Northern Fur Seals: Synthesis paper for the North Pacific Fishery Management Council

October 2017[1]

1 Introduction

In April 2017, the Council received information about the status of northern fur seals in Alaska from Council staff and NMFS AKR PR and NMFS Marine Mammal Lab staff. After presentations that summarized the present state of the fur seal population and NMFS' research and management plans, the Council requested that staff produce a synthesis paper to summarize the state of knowledge of northern fur seals in Alaska to help the Council make informed decisions that may affect northern fur seals or the availability of fur seals for subsistence harvest. This paper provides a summary of the historical and recent population status of northern fur seals, history of northern fur seal exploitation and management, and scientific studies to understand northern fur seal demographics and potential interactions with commercial fisheries. Readers are directed to the northern fur seal Conservation Plan (NMFS 1993, 2007) or Gentry (1988) for more detailed summaries of management actions, specific studies, or population dynamics.

[1] Prepared by: Steve MacLean, Council staff and Michael T. Williams, NOAA, AKR, PRD

2 General Description

Northern fur seals are part of the family Otariidae, known as the eared seals. They have a visible ear flap and have the ability to move their hind flippers forward to walk on land. The Latin name, *Callorhinus ursinus*, means "beautiful-nose bearlike", and fur seals have been known as "sea bears" in some areas. Northern fur seals have a dense fur coat, with nearly 350,000 hairs per square inch, the fine fur was the driver for the industrial scale harvest that occurred from the late 18th to 1984.

Northern fur seals show extreme sexual dimorphism, males are much larger than females. Mature females weigh 35-64 kg (~80-140 pounds) while males weight 200-275 kg (~450-600 pounds) when they arrive at rookery areas. Females and young males are uniformly black when wet, but appear gray or brown when dry, with a lighter colored throat and chest when younger. Mature bulls are predominantly brownish-black and develop a lighter colored mane at around 6 years of age and by 8 or 9 are fully developed. Adult male fur seals become territorial when mature and exhibit extreme aggression and site tenacity compared to other fur seals (Gentry 1998).

Northern fur seals were first described by Georg Steller, after the Bering expedition became stranded on Bering Island in the Commander Island group in 1741. Gerassim Pribilof found the largest concentrations of northern fur seals in 1786 on the island group that now bears his name. When found, the Pribilof Islands were uninhabited, though evidence of prior human presence was reported. The Russians enslaved native Aleut people and transported them to the Pribilof Islands to harvest seals.

3 Distribution and Stock Identification

Northern fur seals occur from southern California to the Bering Sea, and west to the Sea of Okhotsk and Japan (Figure 1). They breed at seven locations in the North Pacific and Bering Sea. Four locations, the Pribilof Islands, Bogoslof Island, San Miguel Island, and the Farallon Islands are within US waters. The other locations, Commander Islands, Robben Island, and the Kuril Islands, are in Russian waters. Two separate stocks of northern fur seals are recognized within US waters; the Eastern Pacific stock (Pribilof and Bogoslof Islands) and the California stock (San Miguel and Farallon Islands).

During the summer breeding season, the largest breeding population is found on the Pribilof Islands in the southern Bering Sea. Historically, the Pribilof Islands contained up to 75% of the breeding population, but because of recent declines, the Pribilofs now hold slightly less than half of the world's population of northern fur seals. Northern fur seals range throughout the North Pacific in winter (Figure 1) and are not segregated by stock.

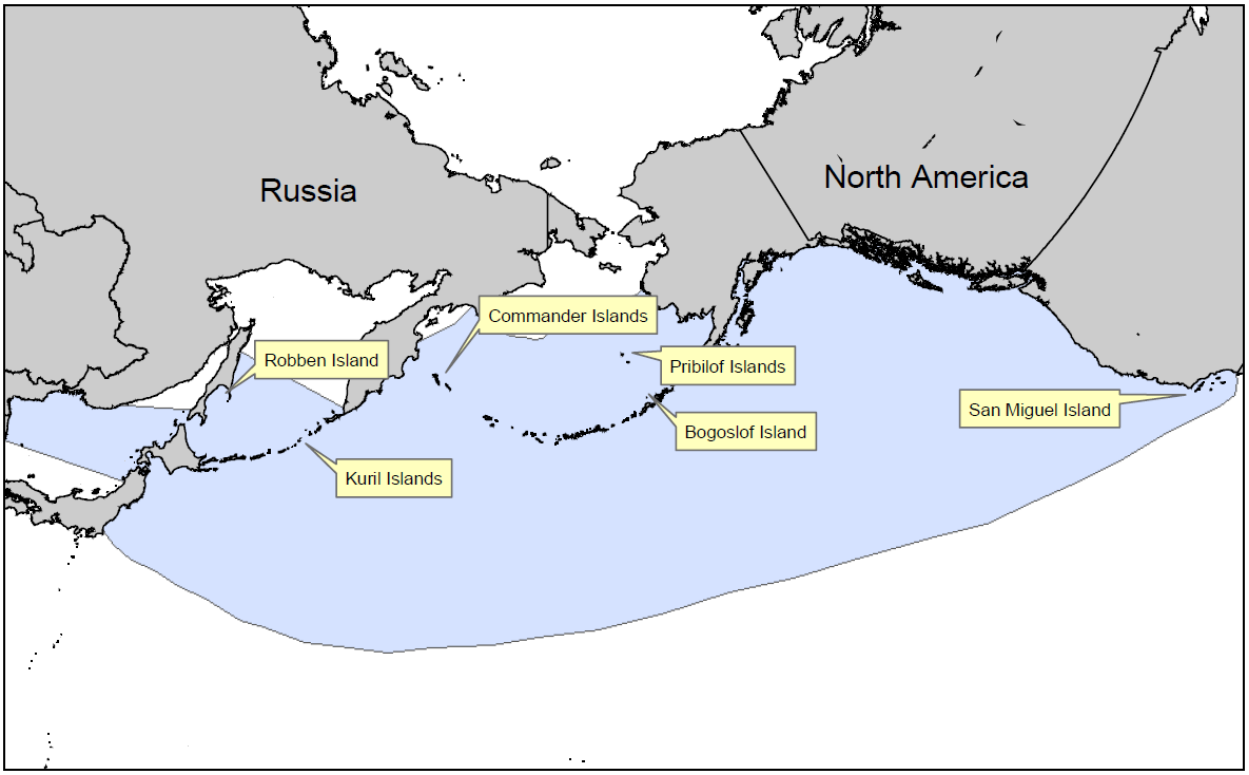

Figure 1. Distribution of northern fur seals in winter, with major breeding areas identified. From Conservation Plan for the Eastern Pacific Stock of northern fur seal (*Callorhinus ursinus*), 2007.

4 Population Size

4.1 Historic population

Since discovery in 1742, the population of northern fur seals has been exploited for their pelts. The global population of northern fur seals when described by Georg Steller in 1742 is not known, but was likely at least as large as the historic high estimate of 2.1 million in the 1950s. The only metrics available to understand the population at this time are records of pelts taken by the Russians. The population has experienced at least three declines due to harvest strategies. Twice it recovered quickly; first when the harvest of females was prohibited by the Russians, and again when international pelagic sealing was controlled in 1911, when the Pribilof Islands fur seal population was estimated to be between 200,000 and 300,000. The third decline began intentionally under the auspices of the Fur Seal Convention when the Pribilof Islands population was thought to be at carrying capacity (about 2 million fur seals) in the 1950s. The herd reduction program was implemented in an effort to increase maximum sustainable yield by killing adult females (Roppel and Davey 1965, York and Hartley 1981). This decline appears to have subsided by the 1980s (York 1990). Whether the current decline is a continuation of that intentionally initiated in the 1950s or is a new decline that began in the early 1990s is not known.

4.2 Russian and early American harvest management

In 1834, the Russian American Company that held the Russian concession for sealing on all the islands in the North Pacific halted the killing of females on the Pribilof Islands. As a result of this first management action, the herd increased at an unknown rate (no data were collected) until 1867 (Stejneger 1896, Lander

1980, Busch 1985). In 1867, the Pribilof Islands population was estimated to be between 2 and 3 million seals (Gentry 1998).

After the Alaska purchase in 1867, the first two years of American harvest management were characterized as a ruthless slaughter, exceeding even that during the early Russian ownership of the islands (Roppel and Davey 1965); as many as 325,000 seals were estimated killed in the first two years. The sale of pelts from the first five years after 1867 repaid the cost of the Alaska purchase (Gentry 1998). In 1869, the Pribilof Islands were set aside as a special reservation for the protection of fur seals, and the U.S. Department of Treasury contracted the American Commercial Company a 20-year lease to harvest fur seals on the Pribilof Islands. A second 20-year lease was contracted to a new sealing company, the North American Commercial Company (NACC). Both leases included similar provisions to provide for the Aleuts, annual harvest quotas, and prohibitions on harvesting females. Concurrently, a price increase for furs in Europe increased pelagic sealing for those not involved in the American leases in the Pribilofs. The roughly 300 boats in the sealing fleet are estimated to have killed as many as 75,000 fur seals per year from 1870 to 1910 (Bush 1985). The total pelagic kill in the North Pacific was large (at least 659,000 skins entered the market from 1890-1910), unregulated (no country had jurisdiction at sea), and poorly documented, and resulted in a rapid decline in the number of northern fur seals throughout their range. Pelagic sealing peaked in 1892, and reached near zero in 1910 due to scarcity of seals at sea. Most of the seals killed at sea were pregnant females. The large harvest at sea also affected the shore-based harvests on the islands; the herd declined so dramatically that the NACC could not meet the annual quotas established by their lease.

