

The distribution, abundance and population trends of gentoo, rockhopper and king penguins in the Falkland Islands

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The Falkland Islands are a globally important breeding location for seabirds, including penguins. The total breeding populations of three of the four main penguin species present in the Falklands were censused in the austral summer of 1995/96. The results for gentoo and rockhopper penguins suggest declines of about 43 and 90 per cent, respectively, since a similar census in 1932/33. Recent monitoring studies suggest that these declines are still continuing; research to investigate causes (which is likely to reflect changes in the marine, rather than terrestrial environment) is a high priority. In contrast, king penguin populations, currently c. 400 pairs, have increased steadily, by 700 per cent since 1980/81, in line with world-wide trends for this species.

Introduction

The Falkland Islands lie in the south-west Atlantic, approximately 450 km north-east of the southern tip of South America. The archipelago is made up of two main islands and several hundred smaller islands, which are home to large numbers of breeding seabirds, including penguins. The Falkland Islands have the world's largest breeding population of rockhopper penguins *Eudyptes c. chrysocome*, and the second largest population of gentoo penguins *Pygoscelis papua* (Croxall *et al.*, 1984).

Data collected from breeding colonies in the Falklands during the past 10 years suggested a decline in the breeding populations of gentoo and rockhopper penguins (Bingham, 1995). The only comprehensive island-wide population census for these species was in 1932/33; a repeat census was needed to confirm whether declines were occurring throughout the islands, and to estimate their magnitude. In addition, the census would establish comprehensive baseline data to complement current monitoring studies. The imminent exploration for oil in Falklands' waters makes the establishment of baseline data for these species particularly important, because of their potential high vulnerability to oil pollution.

The Falklands' population of king penguin *Aptenodytes patagonicus* is very small, but was still included in the census. The fourth main Falklands' penguin, the magellanic penguin *Spheniscus magellanicus*, was not included in this census because of the difficulties of censusing a species that nests in burrows.

Methods

Most breeding-site locations were already known from fieldwork conducted prior to the 1995/96 census but this information was checked by extensive consultation with landowners to ensure that sites were not overlooked.

For a comprehensive census of such a large area, it was only possible to make a single visit to each site. Counts made during a single visit will inevitably underestimate the total number of breeding pairs, because of omitting pairs that have either not yet laid their eggs, or those that have already laid and subsequently failed. In general, counts were timed to correspond with the end of the egg-laying period, thereby ensuring that few pairs were still to lay, and allowing an assessment to be made of the underestimate due to pairs failing, by using failure

