Revised 12/30/2019

HARBOR SEAL (*Phoca vitulina richardii*)

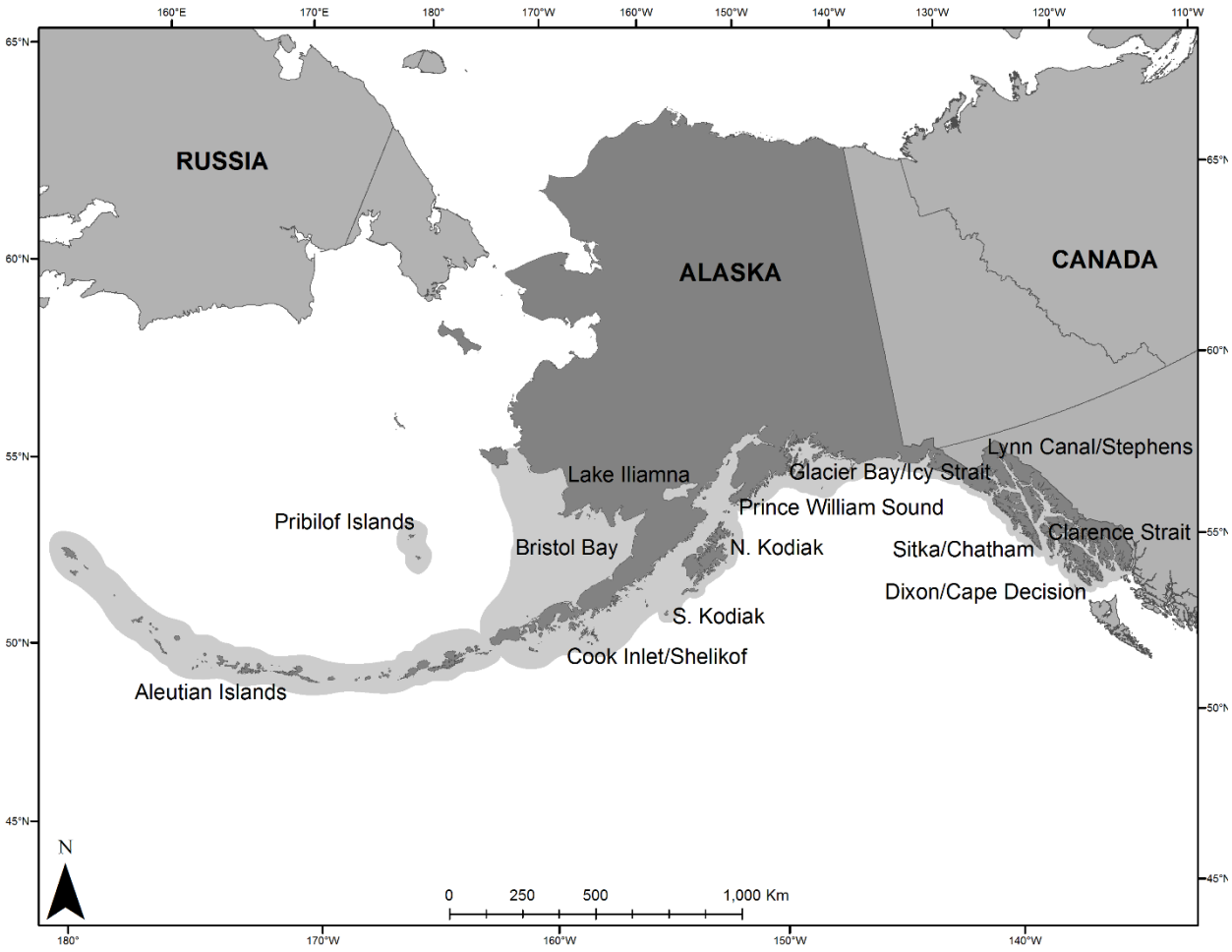

Figure 1. Approximate extent of harbor seals in Alaska waters (shaded coastline area).

STOCK DEFINITION AND GEOGRAPHIC RANGE

Harbor seals inhabit coastal and estuarine waters off Baja California, north along the western coasts of the United States, British Columbia, and Southeast Alaska, west through the Gulf of Alaska and Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands. They haul out on rocks, reefs, beaches, and drifting glacial ice and feed in marine, estuarine, and occasionally fresh waters. Harbor seals generally are non-migratory, with local movements associated with such factors as tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981; Hastings et al. 2004). The results of past and recent satellite-tagging studies in Southeast Alaska, Prince William Sound, Kodiak Island, and Cook Inlet are also consistent with the conclusion that harbor seals are non-migratory (Swain et al. 1996, Lowry et al. 2001, Small et al. 2003, Boveng et al. 2012). However, some long-distance movements of tagged animals in Alaska have been recorded (Pitcher and McAllister 1981, Lowry et al. 2001, Small et al. 2003, Womble 2012, Womble and Gende 2013). Strong fidelity of individuals for haul-out sites during the breeding season has been documented in several populations (Härkönen and Harding 2001), including some regions in Alaska such as Kodiak Island, Prince William Sound, Glacier Bay/Icy Strait, and Cook Inlet (Pitcher and McAllister 1981, Small et al. 2005, Boveng et al. 2012, Womble 2012, Womble and Gende 2013).

Westlake and O'Corry-Crowe's (2002) analysis of genetic information from 881 samples across 181 sites revealed population subdivisions on a scale of 600-820 km. These results suggest that genetic differences within

Alaska, and most likely over their entire North Pacific range, increase with increasing geographic distance. New information revealed substantial genetic differences indicating that female dispersal occurs at region specific spatial scales of 150-540 km. This research identified 12 demographically independent clusters within the range of Alaska harbor seals; however, significant geographic areas within the Alaska harbor seal range remain unsampled (O'Corry-Crowe et al. 2003).

In 2010, NMFS and their co-management partners, the Alaska Native Harbor Seal Commission, identified 12 separate stocks of harbor seals based largely on genetic structure; this represented a significant increase in the number of harbor seal stocks from the three stocks (Bering Sea, Gulf of Alaska, Southeast Alaska) previously recognized. Given the genetic samples were not obtained continuously throughout the range, a total evidence approach was used to consider additional factors such as population trends, observed harbor seal movements, and traditional Alaska Native use areas in the final designation of stock boundaries. The 12 stocks of harbor seals currently identified in Alaska are 1) the Aleutian Islands stock – occurring along the entire Aleutian chain from Attu Island to Ugamak Island; 2) the Pribilof Islands stock – occurring on Saint Paul and Saint George Islands, as well as on Otter and Walrus Islands; 3) the Bristol Bay stock – ranging from Nunivak Island south to the west coast of Unimak Island and extending inland to Kvichak Bay and Lake Iliamna; 4) the North Kodiak stock – ranging from approximately Middle Cape on the west coast of Kodiak Island northeast to West Amatuli Island and south to Marmot and Spruce Islands; 5) the South Kodiak stock – ranging from Middle Cape on the west coast of Kodiak Island southwest to Chirikof Island and east along the south coast of Kodiak Island to Spruce Island, including the Trinity Islands, Tugidak Island, Sitkinak Island, Sundstrom Island, Aiaktalik Island, Geese Islands, Two Headed Island, Sitkalidak Island, Ugak Island, and Long Island; 6) the Prince William Sound stock – ranging from Elizabeth Island off the southwest tip of the Kenai Peninsula to Cape Fairweather, including Prince William Sound, the Copper River Delta, Icy Bay, and Yakutat Bay; 7) the Cook Inlet/Shelikof Strait stock – ranging from the southwest tip of Unimak Island east along the southern coast of the Alaska Peninsula to Elizabeth Island off the southwest tip of the Kenai Peninsula, including Cook Inlet, Knik Arm, and Turnagain Arm; 8) the Glacier Bay/Icy Strait stock – ranging from Cape Fairweather southeast to Column Point, extending inland to Glacier Bay, Icy Strait, and from Hanus Reef south to Tenakee Inlet; 9) the Lynn Canal/Stephens Passage stock – ranging north along the east and north coast of Admiralty Island from the north end of Kupreanof Island through Lynn Canal, including Taku Inlet, Tracy Arm, and Endicott Arm; 10) the Sitka/Chatham Strait stock – ranging from Cape Bingham south to Cape Ommaney, extending inland to Table Bay on the west side of Kuiu Island and north through Chatham Strait to Cube Point off the west coast of Admiralty Island, and as far east as Cape Bendel on the northeast tip of Kupreanof Island; 11) the Dixon/Cape Decision stock – ranging from Cape Decision on the southeast side of Kuiu Island north to Point Barrie on Kupreanof Island and extending south from Port Protection to Cape Chacon along the west coast of Prince of Wales Island and west to Cape Muzon on Dall Island, including Coronation Island, Forrester Island, and all the islands off the west coast of Prince of Wales Island; and 12) the Clarence Strait stock – ranging along the east coast of Prince of Wales Island from Cape Chacon north through Clarence Strait to Point Baker and along the east coast of Mitkof and Kupreanof Islands north to Bay Point, including Ernest Sound, Behm Canal, and Pearse Canal (Fig. 1). Individual stock distributions can be seen in Figures 2a-l.

