The Steller sea lion: A declining species

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Abstract  Steller sea lions (Eumetopias jubatus) are the largest of the sea lion and fur seal subfamily and show a marked difference in size with males two to three times larger than females. Males can be as large as 1,120 kg and grow to 3.25 m; they are about the size of a Kodiak grizzly bear (Ursus arctos). Females average 250 kg and are approximately 3.2 m long. The Steller sea lion breeding range extends across the North Pacific Ocean rim, from the Kuril Islands and Okhotsk Sea, through the Aleutian Islands and Bering Sea, along Alaska’s southern coast, and south to central California. Steller sea lions eat a variety of fishes and invertebrates. In Alaska, the principal prey is walleye pollock (Theragra chalcogramma) with Pacific cod (Gadus macrocephalus), Atka mackerel (Pleuragrammus monopterygius), octopus, squid, herring (Clupea harengus), flatfishes, and sculpins also consumed. There were reportedly over 300,000 Steller sea lions in the world in the late 1970s. Since then, the Alaskan sea lion population has plummeted to a small fraction of earlier levels resulting in the species being listed as threatened under the U.S. Endangered Species Act (ESA) in November 1990; the western stock was changed to endangered in 1997. Possible causes for the decline may include redistribution, changed vital rates, pollution, predation, subsistence use, commercial harvest, disease, natural fluctuation, environmental changes, and commercial fishing. The last two are now considered the most likely links to the decline. Steller sea lions may be affected by commercial fishing directly through incidental catch in nets, by entanglement in derelict debris, by shooting, or indirectly through competition for prey, disturbance, or disruption of prey schools. Current research is trying to determine the relationship between commercial fisheries and the decline and to monitor status. Management regimes include restrictions on incidental take, prohibition of shooting sea lions, no trawl buffer zones around some rookeries, and other measures.

Key words: Steller sea lion, Eumetopias jubatus, population trends, management

INTRODUCTION

There were reportedly over 300,000 Steller sea lions (Eumetopias jubatus) in the world in the late 1970s. It was then that I had the opportunity to assist Clifford Fiscus, a well known marine mammal biologist, on his last field study before his retirement from government service. Cliff, Ancel Johnson (also a well known and now retired sea otter and fur seal biologist from Alaska), David Rugh [staff biologist at the National Marine Mammal Laboratory (NMML)], and I surveyed the Aleutian Islands by boat and mapped sea lion rookeries and haulout sites. We found numerous sea lions throughout the island chain and considered the stock to be healthy and robust. However, another group of biologists from our laboratory noted a decline in sea lion numbers a few years earlier in the eastern Aleutian Islands. We thought that perhaps the missing eastern Aleutian Island animals had redistributed and were seen by us in other parts of the Aleutian chain. Unfortunately that was not the case. Since then, the Alaskan sea lion population has plummeted to a small fraction of earlier levels resulting in the species being listed as threatened under the U.S. Endangered Species Act (ESA) in November 1990. In 1997 the western stock of Steller sea lions was changed to endangered status.

In this article, I summarize some of what we know about Steller sea lion biology, review the brief history
of the sea lion decline and its possible causes, discuss our research to identify the causes, and outline the U.S. government’s management measures to enhance recovery.

BIOLOGY

Steller sea lions were first described by the German physician/theologian George Wilhelm Steller based on a specimen that he obtained from the Russian Commander Islands while serving as naturalist on Vitus Bering’s fateful voyage to Alaska in 1741-42. It was also during this voyage that Steller described the northern fur seal (Callorhinus ursinus) and Steller sea cow (now extinct).

Steller sea lions are the largest of the sea lion and fur seal subfamily and show a marked difference in size with males two to three times larger than females. Males can be as large as 1,120 kg and grow to 3.25 m; they are about the size of a Kodiak grizzly bear (Ursus arctos). Females average 250 kg and are approximately 3.2 m long. The fur of both sexes is light buff to reddish brown and is darker (to black) on the chest and abdomen; pups are a deep chocolate brown at birth that molts to a lighter brown after about 6 months. Pups weigh 16-23 kg, are about 1 m long at birth, and are quite docile.

The Steller sea lion breeding range extends across the North Pacific Ocean rim, from the Kuril Islands and Okhotsk Sea, through the Aleutian Islands and Bering Sea, along Alaska’s southern coast, and south to central California. Nuevo Island off central California is the southernmost breeding site (rookery) and Seal Rocks, near Prince William Sound, Alaska, is the northernmost rookery (Loughlin et al., 1984).