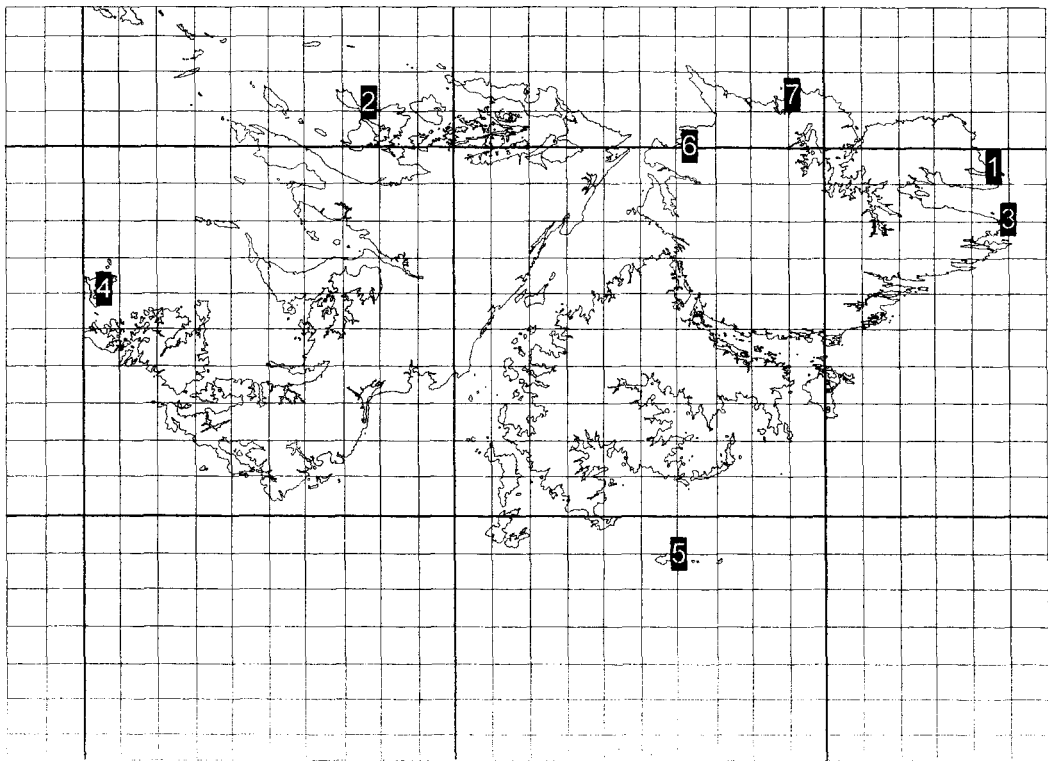


Figure 1. King penguin colony locations 1995/96.

rates during incubation from other studies.

The gentoo penguins concluded their first egg-laying by the end of October 1995. The 1995/96 census counted 15 per cent of the gentoo population between 15 and 31 October, and the remainder between 1 November and 1 December. Because gentoos failing early tend to re-lay, and failure rates during incubation are low (c. 1 per cent/week), the magnitude of any underestimates resulting from differences in survey dates should be well below 5 per cent.

Rockhopper penguins are much more synchronous in terms of egg-laying than gentoo penguins. Laying was concluded by mid-November 1995, and the 1995/96 census counted 98 per cent of the rockhopper population between 1 November and 1 December (2 per cent between 2 and 18 December). Repeated counts of rockhopper colonies in previous years showed that nest counts drop at a rate of about 3 per cent per week for the first month after egg-laying, as a result of failed

nests. It is therefore unlikely that the average underestimate of rockhopper populations exceeded 10 per cent.

For most rockhopper and all gentoo breeding sites, the recorder made two separate counts of all occupied nests using a tally counter. The mean of the two counts was taken as the number of breeding pairs. Where these two counts differed by more than 10 per cent, a

Table 1. King penguin colony counts 1995/96

	Site	Date	No. chicks
1	Volunteer Point	11/11/95	330
2	Saunders Island	01/12/95	3
3	Kidney Cove	28/10/95	2
4	New Island	01/12/95	1
5	Sea Lion Island	12/11/95	1
6	Paloma Beach	12/11/95	1
7	Concordia Beach	26/11/95	1
	Total		339

