Revised 12/30/2018

NORTHERN FUR SEAL (*Callorhinus ursinus*): Eastern Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Northern fur seals occur from southern California north to the Bering Sea (Fig. 1) and west to the Sea of Okhotsk and Honshu Island, Japan. During the summer breeding season, most of the worldwide population is found on the Pribilof Islands (St. Paul Island and St. George Island) in the southern Bering Sea, with the remaining animals on rookeries in Russia, on Bogoslof Island in the southern Bering Sea, on San Miguel Island off southern California (Lander and Kajimura 1982, NMFS 1993), and on the Farallon Islands off central California. Non-breeding northern fur seals may occasionally haul out on land at other sites in Alaska, British Columbia, and on islets along the west coast of the United States (Fiscus 1983).

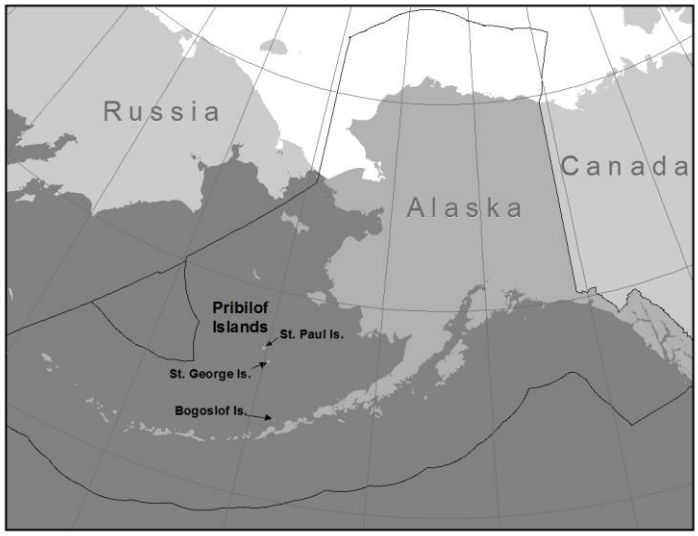

Figure 1. Approximate distribution of northern fur seals in the eastern North Pacific (dark shaded area). Eastern Pacific northern fur seal breeding colonies in U.S. waters are located on the three named islands. The U.S. Exclusive Economic Zone is delineated by the solid black line.

During the reproductive season, adult males usually are on shore during the 4-month period from May to August, though some may be present until November (well after giving up their territories). Adult females are ashore during a 6-month period (June-November). Following their respective times ashore, Alaska northern fur seals of both genders then move south and remain at sea until the next breeding season (Roppel 1984). Adult females and pups from the Pribilof Islands move through the Aleutian Islands into the North Pacific Ocean, often to the waters offshore of Oregon and California. Adult males generally move only as far south as the Gulf of Alaska in the eastern North Pacific (Kajimura 1984) and the Kuril Islands in the western North Pacific (Loughlin et al. 1999). In Alaska, pups are born during summer months and leave the rookeries in the fall, on average around mid-November but ranging from late October to early December. Alaska northern fur seal pups generally remain at sea for 22 months (Kenyon and Wilke 1953) before returning to land, usually at their rookery of birth but with considerable interchange of individuals between rookeries.

Two separate stocks of northern fur seals, an Eastern Pacific stock and a California stock, are recognized within U.S. waters based on the distribution and population response factors of the Dizon et al. (1992) phylogeographic approach: 1) Distribution: continuous during non-breeding season and discontinuous during the breeding season, high natal site fidelity (DeLong 1982, Baker et al. 1995); 2) Population response: substantial differences in population dynamics between the Pribilof Islands and San Miguel Island (DeLong 1982, DeLong and Antonelis 1991, NMFS 1993); 3) Phenotypic differentiation: unknown; and 4) Genotypic differentiation: little evidence of genetic differentiation among breeding islands (Ream 2002, Dickerson et al. 2010). The California stock is reported in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

