

PUP SURVIVAL IN THE MEDITERRANEAN
MONK SEAL (*MONACHUS MONACHUS*)
COLONY AT CABO BLANCO PENINSULA
(WESTERN SAHARA-MAURITANIA)

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ABSTRACT

We surveyed pup survival in Mediterranean monk seals (*Monachus monachus*), at Cabo Blanco Peninsula (Western Sahara-Mauritania) colony from May 1993 to December 1997. This species breeds and hauls out on beaches inside two main caves. During the study period we detected a total of 93 pups that died or disappeared. The survival rate of 84 pups through the age of first moult (approximately two months) was 0.47. This value is similar to those reported for other pinnipeds breeding in caves but lower than for those breeding on open beaches. Mortality varied seasonally and appeared to increase as a result of storms, large ocean swells, and high tides. Mother-pup pair separation (and resulting pup starvation) and physical injury caused by impact against the rock walls of the cave and cliffs were established as the causes of most deaths. Beach surface area inside the caves also appeared to be a mediating factor in the effects of sea conditions. High pup mortality may be a limiting growth factor in this population, although cave dwelling protects the population from predators and human disturbance.

Key words: Mediterranean monk seal, *Monachus monachus*, Western Sahara-Mauritania, pup survival, mortality causes, endangered species.

The knowledge of pup survival and the likely causes of pup mortality in pinnipeds is an important component of demographic studies (Riedman 1990, Boness *et al.* 1992). Five factors have been associated with preweaning pup mortality in pinnipeds: (1) the nature and topography of the nursing habitat, (2) weather and more general environmental variation, (3) population density, (4) disturbance caused by adults in the rookery, and (5) impoverished nutritive condition (Bowen 1991). There is little information on pup survival rates and causes of mortality for the Mediterranean monk seal, one of the most endangered mammals worldwide (Reijnders *et al.* 1993). The data on pup mortality comes from seals killed by fishermen or accidentally entangled in fishing gear reported in Greece (Cebrian and Vlachoutsikou 1991, Panou *et al.* 1993) and dead pups found stranded on the beaches or found inside caves in the colony of Cabo Blanco, Western Sahara-Mauritania (Maigret *et al.* 1976, Trotignon 1979, Marchessaux and Muller 1987) and Sardinia (Bareham and Furredu 1975).

The largest aggregation of this species is found on the Cabo Blanco Peninsula. In this colony, seals of all age classes haul out on the beaches located inside large deep caves along the coast. As many as one hundred individuals have been observed hauled out at the same time. Females give birth throughout the year to a total of about 50 pups (Gazo *et al.* 1999) in two main breeding caves 1.1 km apart. There are many caves along the coast which seals formerly occupied, but most of them are not used now (González *et al.* 1997). It has been suggested that the scarcity of optimal caves (Marchessaux 1989, Francour *et al.* 1990) and mortality due to fishing activities (Marchessaux and Aouab 1988) are potential limiting factors for growth of the population.

The aims of the present study were to obtain reliable data on pup survival to the first moult (about 2 mo of age) and to determine the main causes of pup mortality.

METHODS

The study area is located on the western coast of the Cabo Blanco Peninsula (21°02'N, 17°03'W) in Western Sahara-Mauritania (Fig. 1) (see details in González *et al.* 1997). The area has a high biological productivity due to the effect of continuous strong oceanic upwelling (Tilot 1993). Storms and large oceanic swells are frequent during fall and winter (Nistal and Vega 1997).

Monitoring of pups—Although some pups were marked with plastic tags applied to the rear flippers, most were individually identified by the shape and design of their ventral patch (Badosa *et al.* 1998). This method was useful until the natal coat was shed (about 70 d). Once moulted, the ventral-patch differences between pups are not so apparent. Pups are mother-dependent until the beginning of weaning, which occurs about four months after birth (Aguilar *et al.* 1996).