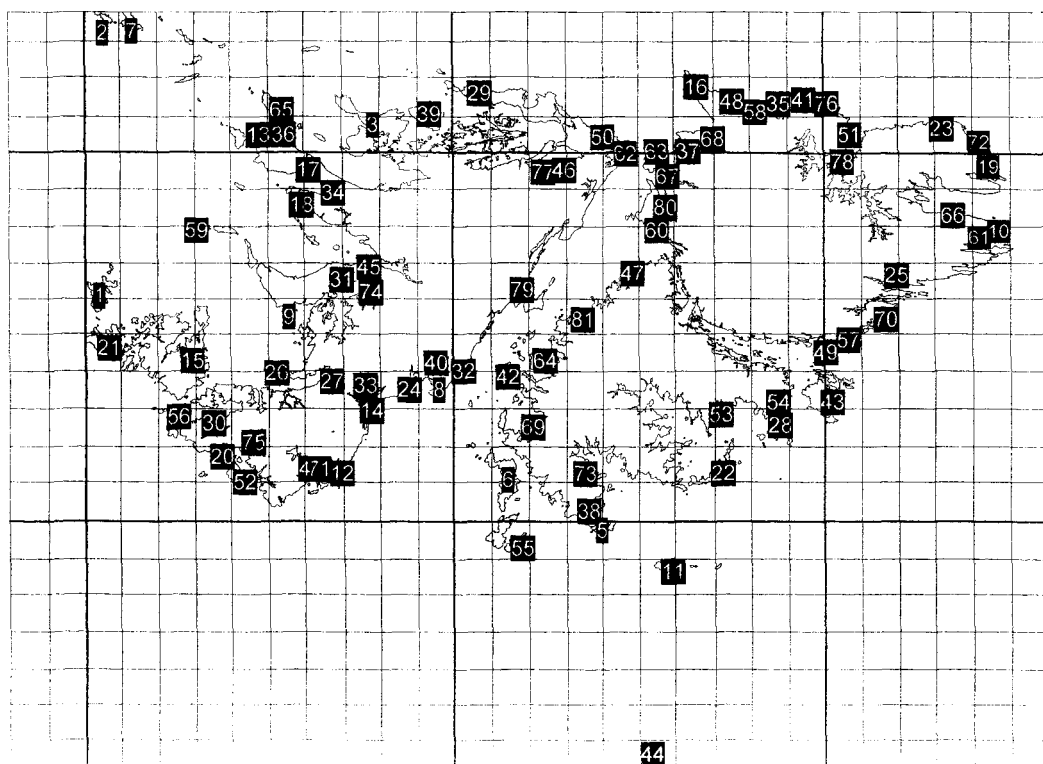


Figure 2. Gentoo penguin colony locations 1995/96.

third count was taken to give a mean value of three counts. In practice this was rarely necessary, and the spread of results was generally well within ± 5 per cent. Reference photographs were also taken at most sites for future comparisons.

For the very large rockhopper colonies on Steeple Jason, Grand Jason, Bird Island and Beauchene Island, direct ground counts were not possible. These sites were counted using a total of 60 randomly selected sample plots to determine the range of nesting densities, and the areas of the colonies were determined, to enable estimates of total breeding pairs. A minimum of 10 per cent and a maximum of 15 per cent of the total colony area was sampled at each of the three sites. These measurements of area and density taken during the site visits were later compared against aerial photographs taken of the colonies. The margin of error for this methodology is greater than for direct counts, but should be within ± 10 per cent.

The breeding cycle of the king penguin is different from that of gentoos and rockhoppers, with chicks over-wintering at the colony, and a complete breeding cycle lasting over a year. This tends to result in individual birds having their following breeding cycle out of phase with its predecessor; thus large chicks and eggs may both occur in a colony at the same time. This complicates assessment of the breeding populations so chick counts were taken instead. The estimation of error for chick counts is well below 5 per cent, but will underestimate the number of breeding pairs by about 20 per cent (Lewis Smith and Tallowin, 1979).

Results

King penguin

The 1995/96 census recorded a total of 339 chicks for the Falklands as a whole (Table 1;

Figure 1). Allowing for losses during incubation and chick-rearing, and the staggered breeding cycle, this figure gives an estimated Falklands population of around 400 breeding pairs. Volunteer Point, on the north-east coast of East Falkland, was the only king penguin breeding colony in the Falkland Islands, with individual pairs breeding in gentoo colonies at all other sites.

Gentoo penguin

The 1995/96 population of gentoo penguins in the Falkland Islands was about 65,000 breeding pairs (Table 2; Figure 2), with an estimated range of 61,750–68,250 pairs. There was a total of 81 breeding sites distributed throughout the archipelago, ranging in size from 7 to 5100 breeding pairs. Eighteen sites had breeding