The population estimate for the Eastern Pacific stock of northern fur seals is calculated as the estimated number of pups born at rookeries in the eastern Bering Sea multiplied by a series of expansion factors determined from a life table analysis to estimate the number of yearlings, 2-year-olds, 3-year-olds, and animals 4 or more years old (Lander 1981). The resulting population estimate is equal to the pup production estimate multiplied by 4.47. The expansion factor is based on a sex and age distribution estimated after the harvest of juvenile males was terminated. There is no coefficient of variation (CV) for the expansion factor. Pup production is estimated at all islands using a mark-recapture method, or "shear-sampling" (Chapman and Johnson 1968, York and Kozloff 1987, Towell et al. 2006), with the exception of estimates conducted at Bogoslof Island through 1995, where the smaller

population size in those years allowed direct counting of pups. As the majority of pups are born on St. Paul and St. George Islands, pup surveys are conducted biennially on these islands. Pup production estimates are available less frequently on Sea Lion Rock (adjacent to St. Paul Island) and Bogoslof Island (Table 1). Annual variation in female reproductive rates is reflected in the respective pup production estimates; because the estimation of stock population size relies on these estimates of pup production, means of recent pup production estimates are used to account for variability in the reproductive rates over time. The most recent estimate for the number of northern fur seals in the Eastern Pacific stock, based on pup production estimates on Sea Lion Rock (2014), on St. Paul and St. George Islands (mean of 2012, 2014, and 2016), and on Bogoslof Island (mean of 2011 and 2015), is 620,660 northern fur seals (4.47 × 138,850).

Table 1. Estimates and/or counts of northern fur seal pups born on the Pribilof Islands and Bogoslof Island. Standard errors for pup estimates at rookery locations and the CV for total pup production estimates are provided in parentheses (direct counts do not have standard errors). The " symbol indicates that no new data are available for that year and, thus, the most recent prior estimate/count was used in determining total annual estimates.

	Rookery location				
Year	**St. Paul**	**Sea Lion Rock**	**St. George**	**Bogoslof**	**Total**
1994	192,104 (8,180)	12,891 (989)	22,244 (410)	1,472 (N/A)	228,711 (0.036)
1995	"	"	"	1,272 (N/A)	228,511 (0.036)
1996	170,125 (21,244)	"	27,385 (294)		211,673 (0.10)
1997	"	"	"	5,096 (33)	215,497 (0.099)
1998	179,149 (6,193)	"	22,090 (222)		219,226 (0.029)
2000	158,736 (17,284)	"	20,176 (271)	"	196,899 (0.089)
2002	145,716 (1,629)	8,262 (191)	17,593 (527)	"	176,667 (0.01)
2004	122,825 (1,290)	"	16,876 (239)	"	153,059 (0.01)
2005	"	"	"	12,631 (335)	160,594 (0.01)
2006	109, 961 (1,520)	"	17,072 (144)	"	147,900 (0.011)
2007	"	"	"	17,574 (843)	152,867 (0.011)
2008	102,674 (1,084)	6,741 (80)	18,160 (288)	"	145,149 (0.009)
2010	94,502 (1,259)	"	17,973 (323)	"	136,790 (0.011)
2011	"	"	"	22,905 (921.5)	142,121 (0.011)
2012	96,828 (1,260)	"	16,184 (155)	"	142,658 (0.011)
2014	91,737 (769)	5,250 (293)	18,937 (308)	"	138,829 (0.009)
2015	"	"	"	27,750 (228)	143,674 (0.006)
2016	80,641 (717)	"	20,490 (460)	"	134,131 (0.007)

Minimum Population Estimate

A CV(N) that incorporates the variance of the correction factor is not available. Consistent with a recommendation of the Alaska Scientific Review Group (SRG) in October 1997 (DeMaster 1998) and recommendations contained in Wade and Angliss (1997), a default CV(N) of 0.2 is used in the calculation of the minimum population estimate (N_{MIN}) for this stock. N_{MIN} is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 620,660 and the default CV (0.2), N_{MIN} for the Eastern Pacific stock is 525,333 northern fur seals.

Current Population Trend

Estimates of the size of the Alaska population of northern fur seals increased to approximately 1.25 million in 1974 after the termination of commercial sealing on St. George in 1972 and pelagic sealing for science in 1974; commercial sealing on St. Paul continued until 1984. The population then began to decrease, with pup production declining at a rate of 6.5-7.8% per year into the 1980s (York 1987). By 1983, the total stock estimate was 877,000 northern fur seals (Briggs and Fowler 1984). Annual pup production on St. Paul Island remained stable between 1981 and 1996 (Fig. 2; York and Fowler 1992). There has been a decline in pup production on St. Paul Island since the mid-1990s. Pup production at St. George Island had a less pronounced period of stabilization that was similarly followed by a decline. However, pup production appeared to stabilize again on St. George Island beginning around 2002 (Fig. 3). During 1998-2016, pup production declined 4.12% per year (SE = 0.40%; P < 0.01) on St. Paul Island and showed no significant trend (SE = 0.57%; P = 0.13) on St. George Island. The estimated pup production in 2016 was below the 1919 level (Bower 1920) on both St. Paul and St. George Islands. Northern fur seal pup production at Bogoslof Island has grown at an exponential rate since the 1990s (Towell and Ream 2012) (Fig. 4). Despite continued growth at Bogoslof Island, recent estimates of pup production indicate that the rate of increase may be slowing. Between 1997 and 2015, pup production at Bogoslof Island increased 10.1% per year. Temporary increases in the overall stock size are observed when opportunistic estimates are conducted at Bogoslof, but declines at the larger Pribilof colony (specifically St. Paul) continue to drive the overall stock estimate down over time.