Cave surveys and monitoring—Counts of pups and monitoring of individual pups over time were obtained using three different methods involving direct observations and video cameras. At the two main caves used by monk seals

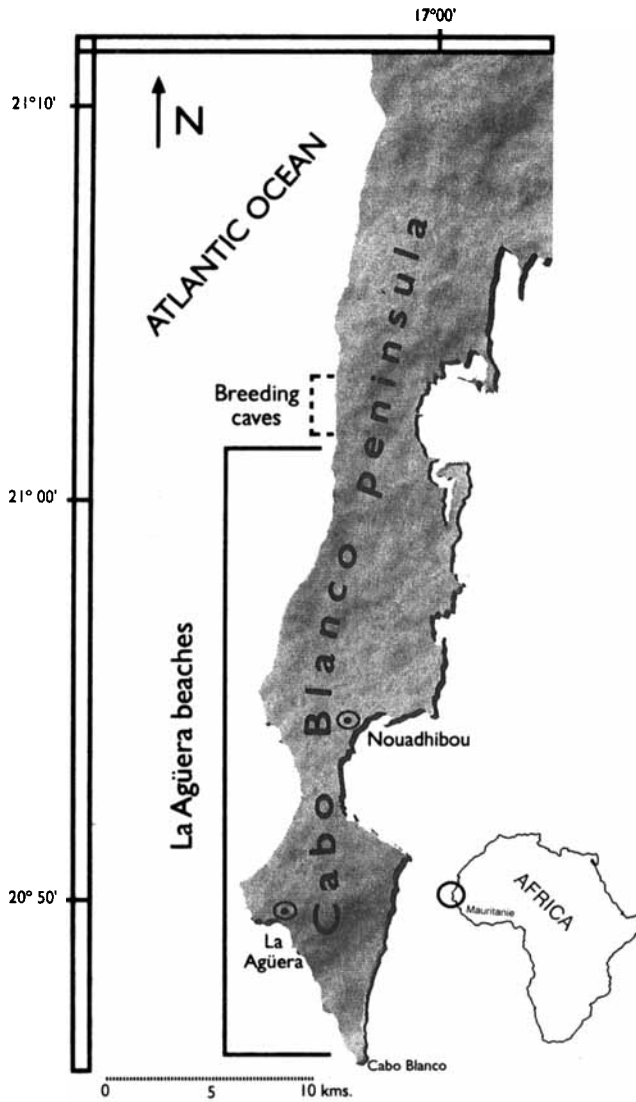


Figure 1. Map of Cabo Blanco Peninsula study area, with principal localities cited in text.

(Caves 1 and 3), between May 1993 and December 1997, counts of seals were made from a hanging platform lowered to the cave entrance. Individual animals were not necessarily identified during these counts, which were made on a weekly basis. Video monitoring of the beach in Cave 1 was done daily from August 1995 to December 1997. This allowed the presence or absence of individually identifiable pups to be determined. The monitoring equipment consisted of a video camera (CCTV Panasonic, model WV-CP610) fixed to the roof at the entrance of the cave. The camera covered up to 70% of the beach

in one frame and was able to scan the cave by remote control. Images were received on a monitor (Panasonic WV-CM140) and recorder (VHS Pal Panasonic AG-6124E) located in a hide at the top of the cliff. In Cave 3, where no camera was installed, observations to identify pups were made from the hanging platform for periods lasting 1–3 h. On several occasions a portable video camera was used to record the beach for later identification of pups. Such methods were also used in Cave 1 during brief periods when the monitoring camera was out of order.

Beach surveys—Based on our experience, the topographic configuration of the coast, and the direction of prevailing wind-driven surface currents (I.H.M. 1975), we surveyed approximately 40 km of beach along the south coast of La Agüera to locate pups washed out of caves. The coast was regularly monitored from the main breeding caves to the tip of the Cabo Blanco Peninsula (Fig. 1). Beach surveys were carried out on nine occasions in 1993 (May–December), 17 in 1994, 16 in 1995, 26 in 1996, and 21 in 1997. Partial surveys were carried out when a pup was noted to be missing from a cave. Recovered pup corpses were examined to determine the age category and the likely cause of mortality. Carcasses found in the first survey in May 1993 were not included in the analysis, because the length of time they had been dead could not easily be determined.

Pup survival rate—Pup Survival Rate (PSR) was estimated using the individually identifiable pups that were monitored from birth through the moult, or until they were found dead or disappeared from the caves. Because a pup has no possibility of survival without maternal attendance, we assumed that death had occurred when the pup was absent and not found in other caves in the area or when the pup was absent but its mother was present. Based on our video and direct observation sessions of Caves 1 and 3, we were able to monitor 84 pups born during September 1995 and December 1997 (32 in Cave 1 and 52 in Cave 3). These were used to estimate PSR.