The extensive pelagic sealing after the Alaska purchase resulted in the second major population decline that was first detected in the 1880s (Allen 1880, Elliott 1882, Stejneger 1896, Jordan 1898). By 1910, the Pribilof herd had declined to about 10% of the estimated population at the time of the Alaska purchase. International negotiations between the United States, Russia, Japan, and Britain (for Canada) culminated in the International North Pacific Fur Seal Treaty of 1911. Under the treaty, nations possessing breeding islands (U.S. and Russia) agreed to share their land kill with nations without breeding islands (Japan and Britain) in exchange for a cessation of pelagic sealing. Between 1912 and 1924, the Pribilof population increased at the rate of 8% per year (Lander 1980), and continued at a slower pace through the 1930s to a population high of around 1.8 million in the 1940s and 1950s. Subadult male seals were taken in the harvest because of the ease of access and predicted availability on the hauling grounds adjacent to breeding rookeries. Pelts from subadult males were also found to be less scarred, and collected a higher price. Northern fur seals give birth to nearly equal proportions of male and female pups. Because very few adult males are necessary to maintain high pregnancy rates, their reproductive strategy results in a substantial number of subadult males for harvest without negatively affecting the reproductive potential of the population.

4.3 American herd reduction program

In the 1950s, managers noted that the number of pups born annually equaled the number of pups born in the period of high growth in the 1930s, but fewer subadult males were being taken for pelts. They surmised that density dependent mortality had reduced the number of subadult males surviving, and postulated that smaller pup cohorts would result in greater survival to the juvenile years, resulting in additional surplus males for harvest (Gentry 1998). Additionally, Japan argued that an excess of fur seals was damaging their fisheries, and announced their intention to abrogate the Fur Seal Treaty. In response to these political and biological pressures, managers killed adult about 315,000 females on land and another 16,000 at sea between 1956 and 1968 to reduce the number of pups born annually to equal the number in the period 1932 – 1937 (400,000). Roppel and Davey (1965) reported that the program had achieved the calculated reduction of adult females to 800,000 individuals by 1963. Further, they reported that the program was “beneficial in eliminating a larger number of old and unreproductive females”.

Based on the recovery of the population in the 1920s, managers expected the population to recover at 8% per year. Instead, the population continued to decline through 1980 at about 7.5% annually (York 1987).

The number of females killed accounted for about 70% of the population decline between 1956 and 1980 (York and Hartley 1981). During the decline, the pregnancy rates of prime-aged females declined, and the mean age at first birth increased (Trites and York 1993). Because of these unexpected results, some researchers to speculated that some unspecified change in the marine ecosystem contributed to the continued decline of northern fur seals. However, not all populations declined between 1956 and 1993; only the Pribilof and Robben Island populations did so, the other populations increased (Gentry 1998). As yet, the additional cause or causes of the continued decline in the Pribilof Islands are not known, although substantial research has been conducted to understand the drivers of the different breeding populations (e.g., Gentry 1998).

4.4 Recent Pribilof Island population

Because the Pribilof Islands population is the largest population of northern fur seals, the dynamics of that population has a large impact on the total global population estimate. The vast majority of Pribilof Island fur seals breed on St. Paul Island, and population trends on St. George Island are often obscured when summarizing for the Pribilof Islands or Eastern Pacific stock. The population estimate for the Eastern Pacific stock of northern fur seals is calculated as the estimated number of pups born at the rookeries, multiplied by a series of different 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 4.5. Surveys of pups born on St. Paul and St. George Islands are conducted biennially, and less frequently on Sea Lion Rock and Bogoslof Island.

The American herd reduction program resulted in a long decline in the Pribilof Islands fur seal population. Even after the cessation of commercial sealing on St. George Island in 1972 and scientific pelagic sealing in 1974, pup production declined at 6.5-7.8% per year into the mid-1980s (York 1987). Pup production appeared to stabilize on St. Paul Island between 1980 and the early 1990s, but there has been a decline in pup production on St. Paul Island since the mid-1990s (Muto et al. 2017).

Estimates of pup production on St. Paul Island since 1992 have generally declined from a high of 192,104 in 1994 to a low of 80,641 in 2016 (Figure 2). Estimates of pup production on St. George Island have also generally declined from a high of 27,385 in 1996 to a low of 16,184 in 2012 (Muto et al. 2017), although the trend on St. George for the last decade is not significantly different from zero (Figure 2, MML unpublished) The estimated pup production in 2014 was below the 1917 level, when the population was recovering from pelagic sealing.

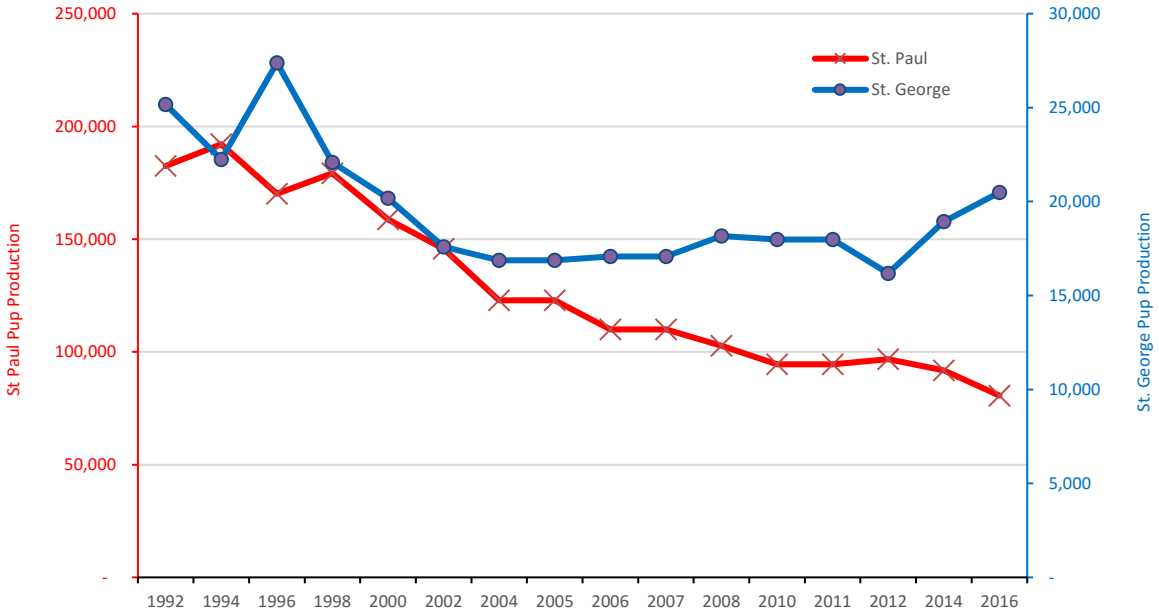

Figure 2. Estimates of northern fur seal pups born on the Pribilof Islands, 1992 - 2014. Muto et al., 2017, Towell et al., 2016.

Since 1998, pup production on St. Paul Island declined 55% (-4.1% annually), while pup production on St. Paul and St. George combined declined 50% (-3.5% annually), suggesting that pup production on St. George may have stabilized or slightly increased over that time (Figure 2).

4.5 Bogoslof Island population

Bogoslof Island is a volcanic island that began forming in 1796. It is about 105 km north of Umnak Island in the eastern Aleutians. Recently, Bogoslof volcano has been very active, and the size, shape, and contours of the island have been changing.

Steller sea lions, harbor seals, and northern fur seals are all found on Bogoslof Island. Positive identification of northern fur seals on Bogoslof did not occur until 1976 (Fiscus 1983 *in* Loughlin and Miller 1989). The first two pups were seen on the island in 1980. Since then, the number of pups born on the island has grown rapidly, to the most recent estimate of 27,750 in 2015 (Figure 3).

