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Mortality of Northern Fur Seal Pups in Relation to Growth and Birth Weights

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Results of post-mortem examinations of pinniped neonates have been reported (Anderson et al., 1979, J. Zool. (Lond.) 189: 407–417; Baker et al., 1980, Br. Vet. J. 136: 401–412; Keyes, 1965, J. Am. Vet. Med. Assoc. 147: 1090–1095; Mattlin, 1978, N.Z. J. Ecol. 1: 138–144). We examined the behavioral histories relative to causes of death of 25 northern fur seal pups, *Callorhinus ursinus*, that died within 60 days of birth.

We sexed and weighed 410 newborn seals on Reef Rookery, St. Paul Island, Pribilof Islands, Alaska, between 21 June and 31 July 1980. Pups were marked with either jumbo plastic Rototags (Dalton Supplies Ltd., Nettlebed, Henley-on-Thames, Oxfordshire, England) placed on the trailing edge of both front flippers or a number–letter mark made by clipping or bleaching some of the outer guard hairs on the pup's back. Observations of marked pups were made daily from 21 June to 19 August and location, behavior, and presence of an adult female with the pup were recorded. A total of 10,995 resightings of marked pups was made during this time. Pups were recaptured and weighed on 1,160 occasions between 23 June and 25 August. All sightings and most of the captures were made with a noose on a long pole from a 3 m high catwalk that extended across the rookery. Additional captures were made during a single sweep through the rookery.

Dead marked pups within 10 m of the catwalk were retrieved on a daily basis with a pole and hook. Those not within reach were collected during three separate sweeps through the rookery concomitant with fur seal management activities. Date of death for each pup was calculated as being the midpoint between the last sighting of the pup alive and its recovery, or sighting, after death.

Gross postmortem examinations were conducted with the help of veterinary personnel on the island after the pups were weighed and sexed. Primary causes of death were assigned based on descriptions of known syndromes and diseases reported by Keyes (1965, op. cit.).

Twenty-six (6.3%) of the total marked pups were found dead and examined. This prevalence falls within the range of neonatal pup mortality (3 to 9%) reported for the Pribilof Islands in the 1970's (Lander, 1980, Nat. Mar. Fish. Serv., Nat. Mar. Mammal Lab., Nat. Oceanic Atmos. Assoc. Tech. Memo. Nat. Mar. Fish. Serv. F/NWC-3, NTIS #PB81 106502, 315 pp.) and the 4% mortality reported for St. Paul Island in 1980 (Kozloff, 1981, Nat. Mar. Fish. Serv., Nat. Mar. Mammal Lab., Proc. Rep. 81-2, 97 pp.). The prevalences of causes of death (Table 1) were similar to those reported previously for fur seals on the Pribilofs (Keyes, 1965, op. cit.; Lander, 1980, op. cit.).

Pups that died from all causes were significantly lighter at birth than the total marked population (Student's t-test, males: $t = 2.13$, $P < 0.05$ and females: $t = 3.59$, $P < 0.001$).

At least 14 of the 410 marked pups were born to females estimated to be 6 yr old or younger, based on vibrissae color patterns reported by Scheffer (1962, U.S. Fish Wildl. Serv., North Amer. Fauna #64, 206

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TABLE 1. Histories of northern fur seal pups that died of various causes on St. Paul Island, Alaska between 21 June and 25 August 1980.

Cause	No.		Mean birth wt. (kg)		Mean age at death (days)	Mean % birth wt. at death	Mean no. days from last female sighting
	M	F	M	F			
Emaciation syndrome	5	5	6.0	4.9	18	0.81	12.3
Trauma	1	3	4.3	4.4	8	1.06	8.1
Hookworm disease	1	3	5.7	4.3	24	1.09	18.3
Pneumonia	0	1	—	4.2	20	1.00	12.0
Pleuritis	1	0	5.1	—	8	1.00	3.0
Other infectious disease	0	1	—	3.3	1	1.06	1.0
Trauma (caused by the investigators)	0	1	—	4.9	1	0.86	1.0
Undetermined	2	1	4.1	5.5	16	1.14	2.7
All pups	10	15	5.3	4.6	15	0.96	10.1

pp.). These 14 pups were significantly lighter at birth than the pups born to older females ($P < 0.001$ for both males and females) and suffered significantly higher mortality ($P < 0.02$); 21% of pups born to younger females died compared to 5.5% of the pups born to older females.

