Module 4
Marine Mammals and Fisheries

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Key Terms and Concepts

- Aleutian Islands
- body condition
- body mass
- cetacean
- eastern population
- Endangered Species Act (ESA)
- index sites
- marine mammal
- Marine Mammal Protection Act (MMPA)
- pinniped
- pollock
- regime shift
- Steller sea lion (*Eumetopias jubatus*)
- subsistence
- threatened species
- western population

Learning Objectives/Outcomes

Upon completion of this module, you should be able to

1. name the marine mammals in Alaska that are declining.
2. explain how scientists count marine mammals in the field.

3. explain how the Endangered Species Act and the Marine Mammal Protection Act interact with fisheries in Alaska.

4. explain what could cause a marine mammal population to decline.

5. explain the role of subsistence hunting and marine mammals in Alaska.

Overview

While the study of marine mammals has a popular and adventurous component to it, it is also extremely challenging because these animals live in an ocean world where it is difficult to follow them in their daily lives. The adventurous view is reinforced in various ways: by popular media representations of marine mammals; by movies depicting the plight of captive marine mammals; by ocean amusement-park shows; by stories of the hunting of seals and whales; and by coverage of events such as oil spills. This view has become so popular in the United States that Congress passed the Marine Mammal Protection Act (MMPA) in 1972, which protects wild marine mammals from harassment by humans. By contrast, there is no such general law for terrestrial mammals.

Part of the attraction of marine mammals is that they are warm-blooded mammals and, as such, related to humans, dogs, cats, and horses; yet they live in a largely unknown oceanic world that is dark, cold, and deep. Somehow, they exist in an environment that is hostile to terrestrial mammals. Some can dive for more than an hour; others dive to depths of more than a mile; and many live in extremely cold polar oceans, where their pups are born on the ice. Some species are rarely seen, and others are extremely common.

While marine mammals have a high profile in public awareness, their marine existence also makes them hard to study. What does a sperm whale do at a mile deep to find and catch squid? Where do seals and sea lions go when they leave the shore to find food? How much food do they need to stay healthy? For that matter, how do you catch a seal, sea lion, or whale to find out whether it is healthy? How do you count marine mammals when most of them are far at sea and only rarely—or not at all—on land?

The discussions in this module will focus on even more difficult questions: Why are some species of marine mammals declining around Alaska while others are not, and do humans have anything to do with these declines? Could these mammals be simply leaving the Alaska region for other places? Are they declining because of sickness? oil spills? overfishing? global climate change? As it turns out, these are multi-billion dollar questions because the interactions of humans and marine mammals affect (1) how we regulate our fisheries, (2) the locations of fleets, (3) scientific studies, and (4) political and financial decisions relative to resource allocation in Alaska. Both humans and marine mammals

consume fish, and this leads to a problem: namely, in light of the regulations that protect marine mammals, how do we balance the food needs of marine mammals with fishing for our own food? On the other hand, if marine mammal populations are declining because of disease or natural patterns, then does fishing have anything at all to do with the patterns of change?

This lecture could easily be entitled: "The Biopolitics of Marine Mammals in Alaska" because it is not possible to study what is happening to these species populations without heavily involving legal, political, financial, and cultural issues. Indeed, in recent years, discussing these issues involves just as many lawyers, lobbyists, special interest groups, and politicians as scientists.

The study of marine mammals has its adventurous component. However, beyond popular views of seals and whales, the implications involved in why populations are declining, how these declines affect the fishing industry, the use of marine mammals in cultural subsistence hunting, and how humans can—or should— protect them, is serious business.

Lecture

Marine Mammal Declines around Alaska

Decline Patterns of Cetaceans

In this section, we discuss cetaceans, which are the whales, dolphins, and porpoises; most of the remainder of the module will deal with seals and sea lions.

In many cases we do not have a good set of estimates for the populations of cetaceans in Alaskan waters. However, there are species that are known to be increasing in numbers and appear to be healthy. For example, the bowhead whale (*Balaena mysticetus*) is a healthy population of animals and is growing at a rate of about 3% per year (Raferty and Zeh 1998). On Alaska's Arctic coast, bowhead whales are part of the subsistence hunt of Alaska's indigenous peoples.

At least 17 species of cetaceans are known to inhabit Alaskan waters (Wynne 1992) and some are commonly seen, such as the bowhead, humpback (*Megaptera novaeangliae*), beluga (*Delphinapterus leucas*), killer whale (*Orcinus orca*), and harbour porpoise (*Phocoena phocoena*). In fact, the tourist industry relies heavily on the routine appearance of animals in Alaskan waters and virtually guarantee the ability to photograph a whale on their popular boat trips from locations along the coast.