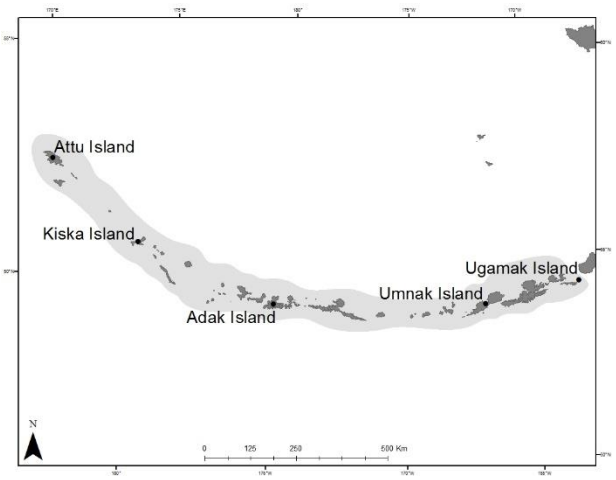

Figure 2a. Approximate extent of Aleutian Islands harbor seal stock (shaded area).

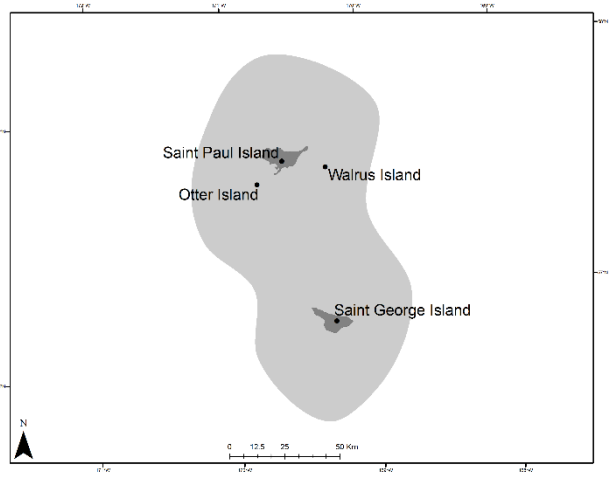

Figure 2b. Approximate extent of Pribilof Islands harbor seal stock (shaded area).

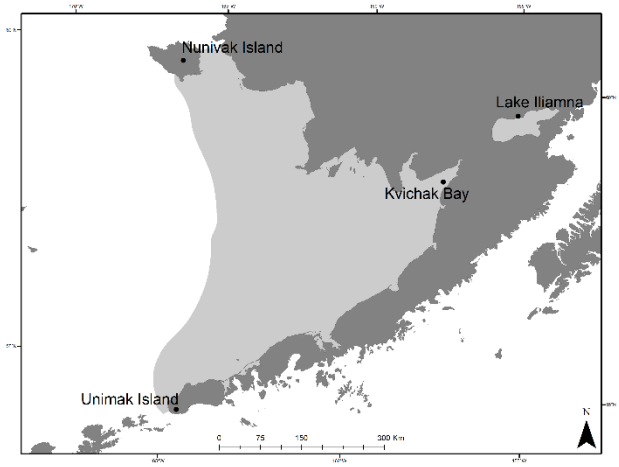

Figure 2c. Approximate extent of Bristol Bay harbor seal stock (shaded area).

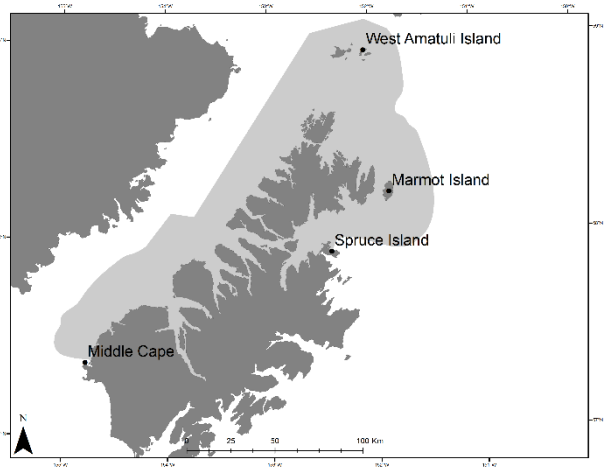

Figure 2d. Approximate extent of North Kodiak harbor seal stock (shaded area).

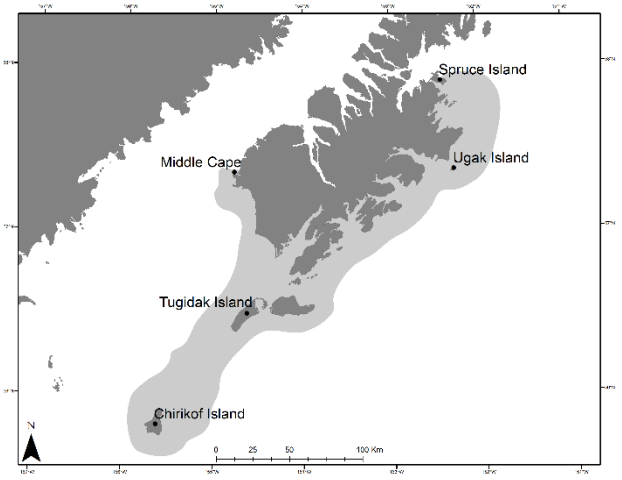

Figure 2e. Approximate extent of South Kodiak harbor seal stock (shaded area).

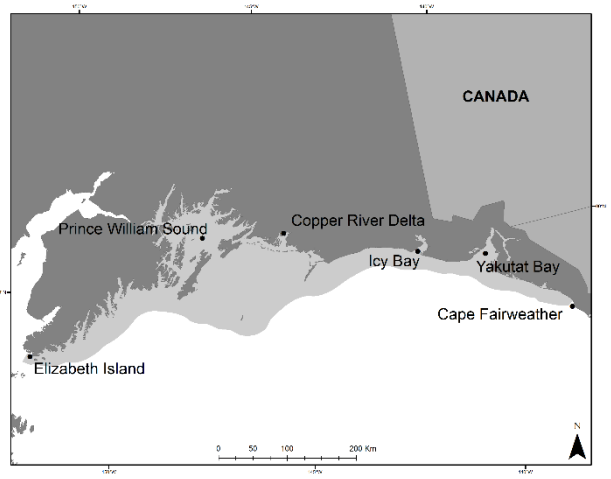

Figure 2f. Approximate extent of Prince William Sound harbor seal stock (shaded area).

