

Population increase in the Amsterdam Island fur seal *Arctocephalus tropicalis* at Gough Island

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Population size of *Arctocephalus tropicalis* on Gough Island was determined by direct censuses of parts of the coast during the summers of 1974 – 1976 and 1977 – 1978 and correction factors for undercounting and seasonal cycles were applied. Present population size is approximately 200 000, giving an intrinsic rate of increase of 15,9% per year since 1955/56, but is now approaching the negative acceleration phase in population growth as a result of optimal breeding space becoming limited. An extension of breeding colony sites has also occurred since 1955.

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Die bevolkingsgrootte van *Arctocephalus tropicalis* te Gougheiland is bepaal deur direkte tellings van gedeeltes van die kus gedurende die somers van 1974 – 1976 en 1977 – 1978, en korreksiefaktore vir onderskattings in tellings en seisoenale siklusse is toegepas. Die huidige bevolkingsgrootte is ongeveer 200 000 wat 'n inherente tempo van toename van 15,9% per jaar sedert 1955/56 aantoon, maar wat nou die negatiewe versnellingsfase in bevolkingsgroei nader as gevolg van die toenemende beperking in optimale teel spasie. 'n Uitbreiding van teelkolonie-liggings het ook sedert 1955 voorgekom.

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Arctocephalus tropicalis breed at Gough Island, Marion Island, New Amsterdam Island, Prince Edward Island, Saint Paul Island and Tristan da Cunha. They also occur at Inaccessible Island and Nightingale Island with stragglers on the Crozet Archipelago, the South African coast, South Georgia and Macquarie Island.

Between 1790 and 1830 *A. tropicalis* were exploited to the brink of extinction on Gough Island, and again between 1869 and 1890 after a partial recovery in their numbers. Up to 400 fur seals were harvested at Gough Island some years before 1956 (Swales 1956), with a few hundred culled since then (Wace & Holdgate 1976). From December 1955 to April 1956 approximately 13 000 fur seals were counted on Gough Island (Swales 1956) with an assumed two-fold increase by 1973 (Shaughnessy 1975).

The rate of population increase is a function of age distribution, sex ratio, fecundity and survivorship, and changing population size a reflection of the history of these, although not revealing their nature (Caughley 1970). The present paper, however, simply provides new information on the size and rate of increase of the Gough Island *A. tropicalis* population in terms comparable to this and a related species elsewhere on temperate and sub-Antarctic Islands (Segonzac 1972, Payne 1977, Condy 1978), and postulates on the causes responsible for these changes.

Study area

Gough Island (40°20'S, 9°54'W) lies well north of the Antarctic Convergence in the temperate zone of the South Atlantic Ocean. The mean annual air temperature is 11,4°C and mean annual rainfall 3 068 mm (1966 – 1970). Sea surface monthly average temperatures range between 10,3 °C and 15,0 °C. Westerly winds predominate. Bester (1977) provides a detailed description of the beaches, categorizing them according to their physiognomy and composition of fur seal aggregations occupying them, the latter being assigned to established breeding, breeding, non-breeding, and idle colonies based on their age and sex specific composition during the height of the breeding season, and ultimate success measured by the number of pups born.

Methods

During the summer of 1974/75 all the fur seals on the beaches from Luff Point to Snug Harbour North were