There does not appear to be a large, overall conflict between tourism, fishing, subsistence hunting, and whale populations, but this does not mean that there are not specific problems. For the bowhead, the ongoing hunt by Alaska's indigenous peoples is a discussion point at the International Whaling Commission

meetings and is linked to the rights of indigenous marine mammal hunters around the world. However, because the whale population is healthy, and because Inuit have been hunting whales for centuries, this issue is not currently controversial within the United States. Near Anchorage, there is a small population of beluga whales that were heavily hunted in recent years, and their numbers have severely declined. Through a significant number of management meetings between the US federal government and local Aboriginal organizations, the hunt of beluga has been mostly curtailed. In southeast Alaska, there is a growing problem with sperm whales removing fish from longlines and creating financial and nuisance issues with local fishing fleets. However, the effect on the animals themselves is negligible. Finally, killer whales are now at the centre of a serious debate about the decline of Steller sea lions and sea otters in Alaska and are receiving a great deal of attention**.** Local populations of orca may have been affected by the Exxon Valdez oil spill, but overall, they are not considered to be compromised. Linked to the Steller sea lion issue is a new theory that the removal of vast numbers of large cetaceans from the Alaskan marine ecosystem by commercial harvesting severely changed the biological system in the North Pacific (Springer et al. 2003). This theory suggests that top predators, such as the orca, must now feed on sea lions and otters instead of the great whales. We will return to this theory later in this module.

Even this cursory examination of cetaceans suggests that local fishing issues, tourism, management regulations, and cultural history must be considered in any basic study of marine mammals.

Student Activity

The Endangered Species Act (ESA) requires that all human activities that could possibly impede the ability of a species to recover must be regulated. If it turns out that competition with fisheries has very little to do with the sea lion declines, then should fishing be regulated, or not? If the sea lions are in trouble, then should everything that could even remotely inhibit their recovery be carefully watched? Sea lions eat the same fish that we target with our fishing fleets and it is very convenient to point potential blame in that direction. But this is a decision that must be balanced with cultural, financial, and political realities. If it is decided to close a major fishery, are we willing to bear the impact to thousands of families in the United States alone, to local economies, and to our consumption levels of fish? Where do we draw the line between protecting endangered species and protecting our own ability to provide for ourselves?

Decline Patterns of Pinnipeds

Pinnipeds are the seals, sea lions, and walruses. Beginning about 30 years ago, a general pattern of population declines began to appear in the pinniped populations around Alaska. It was first noticed in the harbour seal population, then in the Steller sea lion, and most recently, in the northern fur seal. However, it was not until the early 1990s that the declines became significant enough to bring in considerations of the Endangered Species Act (ESA). The Steller sea lion population declines have been at the heart of the problem with more than 10 years of regulations, lawsuits, vast amounts of research, and public debate. In fact, the sea lion problem represents a classic example of the biopolitics of marine mammal biology. It is important to note that none of the marine mammals mentioned so far, however, are pristine populations; that is, Steller sea lions, northern fur seals, and harbour seals have all been heavily hunted by humans in the recent past.

We need to ask two parts of what seems to be a simple question: How many sea lions used to live in Alaska, and what has been the pattern of their decline? To answer this question, let's discuss how sea lions are counted.

Steller sea lions belong to a group of pinnipeds called otariids. These pinniped species can walk on all four limbs; they have external ears; and they usually bark and call while on land and are seen in many aquatic entertainment shows. The Steller sea lion is the largest of this group, and adult males can reach more than 1,000 kg. Adult females can reach up to 300 kg. They breed and pup on remote islands or coastal sites in large groups called harems, which are controlled by adult male bulls. Pups are born in early to mid-June and are mobile enough by mid-July to leave the beach and swim in the nearshore waters. Adult females attend the pups while they are on land and, like all otariids, the mothers make routine trips to sea to catch fish and return every few days to nurse the pups. When the pups are large enough, the females leave the rookery areas with their pups and continue to nurse them for at least a year. During this time, the juvenile learns to hunt and fish on its own.

