Contrasting Western Steller Sea Lion and Northern Fur Seal Population Trends in Alaska

by

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Figure 1. Northern fur seal adult bull and females.

The western stock of Steller sea lion (*Eumetopias jubatus)* (see cover photograph) and the northern fur seal (*Callorhinus ursinus*) (Fig. 1) are sympatric over large portions of their ranges in Alaskan waters, and both have declined substantially over the past 30 years. These population declines have resulted in a listing of 'endangered' for the western Steller sea lion under the Endangered Species Act, and of 'depleted' for the northern fur seal under the Marine Mammal Protection Act. Because Steller sea lions and northern fur seals both consume groundfish prey species important to commercial fisheries with considerable overlap in targeted sizes, they have received considerable scientific and popular attention regarding the relative impact of fisheries interactions, climate change, and predation on their declines and potential recoveries. Though both share some common traits, significant differences exist in body size (northern fur seals are much smaller than similarly aged Steller sea lions), life history traits, and in how each utilizes the marine environment. Exploring the interrelationship among these traits and environmental variables may help elucidate underlying environmental or anthropogenic factors affecting survival and reproductive rates, and hence population trends, of these two species.

Though the timing is somewhat different, both species congregate during summer on rookeries to give birth to a single pup and mate. However, fur seals are extremely concentrated during the summer, when approximately 60% of the total world population breeds on three islands in the eastern Bering Sea: Saint Paul and Saint George of the Pribilof Islands group, and Bogoslof Island (Fig. 2). Steller sea lions, on the other hand, breed on numerous rookeries extending across the North Pacific Ocean (Fig. 2). The western stock of Steller sea lions primarily breeds on rookeries west of Cape Suckling, Alaska (144°W), while the eastern stock breeds in Southeast Alaska, British Columbia, Oregon and California (Fig. 2). Fur seal pups are weaned and independent at about 4 months of age, while sea lion pups may suckle for 9 months to as long as 3 years. Aerial, ship, and land-based surveys are conducted during the summer because a large proportion of the reproductive population spends more time on land and are concentrated on rookeries at this time. Here we present results of the most recently completed Steller sea lion and northern fur seal abundance

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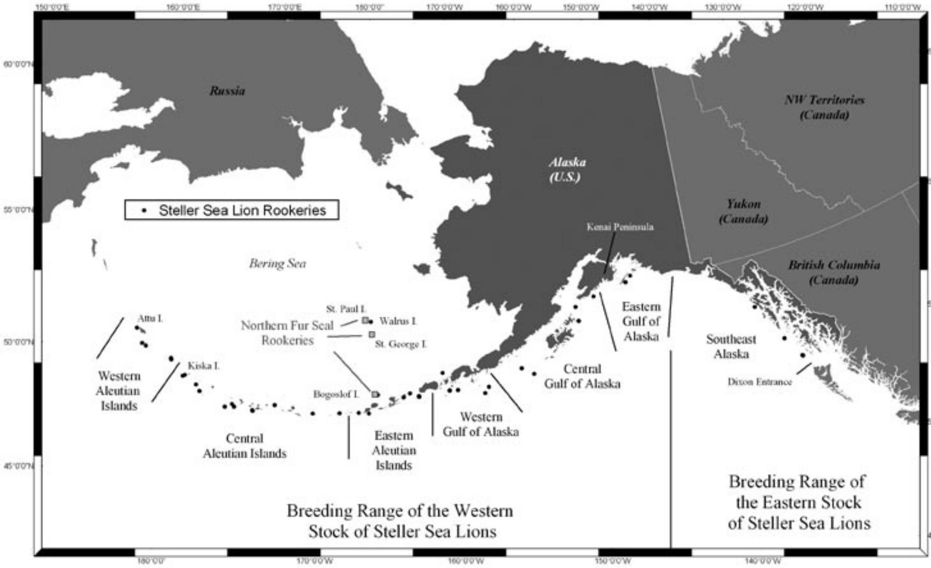

Figure 2. Steller sea lion survey regions in Alaska and the location of the principal sea lion rookeries (dots) and islands with northern fur seal rookeries (squares). The boundary between the breeding ranges of the eastern and western sea lion stocks and between regions used for time-series analyses are noted.

surveys and examine their population trends from 1976 through 2005.