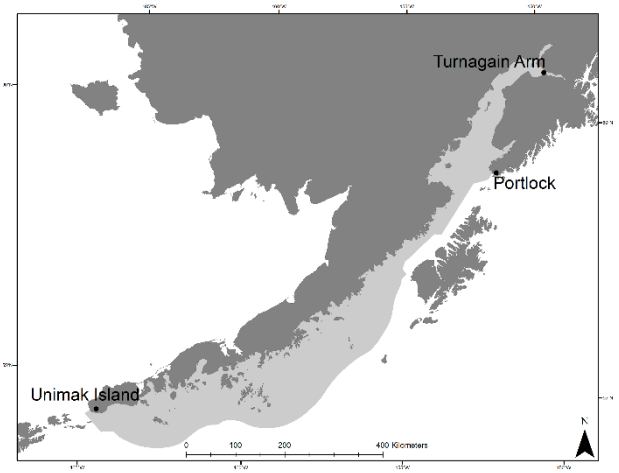

Figure 2g. Approximate extent of Cook Inlet/Shelikof Strait harbor seal stock (shaded area).

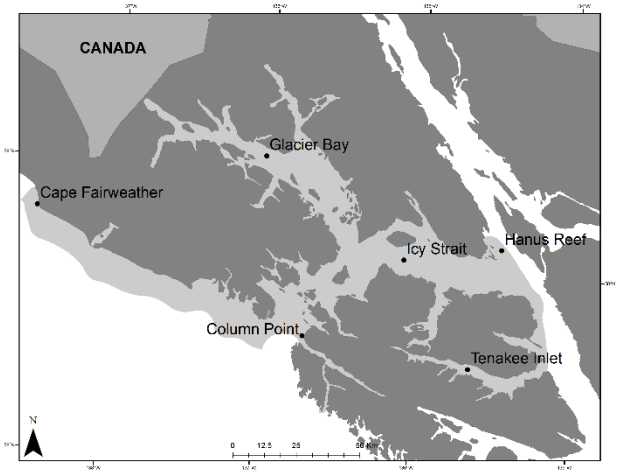

Figure 2h. Approximate extent of Glacier Bay/Icy Strait harbor seal stock (shaded area).

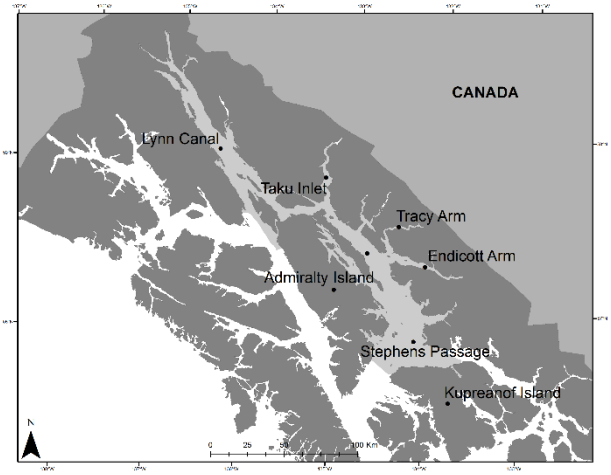

Figure 2i. Approximate extent of Lynn Canal/Stephens Passage harbor seal stock (shaded area).

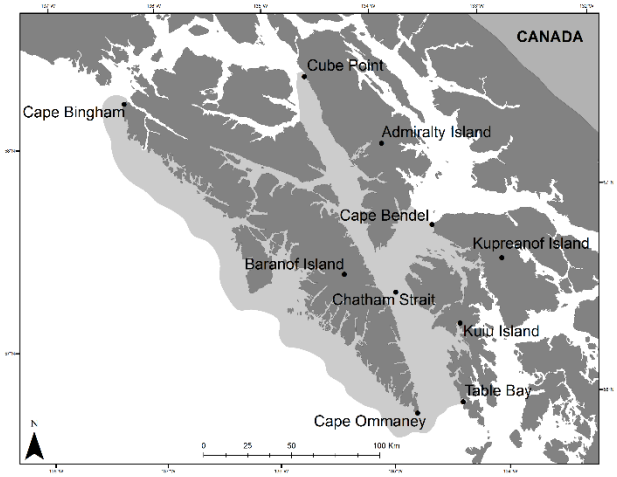

Figure 2j. Approximate extent of Sitka/Chatham Strait harbor seal stock (shaded area).

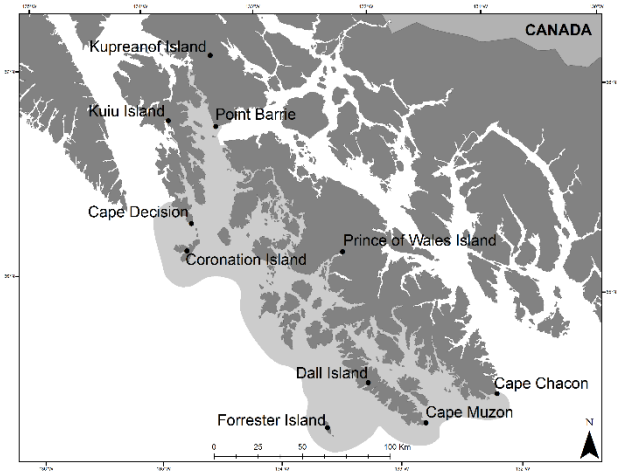

Figure 2k. Approximate extent of Dixon/Cape Decision harbor seal stock (shaded area).

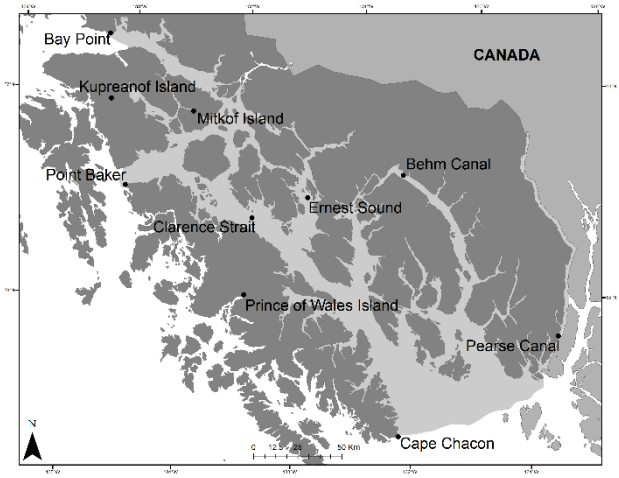

Figure 2l. Approximate extent of Clarence Strait harbor seal stock (shaded area).

POPULATION SIZE

Local or regional trends in harbor seal numbers have been monitored at various time intervals since the 1970s, revealing diverse spatial patterns in apparent population trends. Where declines have been observed, they seem, generally, to have been strongest in the late 1970s or early 1980s to the 1990s. For example, counts of harbor seals declined by about 80% at Tugidak Island in the 1970s and 1980s (Pitcher 1990), and numbers at Nanvak Bay in northern Bristol Bay also declined at about the same time (Jemison et al. 2006). In Prince William Sound, harbor seal numbers declined by about 63% overall between 1984 and 1997, including a 40% decline prior to the *Exxon Valdez* oil spill that occurred in 1989 (Frost et al. 1999, Ver Hoef and Frost 2003). Harbor seal counts in Glacier Bay National Park, where the majority of seals haul out on floating ice calved from glaciers, declined by roughly 60% between 1992 and 2001 and continued to decline through 2008 (Mathews and Pendleton 2006, Womble et al. 2010). At Aialik Bay, a site in Kenai Fjords National Park where harbor seals also haul out on ice calved from a glacier, harbor seal numbers declined by 93% from 1979 to 2009 (Hoover-Miller et al. 2011). In the Aleutian Islands, counts declined by 67% between the early 1980s and 1999, with declines of about 86% in the western Aleutians (Small et al. 2008). Although there is evidence for recent stabilization or even partial recovery of harbor seal numbers in some areas of long-term harbor seal decline, such as Tugidak Island and Nanvak Bay (Jemison et al. 2006), most have not made substantial recoveries toward historical abundances. These areas of localized declines in harbor seals contrast strongly with other large regions of Alaska where harbor seal numbers have remained stable or increased over the same period: trend monitoring regions around Ketchikan and the Kodiak area increased significantly in the 1980s and 1990s and regions around Sitka and Bristol Bay were stable (Small et al. 2003). Differences in trend across the various regions of Alaska suggest some level of independent population dynamics (O'Corry-Crowe et al. 2003, O'Corry-Crowe 2012).