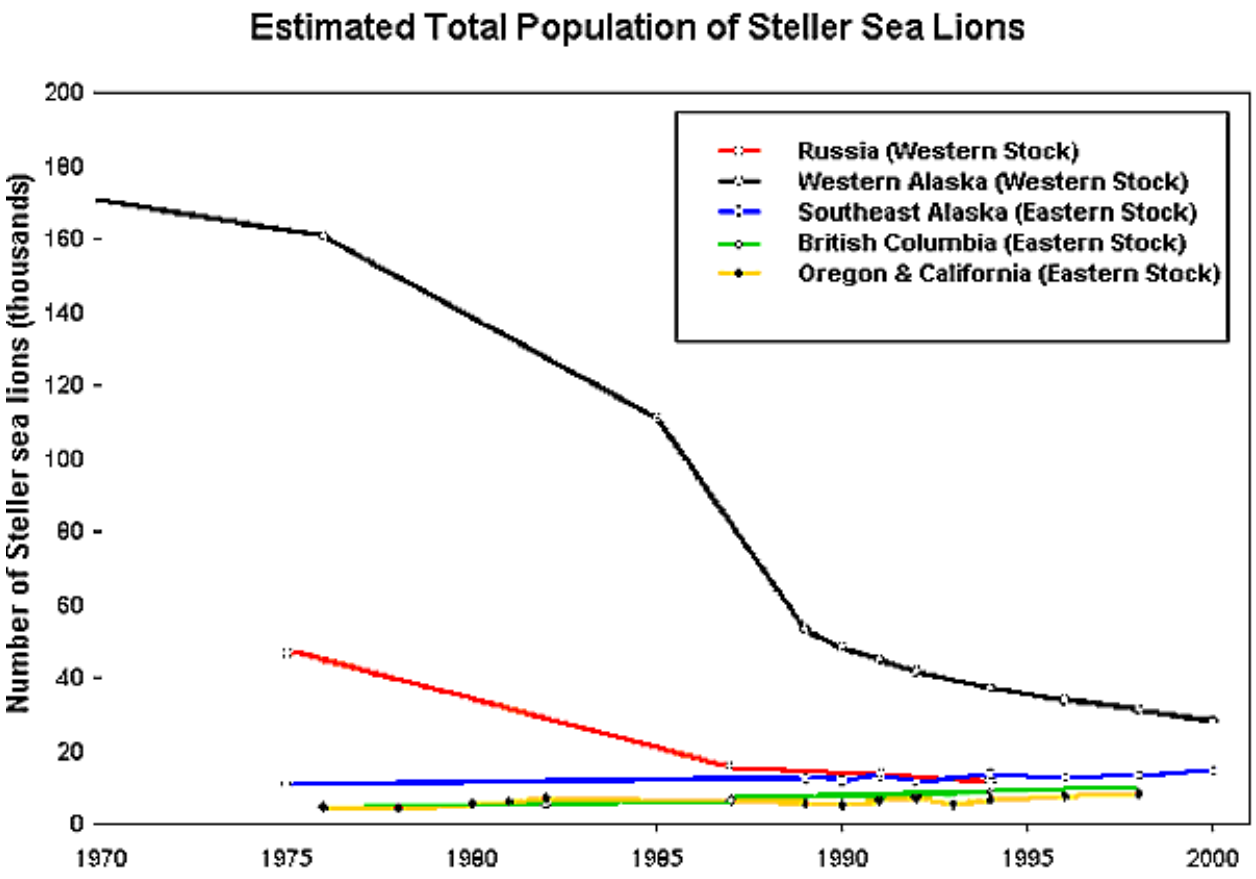
Scientists survey the population of Steller sea lions by locating the rookeries and counting all the adult females and the pups on the beaches. While this sounds straightforward, there are complications. For example, the rookeries stretch from northern California, across Oregon, Washington, British Columbia, and the entire Gulf of Alaska; then out to all the Aleutians, up into the Bering Sea, and over to Russia and Japan. This is a conservative estimate of more than 10,000 miles (1,609,000 km) of extremely rugged, remote, and hostile beach line. Thus, it is impossible to have someone physically land on each and every one of these beaches and count the animals in only a three-to-four-week period. Furthermore, the process of counting the animals is affected by weather, the time of day, and disturbances caused by the survey teams. Steller sea lions will

stampede off a beach and into the water if humans disturb them. Such a full range count on individual beaches in one single four-week season has never been attempted because the ship time, air time, and logistics are insurmountable.

Therefore, most surveys are done by aircraft with a combination of ground truth counts to make sure that the two agree. Ground truth counts are necessary because flying over a rookery to photograph the animals on a beach is difficult: animals can be missed behind rocks or hidden under ledges; or they may be in the nearby surf. The National Marine Mammal Laboratory (NMML) of the National Marine Fisheries Service (NMFS) is the official sea lion census body for the United States, and they use a combination of flights, ground truths, pup counts, adult counts, and index sites to estimate the population of Steller sea lions. Because not all rookery sites can be counted every year, they use index sites to estimate population trends. Ground truth pup counts are done every few years to minimize local disturbance; and full-range aircraft counts are conducted only every five years or so. However, US flights over Russia and Japan are not allowed, and counts from those regions must come from local scientific teams or from collaborative efforts with US research teams.

From a historical perspective, it is important to note that this survey process was not heavily used until the Steller population was thought to be in decline. In fact, not long before that point, sea lions were considered nuisance animals and experimental hunts were conducted to see whether the population could be controlled. Thus, our knowledge of how many animals historically used to live in Alaska is limited. Recent attempts to use archaeological data to estimate sea lion numbers by analyzing their remains at ancient human sites hold some promise for comparing present numbers with values hundreds, or even thousands, of years ago. Accounts from early explorers in the North Pacific suggested that many more animals were in the region then than now exist.

