

Gray seal abundance is likely increasing in the U.S. Atlantic Exclusive Economic Zone (EEZ), but the rate of increase is unknown. Methods to evaluate trends in pup production which account for variation across pupping sites and years are currently being investigated.

The population in eastern Canada was greatly reduced by hunting and bounty programs, and in the 1950s the gray seal was considered rare (Lesage and Hammill 2001). The Sable Island, Nova Scotia, population was less affected and has been increasing for several decades. Pup production on Sable Island increased exponentially at a rate of 12.8% per year between the 1970s and 1997 (Stobo and Zwanenburg 1990; Mohn and Bowen 1996; Bowen *et al.* 2003; Trzcinski *et al.* 2005; Bowen *et al.* 2007; DFO 2011). Since 1997, the rate of increase has been slower (Bowen *et al.* 2011, den Heyer *et al.* 2017), supporting the hypothesis that density-dependent changes in vital rates may be limiting population growth. Pupping also occurs on Hay Island off Nova Scotia, in colonies off southwestern Nova Scotia, and in the Gulf of St. Lawrence. Pup production is 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).

The projected population trends for all Canadian aggregations are still increasing. The model projections in 2016 differed from previous analyses due to changes in adult sex ratio and adult mortality rates (DFO 2017). Uncertainties in the population abundance estimates and mortality could have impacts on the abundance trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Recent studies estimated the current annual rate of increase at 4.5% for the combined breeding aggregations in Canada (DFO 2014), continuing a decline in the rate of increase (Trzcinski *et al*. 2005; Bowen *et al*. 2007; Thomas *et al*. 2011; DFO 2014). 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 for the stock in U.S. waters is 23,158. 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 in U.S. waters is 1,389 animals. Uncertainty in the PBR level arises from the same sources of uncertainty in calculating a minimum abundance estimate in U.S. waters.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2012–2016, the average annual estimated human-caused mortality and serious injury to gray seals in the U.S. and Canada was 5,688 (878 U.S./4,809 Canada) per year. The average was derived from six components: 1) 873 (CV=0.10) (Table 3) from the 2012–2016 U.S. observed fisheries; 2) 4.8 from average 2012–2016 non-fishery related, human interaction stranding and shooting mortalities in the U.S.; 3) 0.8 from U.S. research mortalities; 4) 659 from the average 2012–2016 Canadian commercial harvest*;* 5) 74 from the average 2012–2016 DFO scientific collections; and 6) 4,076 removals of nuisance animals in Canada (DFO 2017).

A source of unquantified human-caused mortality or serious injury for this stock is the fact that observed serious injury rates are lower than would be expected from the anecdotally-observed numbers of gray seals living with ongoing entanglements. Reports of seal shootings and other non-fishery-related human interactions are minimum counts. Canadian reporting of nuisance seal removal is known to be incomplete and there is also limited information on Canadian fishery bycatch (DFO 2017).

Fishery Information

Detailed fishery information is given in Appendix III.

U.S.

Northeast Sink Gillnet

Gray seal bycatch in the northeast sink gillnet fishery was usually observed in the first half of the year in waters to the east and south of Cape Cod, Massachusetts in 12-inch gillnets fishing for skates and monkfish (Hatch and Orphanides 2014, 2015, 2016, Orphanides and Hatch 2017; Orphanides 2019). There were 1, 8, 8, 10, and 6 unidentified seals observed during 2012–2016, 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. See Table 3 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

Gray seal interactions were first observed in this fishery in 2010, since then, when they are observed, it is usually in waters off New Jersey in gillnets that have mesh sizes ≥ 7 in (Hatch and Orphanides 2015, 2016; Orphanides and Hatch 2017; Orphanides 2019). See Table 3 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

One gray seal mortality was observed in 2012 and one in 2013 in this fishery. An expanded bycatch estimate has not been generated. Until this bycatch estimate can be developed, the average annual fishery-related mortality and serious injury for 2012–2016 is calculated as 0.4 animals (2 animals /5 years). See Table 3 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, and was not observed in 2006. No mortalities have been observed, but during this time period 33 gray seals were captured and released alive in 2012, 1 in 2013, and 2 in 2014, 0 in 2015, and 5 in 2016. In addition, during this time period 2 seals of unknown species were captured and released alive in 2015 and 1 in 2016 (Josephson *et al.* 2019).

