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Numerical changes in the population of the Antarctic fur seal *Arctocephalus gazella* at two localities of the South Shetland Islands

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ABSTRACT

The Antarctic fur seal Arctocephalus gazella *was intensively exploited during the 19th century in its distribution area. The ceasing of its exploitation, subsequent international protection, and the availability of food, mainly krill, due to the decreasing of whale production, brought about the recovery of the Antarctic fur seal specially in South Georgia, which became the "dispersing centre" of these animals to recolonize their earlier breeding areas, the Scotia Arc and Subantarctic Islands.*

Since the breeding season 1981-82 until that of 1984-85, population census have been carried out including the pup tagging at Stigant Point (62°02' S, 58°45' W), King George Island, as well as at Cape Shirreff (62°27' S, 60'47' W), Livingston Island, South Shetland Islands.

The population growth in colonies with low density should fit an exponential model. The total population should increase and also the proportion of females, subadult males and pups.

The population growth curve at Cape Shirreff fits an exponential model. The population structure is significantly different between Cape Shirreff and Stigant Poin in 1983-84 and 1984-85. The population growth in Cape Shirreff between 1983-84 and 1984-85 is 64%, the most part of which is explained by immigration.

Results show a rapid population growth, a low neonatal mortality and a higher proportion of males at Cape Shirreff.

Cambios numéricos en la población del lobo fino antártico *Arctocephalus gazella* en dos localidades de las islas Shetland del Sur

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RESUMEN

El lobo fino antártico Arctocephalus gazella, *fue intensamente explotado en toda su área de distribución, llevando a sus poblaciones a niveles extremadamente bajos. El cese de la explotación produjo su recuperación, especialmente en las islas Georgia del Sur, constituyéndose en el centro de dispersión de animales, los que fueron recolonizando sus antiguos lugares de reproducción, como son las islas del Arco de Scotia y las islas subantárticas.*

Entre las temporadas de reproducción 1981-82 y 1984-85 se han realizado censos poblacionales y marcaje de crías en punta Stigant (62°02' S; 58°45' W), isla Rey Jorge y en cabo Shirreff (62°27' S; 60°47' W), isla Livingston, datos que se complementan con los otros autores.

El crecimiento poblacional en sitios con una baja densidad debería ajustarse a un modelo exponencial. La población total debería aumentar, así como la proporción de hembras, machos subadultos y crías en relación a la proporción de machos adultos.

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La curva de crecimiento poblacional en cabo Shirreff se ajusta a un modelo exponencial. La estructura poblacional es significativamente diferente entre cabo Shirreff y punta Stigant en las temporadas 1983-84 y 1984-85. El crecimiento poblacional en cabo Shirreff entre las temporadas 1983-84 y 1984-85 es de 64%, del cual la mitad se explica por inmigracion.

Los resultados muestran un rápido incremento poblacional, una baja mortalidad neonatal y una alta natalidad, además de una mayor proporción de machos en cabo Shirreff.

INTRODUCTION

Heavy exploitation of Antarctic fur seals, *Arctocephalus gazella*, in the 19th century reduced their populations in the Scotia Arc (South Georgia, South Sandwich, South Orkney and South Shetland Islands) to very low levels (O'Gorman, 1961; Bonner, 1968, 1983; Laws, 1973; Torres *et al.*, 1979).

When exploitation ended, there was a slow recovery of the South Georgia population (Bonner, 1968; Payne, 1977) and a reoccupation of former breeding sites (Bonner, 1976). The existence at the South Shetland Islands of a semialbino morph, otherwise characteristic of the South Georgia population, is further circumstancial evidence for the origin of this population from that at South Georgia (Budd, 1972; Cárdenas and Yañez, 1983, and pers. obs.). At a site where suitable habitat is unlimited we might expect population increase to be roughly exponential in nature. Population increase will have an intrinsic component, resulting from the recruitment of animals born at the site, and an extrinsic component, resulting from immigration. An increase in the total population due to immigration should be accompanied by changes in the population structure and in the ratio of males to females.

Here we document the population increases of *A. gazella* at Stigant Point and Cape Shirreff, South Shetland Islands, to provide data on population structure, sex ratio, pup production and mortality.