If we acknowledge that counting sea lions is both difficult and susceptible to a suite of present and historical corrections, then what do we know about the population decline? Figure 4.1 is taken from data provided by the NMML and is probably the most cited figure in the entire sea lion controversy. It shows that the overall decline of sea lions probably began in the mid-1970s, accelerated in the mid-1980s, slowed a little in the 1990s, but continues at a rate that keeps the species on the endangered list.



Source: National Marine Mammal Laboratory

Fig. 4.1 Estimated total population of the Steller sea lion

There are several aspects of the data shown in figure 4.1 that could bear some explanation. First, these data are summed up from all the survey index sites. When individual regions of the Steller sea lion population are examined in detail, the data show regional and temporal differences in population changes. For example, the rate of decline in the western Aleutians is not the same as in the eastern Aleutians; nor the same as in the Gulf of Alaska, or in southeast Alaska. In fact, in southeast Alaska, the population of sea lions is increasing. These regional differences in population pattern data are shown in figure 4.2.

[Figure temporarily not available.]

Source: National Academy of Science

Fig. 4.2 Regional differences in counts of western and eastern populations of Steller sea lions. WAI: western Aleutian Islands; CAI: central Aleutian Islands; EAI: eastern Aleutian Islands; WGOA: western Gulf of Alaska; CGOA: central Gulf of Alaska; EGOA: eastern Gulf of Alaska.

Legal, Political, and Economic Implications

Another component of the data in figure 4.1 that needs further explanation has to deal with the legal aspects of how the animals are counted. In the early 1990s, when it seemed as if this decline was becoming serious, the sea lion "problem" became an issue for environmental and fishing groups. In the simplest analysis, the environmental groups blamed the large and increasing fishing industry for removing too many fish from Alaskan waters; the fishing industry replied that there were no data to show that sea lions were dying from starvation. Further, because the NMML is part of NMFS, which also has the mandated duty of protecting and regulating fishing in US waters, environmental groups thought that NMFS had a conflict of interest between fishing and the protection of sea lions and that the counts might be biased.

At this point, as petitions were made to put the Steller sea lion on the endangered species list, there were a suite of lawsuits against NMFS and their handling of the sea lion situation. This led to a series of legal responses, more lawsuits, closed fisheries, entrance restrictions around rookeries, and increasing awareness of the situation by the public. About this time, a full, two-page advertisement appeared in the Anchorage newspapers, showing a general map of the Gulf of Alaska and the Aleutians. The advertisement claimed that the people of this region who relied on fishing were the endangered species, not the sea lions, and that NMFS was incapable of conducting correct counts; that the NMFS did not even know whether the animals were healthy; and that there was no evidence linking sea lion population changes to fishing.

In 1991, when these lawsuits were being initiated, there were events that today sound extreme, but they illustrate the tension of the time. For example, on one particular summer day, several teams of scientists had just counted groups of pups on a long and complex beach in the rookeries of the eastern Aleutians. As they all came back to the rendezvous point, they reported their pup numbers to the NMML person coordinating the study and then asked: "How many pups total are there on this beach?" His response was, "I can't tell you because we are being sued and this information is part of the contested data."

This was at the beginning of a series of decisions that had far-ranging political, economic, and biological implications that were driven by legal requirements. We refer to this as "policy by court bench," and it has permeated the Steller sea lion field ever since. During the 1990s and since, there have been continual sets of lawsuits, Biological Opinions (BiOps) issued by NMFS, new lawsuits, lobbyists, environmental groups, and claims for data under the US Freedom of Information Act. Entwined with all of this are increasing regulations based on the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA).

The fight over the counts became so serious that there was a proposal to have some group other than NMFS/NMML count the sea lions. This never happened because no agency or group other than NMFS had the resources or the knowledge to conduct such large counts. However, eventually it was decided that the counts were the best possible and that criteria should be established for defining whether the species should be listed under the Endangered Species Act. Under the ESA, a Steller sea lion recovery team was formed to outline what criteria should be used to define an endangered population level for this species. This team drew up a combination of absolute numbers, trends, and pups count definitions.

For the purposes of the ESA ruling, it was decided that the population of sea lions should be listed as two groups—an eastern and a western population—split roughly in the middle of the Gulf of Alaska, at longitude 144^{o} West. Substantial genetic data indicated that the populations were not significantly mixing between these two areas. The western population was subsequently listed as endangered, which means it was in danger of extinction. The eastern population was listed as threatened, meaning it was a population of concern but not necessarily at risk for extinction.

Although it took quite a few years, lawsuits, public discussions, and considerable debate, it was finally admitted by all groups that the population of Steller sea lions was indeed declining in the west and that the criteria for listing them as endangered were sufficient.

After the arguments over the most basic of the data had been mostly settled—specifically, How many sea lions are there? and, What is the overall trend in their population trajectories?—the more difficult questions came to the forefront: What is causing the decline? and, Can we do anything about it?

