

## 9 The Population Decline of Steller Sea Lions

### *Testing the Nutritional Stress Hypothesis*

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#### INTRODUCTION

Steller sea lions (*Eumetopias jubatus*) are the largest of the otariids, or eared seal subfamily, and certainly one of the most difficult to study. This difficulty has been an important determinate of our unfortunate inability, despite over a decade of intensive research, to satisfactorily explain the precipitous population decline of Steller sea lions (a decline that continues, albeit at a more moderate rate than at the beginning of our population monitoring). The decline was so severe that in November 1990 the United States National Marine Fisheries Service (NMFS) listed Steller sea lions as threatened under the Endangered Species Act. In June 1997, because of continued population declines, NMFS declared Steller sea lions as endangered throughout much of their range. As soon as Steller sea lions became a listed species, the amount of research devoted to determining the cause or causes of the decline increased dramatically. Although field experiments have not been conducted, a combination of laboratory experimentation and field observations has resulted in many insights and, one hopes, will eventually lead to an understanding of the factors that are currently limiting the recovery of Steller sea lions.

Adult male Steller sea lions are an impressive sight, weighing up to 1100 kg, but in this sexually dimorphic species, the females average only 250 kg. Pupping occurs from late May through early July, on rookeries that span the Pacific Rim from northern Japan to central California (Pitcher and Calkins 1981). Females give birth to a single pup, and although the exact timing of weaning is unknown, most mothers are thought to wean their pup just prior to giving birth in the subsequent breeding season. Interbirth intervals have not been determined for individual sea lions. Some females have been

observed to continue nursing their young for as long as 3 years. After giving birth, females remain on the rookery to nurse their pups for approximately 9 days. After this perinatal period, females alternate periods of foraging at sea with periods of suckling on shore. Until pups are about 3 months old, they usually remain on the rookery during their mothers' foraging trips.

Although Steller sea lions occur throughout the Pacific Rim, the center of their abundance and distribution was, in the 1970s, from the western end of the Aleutian Islands to the center of the Gulf of Alaska. Evidence from mitochondrial DNA and morphology suggests that there are at least two distinct stocks, a western and an eastern stock, with the dividing line at 144° west longitude, on the edge of Prince William Sound, in the eastern Gulf of Alaska (Bickham, Patton, and Loughlin 1996; Loughlin 1997). In the mid-1960s, there were probably between 200,000 and 300,000 Steller sea lions in the western stock, but by the time that stock was declared endangered in 1997, it had declined by over 75%, to approximately 40,000 individuals (Loughlin 1998). In contrast, over the same period the eastern stock remained stable or increased slightly, with a population size of around 20,000 (Calkins, McAllister, and Pitcher 1999). Therefore, when the NMFS modified the listing status of the Steller sea lion in 1997, the western stock was declared endangered and the eastern stock remained in the threatened category.

While there are a large number of possible causes of the population decline of the western stock, early concerns were raised about the potentially negative impact of the developing groundfish fishery in the Gulf of Alaska and the Bering Sea (Braham, Everitt, and Rugh 1980; Loughlin and Merrick 1989). The take of this fishery was increasing during the period that the sea lion population was dwindling, and the fishery is now valued at nearly U.S.\$1 billion per year, making it one of the largest fisheries in the world. Because of the potential interaction between this fishery and Steller sea lions, management regulations have been imposed upon the fishery, with some parties stating that the management actions have been too severe and others claiming they do not go far enough to protect the sea lions. This disagreement has led to a great deal of interest, and controversy, regarding the cause or causes of the decline in the Steller sea lion population.

#### POTENTIAL CAUSES OF THE POPULATION DECLINE

There are undoubtedly a large number of possible proximate causes of the Steller sea lion population decline, but there are really only four ultimate

TABLE 9.1 Potential causes of population decline of the western stock of Steller sea lions

| Ultimate Causes             | Proximate Causes  |
|-----------------------------|---|
| Decreased adult survival    | Disease   |
| Decreased juvenile survival | Pollution   |
| Decreased fecundity         | Direct human killing  |
| Increased emigration        | Increased predation   |
|                             | Environmental change  |
|                             | Nutritional stress: changes (either natural or anthropogenic) in prey availability or quality |

mechanisms to consider: a decline in adult survival, a decline in juvenile survival, a decline in fecundity, or an increase in emigration out of the western stock (Table 9.1). Emigration is an unlikely explanation because rangewide surveys conducted since 1989 have failed to find large numbers of "missing" sea lions (Loughlin 1998). Decreased fecundity, on the other hand, may play an important role. The pregnancy rate of adult females collected in the mid-1970s was 67%, whereas the pregnancy rate was only 55% in females collected in the mid-1980s (Pitcher et al. 1998). This difference, however, was not statistically significant. A modeling study of the population suggested that a much larger decrease in fecundity would have been necessary to explain the observed population decrease (York 1994).