Table 2. Gentoo penguin colony counts 1995/96

Site	Date	No. nests	Site	Date	No. nests
1 New Island	01/12/95	5,100	43 Lively Island	30/10/95	490
2 Steeple Jason Island	11/11/95	3,923	44 Beauchene Island	28/11/95	444
3 Saunders Island	01/12/95	3,510	45 Town Point	13/11/95	416
4 Albemarle	05/11/95	2,626	46 Gladstone Valley	03/12/95	410
5 Bull Point	02/11/95	2,230	47 New Haven	05/11/95	400
6 Speedwell Island	21/11/95	2,229	48 North Pond	19/11/95	379
7 Grand Jason Island	09/11/95	2,196	49 Fox Point	31/10/95	378
8 Carcass Bay	08/11/95	2,039	50 Little Mountain	01/12/95	375
9 Shallow Bluff	14/11/95	1,737	51 Brazo del Mar	24/11/95	357
10 Kidney Cove	28/10/95	1,730	52 Ten Shilling Bay	02/11/95	342
11 Sea Lion Island	12/11/95	1,484	53 Bluff Head	01/11/95	330
12 Lucas Hill	07/11/95	1,457	54 The Sandhills	16/12/95	330
13 Grave Cove	20/11/95	1,434	55 Barren Island	01/11/95	326
14 Port Edgar	15/10/95	1,408	56 Cape Orford	03/11/95	311
15 Weddell Island	22/11/95	1,220	57 Berthas Beach	31/10/95	310
16 Cape Dolphin	19/11/95	1,148	58 Little Creek	19/11/95	304
17 Stevelly Bay	23/11/95	1,071	59 4th Passage Island	18/12/95	300
18 Whaler Bay	27/10/95	1,000	60 Rookery Point	30/11/95	300
19 Volunteer Point	11/11/95	970	61 Sparrow Cove	28/10/95	300
20 Stephen's Peak	02/11/95	894	62 Leopard Bay	03/12/95	270
21 Beaver Island	27/10/95	892	63 Rookery Sands	17/11/95	249
22 Bleaker Island	31/10/95	875	64 Port King	05/11/95	208
23 Seal Bay	03/11/95	875	65 Carcass Island	03/11/95	180
24 West Head	28/10/95	855	66 Strike off Point	14/11/95	176
25 Bluff Cove	02/12/95	850	67 Fanning Harbour	17/11/95	160
26 Queen Point	09/11/95	832	68 Murdos Cove	02/12/95	137
27 Lake Hammond	31/10/95	830	69 Moffit Harbour	04/11/95	130
28 Motley Point	16/12/95	800	70 Pleasant Road	11/12/95	123
29 Pebble Island	30/11/95	754	71 Rodeo Point	08/11/95	120
30 Fox Point	03/11/95	751	72 Cow Bay	11/11/95	117
31 Isthmus Cove	14/11/95	738	73 Salt House	03/11/95	110
32 Blue Mountain	11/12/95	728	74 North Beach	13/11/95	103
33 Big Seal Rook	29/10/95	716	75 Hoste Inlet	04/11/95	66
34 Port North	24/11/95	705	76 Limpet Creek E	26/11/95	54
35 Concordia Beach	26/11/95	701	77 Long Point	04/12/95	52
36 Hope Point	20/11/95	654	78 Colorado Bay	24/11/95	44
37 Paloma Beach	12/11/95	601	79 Shag Harbour	12/12/95	16
38 Bull Roads	02/11/95	564	80 Ajax Bay	30/11/95	14
39 Keppel Island	04/11/95	560	81 Egg Harbour	05/11/95	7
40 Bottomless Pond	07/11/95	534			
41 Limpet Creek	26/11/95	531			
42 Great Island	02/11/95	490			
			Total		65,000

