

SCOMM

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Dr. Andrew W. Trites

Dr. Trites received his B.Sc. in Ecology and Mathematics at McGill University in Montreal in 1980, his M.Sc. in Zoology from the University of British Columbia in 1984 and his Ph.D. in Zoology from the University of British Columbia in 1990.

He is currently Assistant Professor of the Fisheries Centre and Zoology Department at the University of British Columbia. Since 1992 Dr. Trites has served as Director of the Marine Mammal Research Unit and Research Coordinator for the North Pacific Universities Marine Mammal Research Consortium. From 1990 to 1992 he was NSERC Post-Doctoral Fellow, Fisheries & Oceans Canada, Pacific Biological Station in Nanaimo, B. C. From 1982 to 1992 he worked as a private consultant.

The North Pacific Universities Marine Mammal Research Consortium was formed by a broad-based coalition of North Pacific fishing industry groups in 1992. The industry groups joined forces to fund an independent research effort whose immediate priority was to piece together the Steller sea lion puzzle. The consortium was formed with four participating institutions: The University of Alaska, The University of British Columbia, the University of Washington and Oregon State University. The mission of the Consortium is to undertake a long term program of research on the relation between fisheries and marine mammals in the North Pacific Ocean and Eastern Bering Sea. Studies focus initially on the biology of the Steller sea lion and could include research on the effects of species interactions and oceanographic conditions on changes in sea lion abundance. The scope of the Consortium could subsequently be broadened to include other marine mammals and possibly sea birds.

Dr. Trites resides in Vancouver, B. C. is married and has two children.

The North Pacific Universities Marine Mammal Research Consortium

Major changes have taken place in the population dynamics of marine life in the North Pacific. Stocks of crab and herring have declined, while pollock and salmon populations have increased dramatically. At the same time, some marine mammals have flourished while others have declined.

Nowhere are the changes more evident than in the Gulf of Alaska and Bering Sea, where the Steller sea lion population has undergone a dramatic - and mysterious - decline over the past two decades.

No one knows why Steller sea lions are declining in the North Pacific. But many have speculated that commercial fishing may be to blame. As a result, the National Marine Fisheries Service (NMFS) has placed some restrictions on commercial fishing in the Bering Sea and the Gulf of Alaska. Unfortunately for the fishing industry, many of the fishing restrictions have been implemented without sufficient data or the funding for the research that would provide complete data on the possible effects that fishing might have had on Steller sea lions.

Research: An Urgent Priority

Both the fishing industry and regulators know that resource management decisions should be steered by credible scientific data, not speculation and emotion. For this reason, a broad-based coalition of North Pacific fishing industry groups joined forces to fund an independent research effort. The immediate priority is to piece together the Steller sea lion puzzle.

The North Pacific Universities Marine

Mammal Research Consortium is spearheading the industry sponsored research program. It is a multi-disciplinary team of scientists from the Universities

of Alaska, British Columbia, and Washington, as well as Oregon State University. The team is studying the biology, feeding ecology and developmental phases of Steller sea lions. They are working to understand the factors affecting sea lion survival and the relationship between commercial fishing and marine mammals in the North Pacific. With time, the scope of research will be broadened to include other marine mammals such as harbor seals and whales.

Disappearing Sea Lions

Steller sea lions are declining and have fallen by over 65% since 1980. Once numbering about 225,000; fewer than 85,000 remain in Alaska today. In 1990, Steller sea lions were listed as a *threatened* species under the U.S. Endangered Species Act. Consideration is now being given to changing the classification to *endangered*. Such an action will likely have major ramifications for all sectors of the fishing industry.

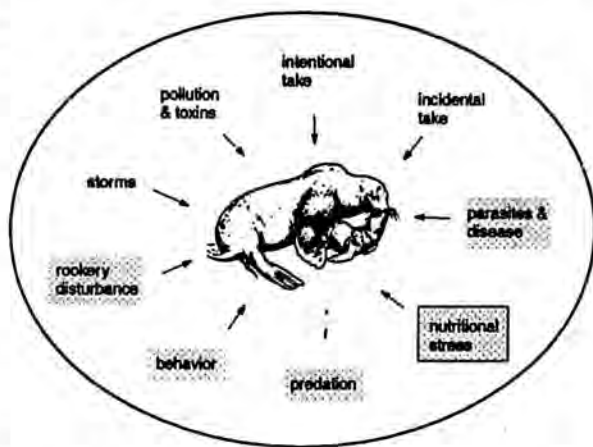
Why Steller sea lions have declined in Alaska remains unresolved. Possible causes are shown in the above diagram. Of the leading hypotheses

(shaded boxes), most of the Consortium's attention is focussed on nutritional stress which could be caused by competition with other species for food, or by natural and/or human induced changes in the ecosystem. For the most part, data to assess each of the possibilities is currently limited.