Forty percent of the marked pups that died showed characteristic signs described by Keyes (1965, op. cit.) and recently referred to as "emaciation syndrome" (Marine Mammal Division, 1975, Fur seal investigations, 1974, Northwest Fisheries Center, Nat. Mar. Fish. Serv., Seattle, Washington, 125 pp.). An adult female was seen with nine of these 10 pups on at least 2 days and the tenth pup was seen with a female on only 1 day and died 3 days later. None of these pups was born to younger females.

There appeared to be more than one initiating factor among the 10 emaciated pups, as their histories showed three basic patterns. The first group consisted of five pups that showed no evidence of weight gain after birth. These pups differed in several ways from the five pups that showed weight gain: 1) they were significantly younger at death (6.6 vs. 28.4 days, $t = 3.45$, $P < 0.01$); 2) they had a significantly shorter interval between the last sighting of the mother and the occurrence of death (5.2 vs. 15.0 days, $t = 2.49$, $P < 0.05$); and 3) the three female pups in their group were significantly lighter at birth than the females of groups that showed weight gain and then became emaciated (4.2 vs. 6.0 kg, $t = 3.73$, $P < 0.05$). Only one of the five pups that showed no weight gain was seen suckling. The factor responsible for the lighter birth weight of these pups may have been responsible also for their eventual death.

The second group of pups that became emaciated consisted of three that gained a minimum of 0.4 kg after birth and starved apparently as a result of the female's departure and failure to return and suckle her pup. We did not see the females associated with these pups for a period of 20 to 33 days prior to the pup's death; the pups had died 25 to 47 days after birth. These three animals represented less than 1% of our marked population; this would reasonably be accounted for by natural mortality during the breeding season, given the approximate 10% annual mortality reported for adult females (Lander, 1982, Fish. Res. 1: 55–70).

The third group of pups that became emaciated consisted of two that showed minimal weight gain (0.2 and 0.4 kg) and died 8.5 and 13 days after the last female sighting, or 13.5 and 22 days after birth.

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The causes of emaciation in this group are more difficult to determine.

The separation or abandonment of pups directly after birth has been reported as a cause of starvation in other pinnipeds (Le Boeuf and Briggs, 1977, Mammalia 41: 167–195; Baker and Doidge, 1984, Br. Vet. J. 140: 210–219). Though we found evidence of some pups dying as a result of the absence of the female this did not occur directly after birth.

Four pups (16%) died of trauma (not including one bitten by an adult male during our marking activities). Three of the pups had fractured skulls, one had a ruptured liver and kidney, and one had bite wounds. All four had gained weight between birth and death. Two of the four pups were born to young females with black or mixed color vibrissae, a significantly greater than normal frequency ($\chi^2 = 27$, $P < 0.001$). The birth weights of the pups that died from trauma were significantly less than those for our total marked sample for both sexes (males: $t = 2.2$, $P < 0.05$ and females: $t = 2.05$, $P < 0.05$).

The lighter birth weight of these pups may indicate that they were either not as able to maneuver away from adult seals or were not as able to tolerate the physical impact of being stepped on or bitten as were normal pups. Trauma is a frequent cause of death in other pinnipeds (Coulson and Hickling, 1964, J. Anim. Ecol. 33: 485–512; Laws, 1953, Falkland Is. Dependencies Surv., Sci. Rep. 8: 162; Mattlin, 1978, op. cit.; Carrick et al., 1962, C.S.I.R.O. Wildlife Research 7: 161–197). Northern elephant seal (*Mirounga angustirostris*) pups are often victims of physical attack after they have been separated from their mothers and are starving (Le Boeuf and Briggs, 1977, op. cit.).