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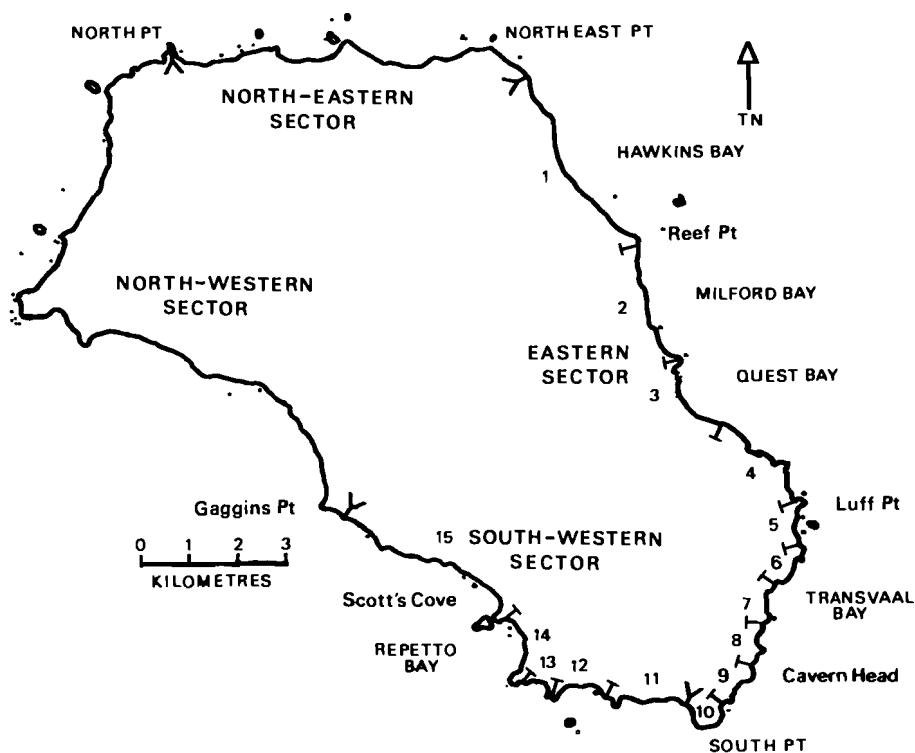


Fig. 1 Gough Island showing the censused areas (numbered) and the partitioning of the coastline used to extrapolate total population size (beaches numbered coincide with those in Table 1).

counted. In 1975/76 the census area was extended from Luff Point to Repetto Bay and in 1977/78 from Hawkins Bay to Gaggins Point (53% of the approximately 41 km coastline, Fig. 1). All the seals counted were allocated to the following categories: adult males (AM), adult females (AF), subadults of both sexes (SUB), unclassified (UNCL), and pups. (See also Bester 1977).

During all three summers seals on the idle, non-breeding, and breeding colony sites (Bester 1977) were counted during the peak haul-out and immediately thereafter (20 December to 3 January), and established breeding colony sites were counted after the pupping season when pups were still confined to the beaches (29 January to 5 February).

Two observers searched for pups on foot using direct methods, and the remaining seals were counted by a single observer from elevated vantage points on and behind beaches prior to pup searches.

The following count corrections were made:

- (a) Fur seal numbers on three inaccessible beaches within the census area (Table 1) were estimated according to the number on two other sites similar in area and topography. Checks done on this method ($n = 24$, involving eight beaches) showed the observed and predicted (extrapolated) totals to differ on average by $39,5 \pm 35,5\%$ (mean \pm S.D.). However, the combined observed ($n = 60723$) and predicted ($n = 69703$) totals showed an overestimate of only 14,8%.
- (b) For the four beaches not revisited during 1977/78, the 1975/76 counts were used. Although dealing with an increasing population, these firm figures would be more reliable than those derived from extrapolation (section (a)) in view of the considerable errors that may exist when comparing single beaches.

- (c) The reduced number of adult males present on breeding colony sites counted after the pupping season were adjusted according to the known post-breeding season decrease (72%) on other breeding colony sites (Bester 1977).
- (d) Pup counts (representing the total number of pups born on all beaches counted) were corrected for undercounting, based on counts before and during an exhaustive search for pups for tagging on each of two breeding colony sites, physiognomically typical of the beaches where only pups were counted. Here 85 pups were recovered subsequent to a count of 64 pups, indicating an undercount correction (33%) higher than the 26% undercount correction calculated for *A. gazella* pups using the same method (Payne 1978).
- (e) On established breeding colony sites only pups were counted since adult male numbers were low at the time (post-breeding season decline), adult females always less than the number of pups (most of them being away presumably on feeding trips) and subadults (both sexes) practically absent (Bester 1977). Adult male numbers were calculated as pup number/male:pup ratio (1:6,6 using corrected pup counts — Bester 1977) and female numbers from corrected pup counts (females normally bearing one pup only). On breeding colony sites (December), actual counts of females were used only when exceeding the total number of pups born there.
- (f) To calculate a population figure for the whole island, the censused east coast and south-west coast sectors were considered separately (Table 1). Physiognomically the non-censused area on the north-west side (Fig. 1) is similar to the south-west coast census beaches (respectively 31,0 and 19,3% of the total coastline, ratio 1,61:1), and both sectors are popular