Student Activity

Should fundamentally biological decisions be heavily influenced by the courts? Can lawyers, lobbyists, and special interest groups direct how the management of wild populations of animals are conducted? If lawsuits can direct how agencies conduct their activities, and the Freedom of Information Act can be used to release data before it can be fully interpreted, are we really acting in the best interest of the threatened population, or are we responding to current political and economic demands?

Why Are Steller Sea Lions Declining?

In theory, what would cause such a significant population of large mammalian carnivores to decline by more than 80% in only 30 years? There are at least three different ways of approaching this question.

First, are there "bottom-up" reasons? In ecological theory, a bottom-up scenario suggests that alterations to the food base for the species are restricting their food in terms of either quality or quantity. These changes could arise from problems caused by humans (e.g., overfishing) or natural change (e.g., global warming).

Second, are there "lateral" reasons for the decline? These would include genetic disease, toxins, pollutants, and epidemics. For example, there have been recent epidemics in northern Europe that have killed thousands of seals.

Third, are there "top-down" conditions that could drive a decline in sea lions? This would include direct human interactions (shooting, bycatch, etc.) and impacts from other predators (e.g., Could sharks or killer whales be decimating the sea lion population?).

While this section of the module will discuss each of these possibilities in more detail, the answer is that not any of these three scenarios can on its own fully explain the initiation of the decline and the failure of the species to recover. In short, we don't know why the population is going down, but data in each of these areas tend to lead us in certain directions.

The Bottom-Up Scenario

This is the theory that has until recently received most of the public attention, most of the research funding, and subsequently, most of the controversy. Basically, it asks whether there have been changes to the food supply of the sea lions that would account for the population decline. This could mean a change in either food quantity or quality, which is reducing the survivability of the Steller sea lion. There are multiple ways to approach this problem, but most of them have focused on several areas.

For example, are there any correlations between the sea lion numbers and obvious changes in the ecosystem? About the same time that the data began to suggest the decline of Stellers (1976–77), the North Pacific and Bering Sea also experienced what is now called a "regime shift." This was a change in the basic oceanographic features of the region to a period of warming. The biological system shifted from a shrimp-crab-herring–dominated profile to one of pollock and halibut. Fisheries responded to the change, and the catch of shrimp, crab, and herring was reduced while the industry catch for pollock was expanded significantly.

Changes in the physical and biological structure of the world's oceans follow a complex pattern over time. For example, there are years when El Niño is dominant and years when it is not. In the North Pacific, there is a general trend that is decadal in period, with general warming and cooling trends occurring over a duration of 10–20 years. This is called the Pacific Decadal Oscillation, (PDO), though recent analysis suggests further oceanographic patterns of different time frames hidden inside the PDO. These patterns are naturally driven systems and, barring the debate over global warming, are not generally considered to be influenced by humans.

Given the coincidental timing of the regime shift and the overall pattern of decline in the Steller sea lions, could these phenomena be related? To answer this question, we need to hypothesize a potential mechanism by which a temperature and biological change in the ocean could compromise an entire sea lion population.

To start, we can eliminate the actual oceanic temperature change itself, which was only a few degrees. Sea lions, like all mammals, thermoregulate with ease and can maintain their body temperature in the face of a relatively small change. They can adjust their cooling and heating requirements by altering the way that heat flows in and out of their bodies.

Next, if the food base changed, could that have affected the animals? Would a change in diet away from herring and other groundfish (which are generally considered to be more fatty than other types of fish), cause a problem for sea lions? This can be further simplified into a question of quantity and/or quality. That is, could the regime shift have caused a change in the amount of food available or would it cause a change in the quality of food; and would either of these factors—or a combination of them—affect the sea lions? In 1991, scientists proposed that this link between food and sea lions was a serious concern and they convened the first "Is It Food?" conference near Fairbanks. (The conference was sponsored by the Alaska Sea Grant College.) At that meeting, scientists from around the world examined the population numbers of sea lions and the changes in the oceanic system, and they made a series of predictions for what would be expected in the sea lion populations if the decline were related to diet. For example, if nursing mothers could not get enough food, then the pups would be left on shore longer because foraging time or distance would have increased. The females would be in a reduced body condition, as would the pups. The rate of pup weight gain would be reduced; the quality of milk would be compromised; and there would be an increase in the number of starving or dead pups on the beaches. Further, in the simplest analysis, there would be a geographical difference between the two populations of sea lions: the endangered western population would show these problems, and the stable eastern population would not.

These hypotheses led to a massive series of experiments and data collections on rookeries throughout the range of the sea lion population during most of the 1990s and continue to a lesser extent today. Teams were put on islands to capture and weigh pups, measure the condition of females, test how long the mothers went to sea, take milk samples, put dive- and satellite-locating monitors on the females, and a range of related studies. The ultimate goal of this work was to determine whether the mothers and pups were healthy and whether there were west–east differences consistent with the "Is It Food?" hypothesis. Two major reviews of all of this work were considered by the "Is It Food II?" conference held in Seward, Alaska, in 2002 and by the National Academy of Science review of the decline of Steller sea lions in 2002–2003.