Methods

Western Steller sea lion population assessment

An aerial survey of adult and juvenile (nonpup) Steller sea lions in the western stock in Alaska (from Cape Suckling, 144°W to Attu Island, 172°E; Fig. 2) was conducted in June 2004. This was the first complete survey conducted using medium format (MF), vertical photogrammetry. In previous years, nonpup counts were made from 35-mm slides shot obliquely (from the side windows) of aircraft. Based on comparison surveys, counts from MF photographs are approximately 3%-4% higher than those from 35-mm slides because of the film resolution and orientation of the photograph. No correction was made for sea lions that may have been at sea during the survey, and therefore, the count represents a minimum population estimate. In 2005, Steller sea lion pup production in Alaska (from Dixon Entrance at 133°W to Attu Island at 172°E; Fig. 2) was estimated through analysis of aerial survey photographs collected during the peak pupping period of 21 June to 10 July 2005. This was also the first Alaska-wide survey to utilize MF vertical photogrammetric techniques to assess Steller sea lion pup production.

Photographs were taken with a MF (5-inch) military reconnaissance camera (with image-motion compensation) mounted in the belly of an AeroCommander aircraft from an altitude of at least 700 feet above a rookery or haul-out site. In the laboratory, counts were made of sea lions by examining MF images under a dissecting scope with up to 20X magnification.

Pups were also counted directly during visits to selected rookeries from the eastern Aleutian Islands (169°W) to Prince William Sound (147°W) during pup branding and assessment cruises conducted from 20 June to 7 July in both 2004 and 2005 aboard the U.S. Fish and Wildlife Service research vessel *Tiglax*. Beach counts of pups were conducted by two to three observers moving slowly through rookeries or counting from vantage points, and the mean of the independent counts was used as the site count. These counts were used to supplement aerial survey estimates.

Time series of pup and nonpup counts at selected terrestrial sites in six regions have been used to determine population trends for the western stock of Steller sea lion in Alaska (Fig. 2). Thirty-one trend rookeries in six regions were chosen because of their size (trend rookeries had 89% of the total number of pups counted at all western sites in 2005) as