The Alaska Fisheries Science Center's Marine Mammal Laboratory (MML) routinely conducts aerial surveys of harbor seals across their entire range in Alaska. Prior to 2008, Alaska was divided into five survey regions, with one region surveyed per year. In 2010, the survey sites were prioritized based on the newly defined harbor seal stock divisions, and annual aerial surveys attempt to sample the full geographic range of harbor seals in Alaska. These surveys focus, annually, on sites that make up a significant portion of each stock's population or have timely conservation interest. Sites with fewer seals are intended to be flown every 5 to 7 years. Reduced funding since 2015 has limited the scope of surveys, and efforts have been focused in regions of specific conservation interest (e.g., the Aleutian Islands).

Count data from surveys were analyzed with Bayesian hierarchical models, where true abundance per site per year was modeled with a Poisson distribution. Only a fraction of the animals could be observed, so counted seals were modeled with a binomial distribution, given the true number and a haul-out probability. The haul-out probability was modeled from bio-logging data on individual seals, using Bayesian beta regression, that accounted for date, time of day, and tide, which were also known for the counted data. The observed count data were thus adjusted for haul out by the hierarchical model. All models accounted for temporal autocorrelation, by site for count models and by seal for haul-out models, but the temporal autocorrelation parameters were pooled within stock. Models were fit with Markov chain Monte Carlo (MCMC) methods. Abundance estimates for sites were aggregated into estimates by stock, with variability in the estimates provided by the variation in the MCMC chains.

Abundance Estimates and Minimum Population Estimates

The current statewide abundance estimate for Alaska harbor seals is 243,938 (Boveng et al. 2019), based on aerial survey data collected from 1996 to 2018 (Boveng et al. 2019). See Table 1 for abundance estimates of the 12 stocks of harbor seals in Alaska. The minimum population estimate (N_{MIN}) for 11 of the 12 stocks of harbor seals in Alaska is calculated as the lower bound of the 80% credible interval obtained from the posterior distribution of abundance estimates. This approach is consistent with the definition of potential biological removal (PBR) in the current guidelines (NMFS 2016). The abundance estimate and N_{MIN} for the remaining stock, the Pribilof Islands stock, is simply the number counted in the most recent survey (2018) of this very small group.

Table 1. Abundance and 8-year trend (number of seals per year) estimates, by stock, for harbor seals in Alaska, along with respective estimates of standard error. The probability of decrease represents the proportion of the posterior probability distribution for the 8-year trend that fell below a value of 0 seals per year. N_{MIN} is the lower bound of the 80% credible interval obtained from the posterior distribution of the abundance estimates The Pribilof Islands stock abundance estimate (*) is simply the count of seals ashore during the survey and does not include a correction for seals in the water.

Stock	Year of last survey	Abundance estimate	SE	8-year trend estimate	SE	Probability of decrease	N_{MIN}
Aleutian Islands	2018	5,588	274	-131	86	0.932	5,366
Pribilof Islands	2018	229*	n/a	n/a	n/a	n/a	229
Bristol Bay	2017	44,781	7,278	1,127	1,196	0.218	38,254
North Kodiak	2017	8,677	1,335	53	236	0.409	7,609
South Kodiak	2017	26,448	5,282	1,234	1,062	0.076	22,351
Prince William Sound	2015	44,756	3,391	-200	555	0.648	41,776
Cook Inlet/Shelikof Strait	2018	28,411	1,839	-111	333	0.609	26,907
Glacier Bay/Icy Strait	2017	7,455	894	-216	147	0.904	6,680
Lynn Canal/Stephens Passage	2016	13,388	1,876	-114	262	0.73	11,867
Sitka/Chatham Strait	2015	13,289	1,734	71	277	0.41	11,883
Dixon/Cape Decision	2015	23,478	2,501	142	450	0.382	21,453
Clarence Strait	2015	27,659	3,030	138	485	0.413	24,854

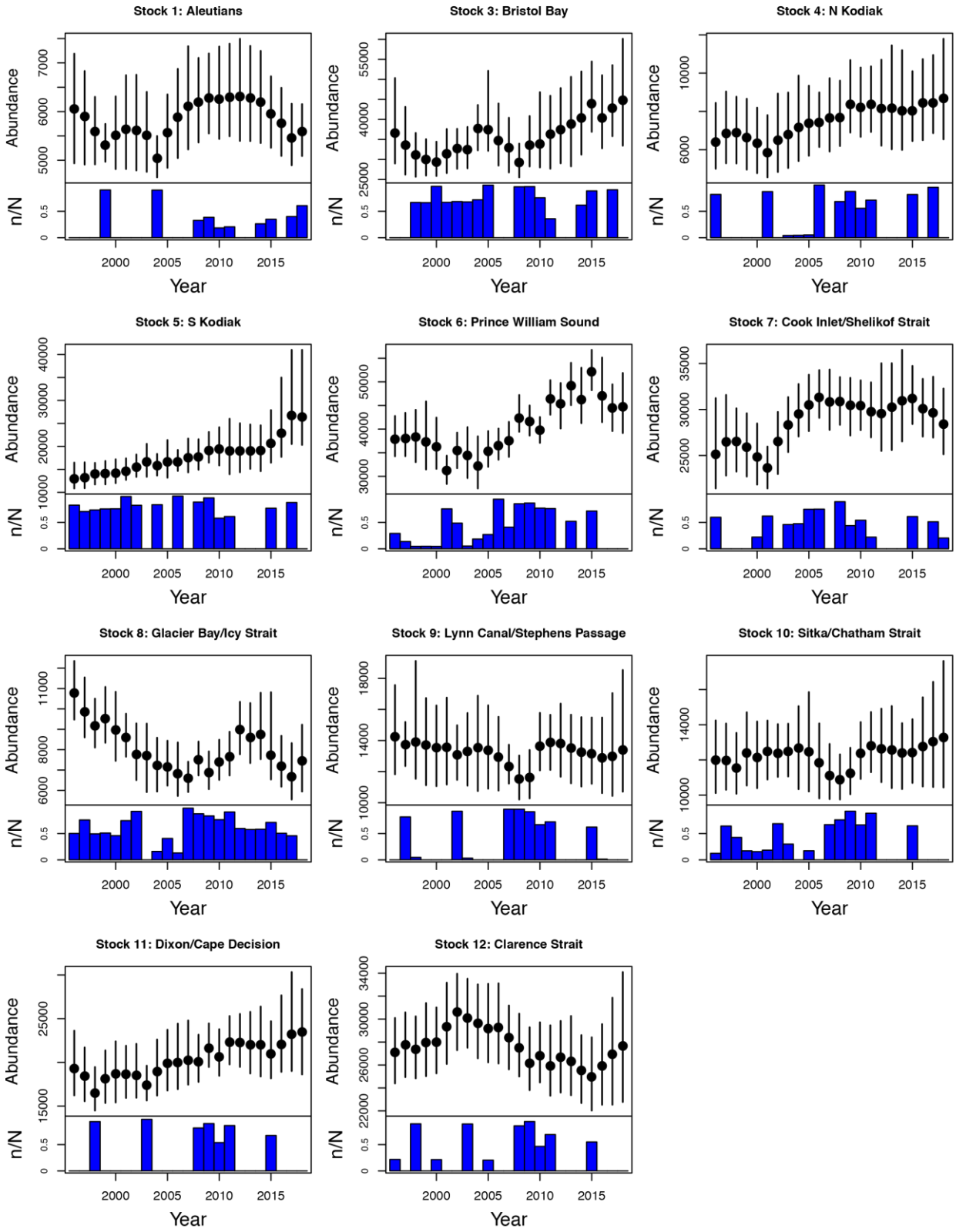

Figure 3. Annual abundance estimates (black dots) of harbor seals in Alaska for all stocks except the Pribilof Islands stock. Black lines represent the 95% credible interval. Blue bars provide a measure of survey effort and indicate the proportion of the estimated abundance likely surveyed each year.