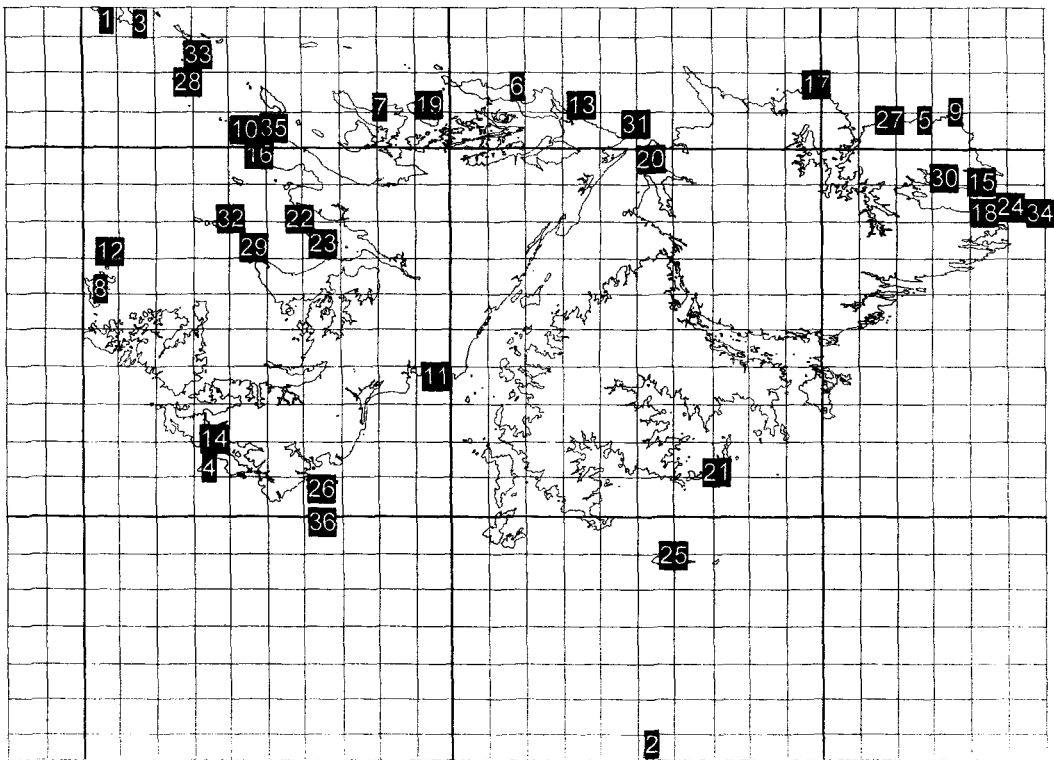


Figure 3. Rockhopper penguin colony locations 1995/96.

populations of >1000 pairs, between them totalling 58 per cent of the overall population. The general distribution was: East Falkland, 16,000 pairs (24.5 per cent); West Falkland, 24,000 pairs (37 per cent); and Outer Islands, 25,000 pairs (38.5 per cent).

Rockhopper penguin

The 1995/96 population estimate for rockhopper penguins in the Falkland Islands was 297,000 breeding pairs (Table 3; Figure 3), with an estimated range of 267,000–327,000 pairs. There was a total of 36 breeding sites, ranging in size from 83 to 115,000 breeding pairs. These sites are distributed around most of the Falklands but the greatest concentrations are on the outer islands. The general distribution was: East Falkland, 21,000 pairs (7 per cent); West Falkland, 11,000 pairs (4 per cent); and Outer Islands, 265,000 pairs (89 per cent).

Discussion

King penguin

The present Falklands' population of *c.* 400 breeding pairs is almost entirely concentrated at one location on the north-east of East Falkland. This colony has expanded from 38 chicks in 1980/81 (Bingham, 1995) to 330 chicks in 1995/96. Nevertheless this comprises less than 0.1 per cent of a world population that has been increasing consistently since the 1970s (Woehler, 1993), and the high rate of increase in the Falklands during this period is likely to be due in part to immigration from the large and expanding population on South Georgia. At least one bird banded on South Georgia has been resighted in the Falklands (O. Olsen, pers comm).