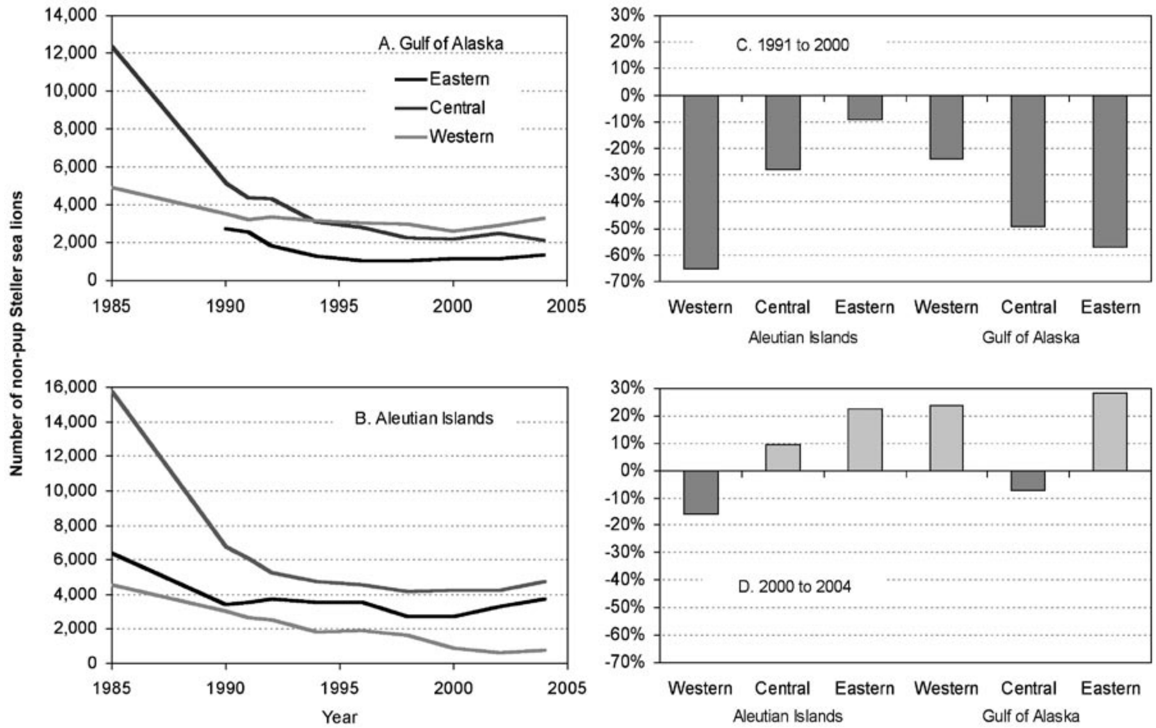

Figure 3. Steller sea lion non-pup counts at trend sites in the range of the western stock in Alaska by region from 1985 to 2004 in the Gulf of Alaska (A) and Aleutian Islands (B). Percent change in counts between 1991 and 2000 (C) and 2000 and 2004 (D) are also shown.

well as the consistency of data collection over time. Because not all trend rookeries were surveyed in a single year prior to 2005, counts were aggregated for multiple years by region. In cases where multiple counts were available from a trend rookery in a single year (MF photograph and a beach count), the maximum pup count at the site was used. For trend rookery sites missed in 2005 (Billings Head on Akun Island, and Yunaska Island), counts from the year 2004 were used. Trends in nonpups were also analyzed at a consistent group of sites in the six regions, along with an index area that extends from the Kenai Peninsula to Kiska Island (Fig. 2) and includes all of the central and western Gulf of Alaska, and the eastern and central Aleutian Islands. This Kenai-Kiska trend area was formerly the center of the Steller sea lion range in the North Pacific Ocean, and now, typically accounts for about 80% of the western stock.

Northern fur seal population assessment

Fur seal pup abundance was estimated on St. Paul and St. George Islands during August 2004 and on Bogoslof Island during August 2005 (Fig. 2) using mark-recapture shear-sampling methods. Approximately 10% of the pups on a rookery, based on the prior estimate of pup abundance, were temporarily marked by shearing a small patch of fur off the top of their heads. After a period of several days to allow marked pups to mix with unmarked pups, ratios of marked to unmarked pups were determined by pairs of observers scanning independently on two separate days for each rookery. Counts of dead pups at sampled rookeries were made after ratio-estimating counts were completed. Additional details are available in Towell et al. (2006).

Comparison of species trends

Population trends of Steller sea lions and northern fur seals were compared directly by standardizing counts to 1976 abundance estimates for each species. Kenai-Kiska area trend counts were used as an index of Steller sea lion population abundance, while Pribilof Island pup production estimates were used as an index of northern fur seal population abundance. For both populations, the 1976 abundance estimate was set to 1, and subsequent abun-