Direct measurements of survival, such as from mark-recapture studies, have not been systematically made on Steller sea lions. There is, however, some evidence that juvenile survival has decreased. The mean age of the adult females collected in the 1980s (Calkins and Goodwin 1988) was about 1.5 years less than the mean age of females collected in the 1970s and modeling suggested that this reflects a decrease in juvenile survival (York 1994). The model also showed that a 10–20% decrease in juvenile survival was the most likely cause of the population decline in the western stock. This model, however, was based on samples of sea lions that were not randomly collected, and therefore these conclusions must be viewed with caution. Further support for a decrease in juvenile survival comes from the observations of a low number of juveniles compared with adults during aerial surveys of haulouts (Loughlin 1998), although the low number of juveniles could also be the result of low fecundity.

### Proximate Causes

A few of the proximate causes for a decrease in either fecundity or juvenile survival are listed in Table 9.1. Although much more work is under way, there is no evidence yet that either disease or pollution played a large role in the population decline (Loughlin 1998). Some Steller sea lions are likely to have died as incidental catch in fishing nets or as a result of having become entangled in marine debris, but this loss was unlikely to have been a major determinant of the decline. Direct killing of sea lions, whether for subsistence or to prevent damage to gear, may have removed a large number of sea lions, especially during the 1970s, but it probably accounted for only a small part of the decline (Trites and Larkin 1992). Currently, subsistence take is only a few hundred sea lions per year, and illegal killing is thought to have been nearly eliminated. The impact of predation by killer whales (*Orcinus orca*) and sharks is difficult to estimate because there have been few observations of such attacks, and these predators are difficult to census. Estimates of the population size of marine mammal-eating killer whales in western Alaska and their energy intake needs have led to the conclusion that although killer whale predation was probably not the primary cause of the Steller sea lion population decline during the 1970s and 1980s, killer whales may currently be responsible for a large fraction of sea lion mortality, now that the population is so much smaller (Barrett-Lennard et al. 1995).

Environmental change, such as increases in sea surface temperature, changes in ocean current patterns, or increases in the frequency of big storms, could impact the survival of Steller sea lions in many ways. For one thing, these changes are likely to affect the sea lions' prey, and it has been frequently proposed that the population decline of Steller sea lions was caused by food limitation, a proposition that has been termed the "nutritional stress hypothesis" (e.g., Alaska Sea Grant 1993; DeMaster and Atkinson 2002). The main evidence that Steller sea lions in the western stock were nutritionally stressed during the period when their population was declining comes from a comparison of female sea lions collected from 1975 to 1978 with females collected from 1985 to 1986 (Calkins and Goodwin 1988). The earlier collection coincided with the approximate start of the decline, and the later collection occurred during a time when the population was declining sharply. The comparison showed that the 1980s females were shorter, thinner, and less massive, so that overall body growth was reduced compared with that of the 1970s females (Calkins, Becker, and Pitcher 1998). Additional support for the nutritional stress hypothesis was that late gestation preg-

nancy rates fell from 67% in the 1970s to only 55% in the 1980s (Pitcher et al. 1998). Although this difference was not statistically significant, the population decline may have already been under way at the time the first collections were made (Calkins, Becker, and Pitcher 1998), so perhaps the surprisingly low pregnancy rate from the 1970s was depressed below a previously unstressed level. Although these results have been taken to indicate that nutritional stress may have contributed to the decline of Steller sea lions throughout the range of the western stock, it should be noted that the collections were made primarily in the central Gulf of Alaska, with the majority in the Kodiak Island area. In the mid-1970s, the total population in the central Gulf of Alaska region was only about 30% of the entire western stock (Trites and Larkin 1996), so these samples may not necessarily be representative of the entire declining population.