Steller sea lions are not known to migrate, but they do disperse widely at times of the year other than the breeding season. Animals marked as pups in the Kuril Islands (Russia) have been sighted near Yokohama, Japan, and in China’s Yellow Sea, and pups marked near Kodiak, Alaska, have been sighted near Vancouver, British Columbia. Generally, animals up to about 4 years of age tend to disperse farther than adults. As they approach the age when they begin to breed, they have a propensity to stay in the general vicinity of the breeding islands, and, as a general rule, Steller sea lions return to their island of birth to breed as adults.

The breeding season extends from late May to early July throughout the range (Pitcher & Calkins, 1981). Males establish territories in early May on sites traditionally used by females for giving birth. Some populations may occur at rest (haulout) sites between females not giving birth and males which cannot hold territories on rookeries. Males are sexually mature by 3-7 years of age, but they generally are not physically large enough to establish and maintain a territory until 9-11 years of age; by 13-14 years of age they are too old and battered to maintain a territory. Females reach sexual maturity between 3 and 6 years of age and may continue to give birth to a pup until they are in their 20s. They give birth to a single pup. Females may nurse their pups from 4 months to 1-2 years, but pups are generally weaned just prior to the next breeding season.

The species was originally listed by the U.S. as “threatened” throughout its range because there were no data to determine the existence of separate stocks. Recent studies of mitochondrial DNA from Steller sea lions throughout the range suggests that at least two stocks exist, an eastern stock (Oregon through southeastern Alaska), and a western stock (Prince William Sound and areas west) (Bickham et al., 1996). Additional studies of nuclear DNA, cell proteins, and morphology are needed to confirm the existence of the two stocks.

Steller sea lions eat a variety of fishes and invertebrates. In Alaska, the principal prey is walleye pollock (Theragra chalcogramma) with Pacific cod (Gadus macrocephalus), Atka mackerel (Pleurogrammus monopterygius), octopus, squid, herring (Clupea harengus), flatfishes, and sculpins also consumed. At specific times of the year other prey may be eaten when plentiful (e.g., Pacific salmon Onychorhynchus sp.). During the breeding season, females with pups generally feed at night; territorial males do not eat while on
story. Feeding occurs during all hours of the day once the breeding season ends.

STORY OF DECLINE AND ITS CAUSES

A 1984 paper documenting our 1979 survey of Aleutian Islands concluded that the world population of Steller sea lions had not changed appreciably between 1956 and 1980 when it was estimated to be between 245,000 and 290,000 sea lions (Loughlin et al., 1984). There were some areas in Alaska that had decreased in numbers during that period (eastern Aleutian Islands) and others that had increased (central Aleutian Islands), but we were of the opinion that the Steller sea lion population was healthy and robust. Following the first range-wide survey in 1989, I published another paper in 1992 with two Russian co-authors that concluded that the world population had declined by two thirds and that only about 116,000 could be counted in 1989. It has declined even more since that time (Loughlin et al., 1992).

What happened to the sea lion population during those 8 years and how had the decline progressed? Howard Braham (Director, NMML) and his co-authors documented a decline of 50% in the eastern Aleutian Islands when the population went from about 50,000 sea lions to 25,000 between the 1960s and late 1970s (Braham et al., 1980). However, as mentioned above, some redistribution of the population may have occurred based on an increase in numbers in the central Aleutian Islands in 1979. I surveyed the eastern Aleutian Islands in 1984 and found that the decline there was still occurring. I then organized a survey of the entire state of Alaska in 1985 and found that the decline in the eastern Aleutian Islands had continued and that the population abundance was once again down by 50%, to about 12,000 sea lions, and that the decline had spread to the east. This study was subsequently reported by Richard Merrick, myself, and Don Calkins in 1987 (Merrick et al., 1987). Results of the 1985 survey were alarming, so I set out to enumerate the status of the world population of Steller sea lions and to determine if the animals missing in Alaska may have redistributed to other parts of the range, namely Canada or Russia. Results of our 1989 range-wide survey confirmed that the missing animals had not moved elsewhere and that, overall, the Steller sea lion population had declined significantly throughout most of its range. The only areas that remained stable were southeastern Alaska, British Columbia, and Oregon (there are no major rookeries in Washington). As a result of the numerical decline noted in 1989, the Federal government listed the species throughout its range as a threatened species under the ESA. U.S. federal and state biologists now conduct annual surveys to monitor the species' status. Those surveys indicate that the decline has continued, albeit at a slower rate. The government changed the status of the western population to endangered in 1997; the eastern population is still listed as threatened. It is presently reviewing the status to determine if a change to endangered is warranted.