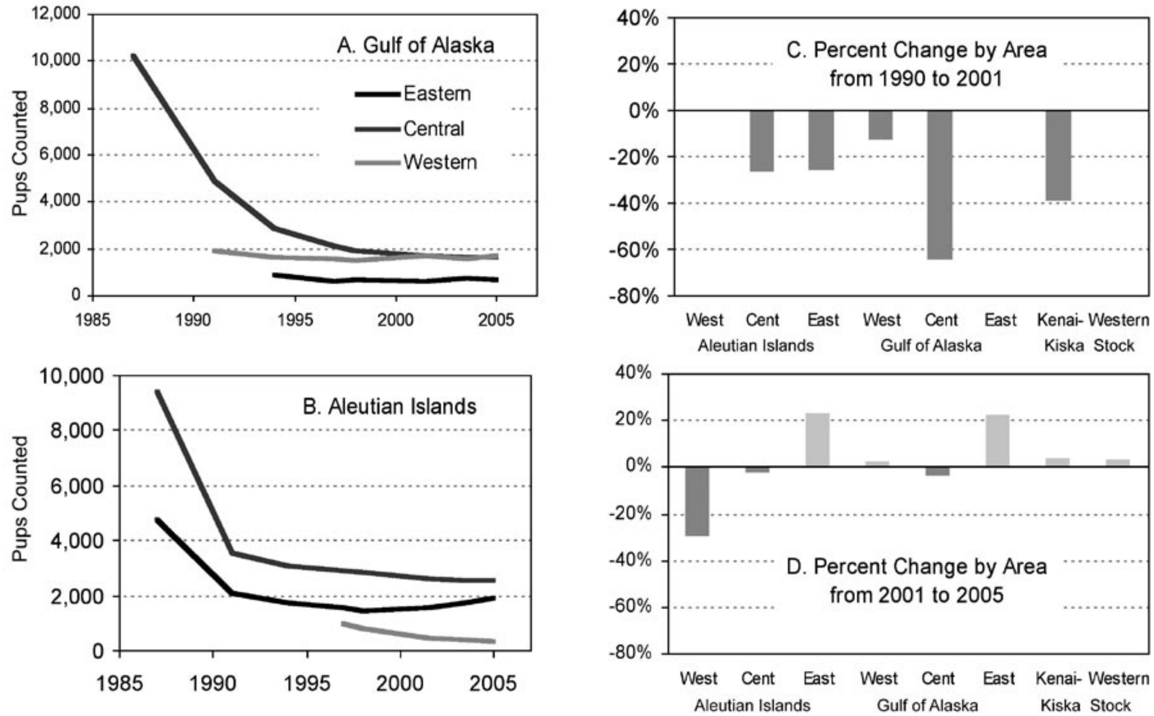

Figure 4. Steller sea lion pup counts at trend rookeries in the range of the western stock in Alaska by region from the late 1980s to 2005 in the Gulf of Alaska (A) and Aleutian Islands (B). Percent change in counts between 1990 and 2001 (C) and 2001 and 2005 (D) are also shown.

dance estimates were scaled as a proportion of the respective 1976 estimate. This standardization more readily permits comparison of population trends for the two species that have much different absolute abundances.

Results

Western Steller sea lion population assessment

In 2004, a total of 28,730 non-pup Steller sea lions were counted on 262 sites surveyed in the range of the western stock. Comparing abundances at a series of 'trend' sites that have been consistently surveyed since the mid-1980s required subtracting the 3%-4% increase due to film format differences from counts made in 2004 (MF format). After this correction, we estimate the western Steller sea lion nonpup population increased approximately 12% from 2000 to 2004.

There were regional differences in the trends observed between 1985 and 2004 (Fig. 3). Trend site counts decreased in all six Alaskan regions between 1991 and 2000, and the rates of decrease were faster at the eastern and western edges of the range than in the center (Fig. 3C). Since 2000, however, non-pup numbers increased in the three central regions (as well as the eastern Gulf of Alaska), but continued to decrease in the western Aleutian Islands and the central Gulf of Alaska (Fig. 3D).