In both investigations—which involved testimony and papers from scientists, national and international agencies, fishing representatives, and the public—the final conclusions were that the changes projected in the sea lions that would be consistent with a food-based problem were not found. However, this is negative evidence; that is, the hypotheses could be challenged. Perhaps the scientists only found the surviving sea lions and, therefore, these were the healthy animals and the sick ones died and were never seen. For these reasons, studies on sea lion nutritional requirements and feeding habits continue in both captive and field conditions in order to expand the geographical range and the number and age of animals handled.

As an aside, catching newborn pups to study is the easiest of all Steller sea lion field work because they can routinely be picked up on the beach. Studying adult females is much harder and requires experts to sedate the animals by darting them; anesthesiologists to monitor and control the animals while working on them; and so on. The expense and difficulty of doing this work with adult females has limited the total number of animals handled in this manner to less than 100. Adult males are even more difficult because of their size and aggressive nature. Less than a dozen adult males have ever been captured. Juveniles are also hard to catch because they do not climb onto rookeries and stay at remote sites, hauled out on rocks and beaches. Until the mid-1990s, less than a dozen juvenile Steller sea lions had been captured alive in the field for study. This was unfortunate, because the health studies had shown that adult females and pups were probably not compromised, and the best population modelling at the time suggested that it might be the juvenile proportion of the population that was disappearing. Then, underwater divers found that they could lure juveniles into a type of lasso that could be put on the animal so that the sea lions could be pulled into a small boat and from there onto a ship for study. This technique is now the primary method used to capture juvenile sea lions, and hundreds have been captured using this method since 1998.

There is now a substantial database comparing the western and eastern populations of juvenile Steller sea lions, and the results show no significant

differences between the two populations in terms of body condition, fatness, or rate of growth.

Nutritional studies continue today, using more refined and powerful biomedical tests and trials. There are captive Steller sea lions in research programs in both Alaska and British Columbia that are testing how the animals respond to different diets, how they digest their food, how their health changes over seasons, and a host of other studies aimed at food and basic health questions. These tests are not only looking for a method or a marker of health that can be used in the field, but they are also yielding the basic biological studies of sea lions necessary to more accurately interpret the data that has already been collected on rookeries and beaches around the North Pacific.

In summary, the best evidence available does not currently support the food hypothesis and severely challenges the "Is It Food?" scenario. On the other hand, it does not disprove it either; therefore, research continues to look at the medical and nutritional requirements of the species. Since the best population models still suggest that the failure of juveniles to reach adult age is the most likely mathematical explanation for the decline, most of this work is currently focused on the younger animals.

The Lateral Scenario

This is the theory that events such as epidemics, poisons, or toxins could be reducing the number of sea lions. This concept has been approached by health studies of wild and captive animals and the collection of carcasses on beaches. A suite of viral and bacterial infections and/or antibodies has been found in both living and dead Steller sea lions; but the frequency of occurrence and distribution of these do not show any particular pattern, nor are they widespread enough to suggest that disease is a serious problem for this species. There are some data that propose an east–west difference in immune and inflammatory response chemistry that would be consistent with the declines, but mechanisms of how immune status could affect reproductive success or cause the death of juveniles is lacking. There is very recent work that suggests pollution levels may cause some health problems, but, generally, there is not a strong link between contaminants found in Stellers and their health or population status.

The pattern of decline in this species is not consistent with an epidemic, such as what was seen in harbour seal die-offs in the North Atlantic in recent years. Moreover, and much more confusing, when an epidemic strikes a seal population, there are usually thousands of carcasses on the beach that can be examined for the cause of death. In the case of Steller sea lions, the animals are simply disappearing. There are normal numbers of dead animals on the beaches, caused by a variety of incidents such as broken bones, fights between large males, pups being abandoned by their mothers, or other normal occurrences. When one is walking on a Steller rookery, there are not very many dead animals to be found.

Thus, it is not a case of thousands of animals dead along a beach and scientists examining them to find the cause. The animals are just not there.

The National Academy of Science panel concluded that

> . . . little is known about the prevalence of infectious diseases in Steller sea lions or their morbidity. Both eastern and western populations of Steller sea lions have antibodies to agents the could decrease survival and reproduction. . . . Although a viral disease could have occurred in the late 1980s, to date there is no direct evidence of an epidemic. . . .

Work continues in this field, mainly by teams trying to find new markers of disease or pollutants that could affect the vital health or reproductive condition of the animals. It is possible that such a marker or toxin will be found, but none of the obvious or well-known diseases are currently considered a major factor in the failure of the population to recover.