It has been suggested that additional support for the nutritional stress hypothesis comes from the concurrence of the timing of the start of the population decline and a "regime shift" of climatic and oceanographic conditions in the North Pacific that is postulated to have occurred around 1977 (Alaska Sea Grant 1993; Francis et al. 1998; Anderson and Piatt 1999). This regime shift consisted primarily of an intensification and a shift in the location of the wintertime Aleutian low-pressure cell, which led to stronger westerly winds and warmer surface waters in the Gulf of Alaska. These physical changes are thought to be linked to biological responses through their effect on ocean circulation and mixing and air-sea heat exchange (Francis et al. 1998). Numerous authors have concluded that the 1977 regime shift reduced the carrying capacity for many populations of marine mammals and birds in the North Pacific because of a transition from an ecosystem dominated by shrimp and forage fish to one dominated by pollock and large flatfish. This switch in the marine community might have been important to Steller sea lions because pollock usually have a much lower energy density than fatty forage fishes such as herring. Furthermore, there is some indication that the diet of Steller sea lions in at least part of the western range did change around this time, with pollock becoming more common in the diet after the mid-1970s (Alaska Sea Grant 1993; Merrick and Calkins 1996).

Some caveats, however, should be noted concerning the regime shift's proposed effect on prey availability and the resulting possible exposure to nutritional stress. Much of the evidence for the regime shift's effect on the ecosystem is based upon trawl surveys that were intended to assess the abundance of shrimp and that were conducted in limited inshore areas of the Gulf of Alaska (Anderson and Piatt 1999; Mueter and Norcross 2000).

Although the results of those studies might lead one to conclude that pollock were not very plentiful in the North Pacific prior to the mid-1970s, more wide-scale assessments that specifically targeted pollock show that in fact they were abundant throughout the Gulf of Alaska and the Eastern Bering Sea in the 1960s and early 1970s, although there clearly was a strong year class in 1978 that might have benefited from the 1977 regime shift (Bakkala 1993). Herring have been cited as an example of fatty forage fish that once were prevalent in sea lion diets but became less common because of their decline after the 1977 regime shift. Herring in the eastern Bering Sea, however, appear to have been increasing throughout the 1970s (Wespestad 1991). Furthermore, during the 1960s and 1970s, eastern Bering Sea pollock abundance was nearly an order of magnitude higher than herring abundance.

The data on Steller sea lion food habits prior to the mid-1970s are so limited in sample size and geographic coverage that participants in a 1991 workshop entitled *Is It Food?* concluded that no firm conclusions on the composition of the Steller sea lion diet before 1975 could be drawn. Subsequent diet data from the stomachs of the sea lions collected from 1975 to 1978 and from 1985 to 1986 did indicate that the proportion of sea lions that consumed pollock increased in the Kodiak Island area, but the limited geographic range of those results should prevent one from drawing conclusions that apply to the entire western stock. Additionally, because the mean size of the pollock found in the stomachs from the mid-1980s collections was smaller than that of the pollock from the mid-1970s stomachs, the total amount of pollock consumed by individual sea lions may actually have decreased, not increased (Merrick and Calkins 1996). Nonetheless, the cumulative evidence in support of the nutritional stress hypothesis was so strong that for most of the 1990s it was the leading hypothesis to explain the decline of Steller sea lions and therefore the hypothesis that received the greatest amount of testing. The following review is not meant to be comprehensive, but I will attempt to highlight some of the tests of the nutritional stress hypothesis that I am most familiar with.

#### LABORATORY EXPERIMENTS AND THE NUTRITIONAL STRESS HYPOTHESIS

Laboratory projects that have been designed to contribute to understanding the role of nutritional stress in the decline of Steller sea lions can be divided into at least three categories: studies that provide basic information on the life history, behavior, or physiology of sea lions; studies to develop or vali-

date techniques that will be subsequently used in the field; and studies that directly test elements of the nutritional stress hypothesis. All three types of studies have been conducted by investigators at the University of British Columbia and the Vancouver Aquarium Marine Science Center, where research with captive Steller sea lions has been pioneered over the last 9 years. Such work has also recently been accomplished at the Mystic Aquarium, in Connecticut, and at the Alaska SeaLife Center, a new facility designed from the ground up to facilitate research on captive marine mammals and other organisms from the North Pacific.