A longer-term comparison revealed a slightly different pattern when region counts from 1989 through 2004 were examined. Steller sea lion non-pup counts in the center of the range (the western Gulf of Alaska and eastern Aleutian Islands) remained relatively stable from 1989 to 2004, with oscillations around a mean. However to the west, sea lion numbers decreased through the mid-1990s in both the central and western Aleutian Islands. Trend site counts stabilized at the 1998 level in the central Aleutians, but continued to decline in the western Aleutians through 2002 followed by a small increase between 2002 and 2004. To the east, trend site counts decreased sharply in both the central and eastern Gulf of Alaska through 1998. Since then, counts increased in the eastern Gulf of Alaska, but have continued to decline, but at a slower rate, in the central Gulf of Alaska.

A total of 9,258 Steller sea lion pups were counted from photographs taken during the 2005 aerial survey of 54 rookery and haul-out sites in the Alaskan range of the western stock (Fig. 2). A total of 3,555 Steller sea lion pups were counted from the beach (or skiff) at 19 sites during the 2005 *Tiglax* cruise. If a site was both photographed during the aerial survey and visited during the *Tiglax* cruise, the maximum pup count at that site was used for trend analyses.

Steller sea lion pup production at western stock trend rookeries in the Kenai to Kiska area (Fig. 2) declined 40% in the 1990s (Fig. 4). However, from 2001 to 2005, there were small increases in pup numbers of 4% (+265 pups) at trend rookeries in the Kenai to Kiska area and 3% (+239 pups) across the range of the western stock in Alaska.

As with the nonpup counts, there were strong regional differences in the recent trends in pup counts, suggesting that the magnitude or number of factors affecting the western stock of Steller sea lions also varied regionally (Fig. 4). Large increases of over 20% were observed in the eastern Gulf of Alaska (+129 pups) and eastern Aleutian Islands (+360 pups), while a smaller increase of only 2% (+36 pups) was seen in the western Gulf of Alaska. The largest decline in pup counts (30% or -145 pups) occurred in the western Aleutian Islands, while smaller declines were observed in the central Gulf of Alaska (4% or -70 pups) and central Aleutian Islands (2% or -61 pups). The time series of regional aggregate pup counts (Fig. 4) suggests that annual pup production has been stable since 2001 in four of the six regions: each of the three Gulf of Alaska regions and the central Aleutian Islands. In the remaining two regions, pup counts have been increasing since 1998 in the eastern Aleutian Islands, but were the smallest on record at the four rookeries in the western Aleutian Islands.

Counts of Steller sea lion pups on Walrus Island (near St. Paul Island in the Pribilof Islands) in 2005 were also the smallest on record. Several hundred pups were born each year on Walrus Island in the late 1980s, but even these levels represented a nearly 90% decline from 1960, when 2,866 pups were born. By the early 1990s, annual pup production dropped under 100 pups at Walrus Island, and this decline has continued through 2005, when fewer than 30 were counted.

Northern fur seal 2004-05 pup counts

In 2004 an estimated 122,825 (SE = 1,290) pups were born on St. Paul Island, and an estimated 16,876 (SE = 239) pups were born on St. George Island. For St. Paul Island, this estimate was 15.7% less than in 2002 and 22.6% less than in 2000. The estimate for St. George Island was 4.1% less than in 2002 and 16.4% less than 2000. Since 1998, estimated pup production has declined at 6.2% per year (SE = 0.78%, P = 0.01) on St. Paul Island and at 4.5% per year (SE = 0.45%, P = 0.01) on St. George Island, and has declined at 6.0% per year (SE = 0.59%, P = 0.01) for both islands combined (Fig. 5). On Bogoslof Island in 2005 an estimated 12,631 (SE = 335) pups were born. In contrast to the Pribilof Islands, pup production has increased on Bogoslof Island at 12% per year since the last production estimate of 1997 (Fig. 6).