The Top-Down Scenario

This concept theorizes that the direct impact of humans on sea lions (hunting, bycatch) or the direct predation by sharks or killer whales could account for the declines. It is supported by the lack of evidence for bottom-up or lateral changes in the ecosystem of the sea lions. That is, sea lions seem healthy, and there is not much evidence suggesting that they have a food problem—and yet they continue to disappear. A top-down driving force generally fits this pattern.

As mentioned earlier, Steller sea lions were once hunted as nuisance animals because they were thought to be a problem for the fishing industry around Alaska. More than 45,000 pups were taken in experimental harvests from 1963 through 1972 in and around the Kodiak and the eastern Aleutian areas. Certainly, since the passage of the Marine Mammal Protection Act, the only legal take of Steller sea lions has been by Aboriginal subsistence hunters, and these numbers are small. Currently, fewer than 200 sea lions are hunted for food each year by Alaska's indigenous peoples. Thus, while the large hunts could have caused a temporary reduction in the population of sea lions in the late 1960s, that impact would have long passed through the population by now.

Another direct human take has been the incidental capture and drowning of sea lions in fishing nets. It is estimated that fewer than ten animals are currently killed in this manner per year. However, in the mid-1980s, off the coast of Kodiak, 1,500–2,000 animals were trapped in fishing nets and drowned. That event has never again occurred, and observers placed on the fishing fleet do not report seeing significant accidental drownings.

Because sea lions are protected under the ESA and the MMPA, any direct take of them (excluding a tightly regulated Aboriginal subsistence hunt) is not legal.

While it is possible that some people may still shoot at the animals, the number of sea lions taken in this manner on an annual basis is not considered significant.

A relatively recent theory that has become popular is the concept that sea lions are being eaten by sharks or killer whales. In Alaskan waters, the large sleeper shark (*Somniosus pacificus*) is known to eat harbour porpoises and seals. In theory, they could easily consume juvenile Steller sea lions. However, examination of stomachs from sharks caught in fishing operations does not support this idea; finding the remains of sea lions in this way is extremely rare.

Much more support is given to the theory that killer whales could be holding down the recovery of sea lions by consuming a large number of them and perhaps could even account for the sea lion decline. There is some background on killer whale biology that is necessary before we can continue to examine their role in the sea lion story. In the North Pacific, there are two distinct types of killer whales: residents and transients. The groups have different social structures, are distinct genetically, and have different vocal patterns. Of most concern to this theory however, is that resident killer whales eat only fish and transients eat only marine mammals. Thus, a count of the total number of killer whales in Alaskan waters must be corrected for the percentage that are transient and those that are resident. Another value that must be considered is the food requirements of a typical transient killer whale. By extrapolating from the known food requirements of killer whales in captivity, and by using general equations that calculate food requirements based on size (body mass), it has been calculated that a single, transient killer whale consumes approximately 200,000 calories per day. By knowing the rough energy content of marine mammals as food items for killer whales (about 500,000 calories for a 100 kg juvenile), estimates can be made of the impact of the whales on sea lions. At this rate, an orca would require about two juvenile sea lions per day.

Based on population estimates of approximately 4,000 total killer whales in Alaskan waters, of which about 7% are considered mammal-eating transients, it is clear that the population of juvenile sea lions would be exterminated in just a few years at this rate of consumption. Because there are still many sea lions in Alaska, there must be some errors in these assumptions. The proponents of the theory suggest that, most likely, killer whales do not feed only on sea lions. The proponents estimate, however, that even if only 10% of the daily diet of a killer whale was sea lion, that would be enough to keep the population of sea lions from recovering.

We do know that killer whales eat sea lions—both from direct observation and from finding sea lion remains in whale stomachs. But because the mathematics works, does that necessarily mean that this is actually taking place? The opponents of the theory point to southeast Alaska, where there are many transient killer whales and yet the sea lion population is growing. They also note

that there are many small cetaceans in the Alaskan waters and that killer whales are not eating those.

This theory was recently expanded beyond the concept that killer whale predation is keeping the sea lion population from recovering and perhaps was also involved in the initial declines. The argument is that when humans removed most of the large cetaceans from the North Pacific through hunting, the killer whales no longer had a large and relatively easy source of food. The killer whales are said to have switched prey and began to consume harbour seals. In fact, the harbour seal populations did decline in Alaska before the sea lions. Then, when the harbour seal numbers became too low, the killer whales moved to sea lions and now are consuming sea otters because sea lions have become relatively scarce. The authors of this theory point out that the sea otter population in the western Aleutians is declining dramatically and that their theory would account for all of the changes in the population of marine mammals.

As expected, this theory is both hard to prove and extremely controversial. It also has polarized much of the marine mammal research community and has focused a great deal of attention on killer whale biology and behaviour. While collecting data to test this theory is becoming widespread, there are those that are worried that if killer whales are implicated in the decline of sea lions, that this might give some weight to trying to control the population of killer whales through culling.

