



## Steller Sea Lion (*Eumetopias jubatus*)

### Background

Steller sea lions inhabit the cool-temperate coastal waters of the North Pacific Ocean from California, north to the Bering Strait, and south along the Asian coast to Japan. They are the largest member of the family Otariidae and only one that resides year-round and breeds in Canadian waters. Two distinct populations are recognized: an eastern stock (California to SE Alaska), and a western stock (Gulf of Alaska, Bering Sea, Aleutian Islands, and Russia).

In B.C., Steller sea lions breed at traditional rookeries on the Scott Islands off the north tip of Vancouver Island, at Cape St. James off the southern tip of the Queen Charlotte Islands, and on North Danger Rocks off the northern mainland coast. There is also a major rookery situated just north of the BC border on Forrester Island in Alaska.

During 1913-68, Steller sea lions in B.C. were subject to major control programs and some commercial harvesting. Breeding rookeries formerly located off the central mainland coast were eradicated by intense kills in the 1920-1930s. A total of 55,000 sea lions were killed during 1912-68, and by the 1970s breeding populations had been reduced to roughly 25-33% of the peak historic levels thought to have been present in the early 1900s.

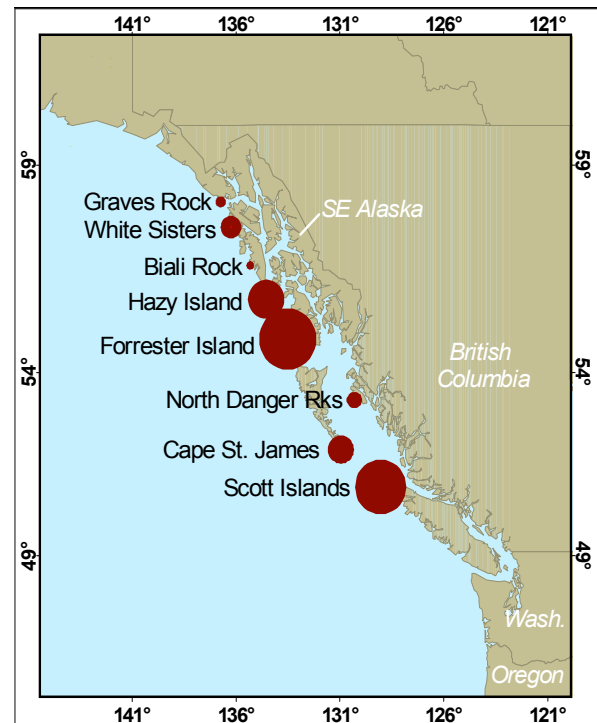


Figure 1. Map showing the location of Steller sea lion breeding areas in B.C. and neighboring waters in SE Alaska. The species does not breed in Washington, with the closest rookeries to the south being in southern Oregon. The size of symbols is drawn proportional to pup production at each rookery during the most recent survey in 2002.

### Summary

- DFO has conducted 9 province-wide aerial surveys since the early 1970s to monitor Steller sea lion populations. Beginning in 1994, the surveys have been conducted at 4-year intervals as part of an international range-wide survey that extends from California to Alaska to Russia. Surveys are timed to coincide with the end of the breeding season so as to provide an estimate of pup production, as well as counts of juveniles and adults (non-pups).

- The abundance of Steller sea lions in B.C. has increased at an overall rate of 3.2% per year since the early 1970s. Non-pup numbers were stable until the early 1980s, but subsequently increased at 4.7% per annum. Pup numbers were stable until the mid-1980s, but subsequently increased at 7.6% per annum.
- During the most recent survey in 2002, a total of 15,402 sea lions were counted in B.C. This included 3,281 pups and 12,121 non-pups (5,439 on rookeries and 6,682 on non-breeding haulout sites).
- The counts from aerial surveys represent minimum abundance because, except for pups, some animals would be foraging at sea and missed. Based on estimated pup production and life table statistics, it was calculated that roughly 18,400 to 19,700 Steller sea lions currently inhabit coastal waters of B.C.
- Abundance of Steller sea lions has also increased in recent year at neighboring rookeries in SE Alaska and Oregon (the species does not breed in Washington). This contrasts sharply with the western stock of Steller sea lions (Gulf of Alaska, Bering Sea, Aleutian Islands, and Russia), which has declined by 80% since the 1970s and been designated as *endangered*.
- Recovery of Steller sea lion populations in the eastern portion of range has renewed concern over their impact on fishery resources and their role in the ecosystem.

