



A fur seal family on St. Paul Island, Pribilof Group, Alaska. (Photo: V. B. Scheffer)

MEASURING MORTALITY OF FUR-SEAL PUPS IS IMPORTANT TO MANAGEMENT OF HERDS

About a million northern fur seals (*Callorhinus ursinus*) return to the Pribilof Islands in the Bering Sea each year. In rookeries on these five small islands, mostly on St. Paul and St. George, the pups are born and the adults breed. Forty to 50 thousand fur seals are harvested annually for their furs. By agreement, these are divided among Canada, Japan, and the U.S.

NMFS is responsible for management and conservation of these herds. Research seeks to determine the most favorable level at which to hold the breeding population in order to produce a maximum sustained yield.

Management is made more difficult by appreciable fluctuations in survival of pups from birth through their early years. So an important research aspect is to detect and measure these fluctuations and to analyze the importance of several survival or mortality factors. Then, independent and collective effects of these factors as related to deliberate population manipulations can be investigated to make possible more effective management of the herds.

Estimating Breeding Population

NMFS wildlife biologists have developed reasonably accurate methods of estimating adult females and males required to produce certain numbers of pups. With a pregnancy rate of 0.6, five adult females are needed to produce three pups. About 500,000 females produced the 300,000 pups (200,000 females were nonpregnant for various reasons) estimated to have been born in 1969-70. The fur seal is a polygamous breeder. So with one male to a harem of many females, about 7,000 "harem" bulls counted on the rookeries in 1969-70 sired the 300,000 pups born in those years.

Causes of Mortality

Pups die on land and in sea. Causes of death on land vary and may or may not be factors in deaths at sea. To meet the need for a continuous systematic approach to research on mortality of newborn seals, Dr. Mark C. Keyes, DVM, joined the Marine Mammal Division of the Northwest Fisheries Center in 1962.

As Research Veterinarian, he has concentrated on mortality factors, especially of newborn. Most deaths occur during first 4 weeks after birth, so field work on mortality is conducted primarily from about June 25 to August 15.

Dead pups are retrieved with a long gaff from catwalks constructed over three rookery study areas. The rookeries cannot be entered at ground level during height of breeding season because the ferocious $\frac{1}{4}$ -ton bulls will attack a man without hesitation. The females and young males also are dangerous; even live pups must be handled carefully. Causes of death are determined by necropsies, post-mortem detailed laboratory examination of pup bodies.

10 Summers of Mortality Research

During the last 10 summers, 1962-71, on St. Paul Island, Dr. Keyes and his assistants retrieved nearly 2,000 dead pups for examination. About 7% of the examinations yielded no diagnosis; 10% of the bodies could not be examined because of advanced postmortem degeneration. Causes of death are grouped into six major categories with most prevalent first: apparent malnutrition, hookworm disease, microbial infection, multiple hemorrhage--liver damage--perinatal complex, trauma, and miscellaneous. In 1971, hookworm disease and malnutrition together accounted for 73.5% of the deaths.

The causes of death are complex. Although the researchers have accumulated considerable data, they do not know the interactions of various factors. Apparent nutrition cannot be explained on the basis of simple starvation due to separation of mother and pup. The mother could have had agalactia, a condition that prevented her production of milk. Also, the pup could have been carrying several diseases leading to loss of appetite, and so emaciation occurred. Investigation of microbial infection would be facilitated if trained virologists were present to develop seal tissue culture cell lines. Where liver damage was the primary lesion, the organ was found to be extremely fragile; it often leaked blood into the body cavity. Trauma was caused by bites from other mothers (protective attitude) or from other seals on the crowded rookeries.

The Hookworm

The hookworm (*Ucinaria lucasi*) long has been known as a major cause of death of pups. In early investigations, infected pups of one-year class were believed to pass the eggs of this parasite into the rookery soil. There they hatched, wintered as larvae, and infected following year-class by penetrating flippers and migrating to intestines to cause anemia by feeding on their hosts' blood. At the same time, biologists were puzzled because hookworms were never found in seals older than pups. The study area was saturated with powerful chemicals to control or eliminate the source of infection by killing overwintering larvae in the soil. Control efforts failed: pups born a few weeks later had mortality equal to pups born on untreated areas.