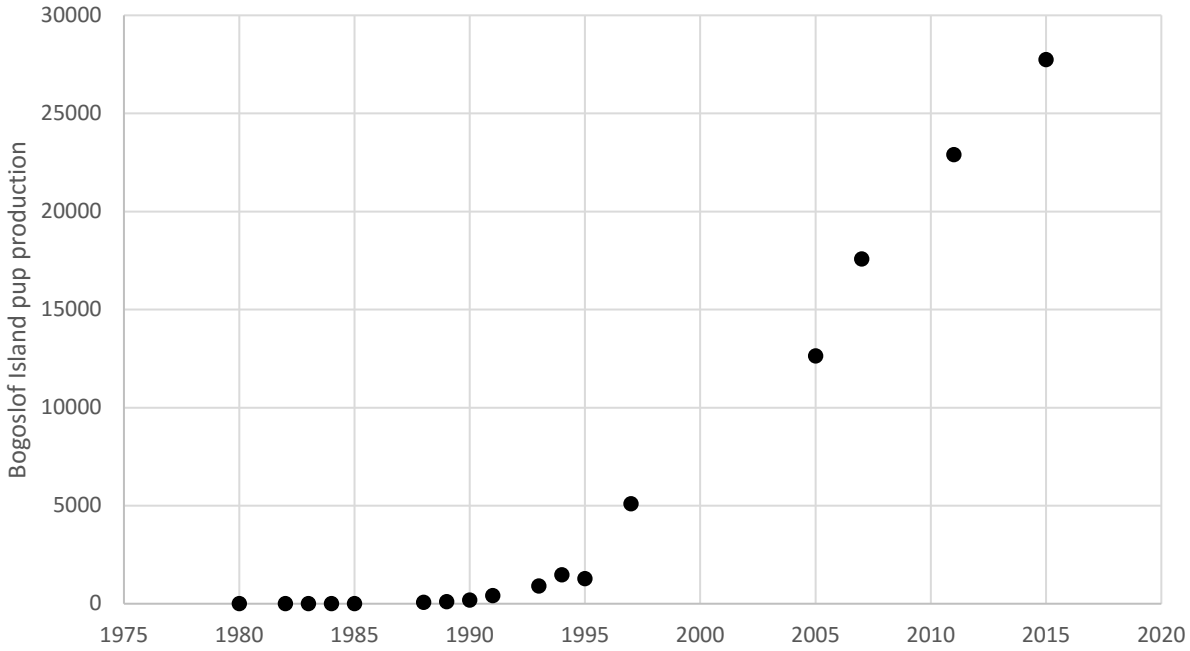

Figure 3. Counts (1980-1995) and estimated (1997 - 2015) northern fur seal pup production on Bogoslof Island, Alaska 1980-2015.

Since the first pup was observed on Bogoslof Island in 1980, pup production has increased at an annual rate of 33.7%, and at an annual rate of 10.1% since 1987. This is higher than the maximum estimated rate of growth for northern fur seals (8%, York 1987), and immigration from other rookeries has contributed to the rate of growth. However, the immigration rate at Bogoslof is not sufficient to explain the declines seen at rookeries in the Pribilof Islands (e.g., decline of >100,000 pups from St. Paul since 1992). It is not yet known how the recent eruptions of Bogoslof volcano will affect the northern fur seals on Bogoslof Island. However, in July and August 2017, northern fur seal adults, juveniles, and pups were seen and photographed on Bogoslof Island during the period of frequent eruptions (https://www.avo.alaska.edu/activity/Bogoslof.php, R. Ream, pers. comm.).

4.6 Minimum population estimate

The minimum population estimate for the Eastern Pacific stock of northern fur seals in 2016 is 530,474 animals of all ages (Muto et al. 2017). The 2016 pup production estimate indicates a decrease on St. Paul Island and stability on St. George Island since the 2014 estimate.

4.7 Status of stock

The northern fur seal was designated as depleted under the Marine Mammal Protection Act (MMPA) in 1988 because population levels had declined to less than 50% of the levels observed in the late 1950s (1.8 million animals; 53 FR17888, 18 May 1988) and there was no compelling evidence that carrying capacity of the Bering Sea had changed substantially since the late 1950s. The Eastern Pacific stock of northern fur seals is classified as a strategic stock because it is designated as depleted under the MMPA. The northern fur seal is not listed under the U.S. Endangered Species Act.

5 Feeding Habits

Northern fur seals consume a wide variety of fishes, and squids (Table 1). The diet of adult female northern fur seals varies according to the hydrographic structure surrounding breeding islands (Sinclair 1988, Sinclair et al. 1994, Antonelis et al. 1997, Perez 1997). Using scats collected between 1987 and 1990, Antonelis et al. (1997) found differences in prey species consumption by adult female fur seals among three breeding islands of variable hydrographic structure: St. Paul Island, St. George Island, and Medny Island (Commander Islands, Russia). On St. Paul Island, the largest component of the biomass estimate of fur seal prey was walleye pollock (93.0%), while on St. George Island, gonatid squid (55.2%), and walleye pollock (44.8%) accounted for the largest biomass component (Antonelis et al. 1997). Diet composition of lactating adult females breeding on the Pribilof Islands continues to be dominated by walleye pollock (Gudmundson et al. 2006; Call et al. 2008; Call and Ream 2012; Joy et al. 2015). Gudmundson et al. (2006) also noted that prey size estimates and prey composition were significantly different between scats and regurgitations collected at the same breeding areas, indicating that sampling bias likely exists in historic diet studies, and multiple types of sampling are necessary to accurately describe feeding habits. Fatty acid signature of fur seal milk also suggested differences in adult female diet between St. Paul and St. George Islands, and also among rookeries on St. Paul Island (Goebel 2002).

Table 1. Percent occurrence of prey species consumed by northern fur seals on St. Paul and St. George Islands, in 1990.

Prey	St. Paul Island	St. George Island
Walleye Pollock	70.0	40.0
Pacific Sand Lance	10.7	6.5
Northern Smoothtongue	1.6	3.0
Pacific sandfish	1.4	2.4
Atka mackerel	9.1	3.6
Deepsea smelt	1.8	3.8
Flounder	1.8	1.8
Bering wolffish	2.4	-
Salmon	4.2	7.7
Capelin	-	-
Pacific herring	2.0	1.2
Sculpin	0.2	1.8
Arctic Flounder	0.2	-
Scaly paperbone	-	-
Smelt	0.4	-
Eulachon	0.2	-
Greenling	-	-
Unidentified Fish	15.1	22.0
Squid	20.7	50.7

Source: Table 1 in Antonelis et al., (1997).

Robson et al. (2004) showed that lactating females from St. Paul and St. George islands traveled in different directions to forage (Figure 4). Robson et al. (2004) found that breeding site predicted foraging area with very little overlap, not only between islands, but between rookeries on individual islands. Females from the southwestern side of St. Paul Island traveled southwest to northwest of the island, whereas females from the northeastern side of the island traveled northwest to southeast of the island. Females from St. George Island traveled south and east of the island. Sterling and Ream (2004) reported that the tagging location (and presumably the rookery of birth) of subadult males predicted marine foraging area, similar to the foraging segregation found for lactating adult females. Subadult males were able to range further and stay at sea longer than lactating females, because they did not need to return to

the island to nurse a pup. Zeppelin et al. (2015) modeled stable isotope ratios from plasma and red blood cells and were able to predict on-shelf and off-shelf foraging differences among lactating females, consistent with prior studies.

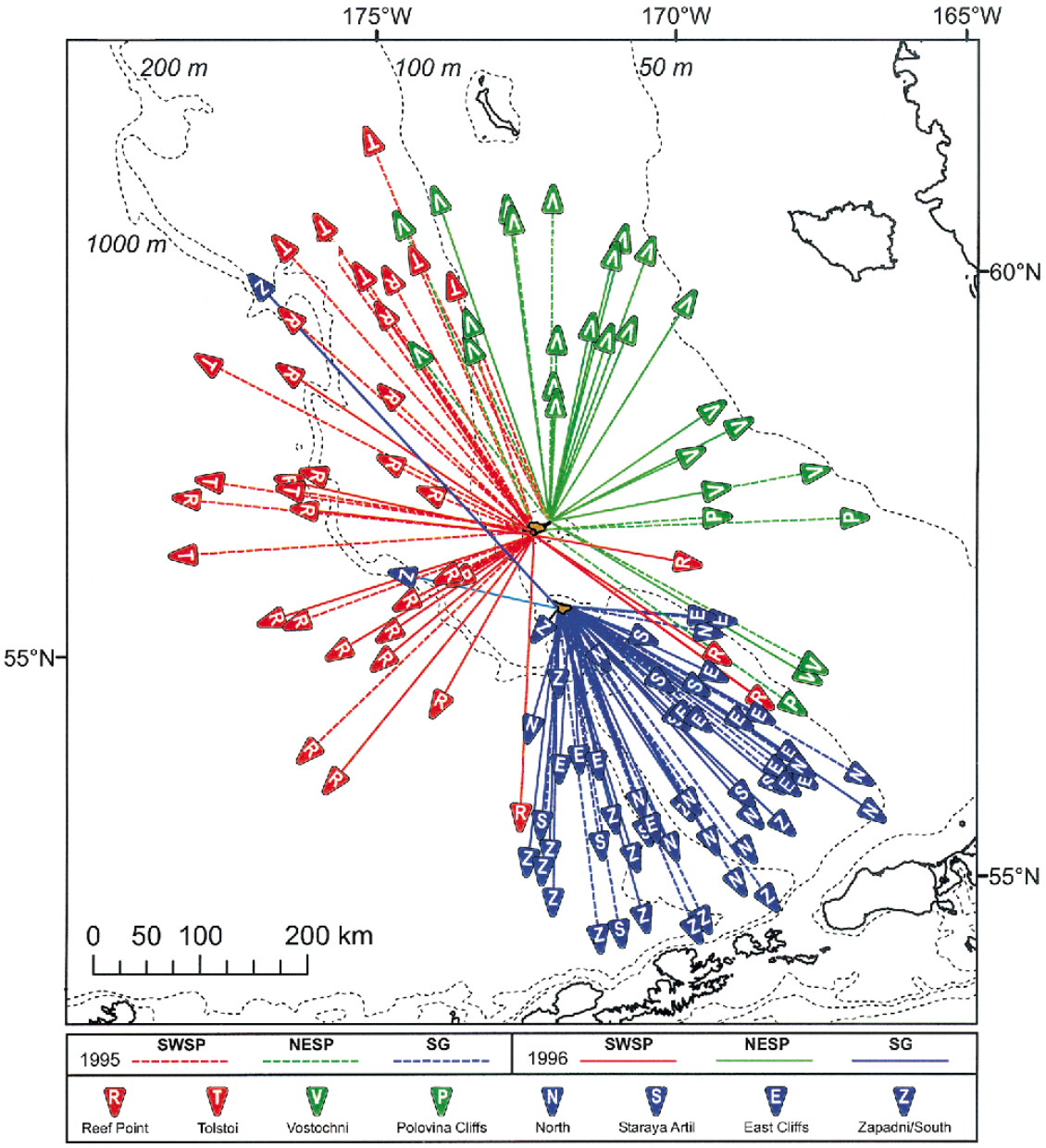

Figure 4. Vectors showing direction and maximum distance from the breeding site for lactating northern fur seals tracked by satellite in 1995 and 1996. SWSP = Southwest St. Paul, NESP = Northeast St. Paul, SG = St. George. Figure 2 in Robson et al. (2004).