### **Species Biology**

The Steller sea lion (*Eumetopias jubatus* Schreber 1776) is the largest otariid and only member of the family that resides year-round and breeds in Canadian waters. Steller sea lions exhibit significant sexual dimorphism. Adult females average 2.1-2.4 meters in length and weigh 200-300 kg. Adult males are noticeably larger, attaining a length of 2.7-3.1 meters and weighing

400-800 kg. Pups are born in June and weigh 16-23 kg at birth.

Steller sea lions have a polygamous mating system and congregate on traditional rookeries to breed. Animals tend to return to rookeries on which they were born. The rookeries currently in use in B.C. were all known to have existed when the first sea lion surveys were conducted in 1913. Males mature at 3-7 years of age, but only the dominant bulls, most aged 9-13 years, breed. They are the first to arrive on rookeries in May to stake out territories, which they will defend while fasting for the next 20-68 days. Females mature at 3-6 years of age. Pregnant cows arrive on rookeries throughout June, and give birth to a single pup within a few days. Pups cannot swim at birth and are confined to rookery for the first month of life. Mothers remain with newborn pups for the first week and then make regular feeding trips lasting 1 day on average, alternated with a day on shore.

During summer, non-breeding animals are found at year-round haulout sites. There are 21 such sites distributed along the B.C. coast, primarily along the outer exposed coast. In August, animals disperse from rookeries to feed, and begin to occupy numerous winter haulout sites, many of which are located in inside protected waters. Young animals remain with their mothers and are typically weaned sometime prior to their first birthday, although a few will continue to nurse into their 2<sup>nd</sup> or even 3<sup>rd</sup> year.

The species is non-migratory, but there are well-defined local seasonal movements in some areas. In southern part of range, both Steller and California sea lion migrate north along the Oregon and Washington coast. This coincides with a dramatic increase in the number of sea lions wintering off southern Vancouver Island. Non-breeding animals have been known to disperse distances of up to 1,700 km from where they were born.

Mortality of pups during the first month of life appears to be high and influenced by factors such as storms. The principle cause of death of pups is drowning, mainly because they are not able to get back out of the water. Deaths can also result from pups being bit, tossed or trampled by older animals, or becoming separated from their mothers. Rookeries are therefore particularly sensitive to disturbances during the breeding season.

Juvenile mortality is difficult to measure due to potential sampling biases, but appears to be fairly high for both sexes – it has been estimated that 48% of females and 26% of males survive to 3 years of age. Mortality rates are significantly lower for adults: 10-15% per year for females, and 13-25% for males, resulting in a progressively skewed sex ratio favoring females. The oldest animals in the wild were aged about 18 years for males and 30 years for females, although very few individuals attain such old ages.

Steller sea lions are opportunistic predators in that they tend to feed on prey that are locally and seasonally most abundant or accessible. Preferred prey appear to be small or medium-sized schooling fishes, which in B.C. include species such as herring, hake, sandlance, salmon, dogfish, eulachon and sardines. Bottom fish, such as rockfish, flounder and skate, can also be important dietary items. In addition to fish, squid and octopus are sometimes consumed. Steller sea lions have also been observed to occasionally prey on birds and other mammals including neonate fur seals and harbour seals.

Bioenergetic models predict that daily food requirements for Steller sea lions in the wild would be about 15-20 kg for mature females, and 30-35 kg for mature males. However, these figures vary with prey quality - animals feeding on low fat fishes such as pollock require significantly more prey than those feeding on fattier fishes such as herring.

