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GROWTH AND DISTRIBUTION OF A SOUTHERN ELEPHANT SEAL COLONY

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ABSTRACT

In contrast with most southern elephant seal, *Mirounga leonina,* colonies, births at Península Valdés, Argentina, increased from 7,455 in 1982 to 9,636 in 1990. Colony size during the 1990 breeding season, including pups, was estimated at 19,000. Colony growth may respond to abundant food resources and lack of competitors. The range of distribution of elephant seals in Patagonia has not changed since at least 1972 but the spatial distribution of births along the coastline of Península Valdés has varied. In 1982, 58% of the births occurred in the northeast portion of the Península versus 36% in 1990. Females may prefer to give birth on broad, sandy beaches. In 1982, 56% of the females gave birth on pebble beaches and 44% on sandy beaches. In 1990, 24% bred on pebbles versus 76% on sand. Sand substrate may be preferred by females because it may confer thermoregulatory advantages in relieving heat stress.

Key words: elephant seals, *Mirounga leonina,* demography, population growth, Península Valdés.

The recovery of the northern elephant seal, *Mirounga angustirostris,* after its virtual extinction (Bartholomew and Hubbs 1960, Antonelis *et al.* 1981) contrasts with a sharp population decline of the southern species, *M. leonina,* at several breeding places in subantarctic and antarctic waters over the past 50 years (Skinner and van Aarde 1983, McCann 1985, Burton 1986, Hindell and Burton 1987). Contrary to this downward trend, preliminary data on the southern elephant seal colony of Península Valdés, Argentina, suggest it could be the only one that is expanding (Scolaro 1976, Vergani *et al.* 1987).

The Valdés colony has ecological, demographic and geographic features that differentiates it from others of the same species and from its northern counterpart (Le Boeuf and Petrinovich 1974). It is the northernmost large seal breeding colony in the Southern Hemisphere. It is located on a continent rather than on an island, in temperate rather than antarctic or subantarctic waters, and 550 km away from deep water, where elephant seals apparently forage (Hindell 1990). Animals are widely distributed along 200 km of coastline (Vergani

1985, Lewis 1989). Breeding groups are unusually small relative to most other large colonies (Honigman 1988), and pup mortality is low compared to its northern counterpart (Le Boeuf and Petrinovich 1974, Lewis 1989). There is no evidence that the Valdés colony has ever been affected by intensive sealing, unlike all other major breeding sites of the species (Laws 1960, van Aarde 1980*a*, McCann 1985, Hindell and Burton 1988).

Here we report on the trends in births, breeding distribution, harem size, and sex ratio of this poorly known colony. These data contribute to a better estimate of the current status of the species and the identification of factors causing its decline in numbers.

Methods

We made aerial surveys during the peak breeding season (first week of October) in 1982, 1989 and 1990, when about 96% of the breeding females were ashore (Lewis 1989). Peak season (time with maximum number of females ashore) was determined by terrestrial counts conducted at several study areas since 1982 (Lewis 1989, Campagna and Lewis, unpublished data). We photographed all breeding groups and recorded all solitary individuals by sex and age category (adults, juveniles, and weanlings) along the 200-km coastline of Península Valdés (Fig. 1) at altitudes of 80–150 m. We also searched for elephant seals during an extensive wildlife aerial survey of the entire coast of Patagonia (about 3,000 km, from 38°40′ to 52°30′ S), including islets located near shore, conducted in November 1990.

We categorized seals as breeding females, males (harem bulls and challengers), pups, and weanlings. Challengers were males aggressively excluded from harems by dominant bulls. A harem was defined as a group of two or more females with a bull in attendance typically positioned closer to the females than any other male. Breeding groups included harems and mating pairs (group of one male and one female). From the survey, we calculated the total number of breeding groups, median harem size, and frequency distribution of harems. A negative binomial distribution was fitted to the frequency distribution of harem size. The parameter k of the binomial distribution indicates here the degree of grouping of females in harems and is inversely correlated with it (Pielou 1977). The fit of the theoretical distribution to the data was statistically significant ($P < 0.05$) and allowed a comparison of the degree of association of females in different years (Pielou 1977).