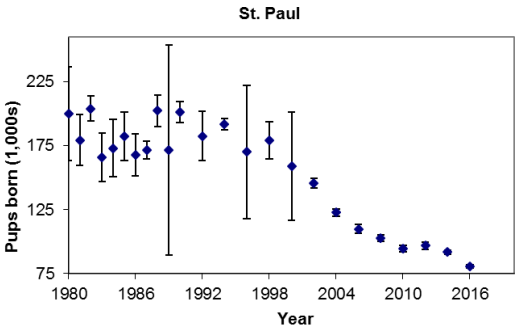

Figure 2. Estimated number of northern fur seal pups born on St. Paul Island, 1980-2016.

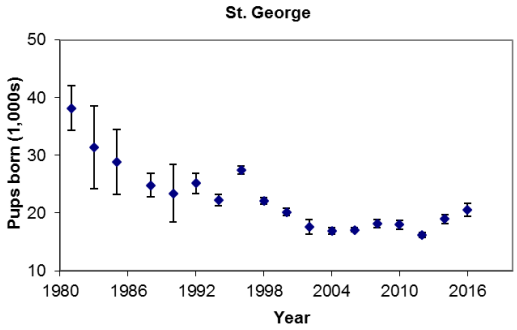

Figure 3. Estimated number of northern fur seal pups born on St. George Island, 1980-2016.

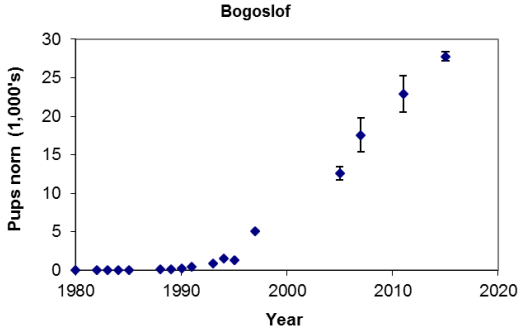

Figure 4. Estimated number of northern fur seal pups born on Bogoslof Island, 1980-2016.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Pelagic sealing led to a decrease in the fur seal population; however, a moratorium on fur seal harvesting and termination of pelagic sealing resulted in a steady increase in the northern fur seal population during 1912-1924. During this period, the rate of population growth was approximately 8.6% (SE = 1.47) per year (A. York, NMFS-AFSC-MML (retired), unpubl. data), the maximum recorded for this species. This growth rate is similar and slightly higher than the 8.1% rate of increase (approximate SE = 1.29) estimated by Gerrodette et al. (1985). Though not as high as growth rates estimated for other fur seal species, the 8.6% rate of increase is considered a reliable estimate of the maximum net productivity rate (R_{MAX}) given the extremely low density of the population in the early 1900s.

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum estimated net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for depleted stocks under the Marine Mammal Protection Act (MMPA) (Wade and Angliss 1997). Thus, for the Eastern Pacific stock, PBR = 11,295 northern fur seals (525,333 × 0.043 × 0.5).

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 in 2012-2016 is listed, by marine mammal stock, in Helker et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The total estimated annual level of human-caused mortality and serious injury for the Eastern Pacific stock in 2012-2016 is 425 northern fur seals: 2.4 in U.S. commercial fisheries, 2 in unknown (commercial, recreational, or subsistence fisheries), 5 in marine debris, 0.4 due to other causes (power plant entrainment and car strike), and 415 in the Alaska Native subsistence harvest. These mortality and serious injury data do not reflect the total potential threat of entanglement, since additional northern fur seals initially considered seriously injured due to entanglement in fishing gear or marine debris were disentangled and released with non-serious injuries in 2012-2016 (see details in text and in Helker et al. in press). Assignment of mortality and serious injury to both the Eastern Pacific and California stocks of northern fur seals, when events occur in the area and time of year where the two stocks overlap (off the U.S. west coast in December through May), may result in overestimating stock specific mortality and serious injury. Additional potential threats most likely to result in direct human-caused mortality or serious injury of this stock include the increased potential for oil spills due to an increase in vessel traffic in Alaska waters (with changes in sea-ice coverage).