In the spring of 1993, the Consortium began a 5-year program to conduct research on Steller sea lions that builds on the work carried out by the National Marine Fisheries Service, the Alaska

Department of Fish and Game (ADF&G), and Fisheries and Oceans, Canada. It combines the skills and talents of university scientists and is designed to complement ongoing research.

The research program contains three



components: field studies, captive studies, and laboratory and data analysis.

The essence of the field program is a comparison of a healthy sea lion rookery in Southeast Alaska with a declining rookery near Kodiak Island; and is being done in collaboration with the ADF&G.

Captive studies began with the capture of 6 Steller sea lion pups from a Canadian rookery, and held in research facilities

donated by the Vancouver Aquarium. The captive studies are providing data about nutritional requirements that cannot be established in the wild, and a means of testing and developing new

techniques for studying sea lions and their diet in the wild.

The third group of studies comprise analysis of historical data sets and development of new laboratory techniques for processing biological samples.

The research program is designed to address the leading hypotheses put forward to explain the decline of Steller sea lions in Alaska. In addition it also considers other aspects of the North Pacific ecosystem, including assessment of population abundance.



The research program is overseen by a Management Committee comprising representatives of universities, industry and government agencies. A Research Committee composed of research leaders at the various universities and government agencies is responsible for conducting the research and for reporting on progress to the Management Committee.

Commercial Fisheries

The Marine Mammal Protection Act was amended by Congress on April 30, 1994. Significant changes were made to the current regime governing marine mammals caught incidentally to commercial fishing. The amendments are not yet fully implemented, but should be in place by September 1995. Until then, the Interim Exemption to the prohibition on incidental take due to commercial fishing remains in effect.

The new law will require that all owners or operators of commercial vessels in all fisheries report incidental death or injury of marine mammals to NMFS on a postage paid form (currently being developed) within 48 hours after the end of each fishing trip. NMFS will also be required to assess the status of every population of marine mammals in U.S. waters. The review must describe the commercial fisheries that are likely to have contact with a particular stock, and estimate the number of animals that can be removed without interfering with its ability to reach or maintain optimum sustainable levels.

Within 90 days of enactment of the amendments, NMFS is required to publish a list of fisheries that interact with marine mammals. Each fishery will be categorized

by its rate of incidental mortality or serious injury to marine mammals as frequent, occasional or unlikely. Vessels in the first two categories will register with NMFS and receive a decal that must be displayed. NMFS can permit the taking of endangered and threatened species for 3-year periods provided that it has a negligible impact on the stock and that a recovery plan has been or is being developed for the species.

The amendments allow persons to prevent marine mammals from damaging private or public property, or from endangering personal safety, as long as the animal is not killed or injured.

However, the amendments prohibit intentionally killing or injuring a marine mammal. Acceptable and non-acceptable deterrence methods should be published by NMFS later this year. In addition, the 1994 amendments reaffirms the zero mortality rate goal caused by incidental takes and specifies that all fisheries must attain the goal within 7 years.

1994 Census

Results of this summer's Steller sea lion census were recently released by NMFS and ADF&G. They paint a rather dismal

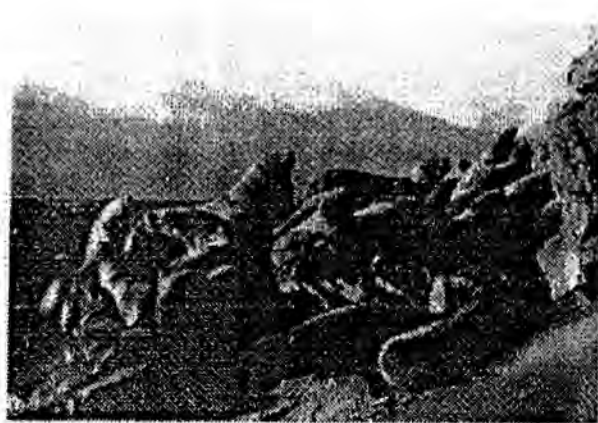
picture. Pup numbers declined in all regions of Alaska, with the sharpest drop (20%) in the central Aleutians (from 1991/92 to 1993/94). Counts of adults and juveniles

are also down, dropping 5% per year since the last survey in 1992.