Adult female northern fur seals with dependent young at Bogoslof Island have forage in different marine habitat than those on St. Paul Island (Springer et al. 2010). Females from Bogoslof Island foraged in deep water a relatively short distance from the island and in all directions in 2005 and 2006 (Figure 5). Foraging behavior described by Springer et al. (2010) for lactating females on St. Paul was consistent with that reported by Robson et al. (2004).

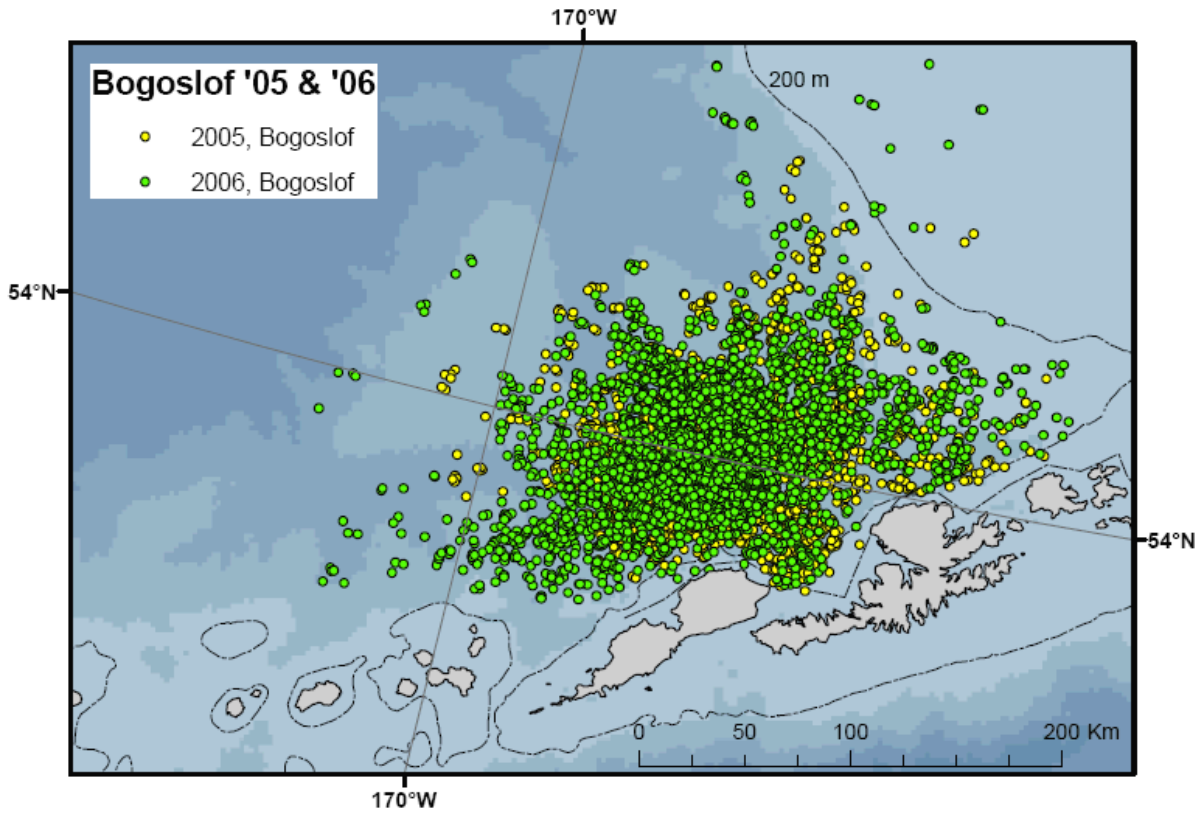

Figure 5. Satellite locations of adult female northern fur seals in the Bering Sea during 2005 and 2006 summer foraging trips from Bogoslof Island. Figure 8 in Springer et al. (2010).

Similarly, the suite of forage species in the diets of adult female northern fur seals at Bogoslof Island and St. Paul Island were consistent with previous studies of fur seal diets in the Bering Sea (e.g., Sinclair 1988, Sinclair et al. 1994, Antonelis et al. 1997, Perez 1997, Zeppelin et al. 2015): females at Bogoslof foraged in the deep Aleutian basin, primarily on northern smoothtongue and squid species, and females on St. Paul Island foraged on pollock and shelf species such as eulachon and sand lance (Springer et al. 2010).

Current and future studies are focused on areas that address foraging success, including the influence of prey quality, quantity, and habitat. The area of most immediate focus is summer foraging on the continental shelf in the Bering Sea. A currently active study involves using satellite tags to track foraging trips of adult female fur seals with concurrent acoustic surveys of fur seal prey (pollock) using wind- and solar-powered autonomous sailing vessels controlled from shore through satellite communications (Saildrones). The goals of this study include:

- Quantifying fish distribution and abundance within the northern fur seal summer foraging range,
- Simultaneously tracking fur seal dive and movement patterns to examine foraging behavior in relation to variation in prey availability,
- Determining specific prey characteristics (e.g., density, depth, size) that are associated with increased fur seal foraging success.

In 2016 AFSC scientist tracked the foraging behavior of 29 adult females from July through early October. They collected over 34,000 hours of at-sea behavioral data, recorded 284,000 dives, and sampled the area for 65 Saildrone days (Figure 6). Figure 7shows data from the echosounder on the

Saildrone and the dive recorder on the fur seal when they passed within 4 km of each other. Although preliminary, these data appear to show an adult female fur seal foraging within the same depth range that young, mostly age-0 pollock are found, then diving deeper to access the larger pollock near the bottom. Additional preliminary analyses show spatial separation between small and large pollock on the shelf. Overlaying fur seal tracks appears to show that fur seals spent a greater proportion of their time foraging in the areas where young pollock were more abundant, although there is significant variation between fur seals, some foraging in areas where large pollock were more abundant. This project will continue in 2017 incorporating video recorders and accelerometer tags to attempt to identify individual prey capture attempts, and adaptive sampling with the Saildrone to sample areas where fur seals show higher residence times or greater foraging success (K. Cuhn, Pers. Comm.).