## ***Need for Advice***

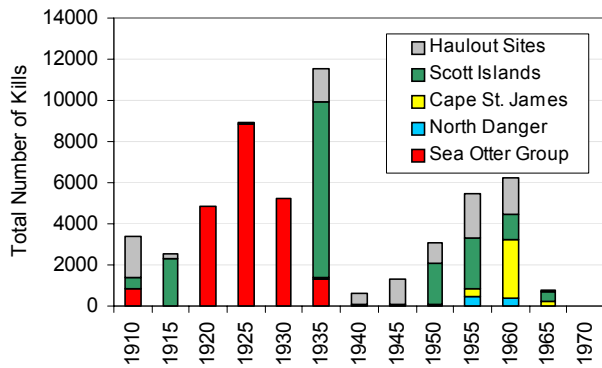
Prior to 1970, predator control programs and commercial harvests had reduced breeding populations of Steller sea lions in B.C. to roughly 25-33% of the peak historic levels thought to have been present in the early 1900s. The previous assessment, published in 1985, found no evidence that populations were recovering.

The western stock of Steller sea lions (Gulf of Alaska, Bering Sea, Aleutian Islands, and Russia) has declined precipitously since the 1970s, and been designated as *endangered* under the U.S. *Endangered Species Act*. Although similar declines were not evident in the eastern stock (California to SE Alaska), the U.S. nevertheless designated it as *threatened* due to uncertainty over stock delineation and concerns the declines may spread eastward.

Although it is now recognized the eastern stock of Steller sea lions has increased significantly in recent years, managers are facing new questions about the impact of sea lions on other fishery resources, and their role in ecosystem. Relatively small numbers of Steller sea lions are still being killed for predator control under special licenses issued to aquaculture and spawn-on-kelp facilities. Although these kills have escalated in recent years (from less than 10 per year up to the mid-1990s, to a peak of 91 in 1999), they appear to be too small to have an overall impact, except perhaps on a localized scale. There is nevertheless concern over expansion of the fish farming industry.

## ***Research Results***

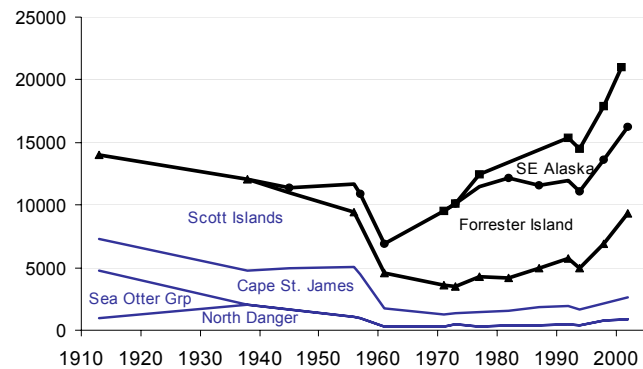
Historical kill and sighting records were compiled and examined to assess the effect of kills had on populations. During 1923-39, an estimated 20,000 animals (including 7,000 pups) were killed at the Sea Otter Group. Pup production at this rookery declined from about 1,200 to fewer than 10 pups, and in recent years it has been used only as a haulout by non-breeding animals.



**Figure 2.** Numbers of Steller sea lions (pups, juveniles and adults) killed during control programs and harvests in B.C. during 1912-68.

Control programs, although not as intense, were also undertaken in other areas. During 1936-39, 7,500 animals were killed on the Scott Islands. Control programs were suspended during WW II, but the Canadian navy and air force may have killed large numbers of animals during bombing practices. During 1956-66, another 11,600 animals were killed at rookeries and haulouts throughout B.C., including some which were harvested for pelts and mink food, but neither operation proved economically viable.

When the first Steller sea lion counts were made in 1913, which was prior to any large-scale kills, the breeding population on rookeries was estimated to be on the order of 14,000 animals. With the elimination of rookeries on the Sea Otter Group, numbers had fallen to roughly 12,000 by 1938. By 1956, kills at other rookeries had reduced numbers to 8,900-9,400. The population declined sharply with the resumption of control programs and harvests in 1956-66, and by the time the species was protected in 1970, total numbers on rookeries had been reduced to about 3,400 animals.