Fisheries Information

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

During 2012-2016, incidental mortality and serious injury of northern fur seals was observed in one of the federally-managed commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl fishery (Table 2; Breiwick 2013; MML, unpubl. data). The estimated mean annual mortality and serious injury rate in this fishery in 2012-2016 is 0.2 northern fur seals.

Observer programs for Alaska State-managed commercial fisheries have not documented any mortality or serious injury of northern fur seals (Wynne et al. 1991, Manly 2007).

Table 2. Summary of incidental mortality and serious injury of Eastern Pacific northern fur seals due to U.S. commercial fisheries in 2012-2016 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2012	obs data	99	0	0	0.2 (CV = 0.04)
	2013		99	0	0	
	2014		99	1	1	
	2015		99	0	0	
	2016		99	0	0	
Minimum total estimated annual mortality						0.2 (CV = 0.04)

Entanglements of northern fur seals have been observed on St. Paul, St. George, and Bogoslof Islands. Since 2011, there has been an increased effort to include entanglement reports in the NMFS Alaska Region stranding database. A summary of entanglements in fishing gear reported in 2012-2016 is provided in Table 3 (Helker et al. in press). 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. Three northern fur seals entangled in commercial Bering Sea/Aleutian Islands halibut longline gear and eight northern fur seals entangled in commercial Bering Sea/Aleutian Islands trawl gear were reported to the NMFS Alaska Region stranding network in 2012-2016, resulting in minimum mean annual mortality and serious injury rates of 0.6 and 1.6 northern fur seals, respectively, in these fisheries (Table 3; Helker et al. in press).

An additional nine northern fur seals were initially considered to be seriously injured due to entanglement in commercial Bering Sea/Aleutian Islands trawl gear (2 in 2012, 1 in 2014, and 1 in 2015), unidentified trawl gear (3 in 2016), and unidentified net (1 each in 2012 and 2016); however, because these animals were disentangled and released with non-serious injuries (Helker et al. in press), they were not included in the mean annual mortality and serious injury rate for 2012-2016.

The total mean annual mortality and serious injury rate incidental to U.S. commercial fisheries in 2012-2016 is 2.4 northern fur seals (0.2 from observer data + 2.2 from stranding data).

The minimum mean annual mortality and serious injury rate due to entanglement in gillnet (0.4), unidentified fishing gear (0.2), unidentified fishing net (0.8), and trawl gear (0.2) in Alaska waters in 2012-2016 is 1.6 northern fur seals (Table 3; Helker et al. in press). These entanglements cannot be assigned to a specific fishery, and it is unknown whether commercial, recreational, or subsistence fisheries are the source of the fishing debris.

The Eastern Pacific stock can occur off the west coast of the continental U.S. in winter/spring; therefore, any mortality or serious injury of northern fur seals reported off the coasts of Washington, Oregon, or California during December through May is assigned to both the Eastern Pacific and California stocks of northern fur seals (see Table 3). During 2012-2016, two northern fur seal entanglements in trawl gear, that occurred off the U.S. west coast in December through May 2014, were reported to the NMFS West Coast Region stranding network (Helker et al. in press), resulting in an average annual mortality and serious injury rate of 0.4 northern fur seals in these waters (Table 3). This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries and is a minimum because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined An additional northern fur seal that stranded with a serious injury, due to an unidentified fishery interaction, in May 2012 in California was treated and released with a non-serious injury (Helker et al. in press); therefore, it was not included in the mean annual mortality and serious injury rate for 2012-2016.

Table 3. Summary of mortality and serious injury of Eastern Pacific northern fur seals, by year and type, reported to the NMFS Alaska Region and NMFS West Coast Region marine mammal stranding networks in 2012-2016 (Helker et al. in press). Only cases of serious injuries are reported in this table; animals that were disentangled and released with non-serious injuries have been excluded.