Studies designed to supply basic biological information include those that are providing measurements of the bioenergetic parameters required to estimate the daily energy expenditures of wild sea lions and to estimate how energy balance might be affected by changes in the environment. For example, a recent study on juvenile Steller sea lions swimming in a swim flume has determined the cost of transport at different speeds (Rosen and Trites 2002). These results can be used to estimate the additional costs that might be incurred by sea lions if the distribution of their prey source shifted further offshore, which would require greater swimming distances (Rosen and Trites 2002). One must be mindful, however, of the potential artifacts or biases associated with data collected in a laboratory experiment. In this case, for example, the costs of transport are likely to be overestimated because the swim flume requires the sea lions to swim at a depth less than three times their body diameter. In the wild, sea lions are likely to spend a considerable portion of their time swimming at deeper depths, where the absence of wave drag reduces the cost of swimming.

Although bioenergetic modeling based on data collected in the lab can be quite useful, it would be very valuable if energetic measurements of free-ranging Steller sea lions could be made routinely. The doubly-labeled-water method has been frequently used on pinnipeds in the past, but this method is less than ideal. The method requires that subjects be recaptured for a blood sample, the measurement period is severely limited (5–10 days), and the result obtained is simply the average metabolic rate over the measurement period, with no information on a finer timescale or for individual behaviors. Butler (1993) has suggested that because there appears to be a strong relationship between metabolic rate and heart rate in many animals, the recording of heart rate in seabirds and marine mammals might overcome the limitations imposed by the doubly-labeled-water method. A relationship between heart rate and oxygen consumption for fasted juvenile Steller sea lions was determined by monitoring both variables from captive sea lions at the Vancouver Aquarium over a range of workloads, from rest-

ing in air to swimming at up to  $1.5 \text{ m s}^{-1}$  in a swim flume (McPhee et al. 2003). However, the validity of applying these equations to free-ranging sea lions was called into question when we tested the relationship on a captive male sea lion performing trials that involved the ingestion of a large meal just prior to a 3-hour swim period. In those trials, the heart rate–metabolic rate relationship from fasted animals significantly underestimated oxygen consumption. In addition to the effects of feeding, we are also concerned about the effects of diving and its accompanying cardiovascular adjustments on the relationship. Therefore, we will now have to consider conducting further experiments that more closely match the conditions expected in free-ranging sea lions before attempting to apply this method to animals in the wild.

To test some of the predictions of the nutritional stress hypothesis, we need tools to remotely monitor the foraging behavior of Steller sea lions. Satellite tracking devices and time–depth recorders (TDRs) allow investigators to monitor beyond visual range as animals migrate out into the open ocean and dive beneath the surface, but these techniques do not provide direct evidence of foraging. Most investigators have usually inferred foraging behavior from the shape of time–depth profiles and movements at sea. A direct method of measuring prey ingestion was suggested decades ago (Mackay 1964), but it was not applied to studies of marine animal foraging until recently (Wilson, Cooper, and Plotz 1992). This method relies on the drop in stomach temperature that occurs when a warm endotherm ingests much cooler, ectothermic prey. Captive juvenile Steller sea lions at the Vancouver Aquarium were used to successfully develop and validate the use of stomach temperature monitoring to determine the timing and quantity of prey ingestion in Steller sea lions (Andrews 1998). Estimation of the quantity of ingested prey was complicated by many factors (e.g., body temperature and stomach heat flux changes, movement of the stomach temperature transmitter within the stomach, diverse prey size and shape, potentially concomitant water ingestion, and insulation of the transmitter by previously swallowed prey) and suffered a large margin of error. Determination of the timing of ingestion, however, was much more accurate, at least for the first few ingestion events in a bout of feeding, and was subsequently used in some field studies that are described below.

Laboratory experiments have also been designed to directly test the nutritional stress hypothesis, and they have been particularly useful for examining the potential consequences of reductions in prey quantity or quality. One prediction of the nutritional stress hypothesis is that the health or body condition of Steller sea lions, and therefore eventually their survival

or fecundity, will be reduced in response to switching to a diet that has a relatively low energy density. However, most wild animals are known to be adept at coping with fluctuations in energy supply, and they can compensate through various mechanisms, such as by increasing food intake or by reducing activity or even maintenance metabolism (King and Murphy 1985). Rosen and Trites (2000) examined the effect of switching the diet of six captive juvenile Steller sea lions from their normal diet of 100% herring (approximate energy density of 7 kJ g<sup>-1</sup>) to a diet of 100% pollock (approximate energy density of 4.6 kJ g<sup>-1</sup>) for an 11-23-day period. The sea lions did not increase their daily food intake and were unable to maintain body mass on the pollock diet. Despite a 15% reduction in resting metabolic rate, the sea lions lost an average of 6.5% of their body mass by the end of the 2-week-long pollock trials. Ingested food mass did not change compared with the previous or subsequent herring feeding periods, but the authors calculated that gross energy intake was substantially reduced during pollock feeding because of the lower energy density, lower digestive efficiency, and higher percentage of gross energy intake devoted to the heat increment of feeding (Rosen and Trites 2000).