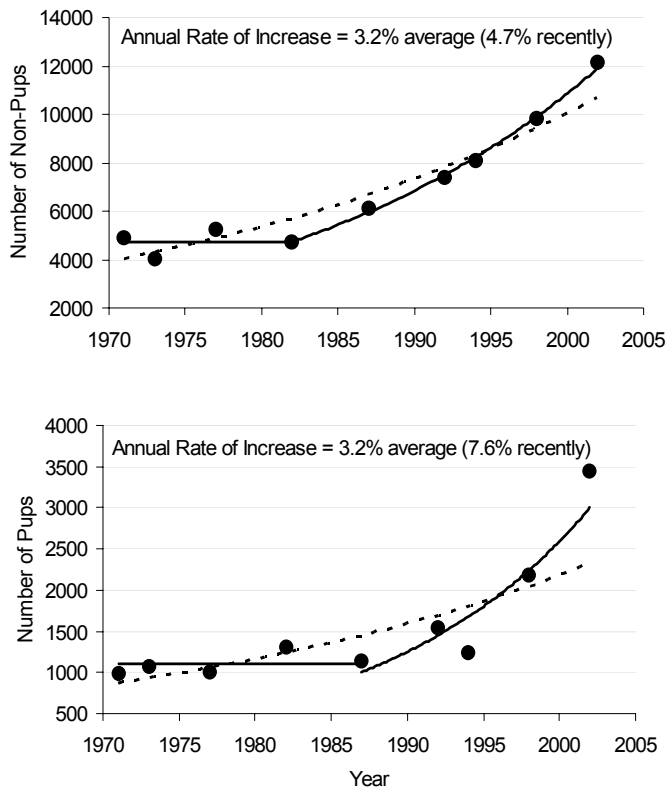


**Figure 3.** Historic trends in total numbers of Steller sea lions (pups, juveniles and adults) on breeding rookeries in B.C. (lower thick line), Forrester Island, Alaska (middle thick line), and other new rookeries in SE Alaska (upper thick line). The thin blue lines show the distribution of animals among rookeries within B.C.

Since the early 1970s, DFO has conducted a series of 9 aerial surveys to monitor the status of Steller sea lion populations. Beginning in 1994, the surveys have been conducted at 4-year intervals as part of an international range-wide survey involving government agencies in California, Oregon, Washington, Alaska and Russia. Surveys are timed to coincide with the end of the breeding season so as to provide an estimate of pup production, as well as counts of juveniles and adults (non-pups).

Recent surveys indicate that both non-pup and pup numbers have increased in B.C. since the early 1970s. Non-pup numbers were stable until the early 1980s, but subsequently increased at 4.7% per annum. Pup numbers were stable until the mid-1980s, but subsequently increased at 7.6% per annum.

Abundance of Steller sea lions has also increased in SE Alaska. While control programs were underway in B.C., a new rookery became established at Forrester Island, situated about 20 km north of the Alaska border. It has since grown into the world's largest Steller sea lion rookery.



**Figure 4.** Number of non-pups (top) and pups (bottom) counted during aerial surveys in B.C. during 1971-2002. Dashed lines show average growth rates, and solid lines show changes in growth rates.

Several other new rookeries also became established in SE Alaska during the 1980s and 90s. Combined abundance in B.C. and SE Alaska – which are difficult to separate due to the large rookery just north of the border, appears to have increased steadily since the 1960s at a rate of 2.4% per year. During the 1960s and 70s, most of the growth occurred Forrester Island, but during the 1980s and 90s most of it has occurred to the south on existing rookeries B.C., or to the north on new rookeries established in SE Alaska. The reason for this shift in distribution is unknown. Abundance of Steller sea lions in Washington and Oregon also appears to be increasing.

Counts from aerial surveys represent minimum abundance since non-pups make foraging trips to sea, and these dispersed

animals are missed in counts made at haulout sites and rookeries. However, because pups are confined to rookeries for the first month of life, total actual abundance can be indirectly determined based on estimates of pup production and life tables (i.e. ratios of pups to older animals).

