

OBSERVATIONS ON THE TREND OF THE BREEDING POPULATION OF SOUTHERN ELEPHANT SEALS, *MIROUNGA LEONINA*, AT MARION ISLAND

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SUMMARY

(1) The annual haulout pattern of adult southern elephant seal cows is described by polynomial functions with differences in the rate of haulout and the asymptote attained resulting in the coefficients and constants of the functions being different.

(2) An analysis of data collected during nine breeding seasons from 1973 to 1982 indicated an overall decrease of 11.0 and 8.0% for the adult bull and cow components of the population breeding at Marion Island.

(3) The number of cows hauling out to produce pups is exponentially related to the number of adult bulls present on land during the year of fertilization. The overall decrease in the population may therefore be ascribed to factors responsible for a decrease in bull numbers.

INTRODUCTION

Southern elephant seals *Mirounga leonina* breed on islands on both sides of the Antarctic Convergence and have been the subject of several independent studies during the past three decades. It has been suggested that survival and breeding of the species is optimal in the circumpolar zone of the Antarctic Convergence as a result of the large, seasonally constant biomass of zooplankton (Carrick & Ingham 1962). Laws (1960) estimated the world stock of southern elephant seals at $600\,000 \pm 100\,000$ with an annual food consumption of 4.5 million tons of squid and 1.5 million tons of fish (Laws 1977). Although sperm whales *Physeter catodon* and elephant seals are potential competitors for food, the timing of their life-history events results in them being separated at the time of maximal potential competition (Laws 1977).

Numerical changes in southern elephant seal populations at various localities in the southern oceans during the latter half of the present century have been reported by Carrick & Ingham (1962), Dacuik (1973), Condy (1977), Barrat & Mougou (1978), Pascal (1979), Bester (1980a) and van Aarde (1980a). Factors responsible for these changes are still unknown, but have been the subject of some speculation (Van Aarde 1980a, b). Earlier attempts to analyse changes in elephant seal numbers were limited primarily by censuses having been conducted at irregular intervals or because data were not directly comparable, either as a result of seasonal changes in numbers ashore, or because different breeding areas were censused.

During 1973 the Mammal Research Institute initiated a long-term monitoring project on the southern elephant seal population at the sub-Antarctic Marion Island (46°54'S, 37°45'E). This population was first studied by Rand (1962) and La Grange (1962) who provided data on population size, distribution and limited information on the annual cycle. Condy (1977) estimated the 1975 population at 4500 individuals with a breeding

component of 1313 cows and 115 bulls and ascribed the decline of 4.8% year⁻¹ from 1951 to 1975 to selective killerwhale *Orcinus orca* predation.

Marion Island is situated approximately 150–300 km north of the Antarctic Convergence and therefore within the suggested optimal zone for the species. The climate of the island is basically oceanic, modified by the topography of the island itself.

METHODS

Direct counts of adult bulls, adult cows and unweaned pups at all breeding beaches along the north-eastern coastline of the island (6.5 km), from Ship's Cove to Archway Bay, form the data base for the present analyses. Approximately 33% of the annual pup crop is produced within this area and trends observed there are considered to be representative for the total population. Weekly censuses were conducted on foot from 11 September to 13 November during all years from 1974 to 1982 with the exception of 1978. The relative ease with which elephant seals can be approached when on land and the accessibility of breeding beaches means that direct counts give an accurate estimate of the number of animals present on land. Seasonal trends in cow numbers were smoothed by the generation of third degree polynomial functions and estimates of intrinsic population growth rates were based on the exponential function $N_t = N_0 e^{rt}$ as suggested by Caughley (1977).