Results from the aerial surveys were compared against counts conducted on foot, within 24 h of the aerial survey, of four reference stations located 20–60 km apart and totaling about 27 km of coastline. Each station had a different substrate and topography (*e.g.,* sandy beaches bordered by cliffs or dunes, open beaches of fine pebbles, beaches of coarse pebbles bordered by cliffs, and small beaches with boulders bordered by cliffs). During terrestrial counts, we recorded 95% (1989) and 98% (1990) of about 1,800 females counted from aerial photographs of the same beaches. Pups and weanlings were easily overlooked from the plane. Thus, we assumed that the number of adult females ashore

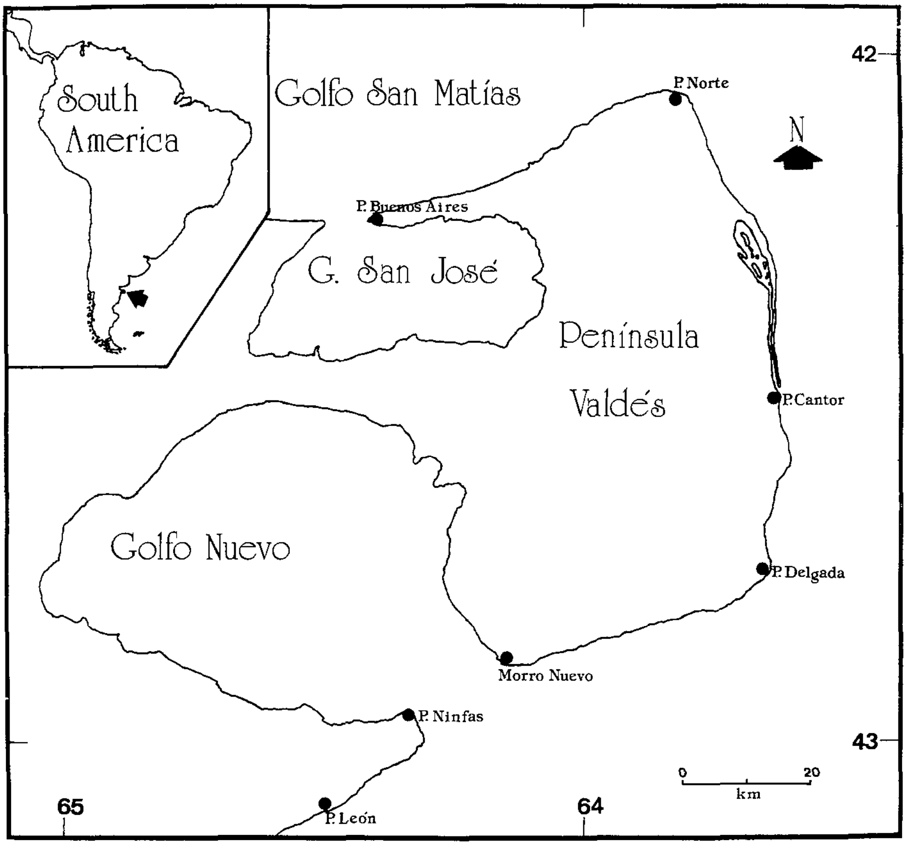

Figure 1. Geographic location of the area of study.

reflected the number of pups (McCann 1985, Wilkinson and Bester 1988). The number of weanlings was estimated as follows. From terrestrial counts, we obtained an index of weanlings per adult female of 0.35, 0.22, 0.36, and 0.11 for the four topographic regions. We then calculated the proportion of the total females found in each region and multiplied this number by the index of weanlings per female.

Pup production was calculated as the total number of breeding females ashore at peak season plus the estimated number of weanlings at that time. This method improves that used in a previous estimate of the size of the Península Valdés colony based on the count of pups rather than females (Vergani *et al.* 1987), which underestimates the number of pups born (McCann 1985). Dead pups were not included in the counts in the present study because females that lost their pups may remain ashore long enough to be counted along with their dead offspring (Laws 1956*a, b*). Weanling sex ratio (males : females), an indicator of pup sex ratio at birth (Campagna *et al.*, in press), was estimated by recording the sex of individuals during on-foot surveys of the reference stations conducted during the last week of October 1984 and 1989.

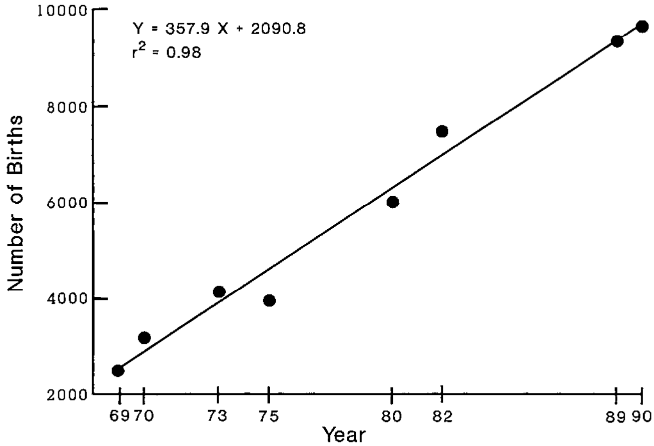

Figure 2. Increase in births from 1969 to 1990. The regression line was highly significant ($F = 357$). NOTE: x-values are given as numbers ranging from 1 (1969) to 21 (1990).