The magnitude of the decline in such a short time is startling. Historically, the Gulf of Alaska and Aleutian Islands contained the largest fraction (74% in 1977) of the world population, but by 1989 it dropped to 56%. The rookery at Walrus Island in the Bering Sea once was the birthplace of over 2,800 pups annually; in 1991 only 50 pups were counted. Once Marmot Island near Kodiak Island was the largest Steller sea lion rookery in the world. In 1979, 6,741 pups were born there but only 804 pups were observed in 1994. Similar declines have occurred in both adult and pup counts in most of Alaska and Russia.

What is causing these dramatic declines? What age and sex of sea lions are disappearing? We do not really know what caused (is causing?) the decline, but what follows is a discussion of some potential population changes that could account for the decline and a list of possible causes.

Redistribution: As mentioned above, one objective of the 1989 range-wide survey was to determine if missing animals had moved to other areas. That survey, and others since, confirm that the observed declines are not due to animals moving to other parts of
the range; declines have occurred throughout most of the species' range.

Changed vital rates: Obviously some change has occurred in either the birth or death rate to cause the decline; deaths are more numerous than births in a declining population. Anne York, who works in my program in Seattle, used available information on birth and death rates to model the population to account for the observed declines. She concluded that a very large decrease in reproductive rates would have had to occur to account for the reduction in numbers. Actual measurements of reproductive rates in Alaska do not correspond to the levels needed to account for the decline (York, 1994). However, a fairly small increase in juvenile mortality could also explain most of the observed decline. Our estimates of the ages of animals seen on land over the years suggests a decrease in the number of young animals at rookeries and haulout sites. These observations, plus York's modeling exercise, suggest that the population decline as a whole can be attributed to an increase in the mortality of young animals and not to a decrease in fertility. If this hypothesis is valid, what is causing the death of young Steller sea lions?

Pollution: Organochloride pollutant residues have been shown to cause reproductive failure and increase the susceptibility to disease in some pinnipeds, such as California sea lions (Zalophus californianus) and harbor seals (Phoca vitulina) in northern Europe, primarily associated with urban areas. However, studies to date on Steller sea lions have shown relatively low levels of these contaminants, as well as heavy metals, and they are not believed to have caused high levels of mortality or reproductive failure (Lee et al., 1996). Therefore, they are not considered significant contributors to observed Steller sea lion declines.

Predation: Steller sea lions are eaten by killer whales (Orcinus orca) and sharks, but there is no scientific evidence to suggest that predation has increased in recent years or that killer whale abundance has increased over the period of the sea lion decline. However, as the sea lion population continues to decline, mortality from any source could exacerbate the decline in localized areas. For instance, the stomach of one killer whale found dead on the beach in Prince William Sound contained flipper tags from 14 sea lions tagged as pups at nearby Marmot Island. One new source of mortality occurs near domestic factory ships which catch and process fish. These vessels often work nearshore and attract sea lions which feed on the offal and fish parts discarded during processing operations. This newly learned behavior by sea lions has not gone unnoticed by some killer whale pods which cruise by the ships and prey on sea lions. Recent surveys of killer whale abundance in Alaska, however, indicate that the largest concentration of these whales is in southeastern Alaska, an area where Steller sea lion numbers are stable or increasing.

Subsistence use: Historically, Alaskan natives used Steller sea lions for food, tools, clothing, and decorative crafts. Sea lions remain an important traditional food resource today in many Alaskan villages. Annual harvest levels in the 1990s have been estimated at about 500 animals a year, a level not considered to be a significant cause of observed declines.

Commercial harvest: Steller sea lions were commercially harvested in the eastern Aleutian Islands and Gulf of Alaska from 1959 to 1972, but none have been harvested since. The impact of the harvests may have had short term impacts on local populations but does not explain declines in areas where no harvest occurred or why declines did not occur until many years after the harvests.

Disease: Blood taken from Steller sea lions in Alaska contained antibodies to two types of bacteria (Leptospira and Chlamydia), one marine calicivirus (San Miguel Sea Lion Virus), and seal herpesvirus (SeHV), all of which could produce reproductive failure or death. The incidence of these pathogens in the population was low and not considered significant.
enough to cause observed declines. However, much additional work remains to be completed before disease can be dismissed as a major contributor to the decline.