Table 1 Results of a census of *A. tropicalis* involving 53% of the total coastline of Gough Island from Hawkins Bay in the north-east, to Gaggins Point on the west coast

Date	Locality	AM	AF	SUB	UNCL.	Pups ^d	Total
20.12.77	1 Hawkins Bay	1962	21	1721	1200	7	(9) (4913)
24.12.77	2 Milford Bay	1040	54	2442	0	13	(17) (3553)
24.12.77	3 Quest Bay ^{a*}	(1517)	(63)	(3228)	0	4	(5) (4813)
20.12.77	4 Waterfall Pt. to Luff Pt. ^a	(304)	(14)	(485)	0	—	— (803)
28.12.77	5 Admiral Beach	462	317	1043	0	35	(46) (1868)
21.12.75	6 South East Point to Archway Rocks ^b	253	10	123	0	4**	(5) (391)
20.12.77	7 Transvaal Bay	666	31	627	0	8	(10) (1334)
3. 1.78	8 Tumbledown Rocks to Cavern Head	515	271	433	0	27	(36) (1255)
23.12.75	South Cavern Head ^b	135	—	6	36	—	— 177
30. 1.78	9 Peninsula Rocks	(160) ^c	119	69	0	33	(44) (392)
23.12.75	The Shelf ^b	52	0	10	0	0	0 62
30. 1.78	Cave Rocks and South Point Beach	(103) ^c	(167) ^e	—	—	126	(167) (437)
23.12.75	10 South Point ^b	1058	1	108	0	1	(1) 1168
Subtotal		(8227)	(1068)	(10295)	1236	258	(340) (21166)
31.12.77	11 Waterfall Cove	21	(119) ^e	46	0	89	(119) (305)
31. 1.78	Snug Harbour South	(351) ^{c+e}	(1644) ^e	—	—	1232	(1644) (3639)
1. 2.78	Snug Harbour North	(186) ^e	(1229) ^e	—	—	922	(1229) (2644)
1. 2.78	12 South West Island Beach	(451) ^e	(2979) ^e	—	—	2234	(2979) (6409)
3. 2.78	South West Point Beach	(187) ^e	(1236) ^e	—	—	927	(1236) (2659)
3. 2.78	13 Point Bay	(581) ^e	(3832) ^e	—	—	2874	(3832) (8245)
3. 2.78	Rockhopper Point	(79) ^e	(523) ^e	—	—	392	(523) (1125)
3. 2.78	14 Repetto Bay ^{a*}	(476) ^e	(3136) ^e	—	—	2352	(3136) (6748)
5. 2.78	15 Scott's Cove	(1168) ^e	(7707) ^e	—	—	5780	(7707) (16582)
Subtotal		(3500)	(22405)	46	—	16802	(22405) (48356)
Total		(11727)	(23473)	(10342)	1236	17060	(22745) (69522)

Figures in brackets represent corrected counts.

For legends a – e see text; a* = Area partly censused, the remainder extrapolated from count.

**Counted on 28.6.78.

pupping sites (Swales 1956, Bester 1977). Similarly, the eastern sector resembles the north-eastern sector (respectively 34,0 and 15,7% of the total coastline, ratio 1:0,46), both typically frequented by non-breeders (Swales 1956, Bester 1977). Checks done on this method of predicting fur seal numbers on non-censused parts of the coastline from the non-censused area : censused area ratio showed an average overestimation of 19,7% ($n = 12$, involving four beaches) for the south-western sector (pup number predictions), and an average overestimation of 5,97% ($n = 12$, involving four beaches) for the eastern sector (total number predictions).

(g) Numbers of non-pregnant females, and year old seals which were absent from the island during the breeding season (Bester 1977) were calculated by assuming a pregnancy rate of 86,0%, and an assumed mortality rate of 23,9% to one year of age (survivors representing 76,1% of the 1976/77 pup yield at a calculated 15,9% intrinsic rate of natural increase of the population) which is the same as for the similar rapidly increasing *A. gazella* population at South Georgia (Payne 1977).

(h) Observations since 1974/75 showed a pup mortality figure of 10% by the end of January; 20 out of a total of 200 pups dying on four beaches searched at least once weekly since the onset of the pupping season, and this figure was subtracted from the population estimate.