To estimate pup production we assumed that: (1) virtually all adult females ashore gave birth to a pup (Laws 1956*a,* McCann 1985), (2) females that weaned their pups had left the area, and (3) few females would come ashore to give birth after the peak of the breeding season. These assumptions are realistic because: (1) virgin females reaching sexual maturity are rarely seen or not seen at all on land during the breeding season (Angot 1954, Laws 1956*a*), and, at two breeding sites at Península Valdés, we found during the 1988 and 1990 breeding seasons that 98% of 506 females marked upon arrival to the rookery had given birth (Campagna, unpublished information); (2) most pups were weaned when their mothers departed to sea but not before (Laws 1956*a,* van Aarde 1980*a*); and (3) during the 1988 breeding season, only 4% of 253 females that gave birth near Punta Norte had yet to come ashore at peak season (Campagna, unpublished data).

To have a crude approximation of colony growth since 1969, we compared previous surveys of all or most of the Peninsula with our censuses, correcting former counts for differences in date within the breeding cycle and area surveyed. Corrections for dates were based on curves of the percentage of breeding females ashore (McCann 1985). Corrections for area surveyed were done by adding animals to counts that covered most but not all the Península using our 1989 census as a reference to estimate the proportion of missed individuals. For the short period ranging from 1969 to 1980, a linear model fit the data slightly better than an exponential model (r^2 = 0.98 and 0.96, respectively).

During aerial surveys, we identified and located unsuitable places for reproduction (*e.g.,* small beaches with boulders bordered by cliffs or flooded at high tides). Out of about 200 km of coast, 163 km were appropriate for reproduction. Areas used for reproduction were categorized as sandy beaches bordered by cliffs or dunes (53% of suitable reproductive area; 86 km), and pebble beaches (47%; 77 km). Pebble beaches prevail in the northeast portion of the Península (from

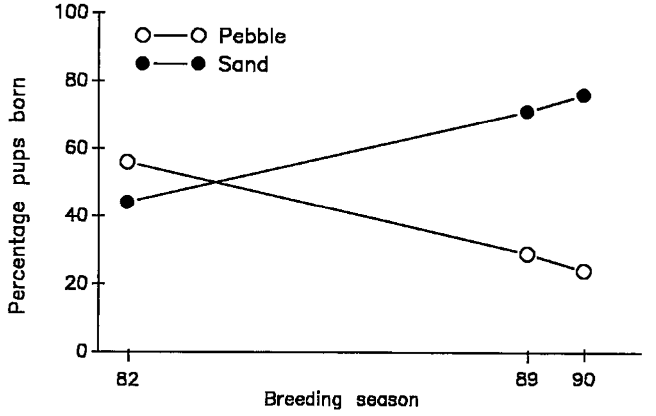

Figure 3. Habitat preference by reproductive females as indicated by the percentage of pups born in sand versus pebble beaches. Sandy and pebble beaches made up a similar percentage of the suitable space for reproduction. Points were connected to highlight the trend.

Punta Buenos Aires to Punta Cantor; Fig. 1) while sandy beaches prevail in the southeast portion (from Punta Cantor to Punta Ninfas; Lewis 1989).

Results

Pup production and sex ratio—Births increased from 7,455 in 1982 to 9,636 in 1990. There was a linear increase in pup production since 1969 (Fig. 2). The number of breeding animals of both sexes ashore at peak season increased from 7,400 in 1982 to 9,800 in 1990.

Weanling sex ratio was not different from unity in 1984 (1.0:0.9, n = 687) and 1989 (1.0:1.1, n = 862) (Chi square = 0.77, 1.04, respectively, $P > 0.05$). Adult sex ratio at peak season was significantly more female-biased in 1990 (1.0:7.5; n = 9,800) and 1989 (1.0:7.0; n = 8,400) than in 1982 (1.0:6.4; n = 7,400; $G = 11.7$, df = 2, $P < 0.05$).