Cause of injury	2012	2013	2014	2015	2016	Mean annual mortality
Entangled in commercial Bering Sea/Aleutian Is. halibut longline gear	0	0	3	0	0	0.6
Entangled in commercial Bering Sea/Aleutian Is. trawl gear	1	0	6	1	0	1.6
Entangled in Bering Sea/Aleutian Is. gillnet gear*	0	0	0	1	0	0.2
Entangled in Bering Sea/Aleutian Is. unidentified fishing gear*	0	0	0	1	0	0.2
Entangled in gillnet*	0	0	1	0	0	0.2
Entangled in unidentified net*	3	0	1	0	0	0.8
Entangled in trawl gear*	0	0	2[a]	0	1	0.6
Entangled in marine debris	4	1	11	0	9	5
Entrained in power plant intake	1[a]	0	0	0	0	0.2
Struck by car	0	0	0	1	0	0.2
Total in commercial fisheries						2.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						2
Total in marine debris						5
Total due to other sources (power plant entrainment, car strike)						0.4

[a]The mortality or serious injury occurred off the coast of Washington, Oregon, or California in December through May and was assigned to both the Eastern Pacific and California stocks of northern fur seals.

Alaska Native Subsistence/Harvest Information

Alaska Natives residing on the Pribilof Islands are allowed an annual subsistence harvest of northern fur seals, with a 3-year take range based on historical local needs. Typically, only juvenile males are taken in the subsistence harvest, which results in a much smaller impact on population growth than a harvest that includes females. However, accidental harvesting of females and adult males does occur. A single female was killed during the harvest on St. George Island in 2012 (Lekanof 2013), three females were killed on St. Paul Island in 2013 (Lestenkof et al. 2014), four females were killed on St. Paul (Melovidov et al. 2014) and one was killed on St. George (Kashevarof 2014b) in 2014, two females were killed on St. Paul in 2015 (Lestenkof et al. 2015), and one female was killed on St. Paul in 2016 (Melovidov et al. 2017). Fifty-four pups were killed during the inaugural pup harvest on St. George Island in 2014 (Testa 2016), 57 pups were killed in 2015 (Meyer 2016), and 46 were killed in 2016 (Meyer 2017). During 2012-2016, the average annual subsistence harvest on the Pribilof Islands was 415 northern fur seals (Table 4).

Table 4. Summary of the Alaska Native subsistence harvest of northern fur seals on St. Paul and St. George Islands in 2012-2016.

Year	St. Paul	St. George	Total harvested
2012	383[a]	64[b]	447
2013	301[c]	80[d]	381
2014	266[e]	158[f, g]	424
2015	314[h]	118[i, j]	432
2016	309[k]	83[l, m]	392
Mean annual harvest			415

[a]Lestenkof et al. (2012); [b]Lekanof (2013); [c]Lestenkof et al. (2014); [d]Kashevarof (2014a); [e]Melovidov et al. (2014); [f]Kashevarof (2014b); [g]Testa (2016); [h]Lestenkof et al. (2015); [i]Kashevarof (2016); [j]Meyer (2016); [k]Melovidov et al. (2017); [l]Testa (2018); [m]Meyer (2017).

Other Mortality

Intentional killing of northern fur seals by commercial fishermen, sport fishermen, and others may occur, but the magnitude of that mortality is unknown.

Because the Eastern Pacific and California stocks of northern fur seals overlap off the west coast of the continental U.S. during December through May, non-fishery mortality and serious injury reported off the coast of Washington, Oregon, or California during that time is assigned to both stocks (see details in Table 3). Reports to the NMFS Alaska Region and West Coast Region stranding networks in 2012-2016 resulted in mean annual mortality and serious injury rates of 5 northern fur seals due to entanglement in marine debris in Alaska waters, 0.2 due to a car strike on St. Paul Island, and 0.2 due to entrainment in the cooling water system of a California power plant (Table 3; Helker et al. in press). 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

An additional 23 northern fur seals that were initially considered seriously injured due to entanglement in marine debris (7 in 2012, 4 in 2014, 6 in 2015, and 6 in 2016) were disentangled and released with non-serious injuries (Helker et al. in press); therefore, these animals were not included in the mean annual mortality and serious injury rate for 2012-2016.

STATUS OF STOCK

Based on currently available data, the minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (2.4 northern fur seals) is less than 10% of the calculated PBR (10% of PBR = 1,130 northern fur seals) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. The total estimated annual level of human-caused mortality and serious injury (425 northern fur seals) does not exceed the PBR (11,295) for this stock. The PBR calculation assumes mortality is evenly distributed across males, females, and each age class; but that is not the case with the subsistence harvest, which accounts for most of the known direct human-caused mortality. The subsistence harvest is almost entirely sub-adult males and male pups and, therefore, has a relatively low impact on the population due to the disproportionate importance of females to the population. Thus, non-breeding male-biased mortality up to the maximum levels authorized for subsistence use does not represent a significant risk to the Eastern Pacific northern fur seal stock. The northern fur seal was designated as depleted under the MMPA in 1988 because population levels had declined to less than 50% of levels observed in the late 1950s (1.8 million animals; 53 FR 17888, 18 May 1988). The Eastern Pacific stock of northern fur seals is classified as a strategic stock because it is designated as depleted under the MMPA.