Gentoo penguin

The Falkland Islands are one of 12 major breeding sites for this species (Robertson, 1986). The 65,000 pairs in the Falklands are widely distributed throughout the archipelago, and represent about 20 per cent of the world population, second in size only to South Georgia. Within the Falklands there are three sites (New Island, Steeple Jason and Saunders Island) that each hold more than 1 per cent of

Table 3. Rockhopper penguin colony counts 1995/96

Site	Date	No. nests
1 Steeple Jason Island	09/11/95	11,5000
2 Beauchene Island	27/11/95	7,4300
3 Grand Jason Island	09/11/95	3,4000
4 Bird Island	23/11/95	10,600
5 Rabbit Rincon	05/11/95	8,487
6 Pebble Island	01/12/95	6,702
7 Saunders Island	01/12/95	5,781
8 New Island	01/12/95	5,500
9 Macbride Head	04/11/95	4,146
10 West Point Island	16/12/95	4,042
11 Carcass Bay	08/11/95	3,783
12 North Island	21/11/95	3,472
13 Tamar Point	02/12/95	2,566
14 Stephens Peak	02/11/95	2,504
15 Rugged/Eagle Hill	13/11/95	2,460
16 Deaths Head	21/11/95	2,243
17 Cape Bougainville	25/11/95	1,943
18 Mount Low	14/11/95	1,910
19 Keppel Island	05/11/95	1,168
20 Fanning Head	18/11/96	1,071
21 Bleaker Island	31/10/95	700
22 Rabbit Island	18/11/95	600
23 Hummock Island	18/11/95	540
24 Cochon Island	29/11/95	515
25 Sea Lion Island	12/11/95	504
26 Arch East Island	25/11/95	411
27 Campa Menta	25/11/95	380
28 South Jason Island	18/12/95	300
29 Ist Passage Island	19/11/95	267
30 Diamond Cove	14/11/95	155
31 White Rock	18/12/95	150
32 2nd Passage Island	29/11/95	125
33 Elephant Jason Island	18/12/95	100
34 Kidney Island	25/11/95	100
35 Grave Cove	22/11/95	93
36 Clump Island	25/11/95	83
Total		297,000

the estimated world population of 318,000 pairs. However, comparison with Bennett's (1933) total of 116,000 pairs for the Falklands during 1932/33 (Table 4) suggests an overall decline of around 45 per cent.

Comparison of single years, widely separated in time, can sometimes be unreliable, especially in a species whose population shows considerable interannual fluctuation (Croxford and Rothery, 1995). However, population counts from 21 colonies, which have been monitored since 1988/89 (Figure 4; Falklands Conservation, unpublished data), show that the 1995/96 census did not coincide with a season of especially low population. Moreover, these data suggest that the decline has been continuing in recent years. Although no records exist as to the methodology employed during Bennett's (1933) census, his numerous publications testify to his reputation as a meticulous and experienced observer and naturalist, and gentoo penguins are a particularly easy species to count accurately. Even if the larger and hence more difficult sites such as the Jason Islands are excluded, comparable counts for the remaining sites still indicate a decline over the 60-year period.

Rockhopper penguin

The Falklands population, of around 300,000 pairs, represents the world's most important breeding site for this species. In addition, the Falkland Islands have 63 per cent of the world population for this subspecies, with most of the remainder being on islands around the coast of Chile (Bingham and Mejias, in press). In the Falklands, the islands of Steeple Jason and Grand Jason to the north-west, and Beauchene to the south, hold the only very large concentrations (> 20,000 pairs) and these account for around 75 per cent of the Falklands' population.

Population counts from study sites monitored throughout the 1990s show that the 1995/96 census did not coincide with a year of naturally low populations (Figure 5). Thus the current population estimate is very considerably lower than the 3,169,000 pairs recorded by Bennett (1933) in 1932/33 (Table 5). Although