Distribution range and pattern—Elephant seals were not recorded elsewhere in Patagonia besides the oceanic shore of Península Valdés, from Punta Buenos Aires to Punta León (Fig. 1).

The distribution of seals in the Península changed from 1982 to 1990. In 1982, 58% of the females gave birth in the northeast portion of it, from Punta Norte to Punta Cantor (Fig. 1). In 1990, only 36% of the females were found in the same area, while 64% of them were located in the southeast part of the Península, from Punta Cantor to Punta Delgada (Fig. 1). Likewise, in 1982, 46% of the sexually mature males were found between Punta Norte and Punta Cantor, versus 28% in 1990.

Changes in distribution patterns may respond to preference for broad, sandy beaches. In 1982, 56% of the females gave birth on steep, pebble beaches versus 44% on sand (Fig. 3). In 1990, the proportions reversed with 24% of the mothers giving birth on pebble beaches and 76% on sand.

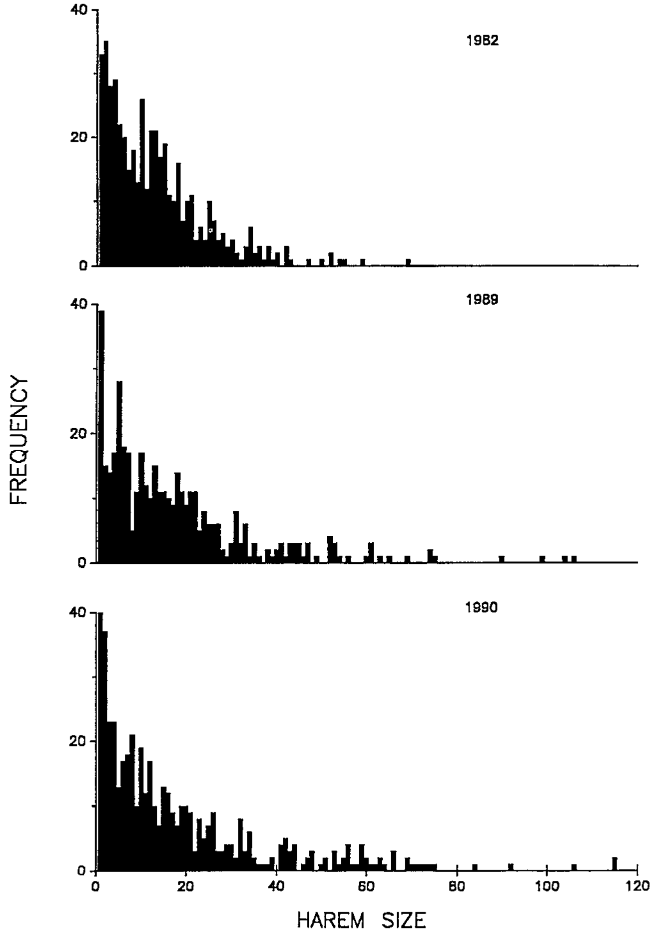

Figure 4. Frequency distribution of harems from 1982 to 1990. The degree of grouping was higher in 1990 than in 1982 (negative binomial distribution, $k_{1982} = 1.13$; $k_{1989} = 0.92$; $k_{1990} = 0.71$; Pielou 1977).

Harem size—Median harem size and total number of mating groups for the whole Peninsula at peak season changed only slightly since 1982 (Table 1). Out of 420–487 mating groups, depending on the year, 91–93% were harems composed of up to 122 females and 7–9% were mating pairs (Table 1). About 0.4% of the females gave birth in isolated locations. Harems larger than 80 females occurred in 1989–1990 but not in 1982 (Fig. 4), and maximum harem size increased considerably (Table 1).

Median size of breeding groups in 1982 was similar for pebble beaches (9.5 females; $n = 237$ harems) and sandy beaches (11.5 females; $n = 240$; Median test, $\chi^2 = 2.3$, $P > 0.05$). Conversely, in 1990, harems on pebble beaches were smaller than on sandy beaches (median = 7.5 *vs.* 17 females; $n = 232$ and 255 harems, respectively; Median test, $\chi^2 = 18.3$, $P < 0.05$).

Table 1. Characteristics of breeding groups for the entire colony during three breeding seasons. Medians were calculated without including solitary females and one-female mating pairs. Sample size (n) includes harems and mating pairs but does not involve solitary females. Adult females include total censused females that were breeding.