MATERIALS AND METHODS

During the development of the Marine Mammal Program of the Instituto Antártico Chileno (INACH) censuses of the *A. gazella* population were carried out by direct counting of animals at Stigant Point (62°02' S; 58°45' W), King George Island (Seasons 1981-82; 1982-83) and Cape Shirreff (62°27' S; 60°47' W), Livingston Island (Seasons 1981-82 to 1984-85 inclusive) (Fig. 1). These counts were supplemented with other published data for these localities which were used to build the population growth curve (O'Gorman, 1961; Aguayo and Torres, 1967; Laws, 1973). We recognize four categories of individuals; females, reproductive (adult) males or bulls, non-reproductive (subadult or juvenile) males and pups. Pups were sexed by direct examination of genitalia. Mortality was determined by keeping records of carcasses in the whole area. In the breeding units the number of females per reproductive male were counted. Significance of difference between population structure was tested applying Kolmogorov-Smirnov test (Sokal and Rohlf, 1981).

RESULTS

Table 1 summarizes the results of the censuses carried out at Stigant Point and Cape Shirreff. The total population increased at both localities.

Fig. 2 shows the growth curve of the *A. gazella* population at Cape Shirreff and Stigant Point. The growth curve from Cape Shirreff data fits an exponential model ($r = 0.079$). Data for Stigant Point are insufficient to test any model; nevertheless, the observed trend would fit a geometrical model.