Taken at face value, this experiment would seem to strongly support the hypothesis that Steller sea lion populations declined at least in part because of the poor nutritional quality of pollock (assuming one accepts the premise that the consumption of pollock increased after the mid-1970s). However, this conclusion might be premature, for a number of reasons. Limitations of this study included the constraint that sea lions were allowed access to food only during the two to three times per day that their trainers offered it by hand, that the experimental period might have been too short to allow a compensatory adaptation to the new prey source, and that there was no control for seasonal effects, such as programmed body mass or food intake changes. Researchers at the Vancouver Aquarium are hoping to repeat these experiments utilizing a protocol that allows the sea lions free access to their prey, a truly *ad libitum* feeding trial, and a longer time period (D. Rosen, personal communication). A similar feeding experiment was conducted on harbor seals that were switched from a 100% herring diet to a 100% pollock diet. In this study, however, each experimental diet period lasted for 4 months and was repeated at three different times of the year. The results showed that seals can compensate so as to maintain body mass and fat stores even when feeding exclusively on pollock (Castellini et al. 2001).

An experiment that more closely approximates the diet shift that may have occurred among some Steller sea lions in the western stock is currently under way at the Alaska SeaLife Center. This experiment involves three

different mixed diets, which are based on the predecline and postdecline diets of the Kodiak Island area and the current diet in southeast Alaska, where sea lion numbers appear to be increasing. Sea lions are maintained on each diet for 4 months, and the trials are repeated at different times of the year to control for seasonal effects. Preliminary results suggest that, like harbor seals, Steller sea lions are indeed capable of adjusting to diets of lower energy density and that it is important to consider seasonal changes in body mass and metabolism (Castellini et al. 2001).

## FIELD STUDIES

A decrease in juvenile survival could be due to the inability of mothers to adequately nourish their pups during lactation or to the inability of weaned juveniles to successfully forage on their own. Other pinniped species have been observed to respond to apparent nutritional stress by increasing female foraging trip durations during lactation, increasing energy expenditure during foraging, or both. Studying the foraging behavior and energetics of pups and lactating females should reveal whether Steller sea lions are food stressed in the areas where their numbers continue to decline. Predictions from the nutritional stress hypothesis include the following: lactating female Steller sea lions will increase their foraging effort in the area of population decline, and this increase may be reflected in increased energy expenditure or a change in diving strategy, such as a reduction in the time spent resting; foraging trip durations will be longer in the area of decline; and sea lions in the area of decline will travel for a longer period, cover greater distances before successfully finding and ingesting prey, or both.

In June 1997, a test of the nutritional stress hypothesis was conducted (Andrews et al. 2002). Steller sea lions were studied at two of the central Aleutian Islands, Seguam and Yunaska, and at the Forrester Island rookery complex in southeast Alaska. At the time of the study, the population at Seguam Island was declining by about 5% per year, whereas sea lion numbers at Forrester Island were stable. In the central Aleutians, five lactating Steller sea lions were captured and instrumented with devices to remotely monitor their foraging behavior (Andrews 1998). Four of the sea lions were recaptured, but because one had lost her instrument package, only three foraging records were recovered from this area. Near Forrester Island, ten lactating Steller sea lions were captured and instrumented. Five of these were recaptured and produced successful data records. During the research cruise near Forrester Island, real-time satellite tracking data on the at-sea locations

of sea lions were relayed to a vessel conducting a fish assessment around Forrester Island, and a similar fish assessment occurred around Seguam Island that summer.