Results

Population increase and present numbers

Table 1 gives a combination of 1975/76 and 1977/78 census data and Table 2 the composition and size of the total population. From these figures it is clear that the *A. tropicalis* population at Gough Island constitutes 93,0% of the world population (Table 3).

For the purpose of this paper, the Gough Island fur seal population is considered closed, although the fur seal population increase of the Tristan da Cunha Island group may have occurred through an influx from Gough Island. It is also assumed that food availability and breeding space are non-limiting factors, it being unlikely that the population has reached the level prevailing before exploitation began (the same assumption was used for the Marion Island *A. tropicalis* population, Condy 1978).

The growth of such a population is exponential (Caughley 1977) and is designated by the symbol r , defined as the instantaneous coefficient of population growth (Odum 1971). By using figures from Table 4 and the expression

$$N_t = N_0 e^{rt} \text{ (Caughley 1977)}$$

where r = $(\ln N_t - \ln N_0)/t$
 N_0 = the number of pups in the population at the start of the observations,
 N_t = the number of pups in the population at time t ,
 e = the base of the natural logarithms,

Table 2 Extrapolated population size during January/February 1978

Sector	AM	AF	SUB	Pups	UNCL	Total	
South-west	3500	22405	46	(16802)	22405	0	48356
North-west ^f (× 1,61)	5635	36072	74	(27051)	36072	0	77853
East	8227	1068	10295	(258)	340	1236	21166
North-east ^f (× 0,46)	3784	491	4736	(119)	156	569	9736
Subtotal	21146	60036	15151	(44230)	58973	1805	157111
*Total	21146	69636	53432	(39807)	53076	1805	199095

For legend ^f see text; uncorrected pup counts bracketed.

*Subtotal + 9600 non-pregnant females and 38281 absent one year-olds; - 5897 dead pups.

r is calculated as 0,159 ($N_o = 484$; $N_t = 15884$; $t = 22$) or 0,172 ($N_o = 484$; $N_t = 21179$ adjusted; $t = 22$). This indicates an estimated mean increase of 15,9 (17,2)% per year on the extended census area since 1955 and 12,6% ($N_o = 2754$; $N_t = 44230$; $t = 22$) or 13,9% ($N_o = 2754$; $N_t = 58973$ adjusted; $t = 22$) for the whole island.

The less extensive census area (Luff Point to Repetto Bay) showed an estimated mean increase of 14,8% per year from 1955 to 1975/76 ($N_o = 297$; $N_t = 5772$; $t = 20$), and 10,8% thereafter ($N_o = 5772$; $N_t = 7170$; $t = 2$).

Extension of breeding colony sites

From Table 4 it is clear that the south-west coast beaches showed an increase in the actual and estimated number of pups born over 22 years rather than an increase in the number of localities used for pupping, while the reverse was true on leeward east coast beaches where breeding seals favoured habitat types which minimize the effect of high ambient temperatures and direct solar radiation (Bester 1977).

Only one established breeding colony existed on the south-east coast (South Point Beach), the remainder being small breeding colony sites and non-breeding colony sites where isolated births were recorded.

Discussion

The estimated Gough Island *A. tropicalis* population is considered reasonable as 53% of the coastline was censused. The predicted overestimate (19,7%) of fur seal numbers in the north-western sector of the island through extrapolation, most probably improved the accuracy of the total population estimate since 81,7% of the 1955/56 pup population (58,5% of the total population) were found here (calculated from Swales 1956). This area is now probably the most densely populated and may therefore have the highest undercount, a similar situation existing in the South Georgia population of *A. gazella* (Payne 1978).

The 10% mortality rate of pups to approximately six weeks of age (almost half the estimated first year mortality) is realistic with the first few weeks most critical for *A. tropicalis* and *Callorhinus ursinus* pups (Paulian 1964, Kenyon, Scheffer & Chapman 1954).

The correction factor for pup undercounts is certainly an underestimate compared with the 34 and 54,1% determined by mark-recapture estimates for *A. tropicalis* at Marion Island (Condy 1978) and *A. gazella* (Payne 1977) respectively. Therefore with the fur seal numbers on the west coast established breeding colony sites largely extrapolated from pup counts, the 199 095 population figure should be a minimum estimate.