Pups are more difficult to census than older animals because they are dark and tend to blend in with the substrate. They are also small and easily obscured by other animals, or hidden in crevices or behind rocks and outcroppings. Traditionally, other agencies have made pups counts from the ground by driving older animals off the rookery and walking through it to tally pups, but these ground counts are highly disruptive. DFO has therefore counted pups from oblique 35mm slides taken during aerial surveys. In recent years, researchers in the U.S. have developed specialized vertical medium-format photographic techniques that provide pup counts that appear to be as accurate as those made from the ground.

Working collaboratively with other agencies, DFO evaluated counts made from oblique 35mm slides by comparing them with those made concurrently from the ground (on Forrester Island in Alaska) or from aerial vertical medium-format images (on B.C. rookeries). The comparison indicated that some pups were missed in oblique 35mm slides. For B.C. rookeries, about 4% of pups were missed, and a correction factor of 1.05 (95% Confidence Interval of 1.018-1.075) was therefore applied to pup counts from oblique 35mm slides. At Forrester Island, about 22% of pups were missed, and a correction factor of 1.28 (95% CI of 1.12-1.44) was applied. The correction was likely greater for the latter site because it was larger and had to be circled more widely, such that pups were photographed at more oblique angles.

In 2002, a total of 3,310-3,566 pups were estimated to have been born on rookeries in B.C. Based on life table statistics, it was calculated that roughly 18,400-19,700

Steller sea lions inhabited coastal waters of B.C. This estimate includes a surplus of non-breeding animals associated with neighboring rookeries in SE Alaska.

### ***Sources of Uncertainty***

Estimates of total abundance of Steller sea lions are based on estimates of pup production and life table statistics, both of which are subject to error.

Almost all pups are born on traditional rookeries during June, and they are confined to land for the first month of life. Surveys of rookeries in very late June or early July can therefore, in theory, provide an essentially complete count of annual pup production. It is possible that some additional pups may be born following the survey, or had already dispersed prior to the survey, but these numbers are likely to be very small. It is also possible, but highly unlikely, that new rookeries have become established in B.C. that have not yet been discovered. In SE Alaska, the only region where new rookeries have become established, they formed at traditional haulout sites, which are included in the province-wide aerial surveys.

In practice, pups are more difficult to census than older age-classes. Ground drive-counts have not been conducted in B.C. since most rookeries have been designated as Ecological Reserves or National Parks, and such disturbances would not be permitted. However, there was a high degree of correlation between pups counts made from oblique 35mm slides and those made from vertical medium-format images, which in other regions have been shown to be as accurate as ground counts. For rookeries in B.C., only about 4% of pups were missed the oblique slides, and this bias appeared to be fairly constant between years and among sites. At Forrester Island, however, comparison of oblique 35mm slides with both ground drive-counts and vertical medium-format images indicated that about 20% of pups were missed in the

35mm slides. It is not known why a greater proportion of pups were missed at Forrester Island. One possible explanation is that the pupping sites tend to be larger at Forrester Island, which have to be circled more widely, such that pups are photographed at more oblique angles. The factors affecting the consistency of corrections for pup counts from oblique 35mm slides warrant further examination

In addition to the uncertainty in estimating pup production, there may be considerable uncertainty associated with the pup to non-pup ratio multipliers used to extrapolate total abundance. The existing life tables for Steller sea lions have all been derived from one sample of animals collected in the Gulf of Alaska in the late 1970s. There may be considerable sampling biases in such collections due to segregation of animals by sex, age and reproductive status. Moreover, vital rates will vary depending on the status of populations. The Gulf of Alaska sample was collected just prior to a period of sharp decline, whereas populations in B.C. have been increasing. There is therefore a need for updated data on life history parameters, and a better understanding of how vital rates vary with population status.