Although a great deal of variability in foraging behavior was observed (both at the individual and group level), some basic differences between Steller sea lions from the different regions were identified. Trip durations and the percentage of time spent at sea were much shorter for Steller sea lions from Seguam Island compared with those from the Forrester Island rookery. The short trips at Seguam Island generally consisted of a single bout of uninterrupted dive cycles, whereas at Forrester Island the trips were broken into dive bouts of varying length separated by periods spent traveling or resting at the surface. On average, however, the proportion of a trip spent submerged was not different. Another measure of foraging effort, the vertical travel distance per unit time at sea, was about 1.5 times as great for Steller sea lions at Forrester Island. The at-sea field metabolic rates, however, were similar for both groups. Data on the time and distance elapsed from departure on a foraging trip until commencement of foraging dives showed that at both rookeries Steller sea lions appeared to begin searching for prey soon after entering the water. If sea lions swam in a straight line away from the rookery at 1.5 to 2.5 m sec<sup>-1</sup>, they would have traveled between 1 and 5 km away from the rookery before commencing foraging dives at both Seguam and Forrester. However, the mean time from departure until the first prey-ingestion event identified on the stomach temperature record was about 5 times as long for Steller sea lions at Forrester Island compared to those at Seguam Island. The rough estimation of prey intake rate at Seguam Island was about 2 times that at Forrester Island. Therefore, it would appear that in 1997, adult female Steller sea lions at Seguam Island found suitable prey much quicker, and once they found it, they were able to ingest it at a much higher rate than Steller sea lions at Forrester Island.

The higher prey-capture rate of Steller sea lions at Seguam apparently allowed them to spend shorter periods away from their pups and thereby spend a greater proportion of total time suckling their pups. This increase may account for the nearly doubled pup-growth rates measured in the central Aleutians compared with Forrester Island (Brandon 2000). Surprisingly, all these results were opposite the predictions of our original hypothesis. Our hypothesis was based on the premise that prey availability around the central Aleutian Islands, where the sea lion population continued to decline, was lower than that around Forrester Island. The results of the fish assessments, however, did not support this premise. Catch per unit effort for the

fishing vessel at Seguam and another central Aleutians rookery was much higher than that at Forrester Island.

Several factors restrict our ability to infer causes of either the past or current Steller sea lion population decline from this limited comparison of the foraging ecology of Steller sea lions from the declining and stable populations: extremely small sample sizes, the possibility of adverse effects of the instruments on foraging behavior and energetics, the difference between the current rate of decline and the larger rate from 1979 to 1990, density-dependent effects on individual foraging success (reduced population size implies reduced intraspecific competition), and the potential interannual variations in many environmental parameters (e.g., the 1997 El Niño and the anomalous conditions in the Bering Sea that year). Nonetheless, the direct comparison between two similarly handled groups should allow at least a tentative conclusion to be drawn. There was no evidence that lactating females at Seguam Island were nutritionally stressed in 1997.

Other studies of maternal attendance, pup birth weights, and pup growth seem to support the conclusion that throughout the 1990s adult females did not appear to be suffering from nutritional stress (Merrick et al. 1995; Davis et al. 2002). These results, of course, tell us little about the role of nutritional stress before the 1990s when the population decline was most severe. It is also worth noting that even during the 1990s, studies of lactating females were conducted only at a small subset of rookeries in the range of the western stock. There is at least one other reason that nutritional stress cannot be ruled out as a factor in the population declines of the 1990s. Adult females without pups have not been studied, and if birth rates continue to be as low as 55%, this omission may be important. It is possible that females may have to reach a threshold body condition to implant a fetus or carry it to term. If this is the case, then the healthy females with pups that have been studied to date may not be truly representative of the population. A large number of new studies are currently in progress, so perhaps a more complete understanding of the problem will soon be attained.

Given the theme of this book, it would have been useful if I could have reviewed the results of an experiment that tested the efficacy of some of the management actions that have been taken over the last decade to protect Steller sea lions. Such experiments, however, have not been conducted. Many experts seem to agree that the existing data are inadequate to determine whether fisheries in the Gulf of Alaska and the Bering Sea are adversely affecting Steller sea lions. Therefore, it might be quite worthwhile to conduct large-scale experiments to determine the effects of fishing on Steller sea lion prey and on the sea lions themselves. Such a proposal raises the ethical ques-

tion of whether experiments of this type should be conducted on endangered species. There should be little disagreement, however, that the laboratory experiments conducted on Steller sea lions have provided valuable information. As long as they are scientifically justifiable, these experiments should continue because they are essential to our understanding of Steller sea lions and the factors that might be contributing to their population decline.

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