Sea condition—In 1995, 1996, and 1997, we measured the height of the waves arriving at the cliff once a day, and we obtained the height of the tide from the Nouadhibou harbor authority. We assumed pups were at risk during the following sea states: (1) *storms*, waves higher than 2 m arriving continuously at the coast; (2) *high swells*, waves higher than 2 m arriving at the coast in discontinual sequences, and (3) *very high tides*, a tide height of more than 2.05 m.

Data on sea condition were correlated with those days when a pup was found dead or was observed alive for the last time. Matching cases were those when a pup was found dead in the caves or on the southern beaches after the presence of at least one of the sea-risk conditions and those when a pup was seen alive for the last time before the occurrence of them. To determine the influence of these sea conditions on pup mortality, we split the period from January 1996 to March 1997 into 91 periods of five days. We used contingency tables to investigate the association between pup deaths (or disappearances) and the presence of severe sea conditions. We combined the 91 periods into groups with presence of at least one of the three different sea conditions

Table 1. Fate of pups considered dead during study period (March 1993–December 1997).

Pups	1993*	1994	1995	1996	1997	Total
Found dead on beaches	11	9	13	14	5	52
Found dead inside caves	1	4	2	4	0	11
Disappeared from the caves	n.d.c.	n.d.c.	4**	9	17	30
Total	12	13	19	27	22	93

* Data obtained from March onwards.

** Data obtained only from August onwards.

n.d.c. No data collected.

and groups without adverse conditions, and each of these groups were tested for pup mortality. We used a 2×2 contingency table, the Chi-square statistic, and the Fisher's Exact Test. The correlation between pup mortality and number of days with high swell or storm per month was also calculated.

Cave topography—We measured the surface of sandy beach available to the seals within each cave. Due to the inaccessibility of the caves it was impossible to take direct measurements regularly. As there was a strong relationship between beach surface area and the presence of identifiable rocks, which were part of the rocky substratum, we used these rocks as an indicator of beach surface area. Variation in the sand level in Cave 3 coincided with the presence of eight identifiable rocks. Beach surface area was at its maximum when no rocks or only rock #1 was visible and at its minimum when all eight rocks could be seen. We recorded the beach area index daily from June 1993 to March 1997 during observation sessions or from the video recordings. Monitoring effort concentrated on Cave 3, which showed the largest variation in sand level.

RESULTS

Pup survival rate—Between May 1993 and December 1997, 93 cases of pup mortality were detected. We found 52 corpses on the La Agüera beaches and 11 inside or near the breeding caves; 30 pups disappeared from the caves during the nursing period and were never found (Table 1). Of the 84 pups for which place of birth and fate could be determined during the period September 1995–December 1997, we observed 45 cases of mortality, yielding a PSR of 0.47. The PSR varied depending on the month of pupping (Fig. 2), in particular being lower ($\bar{x} = 0.29$, $SD = \pm 0.12$, $n = 5$) during the period of a high frequency of storms (September–January) compared to the rest of the year ($\bar{x} = 0.71$, $SD = \pm 0.08$, $n = 7$). Most (80%) of these deaths occurred in the first two weeks after birth.

Effects of sea condition and beach area—Pup mortality was significantly associated with the presence of severe sea conditions, *i.e.*, high swells, storms, and high tides ($\chi^2_1 = 8.53$, $P < 0.004$; 2-tail Fisher's Exact Test, $P < 0.005$). Of 37 deaths that occurred between January 1996 and March 1997, 89% (n