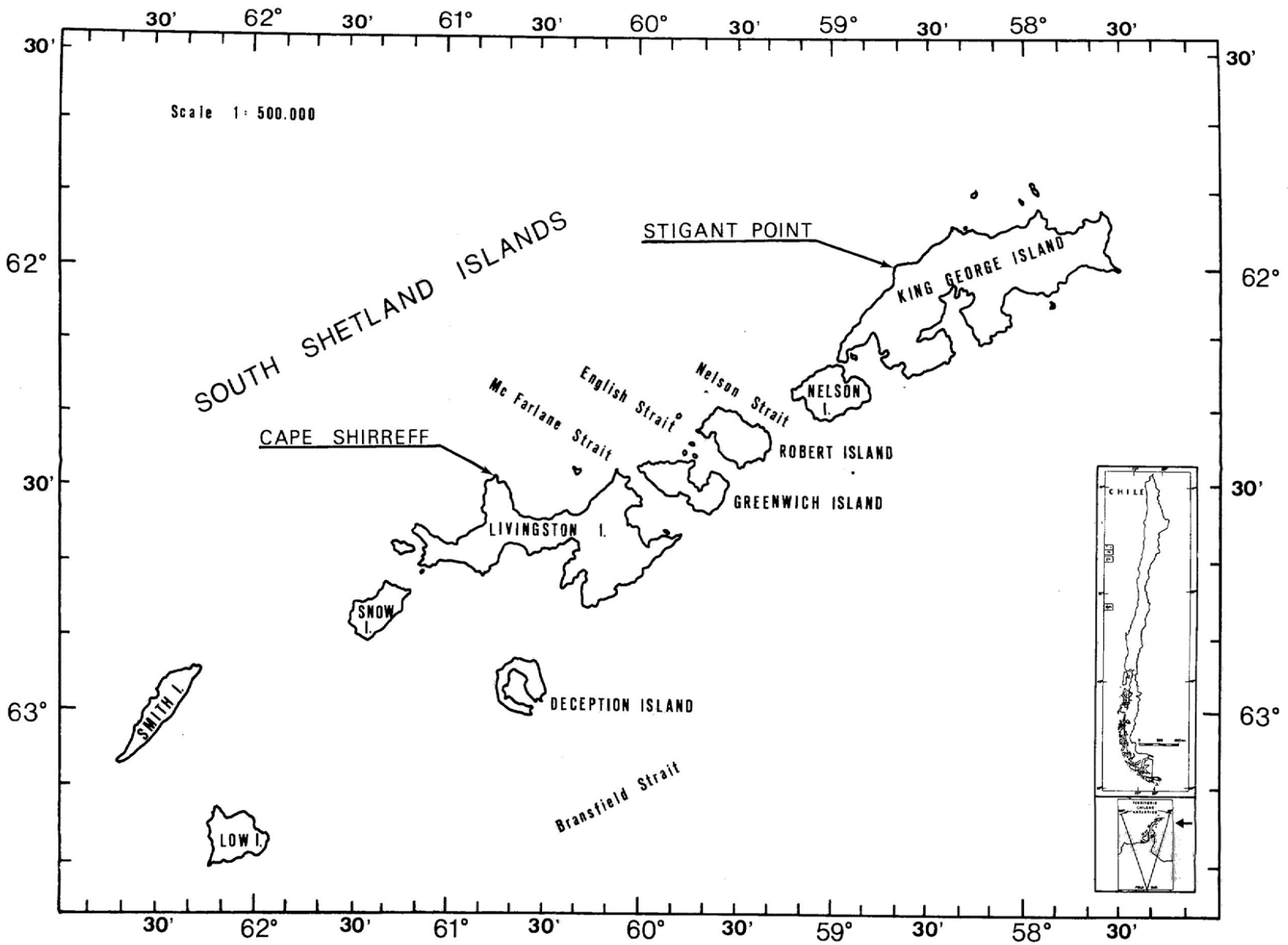


Fig. 1. Geographical location of study sites (indicated by arrows).

At Stigant Point the differences between the seasons 1981-82 and 1982-83 correspond to the increase of females and pups and the absence of juveniles males (Table 2). This decrease may be due to a substantial increase in breeding animals, which used most of the available space. At Cape Shirreff between 1981-82 and 1984-85 there was an increase in the number of females, adult males and pups. The proportion of males remained almost unchanged, and the number of juveniles fluctuated considerably, but their proportion in the total population decreased. Cape Shirreff is a breeding colony, with a steadily increasing female and pup population, but where space is still available for the settling of non-reproductive peripheral males and breeding groups. The distribution of the population structure at Cape Shirreff was not significantly different between the seasons 1983-84 and 1984-85 (Kolmogorov-Smirnov two sample test $D_{0.05} > 0.80$). The structure of *A. gazella* population at Stigant Point is different between 1981-82 and 1982-83 ($D_{0.05} < 5.12$), and also differs from that at Cape Shirreff.

Births at Stigant Point and Cape Shirreff increased substantially in all seasons (Table 3). The sex ratio of pups at Sigant Point for both seasons and at Cape Shirreff in 1984-85 was close to 1:1 At Cape Shirreff in 1983-84, however, there were fewer males than expected ($X^2 = 5.94$, $p < 0.005$). The mortality of the pups there in 1984-85 season was only 2.6%.

The parameters which determine population increase are immigration and natality. The population increase at Cape Shirref between the seasons 1983-84 and 1984-85 was 64.0%. We can very roughly estimate the amount of immigration by calculating the survival of the 1983-84 adults and pups, using the survival rates given by Payne (1977) (0.954 and 0.761, respectively). Of the 722 adults in 1983-84, 689 would survive to the next season, of the 248 pups, 189 would survive to one-year old. Assuming complete site fidelity, this total of 878 animals represent 72.4% of the 1206 adult and juvenile animals recorded in 1984-85. This suggests that at least 27.6% of adults and juvenile animals recorded in that year were immigrants, and the birth rates directly observed account for the 24.2% of the total population growth.

In Figure 3 we compare pup production data for South Georgia , Stigant Point and Cape Shirreff. The curve for South Georgia fits a geometric pattern ($r = 0.992$), whereas for Cape Shirreff an exponential model give the best fit ($r = 0.996$).

At Stigant Point in 1982-83, 24 reproductive units were counted with a mean number of 5.50 females per reproductive male (s.d. = 4.55). The frequency distribution shows a bimodal pattern (Figure 4a). At Cape Shirreff in 1984-85 the mean number of females in the 76 reproductive units was 4.62 (s.d. = 4.15). The frequency distribution is well fitted by a negative binomial distribution with a large number of males and few females (Figure 4b). Only 9.2% of the total population are involved in the reproductive units (breeding groups).

DISCUSSION

Our results show that *A. gazella* population in the South Shetland Islands is continuing to grow rapidly. At South Georgia the pup production doubled over the two seasons and at Cape Shirreff the total population increase was exponential. The large increase in births and the low pup mortality agrees with the findings of Doidge *et al.* (1984) for sites of low, but rapidly increasing population density at South Georgia.