Current Population Trend

Aerial surveys of harbor seal haul-out sites throughout Alaska have been conducted annually and provide information on trends in abundance. The most current estimates of trend (Table 1) were estimated as the means of the slopes of 1,000 simple linear regressions over the most recent eight annual estimates in each of the 1,000 MCMC samples from the posterior distributions for abundance. Thus, they are in units of seals per year, rather than the typical annual percent growth rate. There is no appropriate method for converting these estimates of trend to annual percent growth rate. As a reflection of uncertainty in trend estimates, the proportion of the posterior distribution for each stock's trend that lies below the value of 0 is used as an estimate of the probability that a stock is currently decreasing (Table 1). This allows a probabilistic determination of the qualitative trend status: a value greater than 0.5 means the evidence suggests that the stock is decreasing; a value less than 0.5 means the stock is increasing. For the estimation of trend, an 8-year time interval was used. Eight years is considered to be the approximate threshold of reliability for Marine Mammal Protection Act (MMPA) stock assessment data. One caveat of this approach is that, due to the skewness inherent in the posterior distribution, it is possible for a stock to exhibit a positive trend while also having a probability of decrease greater than 0.5. The following summarizes historical and recent information on the population trend for each of the 12 stocks.

Aleutian Islands: A partial estimate of harbor seal abundance in the Aleutian Islands was determined from skiff surveys of 106 islands from 1977 to 1982 (8,601 seals). Small et al. (2008) compared counts from the same islands during a 1999 aerial survey (2,859 seals). Counts decreased at a majority of the islands. Islands with greater than 100 seals decreased by 70%. The overall estimates showed a 67% decline during the approximate 20-year period (Small et al. 2008). Starting in 2005, the stock abundance estimates show annual increases with a peak abundance of approximately 6,500 in 2010. Since 2010, there is an apparent decline. The current estimate of the 8-year population trend in the Aleutian Islands is -131 seals per year, with a probability that the stock is decreasing of 0.932 (Table 1). Note the survey effort (as represented by n/N in Figure 3) has been consistently below 50% for the Aleutians. This stock represents the most challenging region (due to size, logistics, and weather) in Alaska for aerial surveys. Limited funds and availability of suitable aircraft have prevented greater survey coverage.

Pribilof Islands: Counts of harbor seals in the Pribilof Islands ranged from 250 to 1,224 in the 1970s. Counts in the 1980s and 1990s ranged between 119 and 232 harbor seals. Prior to July 2010, the most recent count was 202 seals in 1995. In July 2010, approximately 185 adults and 27 pups were observed on Otter Island for a maximum count of 212 harbor seals. Counts from 2010 (all ages) are nearly identical to the 1995 counts (212 vs. 202), but 2010 pup numbers were slightly less (27 vs. 42). July 2015 was the first year that counts were conducted on both Otter Island and St. George Island, resulting in a total count of 235 seals (all ages). In 2018, the Aleut Community of St. Paul and MML collaborated on a comprehensive survey of harbor seals in the Pribilof Islands using small unoccupied aircraft. The survey was conducted on the islands of Otter, St. Paul, and St. George in early September, resulting in a total of 229 seals counted across all islands (Boveng et al. 2019). For all other stocks in Alaska, the abundance and trend estimates account for the proportion of seals likely in the water during the survey. This is not done for the Pribilof Island stock because counts have typically been more opportunistic and information on environmental covariates is less standardized. It is also possible the isolated and unique nature of the habitat could lead to very different haul-out behaviors that are unknown without conducting a behavioral study. Analysis of the nearest two stocks (Aleutian Islands and Bristol Bay) estimated standardized correction factors of 1.5 and 3.0. Using the mean correction factor of 2.25 would result in approximately 515 harbor seals in the Pribilof Island region. The current population trend in the Pribilof Islands is unknown.

Bristol Bay: At Nanvak Bay, the largest haul-out location in northern Bristol Bay, harbor seals declined in abundance from 1975 to 1990 and increased from 1990 to 2000 (Jemison et al. 2006). Land-based harbor seal counts at Nanvak Bay from 1990 to 2000 increased at 9.2% per year during the pupping period and 2.1% per year during the molting period (Jemison et al. 2006). After a period of growth in the 1980s, the population in Iliamna Lake appears to be relatively stable at around 400 individuals. A population viability analysis assessing the risk of quasi-extinction in Iliamna Lake, defined as any reduction to 50 animals or below in the next 100 years, ranged from 1% to 3%, depending on the prior scenario (Boveng et al. 2018). The current 8-year estimate of the population trend in the Bristol Bay stock is +1,127 seals per year, with a probability that the stock is decreasing of 0.218 (Table 1).

North Kodiak: The current 8-year estimate of the North Kodiak population trend is +53 seals per year, with a probability that the stock is decreasing of 0.409 (Table 1). The North Kodiak stock appears to have levelled off since 2010 at approximately 8,000 seals.

South Kodiak: A significant portion of the harbor seal population within the South Kodiak stock is located at and around Tugidak Island off the southwest coast of Kodiak Island. Sharp declines in the number of seals present on Tugidak were observed between 1976 and 1998. The highest rate of decline was 21% per year between 1976 and 1979 (Pitcher 1990). While the number of seals on Tugidak has stabilized and shown some evidence of increase since the decline, the population in 2000 remained reduced by 80% compared to the levels in the 1970s (Jemison et al. 2006). The South Kodiak stock has shown a consistent, increasing trend since the low levels in the mid-1990s, with an even more noticeable increase in recent years. The current 8-year estimate of the South Kodiak population trend is +1,234 seals per year, with a probability that the stock is decreasing of 0.076 (Table 1).

Prince William Sound: The Prince William Sound stock includes harbor seals both within and adjacent to Prince William Sound proper. Within Prince William Sound proper, harbor seals declined in abundance by 63% between 1984 and 1997 (Frost et al. 1999). In Aialik Bay, adjacent to Prince William Sound proper, there has been a decline in pup production by 4.6% annually from 40 down to 32 pups born from 1994 to 2009 (Hoover-Miller et al. 2011). The current 8-year estimate of the Prince William Sound population trend is -200 seals per year, with a probability that the stock is decreasing of 0.648 (Table 1). There has been limited survey effort outside of glacial habitats in recent years and, thus, the most recent abundance estimates have larger credible intervals.

Cook Inlet/Shelikof Strait: A multi-year study of seasonal movements and abundance of harbor seals in Cook Inlet was conducted between 2004 and 2007. This study involved multiple aerial surveys throughout the year, and the data indicated a stable population of harbor seals during the August molting period (Boveng et al. 2011). Aerial surveys along the Alaska Peninsula present greater logistical challenges and have therefore been conducted less frequently. The current 8-year estimate of the Cook Inlet/Shelikof Strait population trend is -111 seals per year, with a probability that the stock is decreasing of 0.609 (Table 1).