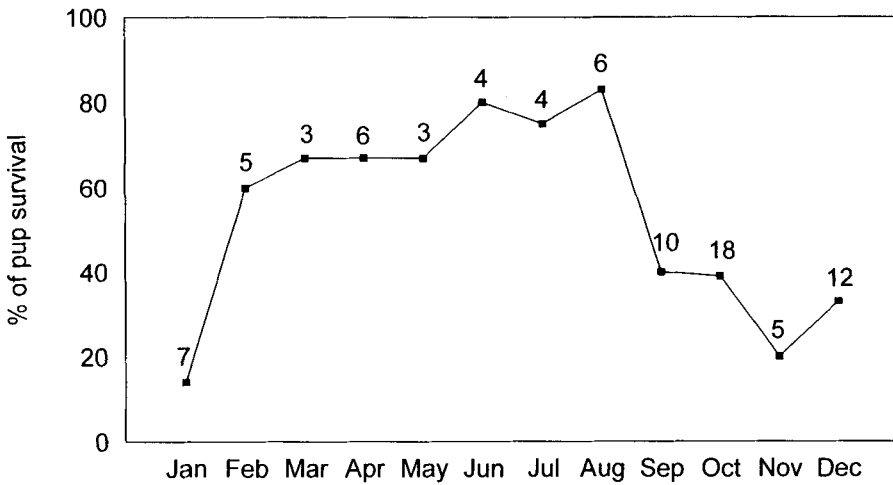


Figure 2. Percentage of pup survival. Data from September 1995 to December 1997. Numbers over each data point show number of pups monitored.

= 33) occurred during the presence of at least one of the sea conditions mentioned above. Moreover, 84% ($n = 31$) of the mortality cases occurred from September to January, the period when most storms typically occur (Fig. 2). There was also a significant positive correlation between the number of dead pups and the number of days per month with storms or high swells ($r = 0.86$ $P < 0.001$) (Fig. 3).

In Cave 3, beach surface area was similar from June 1993 to October 1995,

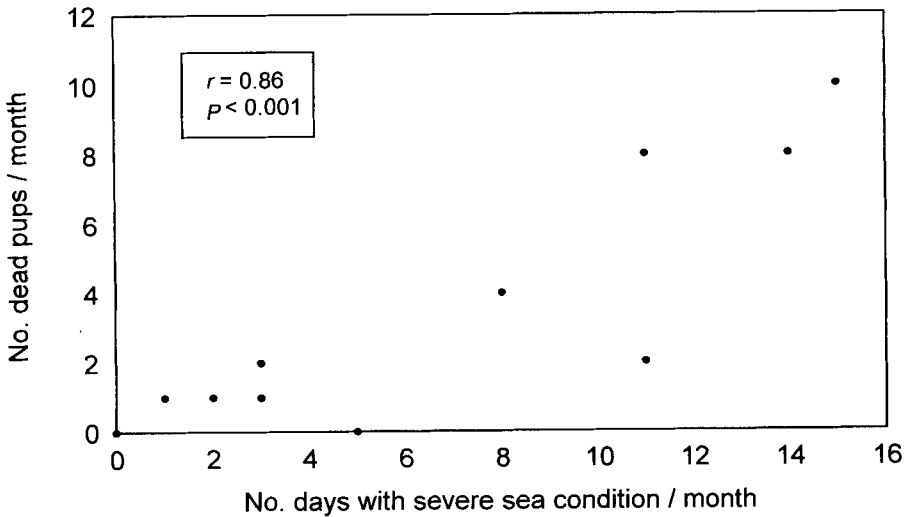


Figure 3. Correlations between number of days with severe sea conditions and number of dead pups per month.

when the area was at its maximum (rocks #1, #2, and #3 were scarcely visible). It was also similar from November 1995 to March 1997, when the area was small (most rocks were visible). Most deaths (86%, $n = 29$) occurred during the second period, when beach surface area was low (from September 1995 to March 1997). From October 1996 to March 1997, 27 pups were born in this cave but only seven survived to the moult. Sandy beach conditions in Cave 1 remained comparatively more stable. This resulted in different pup survival rates for the overall study period in the two caves: while the rate was 69% ($n = 55$) in Cave 1, that in Cave 3 was only 39%.

The predominant cause of death among the pups that were necropsied was multiple skull fractures. One pup that was found alive but died after a few days had hematomas on the skull and along the vertebral column. Three pups died from starvation in the first four days after birth, and three other pups were observed being washed from the cave by high swells. Two of them were captured and returned to the cave, while the other disappeared. The few pups that managed to arrive still alive at the southern beaches probably died in a very short time. Terrestrial predators such as jackals (*Canis aureus*) or wild dogs are common on the area. On several occasions tracks of these predators have been observed near fresh carcasses, and on one occasion two jackals were observed devouring a recently dead pup during daylight hours.

DISCUSSION

The survival rate calculated in the present study corresponds to the period birth to moult, which represents the first two months of life of the pup. However, because weaning takes place at an age of ~ 4 mo, this rate should be considered as a minimum estimate of that of survival to weaning. The magnitude of this bias is however considered to be low because 80% of the cases of pup deaths occurred during the first two weeks after birth.