Ten seasons (between 1951 and 1962) of contract research revealed the hookworm's unique life history. The work was done by Dr. O. Wilfred Olsen--parasitologist with Colorado State University--and his graduate student assistant, Dr. Eugene Lyons. As expected, the larvae were found to penetrate the flippers of seals of both sexes and all ages. Instead of moving to the intestines, however, the larvae migrated to the belly blubber. There they lay dormant in all seals except some females. Carried by the pregnant female, the larvae moved into mammary glands to infect her pup at its first, and only the first, nursing. This discovery emphasized the futility of early control methods of chemical saturation of the ground.

A diagnosis is made on the basis of lesions--alteration of normal structure or function of a part--that are characteristic of a particular cause. It is designated primary, secondary, tertiary, etc., according to relative severity of lesions or order of occurrence.

Mortality Rates

To get estimate of death rate, or percentage of year-class that died, the number of pups born must first be estimated. Several thousands pups are marked temporarily in early August by shearing a patch of fur from top of head. Later counts of several hundred samples of 25 pups each (after sheared and unshaired pups have thoroughly mixed) yield a marked-to-unmarked ratio from which an estimate of total number born is made. Estimates made with this method (or another

method of marking pups with permanent tags) are tested by actual counts on small rookeries. By October, the pups have molted. Those sheared have lost their marks.

Survival of each year-class to ages 2-5 (or reciprocal-mortality rate) is measured by comparing number of pups born against (1) number of young males from year-class harvested and allowed to escape, and (2) an equal number of females from year-class--assuming 1 to 1 sex ratio of survivors. Counts of dead pups on land are made on rookeries each August. Although counts are made carefully, they are not completely accurate because some pups have been eaten by scavengers, others have been washed away by the sea, and some have decomposed.

The Seal as Experimental Animal

For disease and other research, a system of maintaining fur-seal pups in captivity was necessary. To incriminate one organism as causative agent of an infectious disease, it must be isolated from the subject; on exposure of a susceptible subject, it must produce the disease. Then the same organism must be isolated from the experimental subject. For such reasons, fur seals as experimental animals could answer many questions.

The first problems were development of artificial fur-seal milk and establishment of appropriate husbandry practices to rear newborn fur seals. After 3 years of trials, Dr. Keyes was successful. Since then, fur-seal pups have been used in eryogenic (very low temperatures) marking experiments, studies of echo-sounding capabilities of fur seals, and research on experimental transmission of seal diseases.

Nutrition Experiments

Nutrition experiments and knowledge obtained about pups' nutritional requirements led to research and analysis of feeding problems with captive marine mammals in general. Through these efforts, it became apparent that the difficulties in preserving nutritional value of fresh fish fed to seals and porpoises could be solved with a processed food. Such a product was developed at the NMFS Pacific Fishery Products Technology Center, Seattle, by Max Patashnik, Paul Kangas, and Dr. Keyes. It is made mainly

from whole fish and kelp. The food is compact, pasteurized, and stable in storage. It is produced and marketed by a private company under the name "Sea Ration".

Anesthesia and Restraint

While obtaining milk samples from seals so artificial milk could be formulated, Dr. Keyes developed methods of anesthesia and restraint that could be used to implant instruments in fur seals to study their cardiovascular adjustments during diving and various methods of slaughter. During these experiments, conducted by Virginia Mason Research Center, Seattle, an instrument was developed by Dr. M. P. Spencer of VMRC. It detects bubbles in the blood stream of human divers before any signs of decompression sickness were apparent to the divers themselves.

During necropsies of pups in 1962, Dr. Keyes observed the large size of the pineal gland (a brain appendage) of a pup that displayed convulsions before death. It necessitated examination of the central nervous system. This discovery has led to cooperative work on the endocrinology of the pineal gland of fur seals with the Massachusetts Institute of Technology. It has established the fur seal as a model for studying the probable function of the mammalian pineal gland.

Objectives of Future Research

Research on mortality will continue along the lines of animal physiology. The entire process of how disease begins, develops, and causes death or disability of the seal will be investigated. The researchers will emphasize that part of the process that takes place at sea. It will include rearing seals from birth and subjecting them to environmental features similar to those in the ocean.



Massed seals on St. Paul Island. (Photo: V. B. Scheffer)