RESULTS

Temporal changes in the number of cows present on land during the breeding season of each year from 1974 to 1982 (1978 excluded) were similar and were best described by polynomial functions of the third degree ($r^2 = 0.87-0.99$; Fig. 1). Year-to-year differences

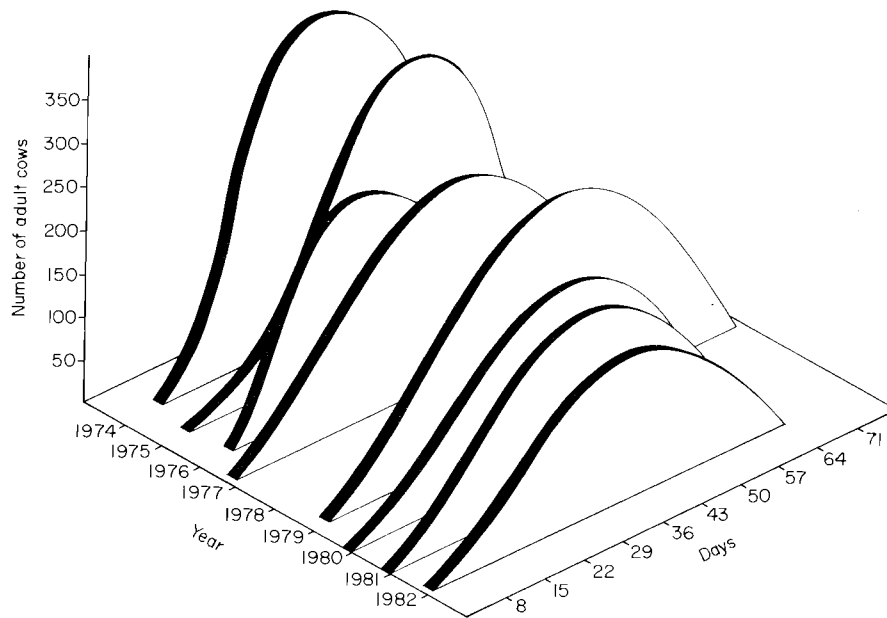


FIG. 1. Seasonal changes in the number of adult cows hauled out on land during breeding seasons from 1974 to 1982. Annual seasonal trends were smoothed by the generation of third degree polynomial functions.

TABLE 1. Constants, coefficients and coefficients of determination for the third degree polynomial functions describing the seasonal haulout pattern of adult cows during the breeding season

Year	Constant	Coefficients			Coefficient of determination (r^2)
		x	x^2	x^3	
1974	-867.4	86.3	-1.86	0.010	0.97
1975	78.5	6.2	1.01	-0.010	0.99
1976	28.4	10.3	0.001	-0.002	0.90
1977	20.6	8.4	0.05	-0.004	0.94
1979	-47.0	6.9	0.13	-0.003	0.97
1980	19.7	4.6	0.17	-0.004	0.92
1981	-28.6	8.0	0.03	-0.002	0.87
1982	20.7	4.8	0.11	-0.002	0.88

in rates of arrival, departure and the maximum number of cows present resulted in different calculated coefficients for all comparable orders as well as different constants (Table 1). In spite of these variations the number of cows on land each year increased rapidly from mid-September to reach a peak during mid-October (mean date of peak is 16 October, ranging from 9 to 23 October ($n = 8$)).

Seasonal increases in pup numbers paralleled those of cow numbers by increasing rapidly from mid-September to attain a peak during November, the mean date of this peak being 7 November, ranging from 31 October to 21 November ($n = 8$). Maximum adult bull, adult cow and pup numbers, as reflected by the census data, decreased from 1973 to 1982 at a mean annual intrinsic rate of 11.0, 8.0 and 8.0%, respectively. The patterns of decrease in pup and cow numbers during this period illustrate the exponential nature of population decrease (Fig. 2).