There are key uncertainties in the assessment of the Eastern Pacific stock of northern fur seals. The abundance estimate is based on pup counts multiplied by a constant; this constant was based on northern fur seal demographic information which is now quite dated and it is unknown whether the constant is still optimum for this population. Because an estimate of variance cannot be determined, the N_{MIN} calculation uses a default CV of 0.2. At this time, the cause of the decline of this stock is unknown. 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.

HABITAT CONCERNS

Northern fur seals are described as generalist or opportunistic foragers consuming a wide variety of midwater shelf and mesopelagic fish and squid species. Walleye pollock is the predominant prey of northern fur seals foraging over the Bering Sea shelf, and progressively greater proportions of oceanic fish and squid are

consumed when they forage over the slope and in off-shelf waters (Zeppelin and Ream 2006). Analyses of scats collected from Pribilof Island rookeries during 1987-2000 found that pollock (46-75% by frequency of occurrence, FO) and gonatid squids dominated in the diet and that other primary prey (FO >5%) included Pacific sand lance, Pacific herring, northern smoothtongue, Atka mackerel, and Pacific salmon (Zeppelin and Ream 2006, Zeppelin and Orr 2010). These analyses also found that diets associated with rookery complexes reflected patterns associated with foraging in the specific hydrographic domains identified by Robson et al. (2004). Comparison of ingested prey sizes based on scat and spew analysis indicate a much larger overlap between sizes of pollock consumed by northern fur seals and those caught by the commercial trawl fishery than was previously known (Gudmundson et al. 2006). Analysis of Bogoslof Island northern fur seal diet found that it comprised primarily off-shelf species (northern smoothtongue, squid, myctophids) as well as juvenile walleye pollock (Zeppelin and Orr 2010, Kuhn et al. 2014).

Robson et al. (2004) and Kuhn et al. (2014) found that lactating female northern fur seals consistently use separate foraging habitats based on groups of breeding rookeries on St. Paul and St. George Islands. Sterling and Ream (2004) found that juvenile male northern fur seals also exhibit habitat segregation similar to that observed by lactating females and also some level of separation between the sexes. Call et al. (2008) also found lactating female northern fur seals had three types of individual foraging route tactics as they depart from the rookery, which is important to consider in the context of adaptation to changes in environmental conditions and prey distributions. From 1982 to 2016, pup production declined on St. Paul and St. George Islands (Figs. 2 and 3). However, it remains unclear whether the pattern of declines in northern fur seal pup production on the two Pribilof Islands is related to natural or anthropogenic changes in the northern fur seals' summer foraging habitat. In contrast, Bogoslof Island northern fur seals that forage in the deeper water of the Bering Sea Basin have shown dramatic increases in pup production (Fig. 4). Bogoslof Island experienced substantial volcanic activity beginning in December 2016 and continuing through the summer northern fur seal breeding season until September 2017. Volcanic activity involved explosive eruptions and ash emissions and dramatically changed the size and shape of the island. Live northern fur seals, including pups, were observed on land in photographs taken during both July and August 2017, but population level impacts on northern fur seals at Bogoslof Island are unknown. Adult female northern fur seals from Bogoslof Island and the Pribilof Islands spend approximately 8 months in varied regions of the North Pacific Ocean during winter and forage in areas associated with eddies and the subarctic-subtropical transition region (Ream et al. 2005). Thus, environmental changes in the North Pacific Ocean could potentially be affecting abundance and productivity of northern fur seals breeding in Alaska.

A variety of human activities other than commercial fishing, such as an increase in vessel traffic in Alaska waters and an increased potential for oil spills, may impact northern fur seals. A Conservation Plan for the Eastern Pacific stock was released in December 2007 (NMFS 2007). This plan reviews known and potential threats to the recovery of northern fur seals in Alaska.

CITATIONS

Baker, J. D., G. A. Antonelis, C. W. Fowler, and A. E. York. 1995. Natal site fidelity in northern fur seals, *Callorhinus ursinus*. Anim. Behav. 50(1):237-247.