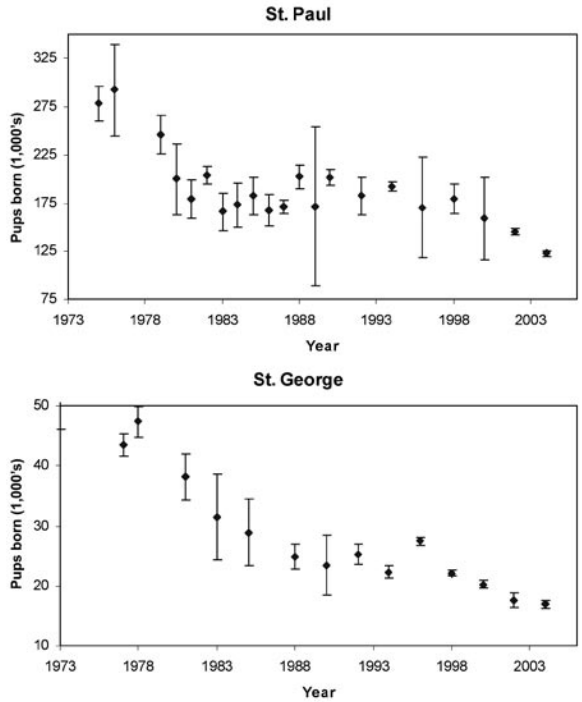

Figure 5. Estimates (mean ±1SE) of northern fur seal pup production at St. Paul and St. George Islands of the Pribilof Islands, Alaska.

Integration of population trends

Patterns emerge when comparing standardized population index trends of the western Steller sea lion and Pribilof Island northern fur seal over the past 30 years (Fig. 7). During 1976-85, both species declined at the same rate, but between 1985 and 1990, the rate of decline for sea lions increased while fur seal abundance stabilized or increased. From 1990 to 1998, sea lions and fur seals again declined at the same rate, while from 1998 to 2004, sea lions were stable but the rate of fur seal decline accelerated (Fig. 7).

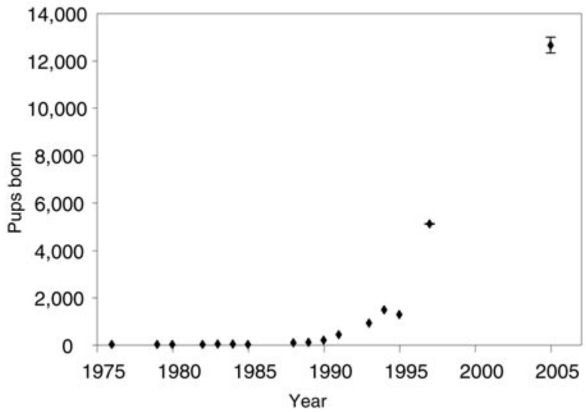

Figure 6. Estimates (mean ±1SE) of northern fur seal pup production at Bogoslof Island, Alaska.

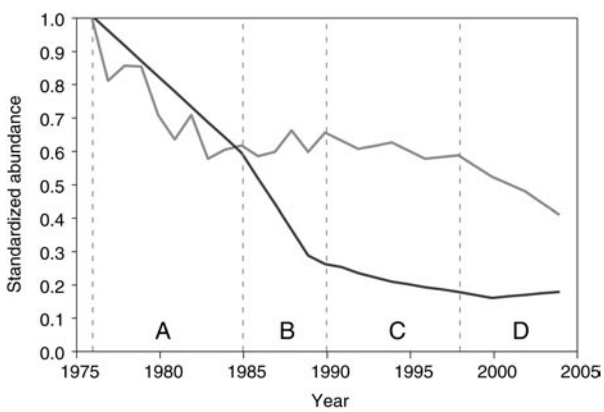

Figure 7. Steller sea lion Kenai-Kiska trend counts (black) and Pribilof Islands northern fur seal pup abundance estimates (gray) standardized to 1976 abundance levels. During period A (1976-85) both sea lions and fur seals declined at the same rate; during period B (1985-90) sea lions declined, but fur seals were stable or increasing; during period C (1990-98) sea lions and fur seals declined at the same rate; and during period D (1998-2004) sea lions were stable or increased, but fur seals declined.