Of particular concern is an apparent decline in pup numbers in southeast Alaska, which until now was considered to

Our research program is designed to address the leading hypotheses put forward to explain the decline of Steller sea lions in Alaska

Changing the classification of Steller sea lions from *threatened* to *endangered* could have major ramifications for all sectors of the fishing industry



be healthy and increasing. However no decline was noted in numbers of juveniles and adults. It is not clear whether the decline that began in the Aleutians is moving southward.

You Can Help

Funding of \$300,000 per year for the Consortium's research program is provided by the North Pacific Marine Science Foundation, formed especially for the purpose. In 1994, tax deductible contributions to the Foundation came from a wide spectrum of donors representative of the industry.

Many members of the fishing industry have decided the time has come for them to take action if their industry is to survive. They urge you to also become involved by encouraging you and your associations to pledge financial support so that incomplete scientific data does not undermine the future of the North Pacific fisheries. Contributions can be sent to:

North Pacific Marine Science Foundation
c/o Farrell A. Born, CPA
2150 6th Ave North, Suite 202
Seattle, WA 98109

Additional information about the Foundation can be obtained from John Roos (206) 281-1667. For further information on the research program, call or write to Dr. A.W. Trites at the address below. We would be pleased to answer your questions or to send you more information.

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University of Alaska
University of British Columbia
University of Washington
Oregon State University

The North Pacific Universities Marine Mammal Research Consortium

ANNUAL REPORT
1993

THE UNIVERSITY OF ALASKA
THE UNIVERSITY OF BRITISH COLUMBIA
THE UNIVERSITY OF WASHINGTON
OREGON STATE UNIVERSITY



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THE PROBLEM

Over the past few decades, major changes have occurred in the abundance of seals, whales and seabirds breeding in the North Pacific. In Alaska, northern fur seals are now *depleted*, while Steller sea lions are *threatened*, and harbour seal numbers are greatly reduced. Similar declines have been reported in some seabird breeding colonies. In British Columbia, Steller sea lion numbers seem stable, but harbour seal populations have increased rapidly. Further south, striking increases are also being observed in the range and abundance of elephant seals and California sea lions.

Such large scale changes may be a natural phenomenon or may be causally connected with similar changes occurring concomitantly in a number of commercial fisheries. All told, they stand to impact the economic development of commercial fisheries throughout the North Pacific.

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Dr. Andrew W. Trites	University of British Columbia

THE CONSORTIUM

In the summer of 1992, John Roos (Vice President of the Pacific Seafood Processors Association) writing on behalf of a group of representatives of the fishing industry, requested Pacific northwest universities to submit proposals for research concerning the decline in abundance of Steller sea lions in the Gulf of Alaska and the Bering Sea. From that request, the *North Pacific Universities Marine Mammal Research Consortium* was formed with four participating institutions: The University of Alaska, The University of British Columbia, The University of Washington, and Oregon State University.

The mission of the Consortium is *to undertake a long term program of research on the relation between fisheries and marine mammals in the North Pacific Ocean and Eastern Bering Sea. Studies will focus initially on the biology of the Steller sea lion and could include research on the effects of species interactions and oceanographic conditions on changes in sea lion abundance. The scope could subsequently be broadened to include other marine mammals and possibly sea birds.*

BACKGROUND

Why Steller sea lions have declined in Alaska remains unresolved. Possible causes are shown in Figure 1 and include increased incidence of parasites and disease, predation by killer whales, meteorological changes (i.e., frequency of storms), pollution and toxic substances, entanglement in marine debris, incidental and intentional take by man, nutritional stress through competition with man or other species for food, or nutritional stress caused by natural and/or human-induced changes in the abundance, quality and distribution of prey. For the most part, data to assess each of the possibilities is currently limited.

In 1990, the Steller sea lion was listed as a *threatened* species under the *US Endangered Species Act*. A team appointed by the National Marine Fisheries Service developed a recovery plan in 1992 to review factors that may have affected the sea lion population and to identify actions needed to stop the decline and encourage population growth. Since then, the National Marine Fisheries Service has initiated a status review of Steller sea lions to determine whether a change in classification from *threatened* to *endangered* is warranted (November 1993).