Even taking this bias into consideration, the survival rate (47%) is below that observed in other pinnipeds (Anderson *et al.* 1979, Gentry and Johnson 1981, Thomas and De Master 1983, Doidge and Croxall 1984, Kovacs *et al.* 1985, Vaz-Ferreira and Ponce de León 1987, Torres 1987, Hindell and Burton 1987, Bowen 1991, Boness *et al.* 1992, Gilmartin *et al.* 1993, Le Boeuf and Laws 1994, Boyd *et al.* 1995). The habit of breeding inside caves undoubtedly accounts for this low survival rate. The PSR of populations of gray seals (*Halichoerus grypus*) that breed in caves (57%–65%) is substantially lower than that obtained for populations of the same species that breed on open beaches (76%–78%) (Anderson 1979). However, the rates found in the present study are lower than even the lowest estimates for other cave-dwelling pinnipeds.

Pup survival rate during the preweaning period of most colonial breeding phocids is usually high, but in some unusual conditions such as the presence of storms, high density of individuals, or shortage of food, it may significantly decrease (Bowen 1991). Sea condition and topography of the breeding sites can act independently or jointly to contribute to mother-pup separation or cause physical injury by impact of pups against rocks (Riedman 1990, Bowen

1991, Boness *et al.* 1992). In gray seals, Hawaiian monk seals (*Monachus schauinslandi*), Guadalupe fur seals (*Arctocephalus townsendi*), and northern elephant seals (*Mirounga angustirostris*), PSR is higher in areas that are sheltered and protected from storms and high surf (Anderson *et al.* 1979, Torres 1987, Pierson 1987, Westlake and Gilmartin 1990, Le Boeuf and Laws 1994). In northern elephant seals and the South American fur seal (*Arctocephalus australis*), storms are responsible for up to 61% and 80% of pup mortality, respectively (Vaz-Ferreira and Ponce de León 1987, Le Boeuf *et al.* 1994).

The monk seal colony of Cabo Blanco occupies an area heavily affected by the action of large oceanic waves and where storms are frequent between September and January. This results in a higher mortality rate of pups during this period as compared to the rest of the year.

Individuals haul out and give birth on narrow sandy beaches at the deepest point of the two main caves. During very high tides or when high swells reach the end of the cave, these sandy beaches disappear. As a consequence, pups try to remain on the few patches of sand still available, where they can be fatally injured against the rock walls due to the action of the waves. This effect is evident from the survival rates at the two main breeding caves in Cabo Blanco: 69% in Cave 1, where changes in sand level were moderate, compared to 39% in Cave 3, where variation in sand level was much higher.

The nursing period of the Mediterranean monk seal does not involve constant close contact with the mother as is typical in the congeneric Hawaiian monk seal (Boness 1990). During lactation, females make feeding trips to sea (M. Gazo, unpublished data) leaving their pups unattended. This behavior contributes to a higher probability for an unattended and inexperienced pup to be carried away by swells. During storm periods the potential adverse effect on the pup of separation from its mother increases. When swells are high, females usually try to protect their pups from being washed away by taking them by the neck and carrying them to the upper zone of the beach, or by interposing their bodies between the pup and the waves. However, despite these actions by females, some pups may still be fatally injured or washed away. In other species the topography of the breeding areas also affects the behavior of pups. For example, in sheltered areas gray seal pups spend more time in the water (Smiseth and Lorentsen 1995) and spend more time resting and inactive, which makes it easier for the females to relocate them (Kovacs 1987).

The low pup survival observed in the Mediterranean monk seal of Cabo Blanco seems to be associated, at least partially, with the use of caves as a breeding habitat. The effects of sea condition are not apparent in pinniped colonies settled on open beaches (Anderson *et al.* 1979, Gentry and Johnson 1981, Hindell and Burton 1987, Gilmartin *et al.* 1993, Le Boeuf and Laws 1994, Boyd *et al.* 1995). However, despite the lower pup survival associated with cave breeding, the Cabo Blanco population is still the largest extant Mediterranean monk seal colony. Presumably, the protection against predators and human disturbance afforded by the caves outweigh its associated mortality,

since colonies settled on open beaches have declined much more dramatically than that of Cabo Blanco.

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