Adult sex ratio changed significantly from year to year (Table 2) but does not appear to show a definite trend ($\chi^2_8 = 11.97$ contingency coefficient = 0.07). No relationship existed between the maximum number of bulls on land during year t and the maximum number of

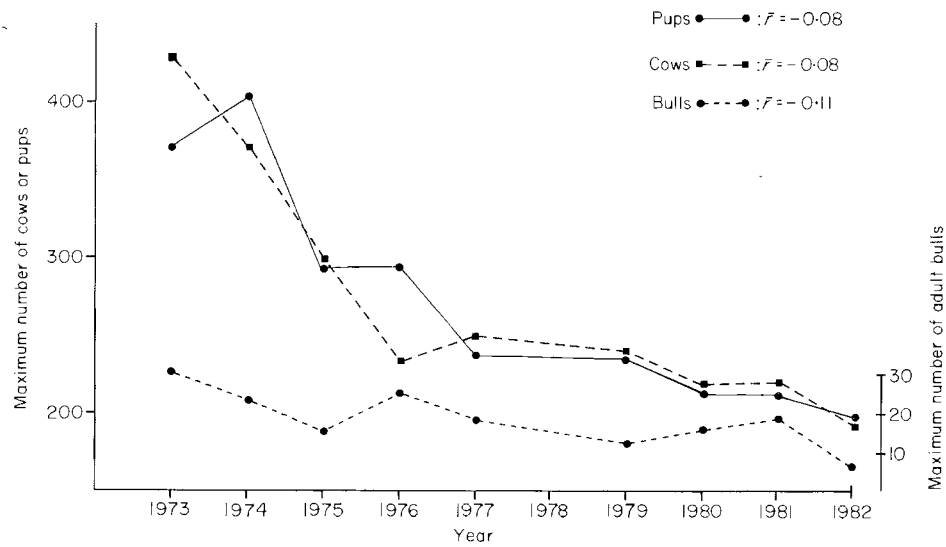


FIG. 2. Population trends in the adult bull, adult cow and pup components.

TABLE 2. Adult sex ratios and the maximum number of adult bulls and cows on land during the breeding seasons from 1973 to 1982

Year	Adult sex ratio		Maximum number on land	
	♂	: ♀♀	Bulls	Cows
1973	1	: 13.90	31	431
1974	1	: 15.46	24	371
1975	1	: 19.93	15	299
1976	1	: 8.07	25	234
1977	1	: 14.00	18	252
1979	1	: 20.00	12	240
1980	1	: 13.56	16	217
1981	1	: 11.53	19	219
1982	1	: 31.33	6	188

cows present on land during the same year ($r_9 = 0.73$). However, the relationship between the number of bulls on land during year t and the number of cows present on land during the following year ($t + 1$) proved to be highly significant ($r_7 = 0.83$; $P < 0.01$; Fig. 3).

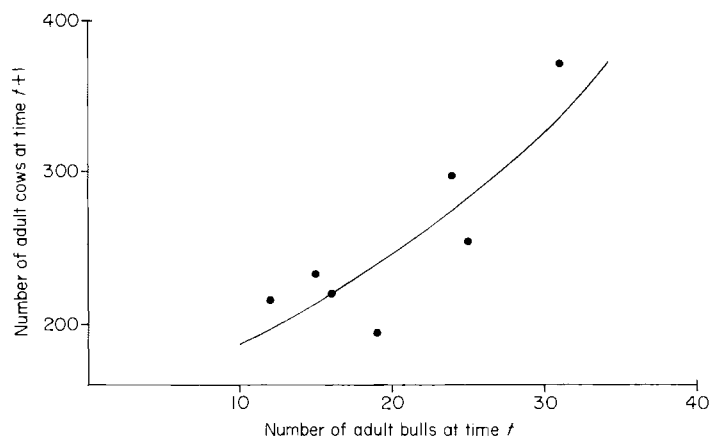


FIG. 3. The relationship between the number of adult bulls on land during year t and the number of adult cows on land during year $t + 1$.