		Harem size				
	n	Median	Max	One-female pairs	Solitary females	Adult females
1982	477	11	69	32	—	6,400
1989	420	13	106	39	32	7,323
1990	487	11	122	44	43	8,668

As the number of harems remained relatively stable but the females increased over the years, the degree of grouping also increased from 1982 to 1990 (Fig. 4).

Discussion

Demography—In contrast with most other southern elephant seal colonies in the world, births at Península Valdés have increased in recent years. The increase in population size is not associated with an expansion in the geographic range of distribution since at least 1970 (Daciuk 1973, Scolaro 1976).

Pup production provides an index to assess total colony size as juveniles and other young age categories are not found during the breeding season (Laws 1960, McCann 1985). Based on a 1:3.5 proportion of pups to other age categories calculated for South Georgia (McCann 1985), the Valdés population size by the end of the 1990 breeding season was roughly estimated as 43,400 animals, including pups produced that year. As this estimate is based on a correction factor calculated for a stationary rather than an expanding colony, it may represent a maximum number rather than a conservative estimate.

In contrast to Valdés, there are large and small breeding colonies of southern elephant seals that are decreasing conspicuously. The Macquarie colony, the third largest in the world (McCann 1985), has decreased by approximately 50% over the last 36 yr (Hindell and Burton 1987). That at Marion Island declined 4.8% per year from 1951 to 1975, and the decrease was even greater from 1973 to 1982 (Condy 1979, Skinner and van Aarde 1983). The seal colony at Possession Island is declining at an annual intrinsic rate of 5.8% (Barrat and Mougin 1978). The small colony at Gough Island has apparently decreased slightly from 1955 to 1978 (Bester 1980). At Kerguelen, bull numbers decreased steadily from 1958 to 1977, and both males and females declined from 1971 to 1977 (van Aarde 1980*a, b*; McCann 1985).

Uncertainties about the causes of its increase preclude predictions about the future of the Valdés colony. There is no evidence of a substantial immigration of seals to Península Valdés from other areas. A few animals seen in Valdés molt in the Falkland (Malvinas) Islands (Scolaro 1976; Fedak, personal communication), the closest seal breeding location to the Península, but the latter colony would be too small (Laws 1960) to significantly affect other colonies through emigration. Life tables are not available for Valdés to determine if population growth may be explained by unusually low mortality, higher recruitment, or higher fertility rates than in declining or stationary populations. A potential cause of population increase may be little competition for abundant food resources. The shallow ocean floor that extends more than 500 km to the east of Península Valdés is a rich fishing ground inhabited by abundant stocks of fish and squid species (Bellisio *et al.* 1979) and other pinnipeds inhabiting the same area that may benefit from these resources, such as the southern sea lion, *Otaria byronia,* which was depleted during this century (Crespo 1988).

Spatial distribution—The variation in the spatial distribution along the coastline of the Peninsula may respond to habitat preference. Females prefer sandy beaches over vegetated hillocks, pebble, cobble and rocky areas (Odell 1977, Bester 1980, van Aarde 1980*b*). The number of adults per km of coastline on sandy beaches at Kerguelen Island is 3.4 times higher than on pebble beaches (van Aarde 1980*b*). This is consistent with Península Valdés where 3.2 times more animals breed on sand than on pebble.

Habitat choice may be related to thermoregulation. As southern elephant seals are mainly subantarctic and antarctic phocids (Laws 1960), heat stress may be critical at the latitude of Península Valdés, where air temperature fluctuates from 18°–25°C and solar radiation may reach 1.42 cal/cm^2/min (Campagna and Le Boeuf 1988). The topography and substrate of the places where pinnipeds haul out are relevant features at the time of reducing thermal stress (Whittow 1987, Campagna and Le Boeuf 1988). Sand would have more advantageous thermal properties for seals than pebble. Wet, fine-grain sand contains more moisture and less air than pebble (Hillel 1982). Furthermore, sand has a higher specific heat, conducts heat better and allows a greater body-to-substrate contact area than pebble (Campbell 1977, Hillel 1982). These properties facilitate heat loss by evaporation and conduction, and buffer the effect of radiant energy on surface temperature.

Redistribution related to habitat preference may be facilitated by a relatively weak philopatric tendency of the seals of Valdés compared to other colonies (*e.g.,* Laws 1956*a,* Carrick *et al.* 1962). Animals born and tagged at Punta Norte and adjacent areas are found molting or reproducing from 100 km away from their place of birth to the Falkland Islands (Campagna and Lewis, unpublished data). This flexibility in the haul-out pattern may facilitate changes in habitat because the seals do not necessarily return to the same beaches during consecutive haul-out periods or years.

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