Natural fluctuation: Steller sea lions (and all other marine mammals) generally exhibit low to modest changes in population numbers that vary around the carrying capacity of their habitat. They do not have the ability to recover quickly from large declines in abundance since they breed at most annually and have only one offspring. Large natural declines in numbers are rare and are typically related to a perturbation, such as a disease. We have no record of any marine mammal species that has undergone a natural decline in numbers to levels currently experienced by the Steller sea lion and which later recovered to previous levels. Of course, some species have been driven to very low levels by commercial exploitation, and some of them have recovered while others have not. My point is to emphasize that the declines observed in Steller sea lion numbers are not solely a result of a natural fluctuation or a recurring cycle. If they were, then such declines would likely have occurred at other times in the evolutionary history of Steller sea lions, and it is unlikely that the species would have recovered from all of them.

Environmental changes: Changes in the environment indirectly influence sea lions principally by affecting their prey. If environmental changes altered the abundance or availability of a necessary prey, the survival and productivity of sea lions could be reduced. These types of responses have been observed in some seals and sea lions in California and South America during 1983 as a result of strong El Niño (warm water) events and in South Africa and Namibia in 1993 and 1994 perhaps because of changes in prey distribution. Evidence that major shifts have occurred in the abundance of fish and shellfish in the Bering Sea over the past several decades is well documented; factors responsible for these changes, however, are not. There has been a general warming trend in the Bering and Okhotsk Seas over the past three decades and shifts in temperature and wind patterns may have influenced recruitment and fish and shellfish population trends, but supporting oceanographic data linking environmental variability to specific changes in fish recruitment are largely absent. Since 1932, northeast Pacific Ocean environmental variability has been characterized by alternating warm and cool eras of 6 to 12 years duration. Interestingly, the decline in Steller sea lions continued unabated during both types of eras. The relationship, if any, between the sea lion decline and environmental changes needs further study.

Commercial fishing: Steller sea lions may be affected by commercial fishing directly through incidental catch in nets, by entanglement in derelict debris, by shooting, or indirectly through competition for prey, disturbance, or disruption of prey schools. The number of sea lions caught in trawl nets was high during the 1960s and 1970s but has declined since and is presently at very low levels (Perez & Loughlin, 1991). Incidental catches probably contributed to the early declines in the Aleutian Islands and western Gulf of Alaska but is not presently considered an important component in the decline. Entanglement rates in derelict gear are low and insufficient to have caused the decline. In some areas, Steller sea lions were killed deliberately by fishermen, but it is unclear how such killing affected the world population especially since declines have occurred in areas uncommonly used by commercial fleets (central and western Aleutian Islands) or where fishermen rarely have guns (Russia). Commercial fisheries target on several of the most important prey eaten by Steller sea lions. In combination, these fisheries remove millions of metric tons of fish. However, the complexity of ecosystem interactions, and limitations of data and models, make it difficult to determine whether fishery removals, directly or indirectly, have influenced sea lion populations or other marine mammal species. As I will discuss below, this is an area of intense research at present and one of the most difficult issues to resolve.
RESEARCH SUMMARY

The U.S. National Marine Fisheries Service (NMFS) works cooperatively with the Alaska Department of Fish and Game (and other agencies and groups) to monitor the Steller sea lion population in Alaska and to determine the cause of the decline. Major monitoring activities include annual surveys of adults and pups in Alaska to determine status and trends. Aerial surveys are flown throughout the State during mid-June to count adults and juveniles; pups are counted from land during late June and early July. Other parts of the range are surveyed intermittently by appropriate government agencies and a range-wide survey is planned every 5 years; the second of these surveys was completed in 1994.