The population structure is significantly different between Cape Shirreff and Stigant Point. At Cape Shirreff, adult and sub-adult males account for c.a. 50% of the whole population. At Stigant Point, in contrast, there is a higher proportion of females and pups which suggest that physical space may have become a limiting resource and now regulates the population. At Cape Shirreff the low proportion of females may be due to its distance from South Georgia. The topography of the island provides space for the aggregation of peripheral subadult males.

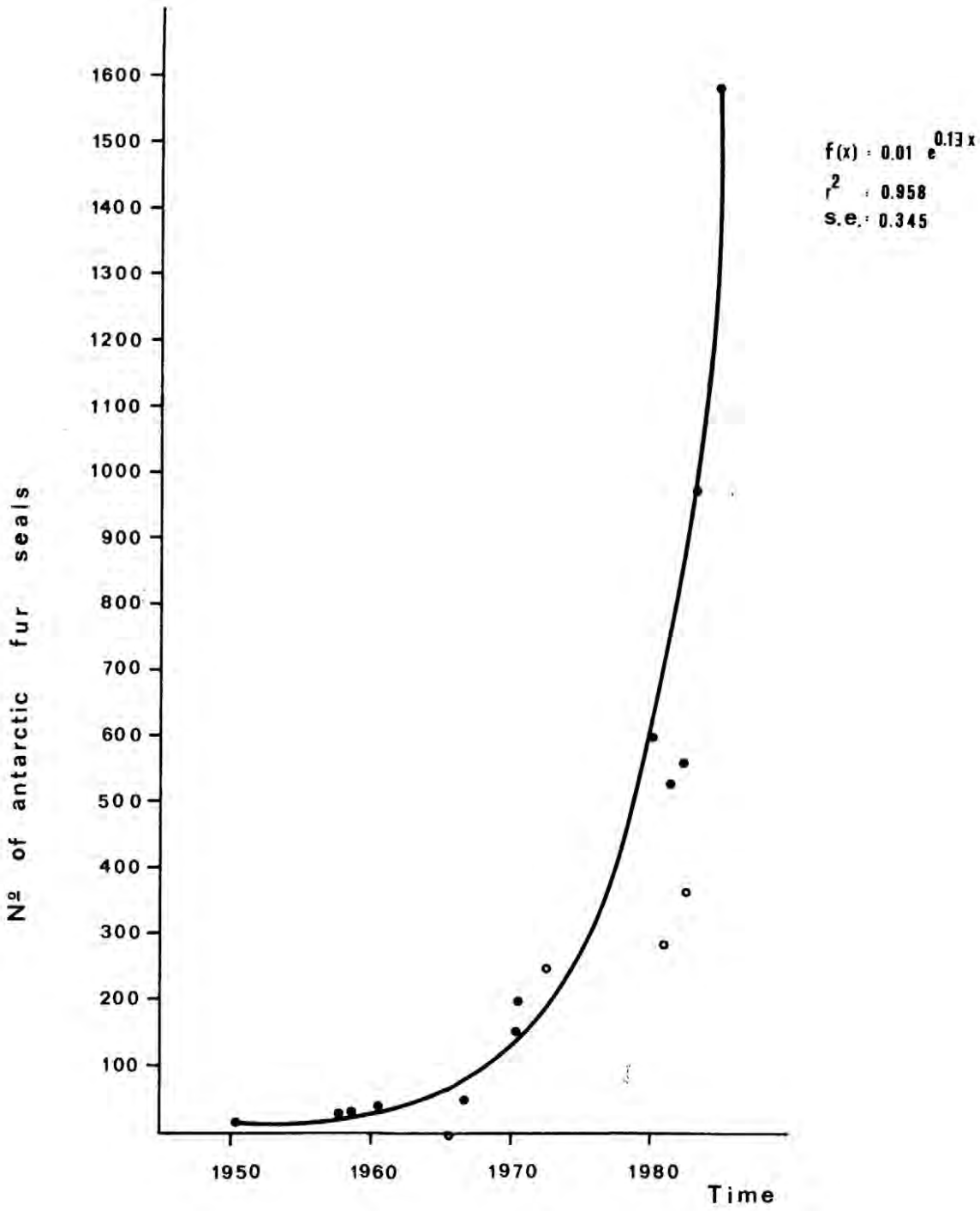


Fig. 2. Growth of the Antarctic fur seal population at Livingston Island (Cape Shirreff) ( ) and King George Island (o) according to O'Gorman (1962), Laws (1973), Aguayo (1978), Cattan *et al.* (1982) and this paper.