Funding of \$300,000 per year for the research program of the Consortium is provided by the North Pacific Marine Science Foundation, formed especially for the purpose. Contributions to the Foundation have come from a wide spectrum of donors representative of the industry.

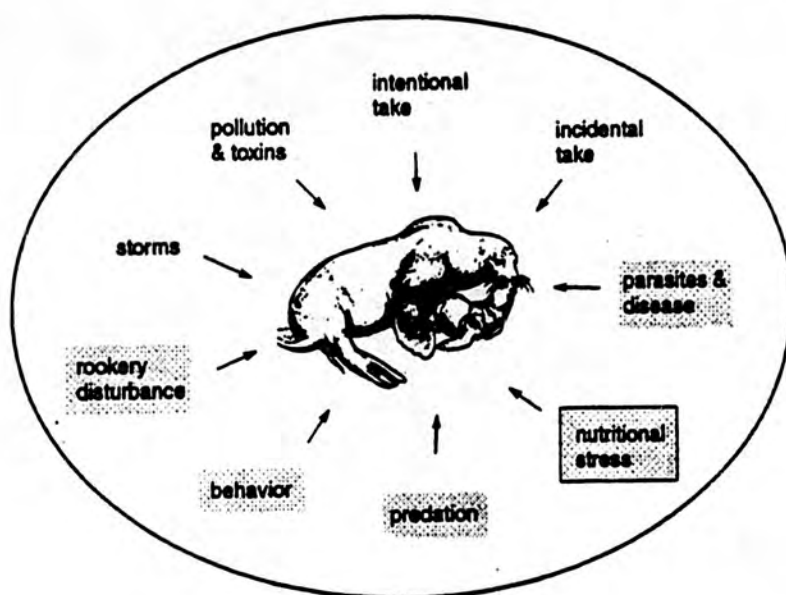
The research program is overseen by a Management Committee comprising representatives of universities, industry and government agencies. A Research Committee composed of research leaders at the various universities and government agencies is responsible for preparing a proposal for research each year and for reporting on progress to the Management Committee.

The Consortium is aided greatly in its work by the guidance and assistance provided by the United States National Marine Fisheries Service, the Alaska Department of Fish and Game, and Fisheries and Oceans Canada.

The first four months of the Consortium's work (September 1 to December 31, 1992) was devoted primarily to developing a research program for 1993. This report

concerns the accomplishments of that first full year of operation and briefly sketches the work proposed for 1994.

Figure 1



Future contributions of the Consortium will lead to a better understanding of the population biology of the Steller sea lion and, in due course, to other marine mammals of the North Pacific. The interactions of fisheries and marine mammals are the subject of intensive research in many parts of the world. They will be a major focus of research in the North Pacific for many years to come. The Consortium brings university resources to help to resolve the issues that arise.

The Marine Mammal Research Unit of the Fisheries Centre at the University of British Columbia administers the Consortium. Core staff of the Consortium consists of an overseer (Dr. P. A. Larkin), a research coordinator (Dr. A. W. Trites) and a part-time administrative manager (P. Rosenbaum).

THE FIVE YEAR RESEARCH PLAN

In January 1993, the Consortium developed a five year research plan to study marine mammal/fishery interactions in the North Pacific: most notably, the effects of commercial fisheries, species interactions and oceanographic conditions on changes in sea lion abundance. The program contains three components: (1) field studies, (2) captive studies, and (3) data analysis and laboratory studies. The essence of the field studies is comparison of a healthy sea lion rookery and a declining rookery at Forrester Island and Sugarloaf Island respectively (Figure 2). Captive studies on Steller sea lions held at the Vancouver Public Aquarium are providing data about nutritional requirements that cannot be established in the wild, and a means of testing and developing new techniques for studying sea lions in the wild. Analysis of historical data sets and development of new laboratory techniques for processing biological samples comprise the third group of studies.

The studies are a balance of short term and long term projects designed to help test the various hypotheses put forward to explain the decline of Steller sea lions (Figure 1). The studies are integrated and draw on the expertise and talents of university-based physiologists, ecologists, marine mammalogists, fisheries specialists and oceanographers. Only a concerted effort and a commitment to long term research will determine the causes of changes in the North Pacific and Bering Sea ecosystems in general, and of abundance of marine mammals in particular. Solutions are not likely to come quickly and will need a sustained effort. Our five year research plan contributes to this end.