Glacier Bay/Icy Strait: The Glacier Bay/Icy Strait stock showed a negative population trend estimate for harbor seals from 1992 to 2008 in June and August for glacial (-7.7%/yr; -8.2%/yr) and terrestrial sites (-12.4%/yr, August only) (Womble et al. 2010). Trend estimates by Mathews and Pendleton (2006) were similarly negative for both glacial and terrestrial sites. Long-term monitoring of harbor seals on glacial ice has occurred in Glacier Bay since the 1970s (Mathews and Pendleton 2006) and has shown this area to support one of the largest breeding aggregations in Alaska (Steveler 1979, Calambokidis et al. 1987). After a dramatic retreat of Muir Glacier (more than 7 km), in the East Arm of Glacier Bay, between 1973 and 1986 and the subsequent grounding and cessation of calving in 1993, floating glacial ice was greatly reduced as a haul-out substrate for harbor seals and ultimately resulted in the abandonment of upper Muir Inlet by harbor seals (Calambokidis et al. 1987, Hall et al. 1995, Mathews 1995). Prior to 1993, seal counts were up to 1,347 in the East Arm of Glacier Bay; 2008 counts were fewer than 200 (Streveler 1979, Molnia 2007). The current 8-year estimate of the Glacier Bay/Icy Strait population trend is -216 seals per year, with a probability that the stock is decreasing of 0.904 (Table 1). The majority of survey effort in recent years has been conducted by the National Park Service and focused, mostly, on glacial ice habitats. Limited surveys have been conducted in the Icy Strait portion of the stock.

Lynn Canal/Stephens Passage: The current 8-year estimate of the Lynn Canal/Stephens Passage population trend is -114 seals per year, with a probability that the stock is decreasing of 0.73 (Table 1). Outside of efforts in 2007 to 2011 and 2015, there has been limited survey effort for this stock and, thus, the recent estimates of abundance include large credible intervals.

Sitka/Chatham Strait: The current 8-year estimate of the Sitka/Chatham Strait population trend is +71 seals per year, with a probability that the stock is decreasing of 0.41 (Table 1). Outside of efforts in 2007 to 2011 and 2015, there has been limited survey effort for this stock and, thus, the recent estimates of abundance include large credible intervals.

Dixon/Cape Decision: The current 8-year estimate of the Dixon/Cape Decision population trend is +142 seals per year, with a probability that the stock is decreasing of 0.382 (Table 1). Outside of efforts in 2007 to 2011 and 2015, there has been limited survey effort for this stock and, thus, the recent estimates of abundance include large credible intervals.

Clarence Strait: The current 8-year estimate of the Clarence Strait population trend is +138 seals per year, with a probability that the stock is decreasing of 0.413 (Table 1). Outside of efforts in 2007 to 2011 and 2015, there has been limited survey effort for this stock and, thus, the recent estimates of abundance include large credible intervals.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Reliable rates of maximum net productivity have not been estimated directly from the 12 stocks of harbor seals identified in Alaska. Based on monitoring in Washington State from 1978 to 1999, Jeffries et al. (2003) estimated R_{MAX} to be 12.6% and 18.5% for harbor seals of the inland and coastal stocks, respectively. Harbor seals have been protected in British Columbia since 1970, and the monitored portion of that population responded with an annual rate of increase of approximately 12.5% through the late 1980s (Olesiuk et al. 1990), although a more recent evaluation suggested that 11.5% may be a more appropriate figure (Fisheries and Oceans Canada 2010). These empirical estimates of R_{MAX} indicate that the continued use of the pinniped maximum theoretical net productivity rate of 12% is appropriate for the Alaska stocks (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. Marine mammal stocks such as the harbor seal stocks in Alaska that are taken by subsistence hunting may be given F_R values up to 1.0, provided they are "known to be increasing" or "not known to be decreasing" and "there have not been recent increases in the levels of takes" (NMFS 2016). For harbor seals in Alaska, these guidelines were followed by assigning all harbor seal stocks an initial, default recovery factor of 0.5. The default value was adjusted up to 0.7 if the estimated probability of decrease was less than 0.3. The value was adjusted down to 0.3 if the estimated probability of decrease was greater than 0.7. This provides a simple, balanced approach for providing a recovery factor consistent with current guidelines while incorporating results from novel statistical methods. Table 2 summarizes the PBR levels for each stock of harbor seals in Alaska based on N_{MIN} estimates, an R_{MAX} of 12%, and F_R values.

Table 2. PBR calculations by stock for harbor seals in Alaska. The N_{MIN} values are determined from the 20th percentile of the posterior distribution for stock-level abundance estimates, except for the Pribilof Islands. A default value of 0.5 was used as the recovery factor. Based on evaluation of the trend estimates and probability of decrease, the recovery factor for some stocks was increased to 0.7. For other stocks, the recovery factor was decreased to 0.3.

Stock	N_{MIN}	R_{MAX}	Recovery Factor (F_R) (default value = 0.5)	PBR
Aleutian Islands	5,366	0.12	0.3	97
Pribilof Islands	229	0.12	0.5	7
Bristol Bay	38,254	0.12	0.7	1,607
North Kodiak	7,609	0.12	0.5	228
South Kodiak	22,351	0.12	0.7	939
Prince William Sound	41,776	0.12	0.5	1,253
Cook Inlet/Shelikof Strait	26,907	0.12	0.5	807
Glacier Bay/Icy Strait	6,680	0.12	0.3	120
Lynn Canal/Stephens Passage	11,867	0.12	0.3	214
Sitka/Chatham Strait	11,883	0.12	0.5	356
Dixon/Cape Decision	21,453	0.12	0.5	644
Clarence Strait	24,854	0.12	0.5	746

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between 2013 and 2017 is listed, by marine mammal stock, in Delean et al. (2020);

however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for all harbor seal stocks between 2013 and 2017 is 1,135 harbor seals: 32 in U.S. commercial fisheries, 0.4 in unknown (commercial, recreational, or subsistence) fisheries, 3.7 due to other causes (illegal shooting, entanglement in ADF&G research trawl gear), and 1,099 in the Alaska Native subsistence harvest. Human-caused mortality and serious injury information for individual harbor seal stocks is listed in the Status of Stock section for each stock. Additional potential threats most likely to result in direct human-caused mortality or serious injury for all stocks of harbor seals include unmonitored subsistence harvests, incidental takes in unmonitored fisheries, and illegal shooting. Disturbance by cruise vessels is an additional threat for harbor seal stocks that occur in glacial fjords (Jansen et al. 2010, 2015; Matthews et al. 2016).

Fisheries Information

Information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Observer programs have documented mortality and serious injury of harbor seals in the Bering Sea/Aleutian Islands Atka mackerel trawl, Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands rockfish trawl, Bering Sea/Aleutian Islands Pacific cod pot, Gulf of Alaska flatfish trawl, and Gulf of Alaska halibut longline fisheries between 2013 and 2017 (Breiwick 2013; MML, unpubl. data) (Table 3).

Although a reliable estimate of the overall mortality and serious injury rate incidental to commercial fisheries is currently unavailable because of the absence of observer placements in salmon gillnet fisheries known to interact with several of these stocks, for the purposes of stock assessment, mean annual mortality and serious injury rates are assigned to the following harbor seal stocks based on the location of takes in observed fisheries between 2013 and 2017 (Table 3): Aleutian Islands stock: 0.2 from the Bering Sea/Aleutian Islands Atka mackerel trawl fishery + 0.2 from the Bering Sea/Aleutian Islands rockfish trawl fishery; Bristol Bay stock: 0.8 from the Bering Sea/Aleutian Islands flatfish trawl fishery + 0.2 from the Bering Sea/Aleutian Islands pollock trawl fishery + 2.8 from the Bering Sea/Aleutian Islands Pacific cod pot fishery; North Kodiak stock: 0.3 from the Gulf of Alaska flatfish trawl fishery; South Kodiak stock: 1.0 from the Gulf of Alaska flatfish trawl fishery; Cook Inlet/Shelikof Strait stock: 0.7 from the Gulf of Alaska flatfish trawl fishery + 1.8 from the Gulf of Alaska halibut longline fishery.