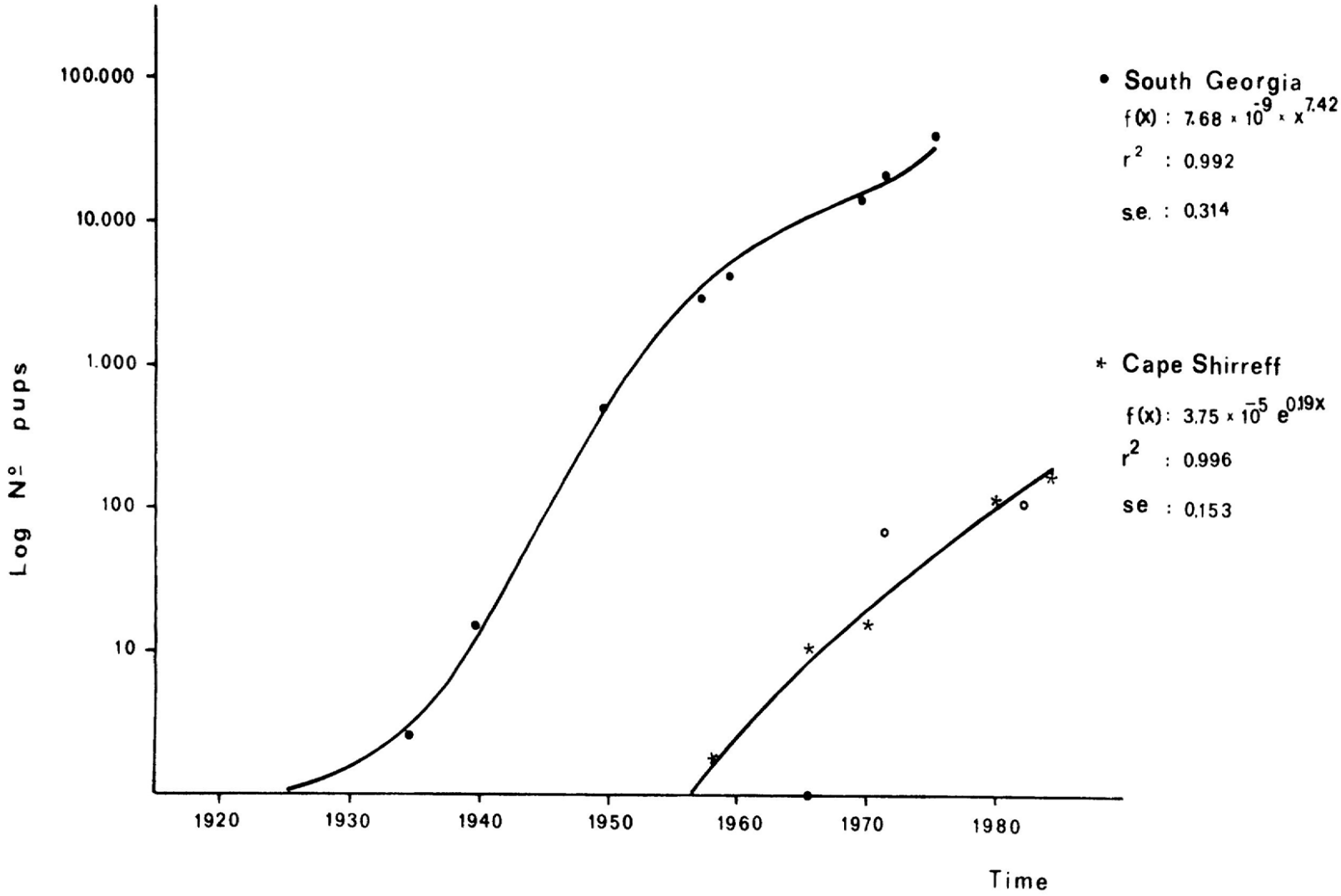


Fig. 3. Pup production of Antarctic fur seals at South Georgia (o) according to Bonner (1964), Laws (1973) and Payne (1977); Livingston Island (Cape Shirreff) (*) according to O'Gorman (1962), Laws (1973), Aguayo (1978), Cattan *et al.* (1982) and this paper; and King George Island (Stigant Point) (o) according to Aguayo (1978) and Cattan *et al.* (1982).