Figure 2



RESEARCH UNDERTAKEN

Census techniques

A study at the University of British Columbia by Drs. R.G. Gosine, L. Gamage, and A.W. Trites considered alternative technology for aerial counting based on video filming and digitized still photographs. Computer algorithms were developed to discriminate sea lions from background image information. An algorithm for tracking sea lions between successive image frames was also developed and tested on a limited number of scenes from the 1992 Aleutian Islands survey conducted by the National Marine Fisheries Service.

Computer counts were made from typical image sequences for a range of terrains (e.g., sandy beach, rocky haulout) and compared to manual sea lion counts from slides. The study showed that the computer accurately counted single sea lions but was unable to correctly count the number of sea lions lying on top of each other. Further work is needed to overcome this problem. Further development of color analysis is also needed.

Computer counts are extremely fast and consistent. A computer-assisted census count (where the computer queries an operator when it cannot distinguish an object) might improve the accuracy and speed of counts from aerial photographs or video tape.

A statistical study at the University of Washington, directed by S. Mathews, examined possible sources of error in the estimation of populations of Steller sea lions from photographic surveys. Using data provided by the National Marine Fisheries Service, the study found no significant biases in the population estimates.

Predation by Killer Whales

The stomach of a dead killer whale that washed ashore in Prince William Sound in 1992 contained 14 flipper tags from Steller sea lions. Predation on sea lions has also been noted from stomach contents of stranded killer whales from other parts of Alaska and British Columbia. Killer whales have been observed attacking sea lions. In view of these observations, we began a study to ask: (1) to what extent does killer whale predation affect sea lion numbers, and (2) has this predation contributed significantly to the recent decline of sea lions in Alaska?

Dr. John Ford and Mr. Lance Barrett-Lennard are using photographic data to estimate numbers and distribution of transient killer whales frequenting nearshore waters from southeastern Alaska to the western Aleutians. Published and unpublished accounts of killer whale stomach contents and observations of predation are being used to estimate predation rates on sea lions of various ages. To obtain additional information about predation rates, questionnaires were distributed to fish and wildlife personnel and to researchers working on sea lions, killer whales, and other marine mammals. The energetic requirements of captive killer whales will be used to determine typical feeding rates. An attempt will be made to model possible minimum and maximum killer whale predation. When completed, the study will provide the first estimates of potential impact of killer whales on Steller sea lion populations.

Human Disturbance and Behavioral Changes

Steller sea lions are easily scared from their rookeries and haulout sites. While animals commonly return after having been disturbed, the effect of prolonged disturbances is not known. Efforts to capture and study Steller sea lions in the wild might be, therefore, a contributing factor to the population decline.

To determine the effect of human disturbance, we began a collaborative study with the Alaska Department of Fish and Game at two sites on Forrester Island, one of which was disturbed on three occasions (by researchers studying pup energetics), and the other which people did not enter.

Preliminary results suggest that disturbances early in the breeding season have little effect, but after the third disturbance late in the season females left with their pups and did not return. It is not clear what the effect might be in following years.

These studies will be continued in 1994 when adults will be driven again from the rookery on three occasions (at two week intervals).

In 1993 we also began to establish protocols for behavioral observations. Behavioral observations in 1994 will contrast reproductive behavior of Steller sea lions at two sites: Forrester Island, where sea lion abundance has been stable or increasing, and at Sugarloaf Island, where sea lion numbers are in decline. Field support and assistance is being provided by the Alaska Department of Fish and Game. The behavioral observations are also designed to test for signs of nutritional stress and to detect aberrant behavior at various densities.

Disease and Parasites

The role of parasites and infectious diseases in the biology of Steller sea lion populations has yet to be evaluated adequately. It is known that disease can affect health, reproductive capacity, and contributes to mortality, but the impact on population dynamics is not clear.

A preliminary study to identify and quantify the presence of parasites from examination of sea lion scats (faeces) collected in Southeast Alaska commenced in 1993. In 1994, researchers at the University of British Columbia will continue to evaluate parasite loads from Southeast Alaska and will begin the same analysis on scats collected at Sugarloaf Island.

Dr. A. Smith at Oregon State University proposed a five year research program to determine whether disease is causing or contributing to the population decline of Steller sea lions. His laboratory has experience with two classes of pathogens known to infect Steller sea lions, *Leptospira interrogans* and a series of caliciviruses known collectively as San Miguel sea lion virus. Both agents are active in marine mammal and other mammal populations, where they are associated with abortion and neonatal death. This study will begin when funds are available.