Table 3. Summary of incidental mortality and serious injury of harbor seals in Alaska due to U.S. commercial fisheries between 2013 and 2017 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data).

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. Atka mackerel trawl	2013 2014 2015 2016 2017	obs	99 100 100 98 100	0 0 0 1[AI] 0	0 0 0 1.1[AI] 0	0.2[AI] (CV = 0.25)
Bering Sea/Aleutian Is. flatfish trawl	2013 2014 2015 2016 2017	obs data	100 100 100 99 100	0 1[BB] 0 0 3[BB]	0 1[BB] 0 0 3[BB]	0.8[BB] (CV = 0.02)
Bering Sea/Aleutian Is. pollock trawl	2013 2014 2015 2017 2017	obs data	98 98 99 99 99	0 1[BB] 0 0 0	0 1.0[BB] 0 0 0	0.2[BB] (CV = 0.14)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. rockfish trawl	2013 2014 2015 2016 2017	obs data	100 100 100 100 100	0 1^{AI} 0 0 0	0 1^{AI} 0 0 0	0.2^{AI} (CV = 0.05)
Bering Sea/Aleutian Is. Pacific cod pot	2013 2014 2015 2016 2017	obs data	18 21 27 21 13	0 2^{BB} (+2^{BB})[a] 0 0 0	0 12^{BB} (+2^{BB})[b] 0 0 0	2.4^{BB} (+0.4^{BB})[c] (CV = 0.78)
Gulf of Alaska flatfish trawl	2013 2014 2015 2016 2017	obs data	46 47 54 39 56	2^{SK} 0 0 0 1^{NK} + 2^{CI}	5.2^{SK} 0 0 0 1.7^{NK} + 3.3^{CI}	1.0^{SK} + 0.3^{NK} + 0.7^{CI} (CV = 0.34)[d]
Gulf of Alaska halibut longline	2013 2014 2015 2016 2017	obs data	4.2 11 9.4 9.5 4.6	0 0 1^{CI} 0 0	0 0 9.1^{CI} 0 0	1.8^{CI} (CV = 0.95)
Minimum total estimated annual mortality						0.4^{AI} + 3.8^{BB} + 0.3^{NK} + 1.0^{SK} + 2.5^{CI} (CV = 0.34)[e]

[a]Total mortality and serious injury observed in 2014: 2 harbor seals in sampled hauls + 2 harbor seals in unsampled hauls.
[b]Total estimate of mortality and serious injury in 2014: 12 harbor seals (extrapolated estimate from 2 harbor seals observed in sampled hauls) + 2 harbor seals (2 harbor seals observed in unsampled hauls).
[c]Mean annual mortality and serious injury for fishery: 2.4 harbor seals (mean of extrapolated estimates from sampled hauls) + 0.4 harbor seals (mean of number observed in unsampled hauls).
[d]This CV is for the mean estimated annual mortality for all harbor seal stocks taken in the fishery.
[e]This CV is for the sum of the mean estimated annual mortality for all stocks.

Harbor seal stock identifications for observed mortality, estimated mortality, and mean estimated annual mortality:
[AI]Aleutian Islands stock
[BB]Bristol Bay stock
[NK]North Kodiak stock
[SK]South Kodiak stock
[CI]Cook Inlet/Shelikof Strait stock

Observer programs in Alaska State-managed salmon set gillnet and salmon drift gillnet fisheries have documented harbor seal mortality and serious injury (Table 4). The Prince William Sound salmon drift gillnet fishery is known to interact with harbor seals, although the most recent observer data available for this fishery are from 1990 and 1991 (Wynne et al. 1991, 1992). The minimum estimated average annual mortality and serious injury rate (24 seals) in this fishery will be applied to the Prince William Sound stock of harbor seals. Although the observer data are dated, they are considered the best available data on mortality and serious injury levels in this fishery.

Observers reported a South Kodiak harbor seal mortality in a federally-managed U.S. commercial Gulf of Alaska pot fishery in 2014; however, there was not enough information in the record to assign the event to a specific fishery. Therefore, the observed mortality is used to calculate a mean annual mortality and serious injury rate of 0.2 South Kodiak harbor seals in commercial Gulf of Alaska pot fisheries between 2013 and 2017 (Delean et al. 2020; Table 5).

Table 4. Summary of incidental mortality and serious injury of harbor seals in Alaska due to U.S. commercial salmon drift and set gillnet fisheries in 1990 and 1991 and calculation of the mean annual mortality and serious injury rate based on the most recent observer program data available (Wynne et al. 1991, 1992).

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Prince William Sound salmon drift gillnet	1990 1991	obs data	4 5	2 1	36 12	24 (CV = 0.50)
Minimum total estimated annual mortality						24 (CV = 0.50)

Reports to the NMFS Alaska Region stranding network of harbor seals entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data (Delean et al. 2020). Between 2013 and 2017, there were two reports of Cook Inlet/Shelikof Strait harbor seal mortality and serious injury due to entanglements in fishing gear, including one in a Cook Inlet salmon set gillnet in 2014 and one in an unidentified net in 2017, resulting in a mean annual mortality and serious injury rate of 0.4 harbor seals from this stock due to interactions with unknown (commercial, recreational, or subsistence) fisheries (Table 5).

Table 5. Summary of harbor seal mortality and serious injury, by year, type, and harbor seal stock, reported to the NMFS Alaska Region marine mammal stranding network between 2013 and 2017 (Delean et al. 2020).

Cause of injury	2013	2014	2015	2016	2017	Mean annual mortality
Gulf of Alaska commercial pot fishery	0	1^{SK}	0	0	0	0.2^{SK}
Entangled in Cook Inlet salmon set gillnet*	0	1^{CI}	0	0	0	0.2^{CI}
Entangled in unidentified net*	0	0	0	0	1^{CI}	0.2^{CI}
Illegally shot[a]	-	-	1^{PW}	3^{PW}	3^{PW}	2.3^{PW}
Illegally shot	0	0	0	6^{BB}	0	1.2^{BB}
Entangled in ADF&G research trawl gear	0	1^{NK}	0	0	0	0.2^{NK}
Total in commercial fisheries *Total in unknown (commercial, recreational, or subsistence) fisheries Total due to other causes (illegally shot, research fisheries)						0.2^{SK} 0.4^{CI} $2.3^{PW} + 1.2^{BB} + 0.2^{NK}$

[a]Dedicated effort to survey the Copper River Delta for stranded marine mammals began in 2015 in response to a high number of reported strandings, some of which were later determined to be human-caused (illegally shot). Dedicated surveys were also conducted in 2016 and 2017. Because similar data are not available for 2013 and 2014, the data were averaged over the 3 years of survey effort for a more informed estimate of mean annual mortality.

Harbor seal stock identifications for observed mortality and mean annual mortality:
[BB]Bristol Bay stock
[NK]North Kodiak stock
[SK]South Kodiak stock
[CI]Cook Inlet/Shelikof Strait stock
[PW]Prince William Sound stock

Alaska Native Subsistence/Harvest Information

The Alaska Native subsistence harvest of harbor seals has been estimated by the Alaska Native Harbor Seal Commission (ANHSC) and the Alaska Department of Fish and Game (ADF&G). Information from the ADF&G indicates the average harvest levels for the 12 stocks of harbor seals identified in Alaska from 2004 to 2008, including struck and lost animals (Table 6: average annual harvest column). Data on community subsistence harvests were

collected for Kodiak Island, Prince William Sound, and Southeast Alaska in 2011 and 2012, Prince William Sound and Cook Inlet/Shelikof Strait in 2014, and Bristol Bay in 2017 (Table 6: annual harvest columns). The remaining stocks do not have updated community subsistence data, therefore, the most recent 5-years of harvest data (2004-2008) will be used for these stocks.

Table 6. Summary of the subsistence harvest data for all 12 harbor seal stocks in Alaska, 2004-2008, 2011-2012, 2014, and 2017. Data are from Wolfe et al. (2005, 2006, 2008, 2009a, 2009b, 2012, 2013); NMFS, unpubl. data.