Table 1

SIZE OF THE ANTARCTIC FUR SEAL POPULATION (N) *ARCTOCEPHALUS GAZELLA* AT STIGANT POINT AND CAPE SHIRREFF, SOUTH SHETLAND ISLANDS

	STIGANT POINT			CAPE SHIRREFF		
Season	Date	N	% Increase	Date	N	% Increase
1981-82	26.01.82	357	–	23.01.82	532	–
1982-83	11.12.82	368	3.1	24.11.82	562	5.6
1983-84	–	–	–	21.01.84	970	72.6
1984-85	–	–	–	04.01.85	1590	63.9

Table 2

POPULATION STRUCTURE OF THE ANTARCTIC FUR SEAL *ARCTOCEPHALUS GAZELLA* AT STIGANT POINT AND CAPE SHIRREFF, SOUTH SHETLAND ISLANDS. REPRODUCTIVE ADULT MALES (♂), FEMALES (♀), NON-REPRODUCTIVE JUVENILE MALES (J) AND PUPS (P)

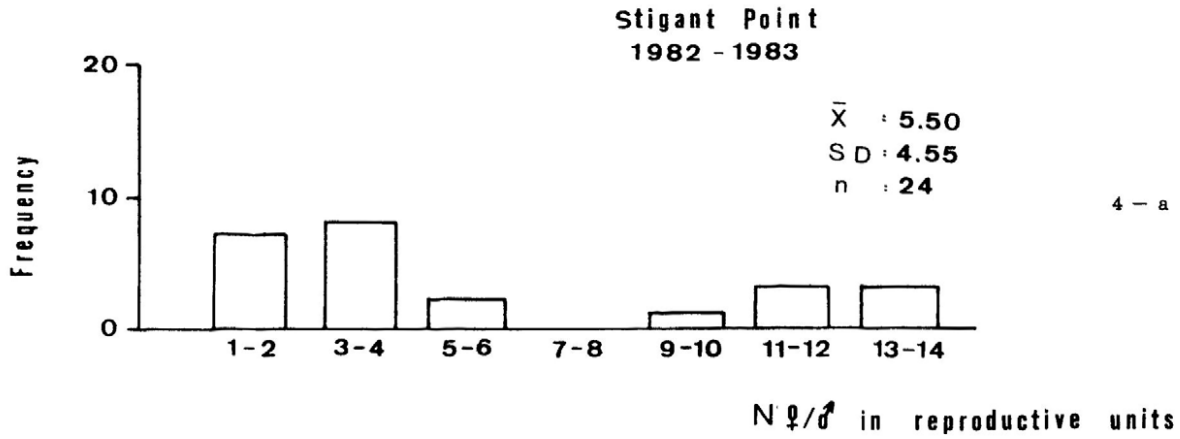
Season/Locality	♂	%	♀	%	J	%	P	%
STIGANT POINT								
1981-1982	40	11.2	85	23.8	168	47.1	64	17.9
1982-1983	69	18.8	175	47.6	0	0	124	33.7
CAPE SHIRREFF								
1981-1982	258	48.5	29	5.4	185	34.8	60	11.3
1983-1984	431	44.4	258	26.6	33	3.4	248	25.6
1984-1985	651	41.4	380	24.0	170	10.7	384	24.2

Table 3

PUP PRODUCTION (P) AND SEX RATIO OF *ARCTOCEPHALUS GAZELLA* AT STIGANT POINT AND CAPE SHIRREFF, SOUTH SHETLAND ISLANDS

Season/Locality	P	♂	♀	Sex ratio ♂ : ♀	% Increase
STIGANT POINT					
1981-82	64	32	32	1:1	–
1982-83	124a)	59	64	0.92:1	93.75
CAPE SHIRREFF					
1981-82	69a)	25	34	0.74:1	–
1983-84	248b)	143	105	0.73:1	313.33
1984-85	384c)	195	189	1:0.97	54.84

a) one pup no sexed
b) sex proportion estimated by a sample of n = 198
c) sex proportion estimated by a sample of n = 299