Discussion

Western Steller sea lion trends

Recent increases in western sea lion pup counts, although encouraging, are smaller than those observed for nonpups from 2000 to 2004. As in past years, however, there were significant regional differences in trends. While the abundance index for the western stock overall has increased since 2000, some areas have shown little change and remain at reduced levels (eastern Gulf of Alaska), while others continue to decline (western Aleutian Islands, Walrus Island in the Bering Sea, and central Gulf of Alaska).

During the 1980s, Steller sea lion declines were believed to be largely driven by greatly reduced rates of juvenile survival and to a lesser extent, by reductions in rates of adult survival and birth (fecundity) (York 1994; Holmes and York 2003). Declines observed in the 1990s, however, appear to be largely driven by continued declines in fecundity, since rates of survival improved (Holmes and York 2003). Many studies have reviewed possible causes for the sea lion decline during the 1970s and 1980s. Likely factors included direct mortality through incidental take by fisheries, experimental commercial or predator-control harvests, and shooting. There may also have been contributions by 'bottom-up' effects that caused reductions or changes in prey availability through environmental change and/or commercial fisheries removals, and by other 'top-down' effects such as killer whale predation.

Studies currently under way suggest that juvenile and adult survival continued to improve between 1998 and 2004. Improvements in survival suggest that direct, 'top-down' sources of mortality are unlikely to be the primary threats to recovery of the western Steller sea lion population. More research is necessary to determine if estimated continued declines in fecundity are due to reductions in adult female condition and birth rate, increases in neonate mortality, longer periods of maternal care (e.g., suckling), or changes in the age structure of the Steller sea lion population (e.g., greater proportion of juveniles).

Northern fur seal trends

The 2004 pup production estimate on St. Paul Island is comparable with the level observed in 1918, while the St. George pup production estimate is below the level observed in 1916. Some, but likely not all, of the increase in Bogoslof Island pup production may have resulted from emigration of adults from Pribilof Islands rookeries. However the increase in numbers on Bogoslof cannot account for the population declines on the Pribilofs.

As with Steller sea lions, trends in fur seal pup production show considerable variation between islands, and between rookeries within islands. For example, pup production on St. George continued to decline after 1980 when production on St. Paul apparently stabilized, but after 1998 both islands declined (Fig. 5). This suggests that multiple mechanisms or changes in spatial and temporal effects were operating. Fur seals were subjected to intensive commercial harvest and management, and the effect