Current work in this area involves a great deal of work not only on killer whale identification and behaviour, but also on biochemical tests that might be able to decipher whether a killer whale has a significant sea lion diet by the appearance of certain biochemicals in their blubber. Since blubber can be obtained from a free-swimming killer whale using a biopsy-dart, this method might provide useful data for this debate.

Student Activity

Other species may also be declining in the same area, but they are not yet "endangered." At what point do we try to get ahead of the problem and study species before they are in trouble? Unfortunately, it is hard to secure funds to work on species that are not in danger, yet those data may be critical to future essential decisions. Because funding for projects can be heavily driven by regional economic and political needs, should scientists "follow the money" and work mainly on those species where there are funds, or should they somehow find the support to study other species?

Summary

The best evidence at this time suggests that the bottom-up scenario is not the strongest of the possibilities for explaining the current inability of the population to recover. Both the second "Is It Food?" conference in 2001 and the National Research Council review of the entire sea lion controversy conclude that there is very limited evidence for food-related problems with the current sea lion populations. Even as far back as 1990 the data did not appear to support this concept. But what about the 1980s and the 1970s? Could a food-related problem have started the decline and something else now be inhibiting their recovery? What historical data would be necessary to test these ideas?

Could the recovery of Steller sea lions be impeded by lateral events? While there are some data suggesting immune/inflammatory/pollutant data differences between the stable and decreasing populations, there are not enough data to show how those problems could keep the animals at a decreased status.

Finally, the most popular current thesis is that top-down predation by killer whales could account not only for the initial decline, but also for the failure of the population to recover. This theory is consistent mathematically with the sea lion and killer whale populations, but it is challenged by the riddle that there are many orca in southeast Alaska while the sea lion population there is slowly increasing.

If the Steller sea lion problem were limited to just a biological curiosity, it would be a complex problem to solve. In this particular case, however, the infusion of economic, political, cultural, and legal restrictions and regulations has turned the problem into a massive biopolitical issue. Because of the significance of the potential limitations to fisheries around sea lion rookeries, this problem has become a focal point for controversy. Until the mid-1990s, scientists had a hard time funding sea lion research. Once the prospect of closing down or limiting fisheries became a possibility, sea lion research was heavily funded. Since about 1998, over $80 million dollars have been directed towards sea lion research programs. This is larger than the entire budget for all other species of marine mammals worldwide. Such a massive infusion of funding has allowed an incredible amount of information to be collected about sea lions that would not have been possible otherwise. It has allowed the research community to test ideas and theories directly challenging all three theories (bottom-up, lateral, and top-down). Currently, the weight of evidence suggests that bottom-up limitations are not well supported, that lateral issues are not significant, and that top-down scenarios best fit the sea lion data.

However, even if it turns out that killer whales are keeping sea lions from recovering, the ESA requires that any human activity that could impede sea lion recovery must be carefully examined and potentially limited or prohibited. Thus, if one makes the argument that the removal of any fish from around a

rookery would be bad for sea lions, then fishing restrictions would still be allowed, even if fish removal was not the major cause of the sea lion decline.

These are not simple decisions and they are certainly not only biological ones. Society must weigh the issues and make decisions. At what cost do we protect the Steller sea lion?

This module has focused on the issue that the study of marine mammals, especially in Alaska, is not a field that involves only watching, counting, and studying behaviour. In Alaska, marine mammals are an integral part of the social, cultural, economic, and political reality. Every study of marine mammals, whether it seems simple or not, is part of a much larger question that ultimately could end up in a management decision, a lawsuit, or a public debate. Certainly, the biopolitics of marine mammals in Alaska is a major concern for all in the state who interact with these fascinating creatures.

Glossary of Terms

Aleutian Islands	the chain of Alaskan islands forming an arc westward into the Pacific Ocean.
body condition	an estimate of the health and energy balance of an animal.
body mass	the weight of an animal.
cetaceans	the group of animals that includes all whales, dolphins, and porpoises.
Congress	the national legislative body of the United States, comprising the House of Representatives and the Senate.
eastern population	the population of Steller sea lions living east of longitude 144° West, which runs through the middle of the Gulf of Alaska.
Endangered Species Act (ESA)	a US law to protect species that might become extinct.
index sites	locations along the Alaska coastline where sea lions are routinely counted.
marine mammal	seals, sea lions, whales, walruses, sea otters, and polar bears.
Marine Mammal Protection Act (MMPA)	a US law for the special protection of marine mammals.

pinniped	*adjective* denoting any aquatic mammal with limbs ending in fins. *noun* a pinniped mammal; the group of animals that includes seals, sea lions, and walruses.
Steller sea lions	the largest of all sea lions; lives in the North Pacific Ocean.
subsistence	human hunting for basic food requirements.
threatened species	under the ENDANGERED SPECIES ACT (ESA), a species that could become endangered in the future.
western population	the population of Steller sea lions living west of longitude 144° West, which runs through the middle of the Gulf of Alaska.

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