Bower, W. T. 1920. Alaska fisheries and fur industries in 1919. U.S. Dep. Commer., Appendix IX to Report of U.S. Commissioner of Fisheries for 1919. Bureau of Fisheries Document No. 891. Washington Government Printing Office. 160 p.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Briggs, L., and C. W. Fowler. 1984. Table and figures of the basic population data for northern fur seals of the Pribilof Islands. *In* Background papers submitted by the United States to the 27th annual meeting of the Standing Scientific Committee of the North Pacific Fur Seal Commission, March 29-April 9, 1984, Moscow, U.S.S.R. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Call, K. A., R. R. Ream, D. Johnson, J. T. Sterling, and R. G. Towell. 2008. Foraging route tactics and site fidelity of adult female northern fur seal (*Callorhinus ursinus*) around the Pribilof Islands. Deep-Sea Res. II 55:1883-1896.

Chapman, D. G., and A. M. Johnson. 1968. Estimation of fur seal pup populations by randomized sampling. Trans. Am. Fish. Soc. 97:264-270.

DeLong, R. L. 1982. Population biology of northern fur seals at San Miguel Island, California. Ph.D. Dissertation, University of California, Berkeley, CA. 185 p.

DeLong, R. L., and G. A. Antonelis. 1991. Impacts of the 1982-1983 El Niño on the northern fur seal population at San Miguel Island, California, p. 75-83. *In* F. Trillmich and K. Ono (eds.), Pinnipeds and El Niño: Responses to Environmental Stress. University of California Press, Berkeley, CA.

DeMaster, D. P. 1998. Minutes from the sixth meeting of the Alaska Scientific Review Group, 21-23 October 1997, Seattle, Washington. 40 p. Available from Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Dickerson B. R., R. R. Ream, S. N. Vignieri, and P. Bentzen. 2010. Population structure as revealed by mtDNA and microsatellites in northern fur seals, *Callorhinus ursinus*, throughout their range. PLoS ONE 5(5):e10671. DOI: dx.doi.org/10.1371/journal.pone.0010671 .

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Fiscus, C. F. 1983. Fur seals. *In* Background papers submitted by the United States to the 26th annual meeting of the Standing Scientific Committee of the North Pacific Fur Seal Commission, Washington, DC, 28 March-5 April, 1983. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gerrodette, T., D. Goodman, and J. Barlow. 1985. Confidence limits for population projections when vital rates vary randomly. Fish. Bull., U.S. 83:207-217.

Gudmundson, C. J., T. K. Zeppelin, and R. R. Ream. 2006. Application of two methods for determining diet of northern fur seals (*Callorhinus ursinus*). Fish. Bull., U.S. 104:445-455.

Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2012-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX, XXX p.

Kajimura, H. 1984. Opportunistic feeding of the northern fur seal, *Callorhinus ursinus*, in the eastern North Pacific Ocean and eastern Bering Sea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-779, 49 p.

Kashevarof, H. 2014a. Northern fur seal harvests, St. George Island, AK: harvest report for the 2013 season 7.8.2013-8.7.2013. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK. 4 p.

Kashevarof, H. 2014b. Northern fur seal harvests, St. George Island, AK: harvest report for the 2014 season 7.7.2014-8.8.2014. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK. 3 p.

Kashevarof, H. 2016. Northern fur seal harvests, St. George Island, AK: harvest report for the 2015 season 7.7.2015-8.7.2015. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

Kenyon K. W., and F. Wilke. 1953. Migration of the northern fur seal, *Callorhinus ursinus*. J. Mammal. 34(1):86-98.

Kuhn, C. E., R. R. Ream, J. T. Sterling, J. R. Thomason, and R. G. Towell. 2014. Spatial segregation and the influence of habitat on the foraging behavior of northern fur seals (*Callorhinus ursinus*). Can. J. Zool. 92:861-873.

Lander, R. H. 1981. A life table and biomass estimate for Alaskan fur seals. Fish. Res. (Amst.) 1:55-70.

Lander, R. H., and H. Kajimura. 1982. Status of northern fur seals. FAO Fisheries Series 5:319-345.

Lekanof, T. 2013. Northern fur seal harvests, St. George Island, AK: harvest report for the 2012 season 7.8.2012-8.8.2012. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK. 5 p.

Lestenkof, P. M., P. I. Melovidov, M. Rukovishnikoff, and P. A. Zavadil. 2012. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2012. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 36 p.

Lestenkof, P. M., P. I. Melovidov, and M. Rukovishnikoff. 2014. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2013. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 17 p.

Lestenkof, P. M., P. I. Melovidov, and A. P. Lestenkof. 2015. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2015. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 16 p.

Loughlin, T. R., W. J. Ingraham, Jr., N. Baba, and B. W. Robson. 1999. Use of a surface-current model and satellite telemetry to assess marine mammal movements in the Bering Sea. University of Alaska Sea Grant Press, AK-SG-99-03, Fairbanks, AK.