Nutritional Stress

D. Calkins and E. Goodwin of the Alaska Department of Fish and Game concluded that Steller sea lions were physically smaller in the mid 1980s than the mid 1970s, a conclusion supported by body measurements of sea lions caught in trawls. Both findings suggested that sea lions may have had inadequate nutrition during the 1980s. Simulation studies by the National Marine Fisheries Service (A. York) further suggest that young sea lions may have had a higher incidence of mortality. These and other findings have led to the hypothesis that a shortage of food during the winter may cause pups to die of starvation or other problems associated with food stress.

This hypothesis has received major attention by government agencies as well as by Consortium researchers. Our approach is four fold: (1) verify changes in body size; (2) determine energy requirements; (3) examine how diet may have changed between sites and over time; and (4) determine whether the forage base has changed with time and, if so, explore whether the change is related to fisheries and/or natural changes in the ecosystem.

Verifying Changes in Body Size

Existing morphometric data are currently being re-analyzed by the Alaska Department of Fish and Game. We are attempting to collect additional data from sea lions taken in the subsistence harvest in a project coordinated by Dr. A. Springer of the University of Alaska. While few specimens were collected in 1993, more are expected as contacts grow in the hunting community.

Another approach to determining how conditions may have changed from previous decades is to measure the annuli of sea lion teeth. Dr. D. Sampson from Oregon State University has proposed such a study. Growth records embedded in the teeth of Steller sea lions would be quantified between sites and over time to test whether a significant change occurred in growth rates, and age of sexual maturity. This study will begin as soon as funding is obtained.

Changes in growth also may be shown in bones in the form of "Harris lines" which appear when young animals are stressed and bone growth slows or ceases. Dr. Springer has proposed a pilot study of the utility of Harris lines in 1994.

Determining Energy Requirements

In 1993, three male and two female Steller sea lion pups were taken from a Canadian rookery and transferred to the Vancouver Public Aquarium. Plans to capture an additional six to ten pups in 1994 are currently on hold because additional funding from outside agencies and foundations has not yet been secured.



Over the next four years the captive animals will be used to determine (1) metabolic rates; (2) nutritional levels for required energy turnover rates; (3) digestive efficiency of different diets such as pollock and herring; (4) their relationship with growth, body composition, blubber thickness, fat distribution, organ maturation level and reproductive maturation (using ultrasound technology); and (5) biases in the use of sea lion scats to determine diet in the wild. Subsequently, a mathematical model will be developed that considers seasonal and annual activity budgets for sea lions at both individual and population levels.

Although the first year of this project was intended to serve as a "shakedown" period, substantial progress was made in 1993. Modifications to the Vancouver Public Aquarium were completed to accommodate the pups, and growth and body morphology has been monitored on an ongoing basis (pups are weighed and measured daily; blood chemistry is done once every two weeks, the autumn moult is being documented to determine the best time to attach recording instruments to animals in the wild). To assess energetic needs, we have acquired a flow-through respirometry system and have built a basic metabolism chamber to use with it. The system has been on-line and collecting data since early October.

Examining Changes in Diet and Foraging Success

Dr. A. Springer of the University of Alaska enlisted the aid of native subsistence hunters to acquire specimens from St. Paul Island (Pribilof Islands) for diet studies. Samples from two juveniles taken by hunters and three beach-cast adults were obtained. Additional samples from several more specimens taken by hunters are awaiting shipment from St. Paul to Fairbanks. In addition, the Aleutian East Borough is assisting in contacts with hunters from Akutan, Nikolski and other villages.

A collaborative study was undertaken with Alaska Department of Fish and Game to collect scats on Forrester Island. Approximately 200 samples were taken at Forrester, and an additional 200 from four other haulout sites in Southeast Alaska. The scats are currently being processed at

Fisheries and Oceans Canada facilities to determine parasite loads and diet (based on identifying bony prey structures). Bones will be identified by Pacific ID in Victoria. Raw data sheets will be distributed to Alaska Department of Fish and Game and National Marine Fisheries Service. A report summarizing findings is planned for the spring.

In 1994 we will continue collecting scats from Forrester Island and will begin a concerted effort to describe the diet of sea lions at Sugarloaf in the eastern Gulf of Alaska where major population declines have occurred.