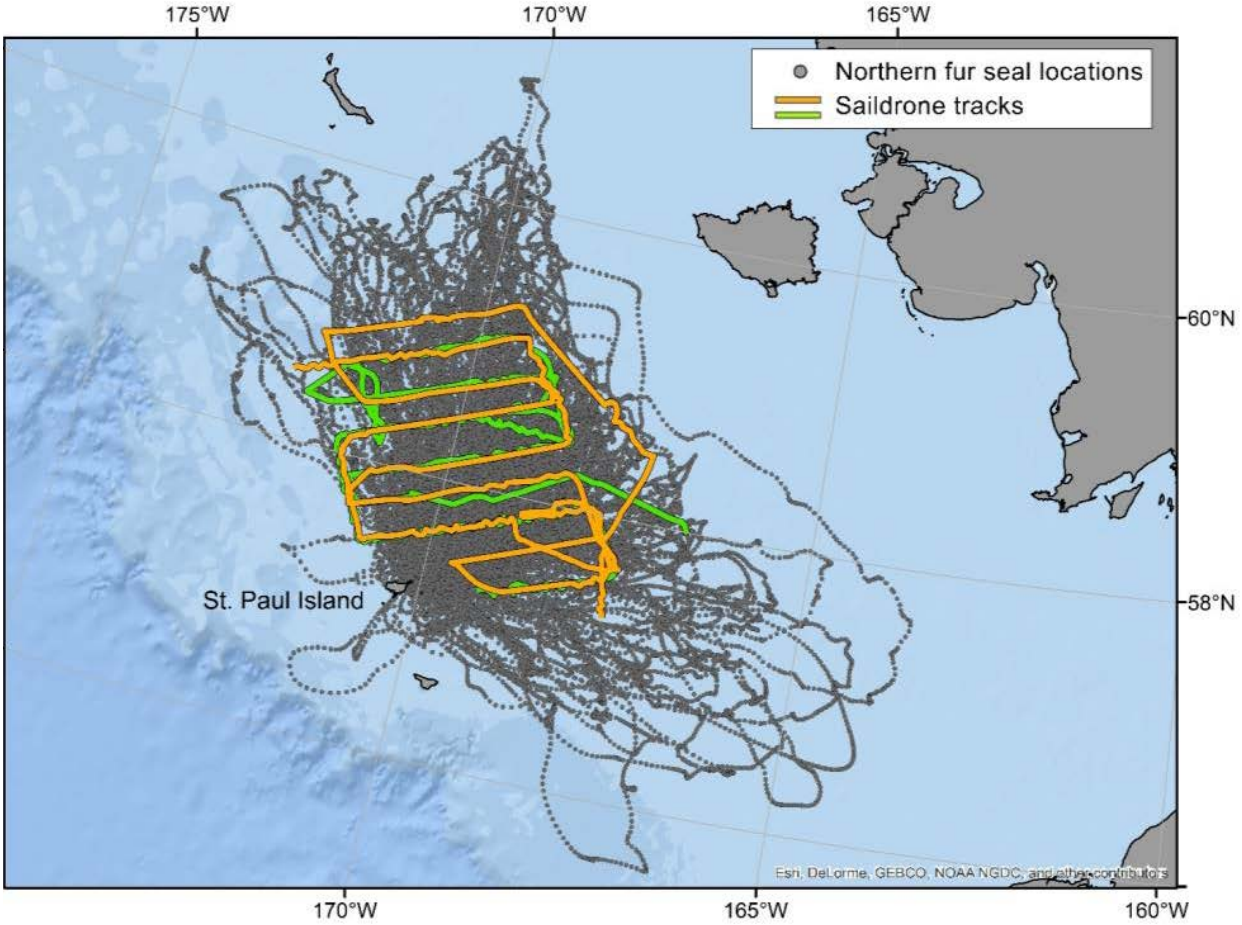

Figure 6. Locations of adult female northern fur seals on foraging trips from St. Paul Island in 2016, with saildrone tracks overlaid. (K. Cuhn, Pers. Comm.)

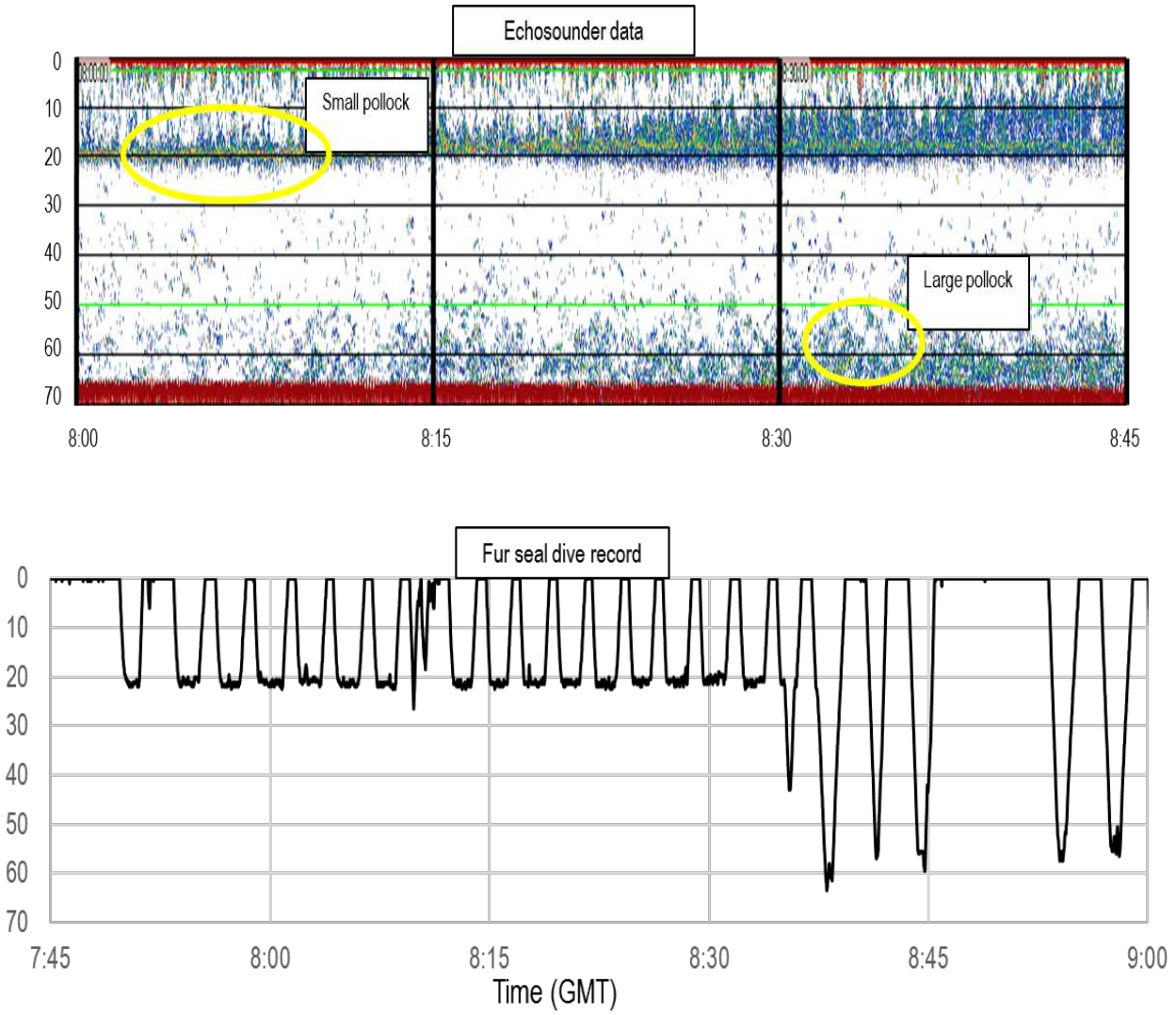

Figure 7. Data from Saildrone (top) and satellite tagged adult female fur seal (bottom) when they passed within 4 km of each other. (A. De Robertis, Pers. Comm.)

6 Winter Movements

The Alaska population of northern fur seals spends summer on the Pribilof Islands or Bogoslof Island, but generally migrates out of the Bering Sea in winter. The Alaska Fisheries Science Center, Marine Mammal Laboratory has tagged five separate cohorts of northern fur seal pups to characterize the migratory dispersal patterns of pups (Lea et al. in prep). A total of 179 tracks of pups from 1996/97, 1997/98, 2005/06, 2006/07, and 2015/16 confirm that weaned pups disperse widely throughout the North Pacific on their first migration (Figure 8). The typical winter range of pups overlaps with both adult females and males, but appears to have more overlap with adult males in the North Pacific and southern Aleutian Islands (Figure 9) (T. Gelatt, Pers. Comm.).

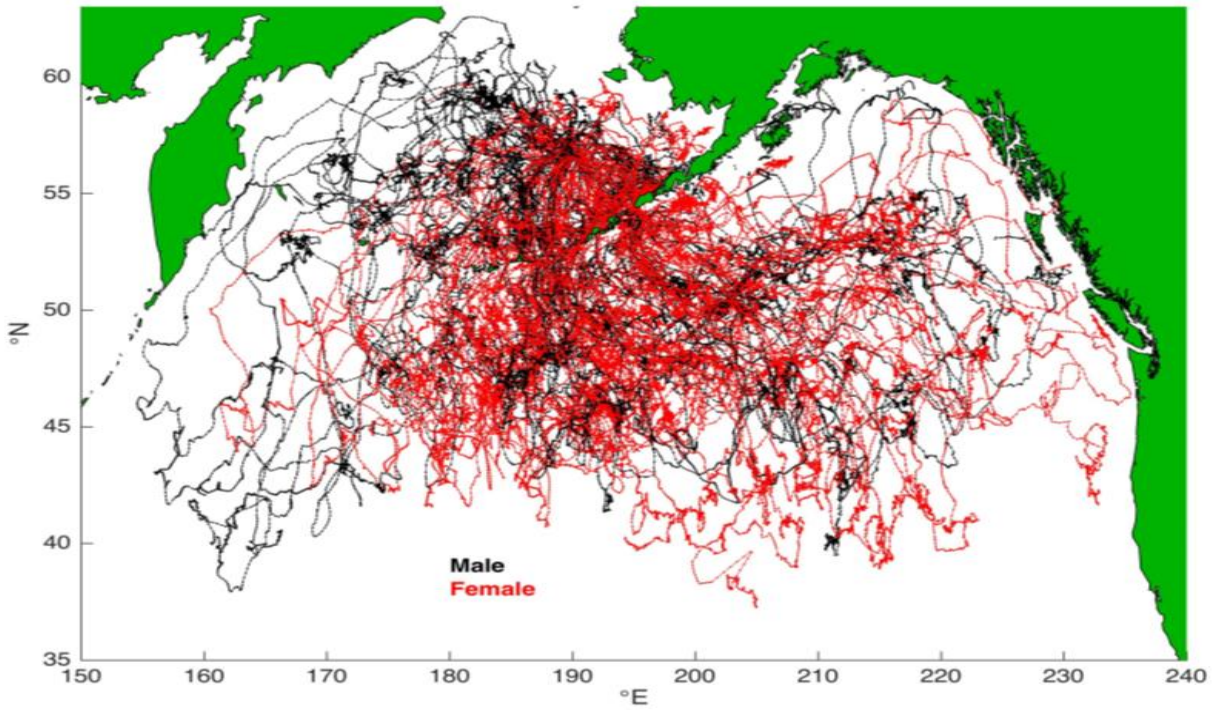

Figure 8. **Tracks of northern fur seal pups tagged in fall of 1996, 1997, 2005, 2006, and 2015. Lea et al. (in prep).**