Four pups (16%) died of hookworm disease as a primary cause. The mean age at death, 24.4 days, was greater than for other causes of death. Birth weights of the three female pups that died of hookworm disease were significantly lower than for our total marked females (4.3 vs. 5.2 kg, $t = 2.34$, $P < 0.05$). All four pups were born between 15 and 20 July, near the end of the pupping season. These birth dates were significantly different (later) than the distribution of births for our entire marked sample ($\chi^2 = 13.4$, $P < 0.01$).

Other causes of death (one pup each) were pneumonia, pleuritis, and other infectious disease. All three of these pups had birth weights lighter than the average for their sex. For three pups the cause of death could not be determined.

The present study investigated only 25 dead pups. But because the histories of all 25 were known, this small sample adds the following information on mortality that has not been documented previously:

1. Pups that die are as a whole significantly lighter at birth than those that live.
2. Pups of younger mothers are lighter at birth and have a higher rate of death in the first 6 wk of life than pups of prime breeding age females.
3. Five of 10 pups dying of emaciation syndrome failed to gain weight from birth to death despite the presence of mothers.
4. Three pups starved after initially gaining weight because their mothers died or failed to continue suckling them.
5. All pups dying of trauma gained weight after birth, but were lighter at birth than normal pups; half of these pups were born to young mothers.
6. The four pups which died of hookworm disease were born well after the mean pupping date for the population.

Mortality studies based on pups of known history reveal the predispositions of the pups to die of certain causes, and show more of the sequence of events leading to death than do conventional methods. Furthermore, this method shows the same primary causes of death and the same proportions attributable to each

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cause as studying pups where historical information is not known. The drawbacks of this method are that it requires considerably more effort per animal examined, and it will not produce large numbers of samples because usually fewer than 10% of pups die within the first 2 mo of life. The optimal study on mortality would include both study methods.

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Fatal Trauma Caused by a Deterrent Device for Bears

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Human/bear interactions have resulted in extensive property damage and/or serious injury or death to man (Herrero, 1970, Science 170: 593–598). In the last decade there has been an increase in the number of nuisance bears shot in defense of life or property in the Northwest Territories (NWT), Canada. When reviewed in conjunction with legal harvest rates and the low reproductive potential of bears, it is possible that these additional removals could adversely affect resident bear populations.

In 1981 the Department of Renewable Resources, Government of the NWT, in conjunction with industry and other government agencies, initiated a Bear Detection and Deterrent Research Program, the goals of which were to: 1) increase safety for people living and working in bear habitat; and 2) reduce the escalating number of nuisance-killed bears by developing and testing detection and deterrent systems.

The majority of tests have been conducted on polar bears (*Ursus maritimus* Phipps). The deterrent system involves the firing of a rubber baton from a 38 mm multi-purpose riot gun at the bear (Stenhouse, 1983, NWT Wildlife Service File Report No. 31, 58 pp.). The baton weighs 135 g, has a diameter of 37 mm, and a length of 101 mm. The muzzle velocity of the projectile is 70 m/sec. When used for crowd control the baton is usually fired from a distance of about 35 m and is designed for ricochet firing. For bear work it is fired directly at the flank of the bear. However, the riot gun was not designed for precision shooting and a considerable amount of practice is needed before an individual can hit a bear in the desired location.

Tests with this deterrent over a 3-yr period have shown that all three species of North American bears can be deterred when struck with the baton. Approximately 400 bears have been struck during this period with no observed mortality or serious injury. From a practical standpoint, it is also important to note that none of these bears charged the gun handlers after being struck.

During tests in October 1983, a subadult (2-yr-old) male polar bear was struck in the thorax from a range of 30 m. The

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