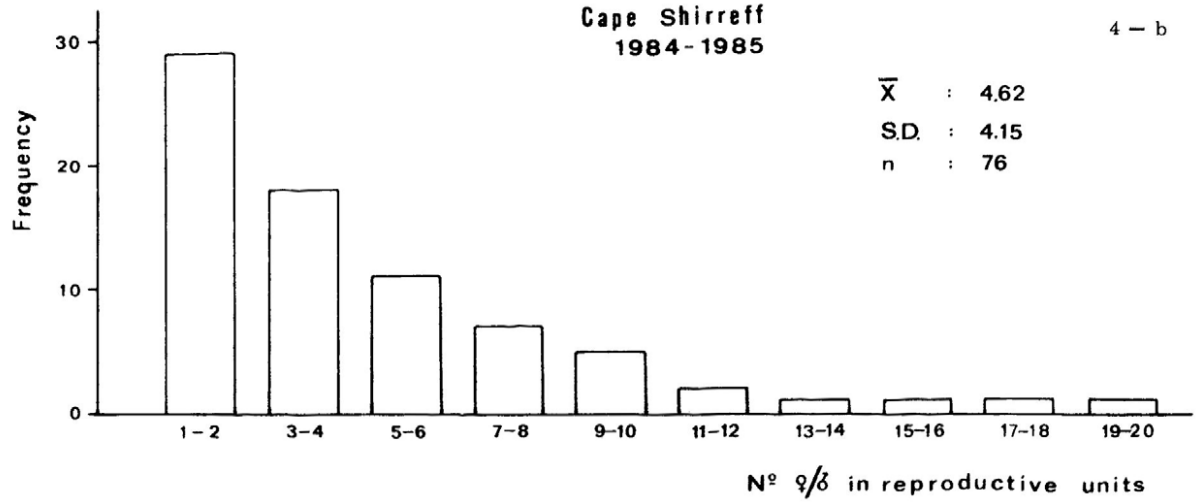


Fig. 4. Number of **females per reproductive male.**
a — Frequency distribution at Stigant Point, King George Island (1981-1982).
b — Frequency distribution at Cape Shirreff, Livingston Island (1984-1985).

We predict that future censuses will indicate a continuing population increase, with a lower proportion of males and a greater number of females per reproductive male. The frequency distribution of females per reproductive male should tend towards a normal distribution in wich the mean value increases and the standard deviation diminishes.

At Stigant Point, if the population has reached its carrying capacity, future counts of total population should fluctuate around the recent counts, but we would expect an increase in the number of females per reproductive male, and a decrease in the number of males due to exclution of non-reproductive juvenile males. The first mode in the frequency distribution of reproductive units should disappear.

The population of the Antarctic fur seal at the South Shetland Islands is growing rapidly because high natality rates have combined with high immigration. In Cape Shirreff the number of females born were significantly greater than the males in 1981-82 and 1933-84. The higher proportion of females produces an extra increase in the population growth by increasing the net reproductive index (R_0).

That the pup production in Cape Shirreff fits an exponential model suggests that the natality is not density-dependent. At Stigant Point the pup production fits a geometrical model with a density-dependent regulation. By comparing the curves of Cape Shirreff and Stigant Point it is possible to infer that in South Georgia (Bird and Elsehul Islands) there is a sustrate saturation. At Cape Shirreff there is a high availability of sustrate and at Stigant Point we may have a situation resembling that at South Georgia.

A population structure with predominance of non-reproductive males, low pup mortality and an increasing number of females, would suggest that the population is not being regulated and therefore its carrying capacity has not been reached. This is the case at Cape Shirreff. It is likely that there is still a considerable possibility for a further increase of the breeding population at Cape Shirreff.

Further censuses at Stigant Point and Cape Shirreff and elsewhere in the South Shetland Islands are urgently needed to monitor more accurately the population growth of *A. gazella* in that archipelago. It is also important to look for tagged individuals so that migration patterns and site fidelity may be determined.

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