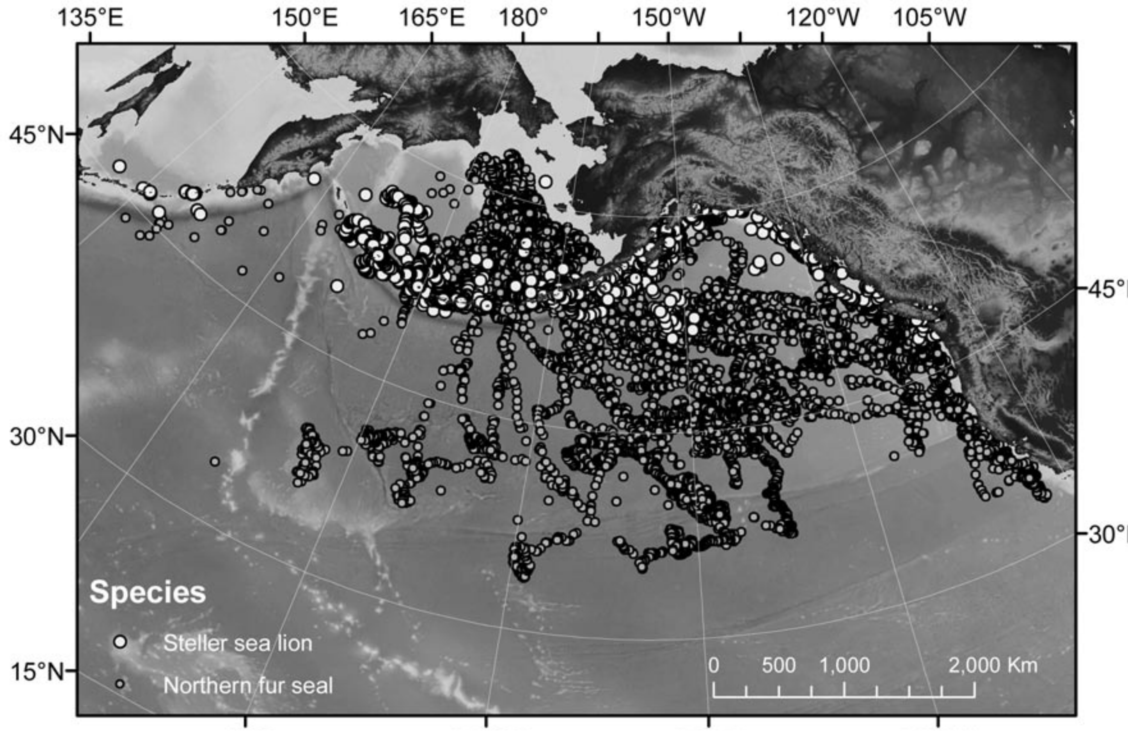

Figure 8. Synoptic-scale spatial segregation of northern fur seals (dark gray) and Steller sea lions (light gray) tracked at sea using satellite telemetry. Data from Merrick and Loughlin (1997), Loughlin et al. (1998), Loughlin et al. (2003), Raum-Suryan et al. (2004), Robson et al. (2004), Ream et al. (2005), Sterling and Ream (2004), and Fadely et al. (2005).

of the commercial harvests on fur seal population dynamics has been examined by several researchers. By 1976, the population was showing signs of recovery from herd-reduction harvests that ended in 1968. Since 1976, causes of the northern fur seal population decline are unknown, but the proposed factors and hypotheses are largely the same as those proposed (and listed above) for western Steller sea lions.

Comparison of population trends

Comparing population trends between western Steller sea lions and northern fur seals by region and different time periods may facilitate testing among the multiple causes hypothesized to be affecting these populations. During the two periods 1976-85 and 1990-98, both the western Steller sea lion and the Pribilof Island fur seal populations declined at the same rate. However, during 1985-90 sea lions continued to decline while fur seals stabilized, and conversely during 1998-2004 sea lion numbers were evidently stable or slightly increasing while fur seals continued to decline. Here we do not present new perspectives on what mechanisms may have been, or continue to be operating on or regulating these populations. Rather, we suggest that any hypothesis broadly based on 'bottom-up' or 'top-down' ecosystem-wide mechanisms must accommodate these alternating periods of similar and dissimilar population trends.

Such spatial and interspecific differences may be related to temporal and spatial habitat segregation within and between the two species. During the summer, fur seals utilize large portions of the Bering Sea, but in winter, undertake migrations into pelagic and coastal waters of the North Pacific Ocean. In contrast, Steller sea lions tend to remain mostly on the continental shelf, as shown by at-sea locations derived from satellite telemetry data (Fig. 8). In collaboration with investigators from the University of Alaska, Fairbanks and Dalhousie University in a study funded by the North Pacific Research Board and NMFS, we are comparing the consequences of fur seal foraging strategies within and between seasons on subsequent pup production. We are also examining interactions between oceanic features that may affect prey distribution and foraging behavior (and ultimately population trends) of fur and Steller sea lions. Ultimately, this will increase our understanding of the effects and consequences of environmental variability on their population dynamics, as well as inform resource managers as they develop recovery strategies for the endangered western Steller sea lion and the depleted northern fur seal.

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