There are many hidden biases in determining diet from scats. For example, otoliths are easily identified by species but for some species may be partially or even totally digested. Dr. A. W. Trites and P. Cottrell began a study on harbour seals held at the Vancouver Public Aquarium and will do a similar study in 1994 on captive Steller sea lions once they are weaned.

Over 4,000 fish were consumed during the experimental period, from which over 50,000 elements (hard parts) were recovered. Only 53% of otoliths were recovered from consumed prey (34% from herring, 64% from chinook smolts, 74% from pollock, 67% from hake, and 26% from smelt). Other structures (such as vertebrae in herring) appeared more consistently in scats. Correction indices based on contingency analysis of different prey structures can be calculated for species that are consumed whole (herring and smelt). Greater biases exist for larger fish whose heads are ripped off and not eaten (pollock, salmon and hake).

A novel study to determine whether the decline of Steller sea lions is related to a shift in diet was proposed by Dr. D. Shell at the University of Alaska. In a pilot study in 1993, the ratio of carbon and nitrogen isotopes was measured in whiskers from Steller sea lions collected over the past 20 to 40 years to determine whether long-term shifts occurred in food sources and in trophic levels at which Steller sea lions fed. An identified shift would support the hypothesis that changes in diet may have played an important role in the recent population declines. This study will continue through 1994.

Studying the feeding behavior of pups and lactating females might reveal whether Steller sea lions are food stressed in the eastern and western Gulf of Alaska. First steps were taken in 1993 for a comparative study of the foraging biology and behavioral ecology of juveniles and adult females in both the eastern Gulf of Alaska (Sugarloaf Island), and in southeastern Alaska (Forrester Island) where no population decline has occurred.



At Forrester Island, protocols were developed for making behavioral observations. The Alaska Department of Fish and Game erected a cabin and field station on the island. With their leadership a second field camp will be set up at Sugarloaf in 1994. A biologist from the Consortium and from the Alaska Department of Fish and Game will be paired on each of the two study sites in 1994 and 1995. The study will measure the time that pups, cows and bulls rest while ashore, male investment (size of territories, length of bull's tenure, number of copulations), and maternal investment (number of suckling juveniles, time spent nursing pups, length and start of mother's first feeding trip, sex ratio of pups born).

A second study is proposed on juvenile winter behavior to determine whether mothers can adequately nourish their pups during lactation and/or whether weaned juveniles are able to successfully forage on their own. The Alaska Department of Fish and Game plans to deploy satellite tags on juveniles in October and November, 1994, and have indicated that they will provide logistical support and financial assistance to a graduate student. We anticipate that the work will involve at-sea tracking of juveniles and "on-shore" monitoring of daily and seasonal changes in juvenile abundance at Cape St. Elias (located east of Prince William Sound on the southern tip of Kayak Island).

In 1993 we developed and field tested a portable data logger for attachment to Steller sea lions to record location, diving depth, swim speed, and changes in stomach temperature (an index of feeding activity). Backpack-data loggers and stomach temperature telemeters were tested on captive California sea lions and proved capable of recording when and how much prey were ingested. At Forrester Island, three female Steller sea lions were equipped with data loggers and temperature sensors. One of the three made a feeding trip on which four dramatic drops in stomach temperature were recorded, indicating prey ingestion events. Although further field trials are needed, the system has provided the first conclusive record of foraging by a wild sea lion, a significant breakthrough in determining where and when sea lions feed.

The capabilities of the data loggers are being expanded to include heart rate and stomach pH measurements (indices of metabolic rate and prey type, respectively). Testing of the devices and heart rate units will be done by R. Andrews (University of British Columbia) on captive California sea lions held in Santa Cruz and on captive juvenile Steller sea lions in Vancouver. The 1994 research plan calls for studies of the foraging behavior and energetics of adult female Steller sea lions with young pups in the summer; and of females and pups near the time of weaning in winter. We will collaborate with D. Calkins of the Alaska Department of

Fish and Game and researchers from the University of Alaska, and Texas A&M University to deploy the electronic devices on five sea lions at Forrester Island in the summer and five adults and five juveniles at Cape St. Elias in the winter. Data concerning development of independent foraging by juveniles in winter will be relayed by satellite and radio transmission.