Survey procedures are quite straightforward for non-pups. They tend to occur on traditional rookeries and haulout sites, are highly visible and easily counted from 35mm oblique photographs, and are not disturbed by survey aircraft. Counts are generally made between 10:00 and 18:00 when peak numbers are expected to be hauled out. An attempt is made to survey all known haulout sites, and small corrections are applied to account those that are missed. However, an unknown proportion of non-pups will be foraging at sea (or hauled out at unknown sites) and not included in counts. Based on estimates of total abundance from pup production and the number of animals actually seen during surveys, it was indirectly estimated that 75-80% of all non-pups are counted. This figure seems reasonable, but needs to be validated by

examining daily activity and haulout patterns.

Counts have been made without regard to environmental factors that may affect the proportion of animals hauled out or visible during surveys, such as sea state, tide height, wind speed, and precipitation (although the small aircraft used in surveys can only be safely operated under certain conditions). Other researchers have attempted to adjust Steller sea lion counts for these co-variates, but samples sizes were small and the adjustments had no discernible effect on population trend estimates.

Population trends prior to the first systematic aerial surveys in the early 1970s were reconstructed from historic records of sea lions sightings and kills. Most of these records are for rookeries, and thus insufficient for examining trends in total abundance. However, surveys conducted between 1971-2002, during which period abundance doubled, indicated that a relatively constant proportion (60%) of the population occurred on rookeries. This suggests that numbers on rookeries may provide a good index of total abundance.

Considerable judgment had to be used in interpreting the historic sighting and kill records. In some cases, counts may have been influenced by disturbances associated with control programs and harvests, which could have displaced animals from the site, or disturbances in adjacent areas that may have driven animals to the site. Some of the counts seem to have been made precisely, while we suspect others were ballpark estimates. Some of the counts were made at sub-optimal times, although in these cases it was sometimes possible to apply crude adjustments based what we know about the chronology of pupping and the arrival schedule of animals on rookeries. The subjectivity involved in the interpretation precludes any formal statistical analysis of historic population trends.

## **Outlook**

Abundance of Steller sea lions in B.C. has doubled since the species was protected in 1970. Populations have also been increasing in neighbouring waters in SE Alaska. Combined abundance in this region appears to have attained and exceeded estimates of the peak historic levels thought to have been present in the early 1900s before any large-scale kills. Given the recent recovery of populations, one might expect natural regulatory mechanisms to begin to play a greater role in local waters.

## **Other Considerations**

The recovery of Steller sea lion populations has renewed concerns over their impact on other fishery resources. Public attitudes have changed since the last era of predator control, and management decisions need to be made and justified on the basis of sound science. Our understanding of the feeding habits of Steller sea lions and their role in the ecosystem are still poorly known. Although the earlier predator control programs have not been assessed in detail, one study noted there did not appear to be any noticeable increase in salmon catches following the reduction of sea lions on the Scott Islands. Despite the eradication of sea lion rookeries on the Sea Otter Group in an effort to protect the Rivers Inlet sockeye fishery, sockeye salmon stocks in that area remain critically depressed. Additional research will be required on the diet, foraging patterns, and energy requirements to assess sea lion – fishery interactions.

Although populations have grown in recent years, Steller sea lions still face a number of potential threats. During the breeding season, animals gather in large concentrations on rookeries (70% of pup production occurs on the Scott Islands), at which time they are particularly sensitive to disturbances. These concentrations are also vulnerable to environmental accidents, such as chemical or oil spills. Being long-lived and at the top of the food chain, sea lions tend to accumulate contaminants in

their tissues, such as heavy metals and organochlorines. In other pinnipeds, high levels of these contaminants have been implicated with reproductive impairment, premature births, birth defects, skeletal deformities, suppression of the immune system, and disruption of endocrine function.

With the recent shift toward ecosystem-based management, there may be potential for using species like the Steller sea lion as a general indicator of the status of food webs in the North Pacific. In western Alaska where populations have declined precipitously, the rates of decline in different areas were inversely related to the diversity and quality of diet. The sharp declines that occurred during the 1980s appeared to coincide with a period of reduced body growth, reduced juvenile survival, and increased incidence of reproductive failure, which are suggestive of nutritional stress. Captive studies have also identified negative health risks for sea lions feeding on low-fat fish such as pollock.

### **For more Information**

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