Stock	Minimum annual harvest 2004-2008	Maximum annual harvest 2004-2008	Average annual harvest 2004-2008	Annual harvest 2011 or 2012	Annual harvest 2014	Annual harvest 2017
Aleutian Islands	50	146	90	N/A	N/A	N/A
Pribilof Islands	0	0	0	N/A	N/A	N/A
Bristol Bay[a]	82	188	141	N/A	N/A	15[b]
North Kodiak	66	260	131	37	N/A	N/A
South Kodiak	46	126	78	126	N/A	N/A
Prince William Sound	325	600	439	255[c]	387	N/A
Cook Inlet/Shelikof Strait	177	288	233	N/A	104	N/A
Glacier Bay/Icy Strait	22	108	52	104	N/A	N/A
Lynn Canal/Stephens Passage	17	60	30	50	N/A	N/A
Sitka/Chatham Strait	97	314	222	77	N/A	N/A
Dixon/Cape Decision	100	203	157	69	N/A	N/A
Clarence Strait	71	208	164	40	N/A	N/A

[a]Seals taken in summer on shore in Bristol Bay could be either harbor seals or spotted seals. Absent specific identification, we have listed the species as reported to the ADF&G. NMFS will work with the organizations that work with harbor seals to determine how to apportion the harvest in this area between the two species.
[b]This is a minimum estimate because it includes subsistence harvest data from only one community (Clark's Point) and does not include the number of struck and lost animals.
[c]This is a minimum estimate because it includes subsistence harvest data from only one community (Yakutat).

Other Mortality

Reports to the NMFS Alaska Region stranding network of harbor seals entangled in marine debris or with injuries caused by other types of human interaction are another source of mortality and serious injury data (Delean et al. 2020). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. From 2013 to 2017, reports to the NMFS Alaska Region stranding network resulted in mean annual mortality and serious injury rates of 2.3 Prince William Sound harbor seals illegally shot in the Copper River Delta (3-year average), 1.2 Bristol Bay harbor seals illegally shot, and 0.2 North Kodiak harbor seals entangled in ADF&G research trawl gear. Gunshot mortality of an additional five harbor seals was reported to the NMFS Alaska Region between 2013 and 2017, including two Cook Inlet/Shelikof Strait harbor seals (one each in 2013 and 2014) and three Prince William Sound harbor seals (two in 2014 and one in 2015). However, these events are not included in the estimate of the mean annual mortality and serious injury rate for 2013 to 2017 because it could not be confirmed that the deaths were due to illegal shooting and were not already accounted for in the estimate of animals struck and lost in the Alaska Native subsistence harvest.

STATUS OF STOCK

No harbor seal stocks in Alaska are designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act, and the minimum estimate of the mean annual level of human-caused mortality and serious injury does not exceed PBR for any of the stocks; therefore, none of the stocks are strategic. At present, mean annual mortality and serious injury rates incidental to U.S. commercial fisheries that are less than 10% of PBR can be considered insignificant and approaching a zero mortality and serious injury rate. Reliable estimates of the mean annual rates of mortality and serious injury incidental to U.S. commercial fisheries are unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rates due to U.S. commercial fishing

are insignificant. The status of all 12 stocks of harbor seals identified in Alaska relative to their Optimum Sustainable Population is unknown.

There are key uncertainties in the assessment of the abundance and trend of harbor seals in Alaska. The population abundance is based on counts of visible animals and adjusted to account for seals in the water based on haul-out behavior data obtained from bio-logging studies. These deployments are confined to a small portion of the geographic range and only a portion of the recognized stocks. Additionally, many of these deployments rely on bio-loggers attached to seal hair with adhesive. These tags fall off during the annual molt. Since the surveys are typically conducted during the molt period, there is some additional uncertainty due to reduced sample size. Reduced funding and limited availability of suitable aircraft has prevented regular surveys that properly sample the full expanse of harbor seal distribution in Alaska. Instead, resources are prioritized to areas of special conservation or management concern. This means some stocks or portions of stocks are not surveyed annually and, consequently, uncertainty is increased for those areas.

In addition to uncertainties related to assessment, evaluation and documentation of human-caused mortality could be improved. There are multiple nearshore commercial fisheries which are not observed; thus, there is likely to be unreported fishery-related mortality and serious injury of harbor seals. Estimates of human-caused mortality and serious injury from stranding data are underestimates because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined.

Aleutian Islands: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 9.7 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (0.4 (commercial fisheries) + 90 (harvest) + 0 (other fisheries + other mortality and serious injury) = 90) is not known to exceed the PBR (97). The Aleutian Islands stock of harbor seals is not classified as a strategic stock.

Pribilof Islands: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 0.7 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (0 + 0 + 0 = 0) is not known to exceed the PBR (7). The Pribilof Islands stock of harbor seals is not classified as a strategic stock.

Bristol Bay: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 161 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (3.8 + 15 + 1.2 = 20) is not known to exceed the PBR (1,607). The Bristol Bay stock of harbor seals is not classified as a strategic stock.

North Kodiak: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 23 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (0.3 + 37 + 0.2 = 38) is not known to exceed the PBR (228). The North Kodiak stock of harbor seals is not classified as a strategic stock.

South Kodiak: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 94 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean

annual level of human-caused mortality and serious injury (1.2 + 126 + 0 = 127) is not known to exceed the PBR (939). The South Kodiak stock of harbor seals is not classified as a strategic stock.

Prince William Sound: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 125 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (24 + 387 + 2.3 = 413) is not known to exceed the PBR (1,253). The Prince William Sound stock of harbor seals is not classified as a strategic stock.

Cook Inlet/Shelikof Strait: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 81 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (2.5 + 104 + 0.4 = 107) is not known to exceed the PBR (807). The Cook Inlet/Shelikof Strait stock of harbor seals is not classified as a strategic stock.

Glacier Bay/Icy Strait: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 12 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (0 + 104 + 0 = 104) is not known to exceed the PBR (120). The Glacier Bay/Icy Strait stock of harbor seals is not classified as a strategic stock.

Lynn Canal/Stephens Passage: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 21 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (0 + 50 + 0 = 50) is not known to exceed the PBR (214). The Lynn Canal/Stephens Passage stock of harbor seals is not classified as a strategic stock.

Sitka/Chatham Strait: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 36 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (0 + 77 + 0 = 77) is not known to exceed the PBR (356). The Sitka/Chatham Strait stock of harbor seals is not classified as a strategic stock.

Dixon/Cape Decision: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 64 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean annual level of human-caused mortality and serious injury (0 + 69 + 0 = 69) is not known to exceed the PBR (644). The Dixon/Cape Decision stock of harbor seals is not classified as a strategic stock.

Clarence Strait: At present, U.S. commercial fishery-related mean annual mortality and serious injury rates less than 75 animals (i.e., 10% of PBR) can be considered insignificant and approaching a zero mortality and serious injury rate. A reliable estimate of the mean annual rate of mortality and serious injury incidental to U.S. commercial fisheries is unavailable. Therefore, it is unknown whether the mean annual mortality and serious injury rate due to U.S. commercial fishing is insignificant. Based on the best scientific information available, the minimum estimated mean

annual level of human-caused mortality and serious injury (0 + 40 + 0 = 40) is not known to exceed the PBR (746). The Clarence Strait stock of harbor seals is not classified as a strategic stock.

HABITAT CONCERNS

Glacial fjords in Alaska are critical for harbor seal whelping, nursing, and molting. Several of these areas have experienced a ten-fold increase in tour ship visitation since the 1980s. This increase in the presence of tour vessels has resulted in additional levels of disturbance to pups and adults (Jansen et al. 2015, Matthews et al. 2016). The level of serious injury or mortality resulting from increased disturbance is not known.

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