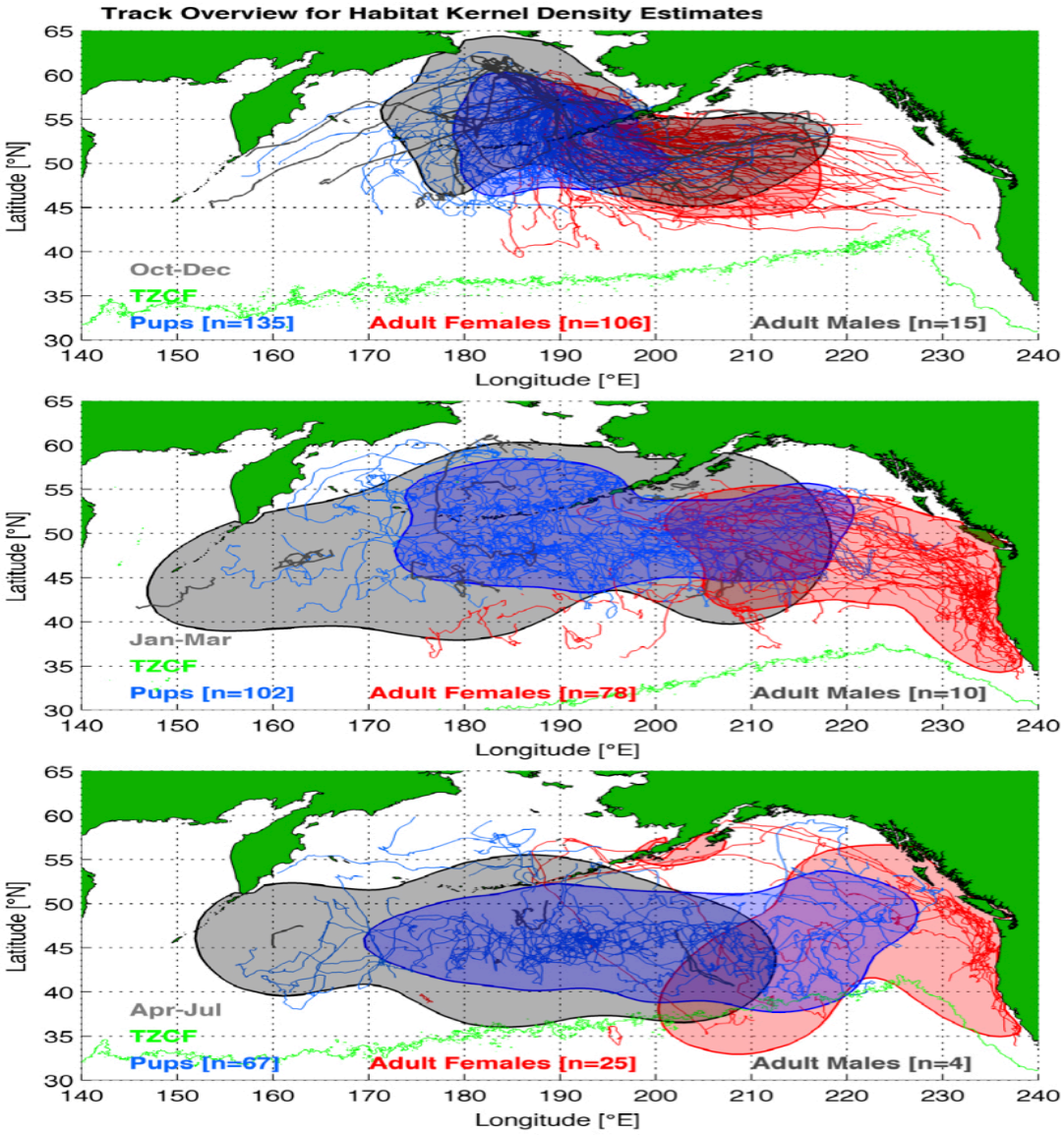

Figure 9. Overlap of adult female, adult male, and pup winter tracks. (T. Gelatt, Pers. Comm.)

Juvenile fur seals tagged on St. Paul and Bogoslof Islands in 2006 and 2007 showed little difference in winter distribution, but there appeared to be some segregation in the general distribution of males and females in winter (Figure 10).

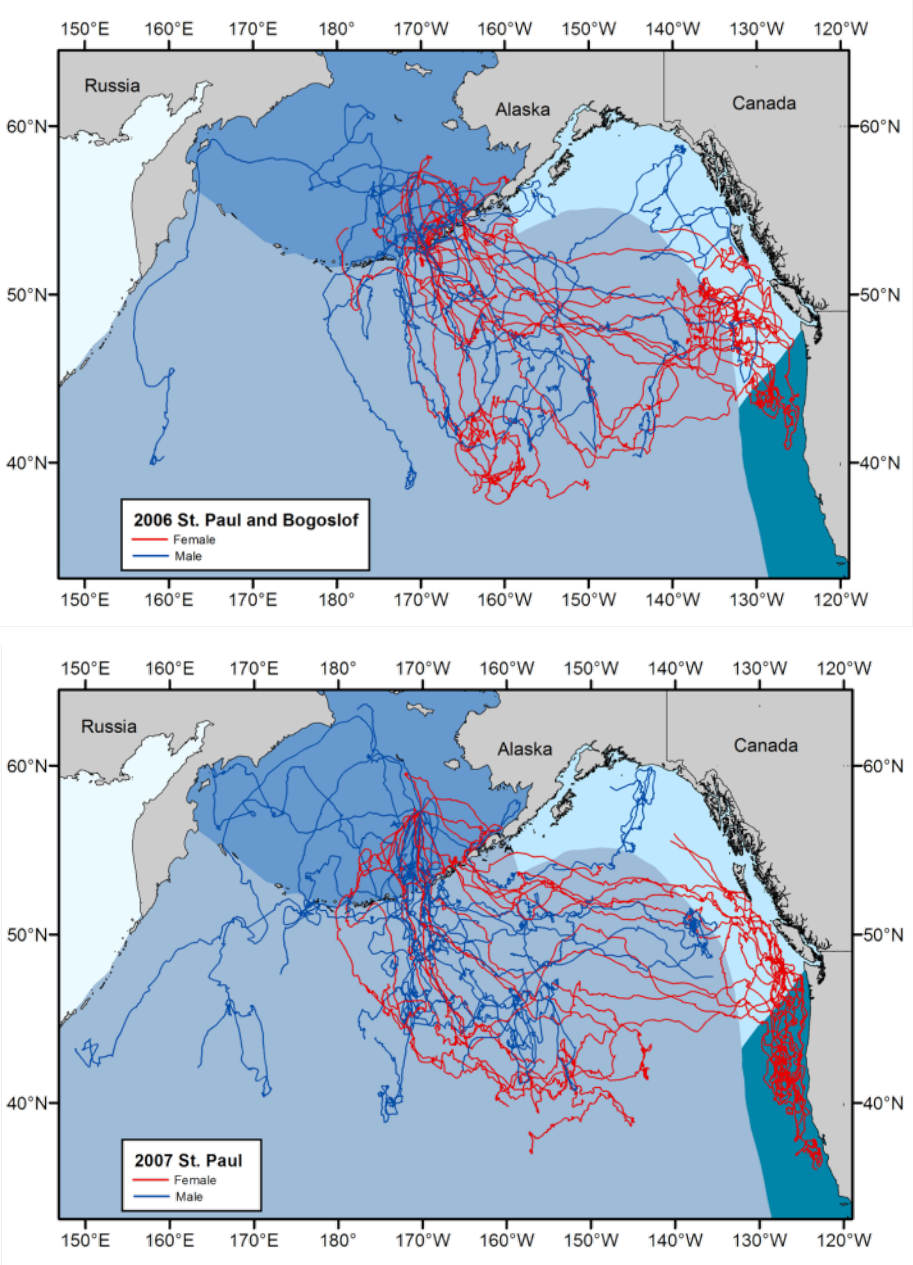

Figure 10. Winter migration of juvenile northern fur seals from St. Paul and Bogoslof Islands in 2006 (top) and 2007 (bottom). (Zeppelin et al. 2017)

Winter foraging areas are suspected to vary geographically. Ream et al. (2005) showed that female fur seals are closely associated with eddies, the subarctic-subtropical transition region, and areas that undergo coastal mixing from the California Current during the winter and spring. Sterling et al. (2014) also suggested that fur seals may cue on a variety of oceanographic features to reduce energetic expenditures and optimize foraging (Sterling et al. 2014). The transition zone may bound the pelagic distribution of fur seals in the North Pacific Ocean between the subarctic and subtropical water masses, possibly because those fronts serve as physical barriers to fur seal prey (Sinclair 1990, Ream et al. 2005).