DISCUSSION

Recently, considerable interest has been shown in the population estimates of southern ocean pinnipeds, their population biomass and annual food consumption (Laws 1977; Øritsland 1977; Condy 1981). Investigations of the three pinniped species inhabiting Indian and Atlantic ocean temperate and sub-Antarctic islands suggested total recovery of some of these populations after the cessation of sealing. Recent estimates of intrinsic rates of natural increase for the two fur seal species (*Arctocephalus tropicalis* and *A. gazella*) were between 7.8 and 16.8% year⁻¹ (Payne 1977; Condy 1978; Bester 1980b). Rapid population increases are assumed to be related to a krill 'surplus' resulting from a reduction in baleen whale numbers (Laws 1977; Payne 1977) as well as an increase in squid stocks following the decline in sperm whales (Gulland 1974). Bester (1980b) concluded that population recoveries simply resulted from a cessation in sealing activities.

Notwithstanding, several populations of southern elephant seals, breeding on these islands have, following recovery (Carrick & Ingham 1962), since 1970 been decreasing at rates varying from 4.6 to 8.0% year⁻¹ (Condy 1977; Barrat & Mougin 1978; Pascal 1979; van Aarde 1980a).

Condy (1977) ascribed the decrease in the Marion Island elephant seal population from 1951 to 1975 to a lowered recruitment of the third year age class of cows caused through predation by killer whales. A similar suggestion has been made by Barrat & Mougin (1978) in their attempt to clarify the observed decrease in the population at Possession Island from 1940 to 1976. On the other hand van Aarde (1980a) ascribed the dramatic decrease in the breeding population at Kerguelen Island since 1970 to direct competition for food between seals and the fishing fleets.

On three comparable counts conducted by Rand (1962) during 1951/52, E. M. van Zinderen Bakker (pers. comm.) during 1965/66 and by himself during 1974/75, Condy (1977) estimated the intrinsic rate of decrease of the Marion Island breeding population at 4.8% year⁻¹. Furthermore, a breakdown of the rate of decrease from 1965 to 1975 to the components of the population, suggested that these were 10.2, 1.7 and 7.3% for cows, bulls and pups, respectively (Condy 1977). The values for cows and pups do approximate those estimated here for the period 1973 to 1982 (8.0 and 8.0% respectively) but our values are not based on the same part of the population as that considered by Condy (1977). On the other hand, differences in the rates of decrease for bulls (1.7 cf. 11.0% for the periods 1965 to 1975 and 1973 to 1982, respectively) cannot be explained by study area differences, and it therefore seems that the bull component of the population is decreasing at an increasing rate. In addition, the rate of decrease for adult bulls is also greater than that for adult cows for the Kerguelen Island population (van Aarde 1980a).

We can only speculate on the implications involved here. However, in considering the social organization of the species it became apparent that breeding rookeries comprising females under the 'control' of a beachmaster (referred to as harems) are, in the case of Marion Island, surrounded by fewer subordinate bulls than the harems at Kerguelen Island. The fact that all cows observed leaving their harems at Kerguelen were mated by lower ranking bulls surrounding the harem after having been mated by a harem bull ($n = 98$) suggested a social mechanism in operation to ensure that all females are inseminated before leaving the land. The lack of bulls surrounding harems at Marion Island may have resulted in a negation of this insurance mechanism.

The gestation period is about a year (Laws 1960) and a cow hauls out to pup in year $t + 1$ if she has been fertilized in year t . If the reduced number of subordinate bulls at Marion Island is limiting, it would explain the observed relationship of the number of cows, and therefore of pups produced, to the number of bulls ashore in different years. In fact, the analysis does show that the number of cows on land at year $t + 1$ is directly correlated with the number of bulls on land at year t (the year of fertilization), supporting the hypothesis that bull numbers are a factor limiting fertilization success.

It would seem from the available data that a decrease in the cow population, and therefore pup production, emanates from factors responsible for a decrease in the bull component of the population. This is indicated by the trends since 1975 when low pup production in a specific year is equalled or exceeded the following year (Fig. 2). The progressive decline in bull numbers prevents all cows hauling out in more productive seasons from being fertilized. Factors responsible for this decline in bull numbers are still unknown, nor whether such factors also affect the physiological state of bulls such as age at puberty or subsequent sexual status.

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