Manly, B. F. J. 2007. Incidental take and interactions of marine mammals and birds in the Kodiak Island salmon set gillnet fishery, 2002 and 2005. Final Report to Alaska Marine Mammal Observer Program, NMFS Alaska Region. 221 p.

Melovidov, P. I., P. M. Lestenkof, M. Rukovishnikoff, Sr., and D. V. V. Roberts. 2014. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2014. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 16 p.

Melovidov, P. I., P. M. Lestenkof, A. P. Lestenkof, L. M. Divine, and R. M. Rukovishnikoff. 2017. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2016. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 14 p. + appendices.

Meyer, B. 2016. Harvest monitoring services, subsistence harvest of northern fur seals on St. George Island, AK: harvest report for the 2015 season September 15 to November 30, 2015. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

Meyer, B. 2017. Harvest monitoring services, subsistence harvest of northern fur seals on St. George Island, AK: harvest report for the 2016 season September 16 to November 30, 2016. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

National Marine Fisheries Service (NMFS). 1993. Final conservation plan for the northern fur seal (*Callorhinus ursinus*). Prepared by the National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA, and the Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD. 80 p.

National Marine Fisheries Service (NMFS). 2007. Conservation plan for the Eastern Pacific stock of northern fur seal (*Callorhinus ursinus*). National Marine Fisheries Service, Alaska Regional Office, Juneau, AK.

Ream, R. R. 2002. Molecular ecology of northern otariids: genetic assessment of northern fur seal and Steller sea lion distributions. Ph.D. Dissertation, University of Washington, Seattle, WA. 134 p.

Ream, R. R., J. T. Sterling, and T. R. Loughlin. 2005. Oceanographic features related to northern fur seal migratory movements. Deep-Sea Res. II 52:823-843.

Robson, B. R., M. E. Goebel, J. D. Baker, R. R. Ream, T. R. Loughlin, R. C. Francis, G. A. Antonelis, and D. P. Costa. 2004. Separation of foraging habitat among breeding sites of a colonial marine predator, the northern fur seal (*Callorhinus ursinus*). Can. J. Zool. 82:20-29.

Roppel, A. Y. 1984. Management of northern fur seals on the Pribilof Islands, Alaska, 1786-1981. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-4, 32 p.

Sterling, J. T., and R. R. Ream. 2004. At-sea behavior of juvenile male northern fur seals (*Callorhinus ursinus*). Can. J. Zool. 82:1621-1637.

Testa, J. W. (ed.). 2016. Fur seal investigations, 2013-2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-316, 124 p.

Testa, J. W. (ed.). 2018. Fur seal investigations, 2015-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-375, 107 p.

Towell, R., and R. Ream. 2012. 2011 northern fur seal pup production estimate on Bogoslof Island, Alaska. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Towell, R. G., R. R. Ream, and A. E. York. 2006. Decline in northern fur seal (*Callorhinus ursinus*) pup production on the Pribilof Islands. Mar. Mammal Sci. 22(2):486-491.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.

Wynne, K. M., D. Hicks, and N. Munro. 1991. 1990 salmon gillnet fisheries observer programs in Prince William Sound and South Unimak Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 65 p. Available from NMFS, Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.

York, A. E. 1987. Northern fur seal, *Callorhinus ursinus*, eastern Pacific population (Pribilof Islands, Alaska, and San Miguel Island, California), p. 9-21. *In* J. P. Croxall and R. L. Gentry (eds.), Status, biology, and ecology of fur seals. Proceedings of an international symposium and workshop, Cambridge, England, 23-27 April 1984. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-51.

York, A. E., and C. W. Fowler. 1992. Population assessment, Pribilof Islands, Alaska, p. 9-26. *In* H. Kajimura and E. Sinclair (eds.), Fur seal investigations, 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-2.

York, A. E., and P. Kozloff. 1987. On estimating the number of fur seal pups born on St. Paul Island, 1980-86. Fish. Bull., U.S. 85:367-375.

Zeppelin, T. K., and A. J. Orr. 2010. Stable isotope and scat analyses indicate diet and habitat partitioning in northern fur seals, *Callorhinus ursinus*, across the eastern Pacific. Mar. Ecol. Prog. Ser. 409:241-253.

Zeppelin, T. K., and R. R. Ream. 2006. Foraging habitats based on the diet of female northern fur seals (*Callorhinus ursinus*) on the Pribilof Islands, Alaska. J. Zool. 270:565-576.