7 Vital Rates

7.1 Survival and Reproduction

Researchers continue to estimate indices of abundance, examine foraging behavior and diet, and monitor the subsistence harvest. Much of the new research conducted by the Alaska Fisheries Science Center has focused on northern fur seal vital rates (e.g., survival and reproduction) to understand the underlying causes of the continued decline on the Pribilofs. Estimates of adult and juvenile survival and adult reproduction are being incorporated into population models to explain the continued decline, or detect evidence for a change in the population trajectory.

To assess survival and reproduction rates, more than 15,000 adult females, juveniles, and pups have been tagged since 2007 to allow for Capture-Mark-Resighting statistical models to develop age-specific estimates of survival. Resighting involves daily monitoring while the animals are on the islands. High resighting effort has resulted in very high annual resighting rates, which provides high precision in both survival and reproductive estimates.

The preliminary results of the tagging surveys suggest that northern fur seal survival to age 4 ranges from 18 to 21 percent, and survival of adult females between 70 and 80 percent. These estimates of survival are capable of causing a population decline of approximately 5%; however, during the period over which the survival and reproduction estimates were derived, the population declined at a rate slower than predicted by the models. Additional studies that take levels of emigration rates among breeding areas are planned to investigate differences in survival among sites.

Lethal, pelagic collections were the basis for estimates of fur seal pregnancy rates from the 1950s through the 70s. Alternative methods (e.g., ultrasonography) are now required to assess pregnancy without lethal collections. Pregnancy rates derived from ultrasound techniques in 2005-2008 are as high or higher than rates found in the 1960s (Adams et al. 2007). Additionally, recent studies show that over half of young females have their first pup by 5 years of age. This is at least a year younger than historic estimates, indicating good growth and maturation of juvenile females. These data suggest that a decline in reproduction is not a contributing factor to the continued population decline on the Pribilofs.

7.2 Mortality

7.2.1 Fisheries Information

Northern fur seals are taken infrequently in commercial fisheries in Alaska. During 2010 – 2014, incidental mortality and serious injury of northern fur seals was observed in the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 2). The estimated mean annual mortality and serious injury rate from these fisheries in 2010-2014 is 1.1 northern fur seals (Muto et al. 2017). Observer programs for Alaska State-managed commercial fisheries have not documented any mortality or serious injury of northern fur seals.

Northern fur seals are regularly entangled in marine debris, and entanglement studies on the Pribilof Islands are another source of information on fishery-specific interactions with fur seals. Studies on the Pribilof Islands (Zavadil et al. 2003, 2007) have estimated that the juvenile male entanglement rate on St. Paul Island is between 0.15 and 0.35%, and between 0.06 and 0.08% on St. George.

Estimates of mortality and serious injury are well below estimated potential biological removal (PBR) of 11,405 (Muto et al. 2017). It is, therefore, unlikely that mortality from fisheries interactions or entanglement are contributing significantly to the continued decline in the Pribilof population of northern fur seals.

Table 2. Summary of incidental mortality and serious injury of Eastern Pacific northern fur seals due to US commercial fisheries in 2010-2014. (Muto et al. 2017).

Fishery	Years	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Islands flatfish Trawl	2010	0(+1)[a]	0+(1)[b]	0.2 (+0.2)[c] CV=0.04
	2011	0	0	
	2012	0	0	
	2013	0	0	
	2014	1	1	
Bering Sea/Aleutian Islands pollock trawl	2010	2	2	0.4 CV=0.07
	2011	0	0	
	2012	0	0	
	2013	0	0	
	2014	0	0	
Bering Sea/Aleutian Islands Pacific cod longline	2011	1	1.4	0.3 CV = 0.52
	2012	0	0	
	2013	0	0	
	2014	0	0	
Minimum total estimated annual mortality				1.1 CV = 0.17

[a]Total morality and serious injury observed in 2010:0 fur seals in sampled hauls + 1 fur seal in an unsampled haul

[b]Total estimate of mortality and serious injury in 2010: 0 fur seals (extrapolated estimate from 0 fur seals in observed sampled hauls) + 1 fur seal in an unsampled haul

[c]Mean annual mortality and serious in jury for fishery: 0.2 fur seals (mean of extrapolated estimates from sampled hauls) +0.2 fur seals (mean of number observed in unsampled hauls).

7.2.2 Alaska Native Subsistence Information

Alaska Natives residing on the Pribilof Islands are authorized an annual subsistence harvest of northern fur seals under regulations at 50 CFR 2017, Subpart F. The allowed take is based on subsistence needs, and is managed independently on St. Paul and St. George Islands. Typically, only juvenile males are harvested, although harvest of young of the year was authorized on St. George Island in 2014. A Draft Environmental Impact Statement analyzing the potential impacts of changing the management of the subsistence harvest (including a pup harvest) on St. Paul was completed in January 2017 (82FR 4336, January 13, 2017). From 2013 to 2017, the reported number of fur seals harvested on St. Paul and St. George ranged from 266-314 and 80-158, respectively (Table 3). The average number of male seals harvested annually during the past decade on St. Paul was 318 (262-383), and on St. George was 119 (63-206), including pups.

Table 3. Summary of Alaska Native subsistence harvest of northern fur seals (including males and accidental females[*]) on St. Paul and St. George Islands in 2013-2017.

Year	St. Paul Island	St. George Island	Total harvest
2013	301	80	381
2014	266	158	424
2015	314	118	432
2016	309	83	392
2017	N/A	38[**]	N/A
Mean annual take			407

[*] Ten females were killed accidentally during 2013-2017
[**] Does not include the pup harvest which begins on September 17, 2017.

The total annual subsistence harvest of northern fur seals on the Pribilof Islands is well below the estimated potential biological removal (Muto et al. 2017). It is therefore unlikely that the subsistence harvest of fur seals has a significant effect on the continued decline of northern fur seals on the Pribilof Islands. It should be noted, however, that the residents of the Pribilof Islands raised concerns with representatives of the North Pacific Fishery Management Council that the continued decline in the number of fur seals on the Pribilofs or a listing under the US Endangered Species Act may, at some point, affect their ability to harvest fur seals.

8 Habitat Concerns

Northern fur seals in Alaska spend time in two different oceanic areas. They spend the summer breeding season in the Bering Sea on the Pribilof Islands and Bogoslof Island, and the winter season feeding at sea in the North Pacific. Northern fur seals forage on a variety of fish species while in the Bering Sea. Some historically important prey items, such as capelin, have disappeared entirely from the northern fur seal diet, and pollock consumption has increased (Sinclair et al. 1994, Antonelis et al 1997). There is some concern that fishing effort displaced by Steller sea lion protection measures may have moved to areas important for fur seals; recent tagging studies have shown that lactating female fur seals and juvenile males from St. Paul and St. George Islands segregate their marine foraging habitat in the Bering Sea (Robson et al. 2004, Sterling and Ream 2004). However, it remains unclear whether the pattern in declines of fur seal pup production in the two Pribilof Islands is related to the relative distribution of pollock fishery effort in summer on the eastern Bering Sea shelf. Adult female fur seals spend approximately 8 months in varied regions of the North Pacific during winter, and forage in areas associated with eddies and the subarctic-subtropical transition area (Ream et al. 2005). Environmental changes in the North Pacific could potentially be affecting abundance and productivity of fur seals breeding in Alaska.

9 Conservation and Management

The Conservation Plan for the Eastern Pacific Population of Northern Fur Seals (Plan, NMFS 1993, 2007) was released in 1993 with the goal of recovering the population to Optimum Sustainable Population (OSP, 60% of peak historical estimates) and removing the northern fur seal from the MMPA list of depleted species. The updated Plan (NMFS 2007) implemented a place-based research and monitoring program to evaluate both the effectiveness of conservation measures and the general trends of various population parameters and vital rates, and identify additional measures to promote recovery. The Plan also called for Federal, Tribal, state, international, and private entities to work together to coordinate research, management, and recovery efforts. Specifically, the Plan called for NMFS to strengthen their relationships with the Tribal Governments of St. Paul and St. George through the co-management process to allow NMFS better utilization of local expertise to implement various measures identified in the Plan and allow tribal groups to pursue conservation actions independently. Although co-management

agreements between NMFS and the Tribal Governments of St. Paul and St. George to manage northern fur seals and Steller sea lions have been in place since 2000, the Tribal Governments continue to seek a partnership that provides for full participation by the Unangan of the Pribilof Islands in decisions affecting the management and research of marine mammals used for subsistence purposes.

The Plan (NMFS 2007) was intended to be dynamic document, and thus focused on short-term actions that NMFS identified as needed "in the next five years", and stated that the Plan would be reviewed and revised periodically, to assess the success of actions taken to recovery the stock, and prioritize new actions, as needed. The Plan has not been updated since 2007, though numerous conservation actions have been and continue to be implemented by NMFS.