Northeast Bottom Trawl

Vessels in the North Atlantic bottom trawl fishery, a Category III fishery under MMPA, were observed in order to meet fishery management, rather than marine mammal management needs. Eight gray seal mortalities were observed in this fishery in 2012, 5 in 2013, 4 in 2014, 4 in 2015, and 0 in 2016. See Table 3 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

One gray seal mortality was observed in this fishery in 2012, 2 in 2013, 1 in 2014, none in 2015, and 3 in 2016. See Table 3 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

CANADA

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 3. Summary of the incidental serious injury and mortality of gray seal (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 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	2012 2013 2014 2015 2016	Obs. Data,Weighout, Trip Logbook	0.15 0.11 0.18 0.14 0.10	0 0 0 0 0	91 69 159 131 43	0 0 0 0 0	542 1127 917 1021 498	542 1127 917 1021 498	0.19 0.20 0.14 0.25 0.33	821 (0.10)
Mid-Atlantic Gillnet	2012 2013 2014 2015 2016	Obs. Data, Trip Logbook, Allocated Dealer Data	0.11 0.03 0.05 0.06 0.08	0 0 0 0 0	1 0 1 1 1	0 0 0 0 0	14 0 22 15 7	14 0 22 15 7	0.98 0 1.09 1.04 0.93	12 (0.56)
Northeast Bottom Trawl	2012 2013 2014 2015 2016	Obs. Data,Trip Logbook	0.17 0.15 0.17 0.19 0.12	0 0 0 0 0	8 5 4 4 0	0 0 0 0 0	37 20 19 23 0	37 20 19 23 0	0.49 0.37 0.45 0.46 0	20 (0.23)
Mid-Atlantic Bottom Trawl	2012 2013 2014 2015 2016	Obs. Data,Trip Logbook	0.05 0.06 0.08 0.09 0.097	0 0 0 0 0	1 2 1 0 3	0 0 0 0 0	4 25 7 0 26	4 25 7 0 26	0.96 0.67 0.96 0 0.57	20 (0.47)
Northeast Mid-water Trawl – Incl.Pair Trawl	2012 2013 2014 2015 2016	Obs. Data,Trip Logbook	0.45 0.37 0.42 0.08 0.27	0 0 0 0 0	1 1 0 0 0	0 0 0 0 0	na na 0 0 0	na na 0 0 0	na na 0 0 0	0.4 (na) [d]
TOTAL	-	-	-	-	-	-	-	-	-	873 (0.10)

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 2012–2016 period (Josephson *et al.* 2019)

Other Mortality

U.S.

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.

From 2012 to 2016, 482 gray seal stranding mortalities were recorded, extending from Maine to North Carolina (Table 4; NOAA National Marine Mammal Health and Stranding Response Database, accessed 03 November 2017). Most stranding mortalities were in Massachusetts, which is the center of gray seal abundance in U.S. waters. Fifty (10%) of the total stranding mortalities showed signs of human interaction (4 in 2012, 17 in 2013, 8 in 2014, 20 in 2015, and 1 in 2016), 27 of which had some indication of fishery interaction (2 in 2012, 9 in 2013, 2 in 2014, 14 in 2015, and 0 in 2016). One gray seal is recorded in the stranding database during the 2012 to 2016 period as having been shot—in Maine in 2015. Another gray seal mortality due to shooting in Maine in 2016 was prosecuted by NOAA law enforcement. 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 2012 and 2016, the average annual human-caused mortality and serious injury to gray seals in Canadian waters from commercial harvest was 659 per year though more are permitted (up to 60,000 seals/year, see http://www.dfo-mpo.gc.ca/decisions/fm-2015-gp/atl-001-eng.htm). This included: 0 in 2012, 243 in 2013, 82 in 2014 and 1,381 in 2015, and 1,588 in 2016 (DFO 2017). In addition, between 2012 and 2016, an average of 4,076 nuisance animals per year were killed. This included 5,428 in 2012, and 3,757 in 2013, 3,732 anually in 2014– 2016 (DFO 2017). Lastly, DFO took 159 animals in 2012, 58 animals in 2013, 83 animals in 2014, 42 animals in 2015 and 30 animals in 2016 for scientific collections, for an annual average of 74 animals (DFO 2017).

Table 4. Gray seal (Halichoerus grypus atlantica) 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
ME	10 (2)	9 (4)	3 (1)	5	6	33
NH	1 (1)	1 (0)	3 (2)	2	0	7
MA	38 (21)	82 (8)	62 (6)	77 (3)	54	313
RI	13 (5)	11 (2)	8 (1)	7 (1)	4	43
NY	5 (3)	18 (5)	12 (4)	10	1 (1)	46
NJ	4 (0)	7 (2)	7 (6)	7 (6)	3 (1)	28
DE	0	0	3 (3)	3 (3)	0	6
MD	0	0	1 (0)	0	0	1
VA	0	0	0	3	0	3
NC	0	0	2 (2)	0	0	2
Total	71 (32)	128 (21)	101 (25)	114	68 (2)	482
Unspecified seals (all states)	28	25	38	31	13	135

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 U.S. portion of2012–2016 average annual human-caused mortality and serious injury in U.S. waters does not exceed the portion of PBR in U.S. waters. 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 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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