Table 3 World population of *A. tropicalis*

Island and position	Population size	Pup number	Time of census	References
Amsterdam Island (37°50'S, 77°31'E)	4868	1498	Mar 1970	Segonzac (1972)
Saint Paul Island (38°43'S, 77°30'E)	353	7	Feb 1970 Mar 1971	Segonzac (1972)
Marion Island (46°54'S, 37°45'E)	7000*	1854**	Feb/Mar 1974, 1975	Condy (1978)
Prince Edward Island (46°38'S, 37°57'E)	2000*	309	Mar 1977	Condy (1978)
Tristan da Cunha (37°02'S, 12°30'W)	500*	20	Jan 1978	E. Glass, 1978 (pers. comm.)
Inaccessible Island (37°04'S, 12°42'W)	} 600*	-	-	Swales (1956)
Nightingale Island (37°11'S, 12°35'W)		90	-	Nov 1951
Gough Island (40°20'S, 9°54'W)	199095**	53076**	1977/78	Present study
Total	214416	56764		

*Estimated

**Adjusted counts

Table 4 Comparative pup numbers for various years on beaches subjected to ground counts during the present study

Locality	1955/56*	1975/76	1977/78	
Hawkins Bay	0	—	7	(9)
Milford Bay	0	—	13	(17)
Quest Bay	0	—	4	(5)
Admiral Beach	0	26	35	(46)
Archway Rocks	0	1	4	(5)
Seal Beach	0	1	1	(1)
Standoff Rocks	0	7	7	(9)
Tumbledown Rocks to Cave Beach	0	10	24	(32)
Richmond Point to Cavern Head	0	—	3	(4)
Peninsula Rocks	0	—	33	(44)
Cave Rocks	0	7	20	(26)
South Point Beach	1	35	106	(141)
South Point	0	1	1	(1)
Snug Harbour	131	1458	2243	(2992)
South West Island Bay	105	2951	3161	(4215)
Point Bay	9	**	2874	(3832)
Rockhopper Point	0	410	392	(523)
Repetto Bay South	60	865	1176	(1568)
Scott's Cove	178	—	5780	(7707)
Total	484	—	15884	(21177)
Subtotal	297	5772	7170	(9559)
Island total	2754	—	44230	(58973)

Figures in brackets adjusted counts.

*Data from Swales (1956)

**Count unreliable.

The 1955/56 and 1977/78 pup counts (both unadjusted) are comparable and the 15,9% annual intrinsic rate of natural increase presumably reflects the real increase over 22 years. The lower estimated mean increase calculated from the total pup population probably results from the underestimation of the total pup number mentioned above. The reduction in the rate of population increase on south-west coast beaches since 1975/76 with at least one showing no increase over two years, and the reluctance of pregnant females to pup on east coast beaches (Fig. 1) subject to their specific habitat requirements (Bester 1977), show that optimum breeding space is becoming limited.

The estimated mean increase since 1955/56 (15,9%) is higher than in the small Marion Island (10,5% — Condy 1978), New Amsterdam Island (7,8% — extrapolated from Segonzac 1972) and earlier at Gough Island (8,9% from 1892 to 1955/56 — Swales 1956) *A. tropicalis* populations, but is approximately the same as that for *A. gazella* at South Georgia (16,8% — Payne 1977). The differences in growth rates probably result from different phases in population growth after cessation of exploitation; the small *A. tropicalis* populations in the slowly increasing establishment phase, the *A. gazella* population in the exponential phase, with Gough Island *A. tropicalis* approaching the asymptote where environmental resistance increases (density dependent factors).

The rapid *A. gazella* population increase at South Georgia, and the increase in penguins in the Antarctic is assumed to be related to the krill 'surplus' resulting from the reduced number of baleen whales (Sladen 1964, Laws 1977, Payne 1977), although Gulland (1970, 1974) contested these assumptions. *A. tropicalis* at Gough Island (Bester 1978), however, feed almost exclusively on squid, stocks of which may have increased following the decline in sperm whales (Gulland 1974). The Tristan da Cunha fur seal population was, however, much larger before exploitation than at present (Swales 1956, Wace & Holdgate 1976) which was presumably also true for Gough Island and the population recovery may therefore simply be a direct result of the cessation of sealing.

The continued relatively high growth rate of the *A. tropicalis* population at Gough Island therefore apparently depends on the ability of pregnant females to exploit less suitable east coast open beaches, currently densely populated by non-breeders (mostly males) during the breeding season.

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