The Plan called for research to collect data that can be compared with historical data to compare important ecological parameters for fur seals (e.g., population trends, fecundity and survival, foraging, growth rates, maternal investment) and the Bering Sea ecosystem. The Plan also suggested that research should be coordinated between multiple locations (e.g., Pribilofs, Bogoslof, Commander Islands, etc.) to investigate regional differences in fur seal population dynamics and the range of responses to different stressors.

The Plan identified four objectives to restore and maintain the Eastern Pacific stock at its OSP level:

1. Identify and eliminate or mitigate the cause or causes of human related mortality,
2. Assess and avoid or mitigate adverse effects of human related activities on or near the Pribilof Islands and other habitats essential to survival and recovery,
3. Continue and, as necessary, expand research or management programs to monitor trends and detect natural or human-related causes of change in the stock and habitats essential to its survival and recovery, and
4. Coordinate and assess the implementation of the conservation plan, based on implementation of conservation actions and completion of high priority studies.

The Plan identified conservation actions in a Conservation Action Outline (Appendix 1) that were designed to meet the objectives identified above. The Conservation Actions in Appendix 1 are not presented in order of priority, but the Plan contains a Conservation Action Narrative that prioritizes conservation actions.

The Council and commercial fisheries have been actively engaged in Conservation Action 1.2 *Improve assessments of incidental take of fur seals in commercial fishing operations*. Of direct relevance to the Council are Conservation Actions related to Objective 2, specifically 2.7.4 *Quantify relationships between fur seals, fisheries, and fish resources*.

10 Conclusions

The Eastern Pacific stock of northern fur seals has been impacted by large-scale commercial harvests from the mid-18th century through 1984. Since their description by Georg Steller in 1742, the Eastern Pacific stock of northern fur seals has undergone several large population declines due to excess harvest and poor management. In two of these instances, changes in harvest strategy to prohibit killing adult females on land or at sea have allowed the population to recover. The most recent decline from a high in the 1950s was also attributed to the deliberate harvest of adult females in an attempt to increase cohort reproduction and survival, and thereby increase the number of subadult males available for harvest. However, after the killing of adult females was suspended, the population continued to decline after a brief period of stability. Despite the cessation of commercial harvests in 1972 on St. George Island and 1984 on St. Paul Island, the population continues to decline at 3.5% to 4.1%, annually, though differential trends exist for breeding islands. Historically the large-scale commercial harvest allowed NMFS to take direct management actions to manipulate survival. Without the ability to manipulate the harvest, NMFS must consider more indirect means to assess the factors contributing to the decline in fur seal abundance

on the Pribilofs. Other direct causes of mortality, Native Alaskan subsistence harvest and fishery interactions, do not appear to be sufficient to significantly affect the population decline or recovery of Eastern Pacific stock of fur seals.

Research by the Alaska Fisheries Science Center, Marine Mammal Laboratory has concentrated on population assessment, foraging behavior, diet, and most recently on understanding vital rates (reproduction, mortality, etc.) to determine whether there are changes that can account for the continued decline. Pregnancy rates and age at first reproduction are both as high or higher than historical estimates, suggesting that a reduction in reproduction is not contributing to the continued decline. Survival estimates of juveniles and adult females can explain the decline, and research is underway to quantify rates of emigration between breeding areas, and the resulting effect on estimates of survival.

Northern fur seals forage on a variety of fish species and gonatid squid; prey composition and concentration are contingent on location and season, with significant variation between the Bering Sea and North Pacific Ocean. Adult female northern fur seals from different breeding areas on St. Paul, St. George, and Bogoslof Islands feed in discrete, predictable, and non-overlapping marine areas within the Bering Sea. The degree of overlap in time and space between foraging northern fur seals and commercial fisheries is not well quantified. Current studies by the Alaska Fisheries Science Center, Marine Mammal Laboratory are focused on understanding whether and how anthropogenic activities in the Bering Sea affect foraging success and, ultimately, the relationship to survival and reproduction. The distribution of seals during their winter migration has been generally described. Current studies that investigate northern fur seal foraging behavior with concurrent surveys of prey (pollock) abundance show promise to better understand the resources upon which northern fur seals rely during the breeding season.

Northern fur seals spend time in two very different marine regimes; the Bering Sea during the summer reproductive season, and the North Pacific during winter. Because of the difficulty of studying a marine mammal at sea for extended periods, much is not known about the winter habits and survival of northern fur seals. Tagging studies conducted by the AFSC, MML are designed to provide information to understand movements of northern fur seal pups, juveniles, and adults to assess potential mortality during the pelagic winter season.

Northern fur seals are not listed under the U.S. Endangered Species Act, but are considered depleted under the Marine Mammal Protection Act. The Conservation Plan for the Eastern Pacific Stock of Northern Fur Seals (NMFS 2007) identifies a number of conservation actions intended to support recovery of the stock to OSP, when it can be removed from the MMPA list of depleted species. The Plan has not been reviewed or revised since 2007, although the objectives and conservation actions are still relevant and inform the Agency's research and management agenda.

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Appendix 1. Conservation Action Outline from the Conservation Plan for the Eastern Pacific Stock of Northern Fur Seals

Objective 1. Identify and eliminate or mitigate the cause or causes of human related mortality of the Eastern Pacific stock of northern fur seals.

1.1 Improve understanding of the sources, fates, and effects of marine debris
- 1.1.1 Continue disentanglement program to reduce mortality and harm to fur seals entangled in marine debris
- 1.1.2 Remove marine debris and incorporate surveys of debris in northern fur seal habitat
- 1.1.3 Examine the fate of entangling debris
- 1.1.4 Develop and implement additional statutes, regulations, education and enforcement of marine debris reduction programs
- 1.1.5 Determine the sources of marine debris

1.2 Improve assessments of incidental take of fur seals in commercial fishing operations
- 1.2.1 Implement and evaluate fishery and marine mammal observation programs in the North Pacific Ocean and Bering Sea
- 1.2.2 Review observer and incidental take data

1.3 Evaluate harvests and harvest practices
- 1.3.1 Monitor and manage subsistence harvests
- 1.3.2 Develop and implement harvest sampling programs
- 1.3.3 Compile and evaluate existing data
- 1.3.4 Identify and evaluate illegal harvests

Objective 2. Assess and avoid or mitigate adverse effects of human related activities on or near the Pribilof Islands and other habitat essential to the survival and recovery of the Eastern Pacific stock of northern fur seals.

2.1 Work with the Tribal governments under co-management agreements

2.2 Advise and consult with the relevant action agencies and industries

2.3 Review and make recommendations on proposed activities and actions that have the potential for adversely affecting northern fur seals (e.g. local development, industrial expansion, regulatory actions, research activities, and permitting)

2.4 Conduct studies to quantify effects of human activities (e.g. research, hunting, tourism, vehicles, discharges, facilities) at or near breeding and resting areas

2.5 Undertake conservation or management measures as necessary to eliminate or minimize deleterious impacts to fur seals

2.5.1 Develop oil spill response plans and mitigation strategies specific to fur seal breeding and resting areas on the Pribilof Islands and Bogoslof Island

2.6 Assess and monitor pollutants

2.6.1 Compile and evaluate existing data
2.6.2 Monitor and study environmental pollutant exposure
2.6.3 Evaluate carcass salvage programs

2.7 Quantify relationships between fur seals, fisheries, and fish resources

2.7.1 Study the natural and anthropogenic influences on fur seal feeding ecology
2.7.2 Evaluate pelagic fur seal sampling
2.7.3 Report fishery interactions
2.7.4 Determine impact of fisheries

Objective 3. Continue and, as necessary, expand research or management programs to monitor trends and detect natural or human-related causes of change in the northern fur seal stock and habitats essential to its survival and recovery.

3.1 Monitor and study changes in fur seal populations

3.1.1 Analyze fur seal teeth
3.1.2 Continue regular counts of adult males and estimates of pup production on St. Paul, St. George, and Bogoslof Islands
3.1.3 Estimate pup survival
3.1.4 Evaluate marking programs
3.1.5 Estimate stock vital rates
3.1.6 Evaluate Behavioral/physiological studies
3.1.7 Continue comparative studies on other islands
3.1.8 Conduct appropriate studies to assess the impact of predation (e.g., killer whales, Steller sea lions, sharks) on fur seal populations
3.1.9 Promote joint research and collaborative programs

3.2 Improve assessment of the effects of disease

3.2.1 Compile and evaluate existing data
3.2.2 Determine and mitigate disease effects
3.2.3 Continue management program to prohibit disease transmission to fur seals from introduced species

3.3 Describe and monitor essential fur seal habitats

3.3.1 Compile and evaluate available habitat-use data
3.3.2 Conduct oceanographic and fishery surveys based on pelagic fur seal habitat use

3.4 Identify and evaluate natural ecosystem changes

3.4.1 Reevaluate carrying capacity
3.4.2 Continue and evaluate Pribilof Islands Sentinel Program
3.4.3 Compile and evaluate existing physical environmental data
3.4.4 Select appropriate environmental indices

3.4.5 Quantify environmental effect on behavior and productivity
3.4.6 Ecosystem modeling

Objective 4. Coordinate and assess the implementation of the conservation plan, based on implementation of conservation actions and completion of high priority studies.

4.1 Establish conservation plan coordinator position

4.2 Develop and implement education and outreach programs

4.3 Develop and promote international conservation efforts

4.4 Enforce existing regulations