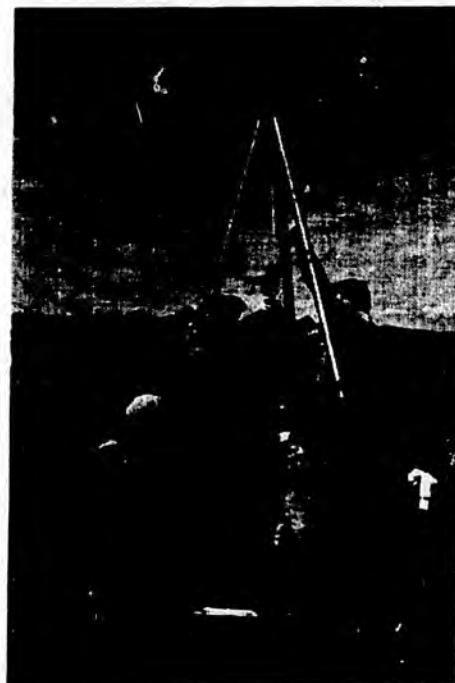
Changes in the Forage Base

The University of Alaska and the University of Washington are jointly preparing a proposal to sample and determine abundance of forage fish near the two primary field sites. At the same time, a project will try to establish what fishing activity occurred around sea lion rookeries, and how much fish was removed over the past decade.

Population trends of sea lions at different rookeries differ perhaps because of different levels of disturbance from nearby fishing operations or different histories of local prey abundance. In 1993 a study was begun by Dr. D. Sampson at Oregon State University to test these conjectures by analyzing historical and current fishing activities near selected sea lion rookeries.

The first part of the study involved compiling and analyzing data on catch and fishing effort from commercial fisheries operating near sea lion rookeries during the 1970s and 1980s. Previous analyses of commercial fisheries data have focussed on removals of groundfish, particularly pollock, or have looked at coarsely aggregated catch and effort data for various fisheries. This project concentrates on cumulative and seasonal levels of fishing effort and relative catch rates at different sites for as many different fisheries as possible. Analyses have started with data provided by the National Marine Fisheries Service on the quarterly catch and effort data from the observers, since 1979, on foreign, joint-venture, and domestic groundfish vessels. Fish ticket data (landings receipts) are being obtained from the Alaska Department of Fish and Game to document monthly landings and number of fishing trips by statistical area for domestic fisheries for groundfish, salmon, herring, halibut, shrimp, and crab. The data compilation, tabulation, and preliminary analyses of these two data sets will be completed by March 1994 with additional analyses completed during the remainder of 1994.

The second part of this study will compile and analyze information from commercial fishing operations near the primary field sites (Forrester and Kodiak regions). Although protected areas have been established around sea lion rookeries and major haulouts west of 140° west longitude to limit disturbances by the groundfish fishery,



other fisheries such as those for herring and salmon still operate near these sites. At the end of each field season, data from the Alaskan fish tickets on the landings and number of fishing trips will be compiled and examined to document differences in the amount of nearby fishing activity and, possibly, the relative levels of local prey abundance.

Another possible explanation for the decline of Steller sea lions is that an ecosystem shift changed the food base in the North Pacific in the mid 1970s. One hypothesis, for example, is that mass removals of whales from the North Pacific in recent times contributed to ecosystem change and declines in the abundance of pinnipeds and seabirds. The International Whaling Commission reports that between 1950 and 1975 over 45,000 fin whales were harvested in the North Pacific. "Best guess" estimates indicate the population fell some 90% from a pre-exploitation level of about 50,000 whales to under 5,000. Approximately 75% of the harvest came from the Gulf of Alaska, Bering Sea, and Kamchatka Peninsula area. The harvest was concentrated on feeding grounds at the edge of the continental shelf in the Gulf of Alaska and Bering Sea and along the Aleutian Archipelago where the whales fed on large calanoid copepods, euphausiids, and small schooling fishes such as juvenile pollock. Removal of these whales may have changed the composition and abundance of forage fish available to the Steller sea lion and other marine mammals by reducing predation on young pollock and increasing the amount of euphausiids and copepods available to other fish species.

Dr. A. Springer (University of Alaska) has begun a thorough analysis of whaling records and models of whale consumption and population dynamics to test the notion that whaling was a contributing cause of recent changes in the Bering Sea. In 1994 information on harvest using the detailed records of the International Whaling Commission, obtained from National Marine Fisheries Service, will be refined. Population estimates for fin and sei whales will be derived from a mathematical model. Carbon budget and food web models, with appropriate spatial scales, will then be developed to evaluate possible effect of the removals on the pelagic ecosystem.

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