One of the major research efforts that we have been involved with is to describe Steller sea lion feeding ecology and movements at sea. Some major accomplishments to date include the refinement of techniques to immobilize adult sea lions (Loughlin & Spraker, 1984) and to develop satellite transmitters that provide information on sea lion location, dive behavior, and water temperature. From these advances, we have learned that female Steller sea lions typically feed within 20 miles of their rookery during the breeding season but go as far as 600 miles or more later in the year (Merrick & Loughlin, 1997). Pups travel less distances while with the mother but the pups may then range hundreds of miles from the rookery once weaned. Females usually dive to about 50 m or less during the breeding season, but often dive deeper, as much as 330 m, later in the year. Pups dive to shallower depths, rarely going below 35 m. Dives for adult females usually last less than 6 minutes but may last as long as 11 minutes. These studies will continue with an emphasis on determining when and where Steller sea lions feed at sea with concomitant surveys to establish prey distribution and abundance in locations. Ultimately, these studies will be correlated with commercial fishing information to establish the nature and magnitude of overlap between the two. We have also worked with physiologists and geneticists at major universities to determine the health, physiological status, and stock structure of sea lions throughout their range. Results of studies to date indicate that pups and adult females are healthy and have physiological measures indicative of normal pinnipeds during the breeding season (Castellini et al., 1993). These results support our hypothesis that juvenile mortality rates between weaning and recruitment have increased. Future work will focus on these age groups and attempt to measure vital parameters to provide information on possible causes of mortality. Further research efforts focus on improved methods to measure food habits, safer ways to immobilize adults, and better and safer methods to monitor status. We are also instituting a major effort to determine the possible role that environmental variability may have on sea lion population trends.

MANAGEMENT MEASURES

Results from the 1985 survey and high levels of incidental catch of Steller sea lions reported in the Shelikof Strait joint venture pollock fishery in the early 1980s prompted Congress to take special action to protect Steller sea lions. The 1988 amendments to the MMPA specifically state that the Secretary of Commerce shall not authorize the intentional lethal take of Steller sea lions and that no more than 1,350 sea lions shall be incidentally taken in a calendar year. Prior to the 1988 amendments, fishermen could shoot sea lions that were interfering with their catch and there was no limit on the number allowed to be incidentally caught. NMFS implemented several management measures in 1990 which were designed to protect sea lions and to enhance their recovery (Fritz et al., 1995). For example, only 675 of the 1,350 animals allowed to be incidentally taken could be caught west of 141° W longitude (the area with the severest decline). Shooting at or near sea lions was prohibited, 3 nautical mile (nm) no-entry zones were implemented around rookeries west of 150° W longitude, and trawl fishing for groundfish was prohibited within 10 nm of rookeries in the Gulf of Alaska. The later was expanded to the eastern Aleutian Islands, then expanded to 20 nm dur-
ing certain times of the year. An additional conservation effort was to add a marine mammal biologist to the North Pacific Fisheries Management Council Plan Teams. These teams review information and recommend take levels for commercially caught fish. Having a marine mammal biologist on the teams facilitates consideration of marine mammal issues during the deliberations on recommending catch quotas.

It is not clear what effect these management practices have had on sea lions since they have only recently been implemented. Also, it is difficult to measure their efficacy since they were not established with controls in a scientific framework and it will be difficult to test them. However, most agree that the measures were needed and that sea lions will benefit by their implementation.

In April 1990, the NMFS established a Steller Sea Lion Recovery Team consisting of 11 biologists from the government and the private sector. This team prepared a Steller Sea Recovery Plan which was submitted to NMFS and published in 1992. Copies are available through the NMFS in Washington, D.C. The Plan summarizes available data on the species and decline, suggests research and management actions needed to facilitate recovery of the species, and proposed criteria (still under consideration by NMFS) for determining when changes in listing criteria should occur.

Additionally, the NMFS designated critical habitat under the ESA which includes all U.S. rookeries and major rest sites and nearby waters, and three aquatic areas (Shelikof Strait, Bogoslof Island, and Seguam Island) known to be used by sea lions during certain times of the year. Designation of critical habitat requires that all Federal agencies consult with NMFS prior to any action that the agency might take within the critical habitat area that could affect Steller sea lions or adversely modify their habitat. The designation only pertains to the Federal agencies and does not place any specific prohibition on activities within the habitat unless promulgated under regulation.

It is worth noting that there is a remarkably good working relationship between the Federal and State governments, the commercial fishing industry, and the environmental community on this issue. There are differences of opinion as to the cause of the declines and how to best conserve sea lions, but these differences have been manifested in healthy debate working toward a common goal. But what else can be done? We are not really sure at this point what additional management measures need to be implemented. The NMFS does not want to impose regulations that might needlessly stifle the fishing industry, yet the government is required to protect and conserve this species. There seems to be little doubt that sea lions and commercial fishing efforts concentrate on the same prey, yet it is not fair to imply that the fishing fleet is responsible for the decline given the available data. However, the fleet bears the brunt of the management regime since the government is required to do its best to stop the decline and facilitate recovery; management of the fishing fleet is the parsimonious way to do this. We will be challenged in the next several years to identify and mitigate the causes of the decline and to create meaningful protective measures for a declining species without further restricting one of the nation's largest fisheries.

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