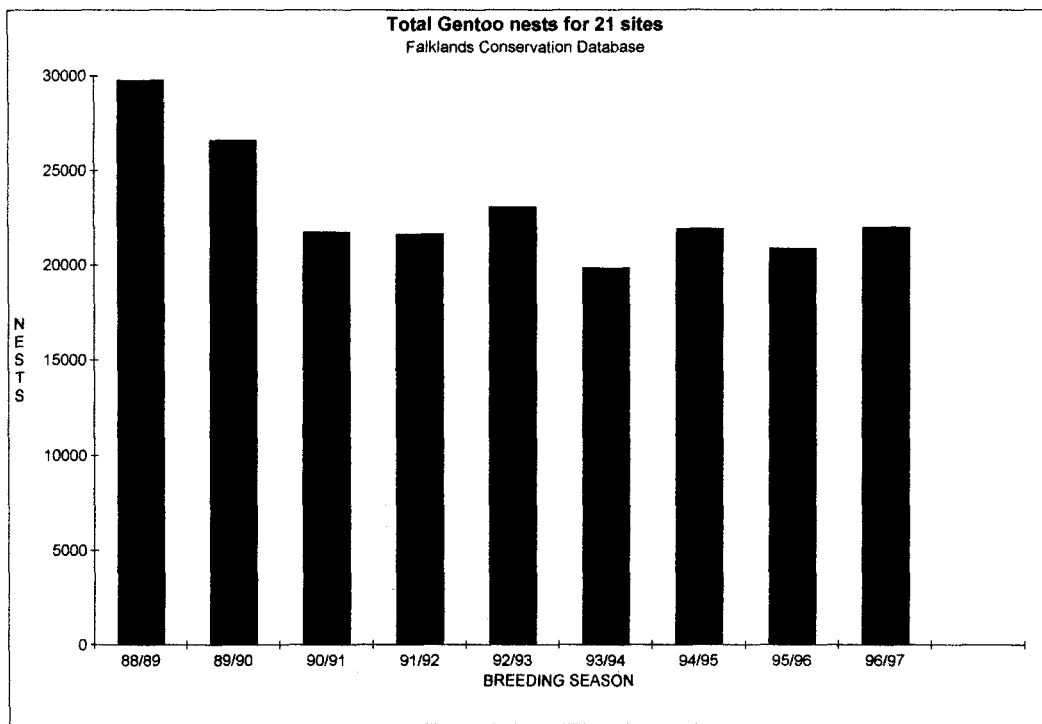


Figure 4. Gentoo population trends monitored for 21 sites since 1988/89. Site names and grid references: Bull Point UB4298/UB4399/UC3701; Volunteer Point VC4297/VC4693/VD3903; Berthas Beach VC0651; Fox Point VC0147; Cape Dolphin UD6717/UD6418/UD6817; Strike off Point VC 3384; Kidney Cove VC4779; Seal Bay VD2907; Fanning Harbour UC5597; Paloma Beach UD6101; Rookery Sands UD5400; Rookery Point UC5479; Port Edgar TC7524/TC7625; Long Point UC2497; Gladstone Valley UC2995; Little Mountain UD4005; Albemarle TC5910/TC6011; Carcass Bay UC0139/TC9938; Saunders Island TD7200/TD7801/TD8510; Sea Lion Island UB5989; Beaver Island TC0844.

Bennett gave no account of the methodology used, he stated that his figures were most likely to be underestimates, and did not include the large colonies on Beauchene and Bird Islands, which currently hold 28 per cent of the Falklands' population. It therefore appears that the Falklands population has declined to about 10 per cent of its 1932/33 level.

Population changes

Whereas populations of king penguins in the Falklands have increased in recent years, in line with world-wide trends, populations of gentoo and rockhopper penguins have decreased substantially over the last 60 years, perhaps by as much as 50 and 90 per cent,

Table 4. Gentoo population comparison

Area	1932/33	1995/96
East Falkland	17,800	16,407
West Falkland	16,470	23,490
Speedwell Island group	6,150	2,555
Bleaker Island	1,600	875
Lively Island	2,400	490
Sea Lion Island	18,000	1,928
Saunders & Kepple Islands	1,900	4,070
Jason Islands	35,000	6,119
Passage Islands	1,000	300
Pebble Island	1,000	754
Carcass Island	200	180
New Island group	2,500	5,100
Weddell Island group	12,000	2,112
Total pairs	116,020	64,380

Sites are grouped into areas used by Bennett (1933).

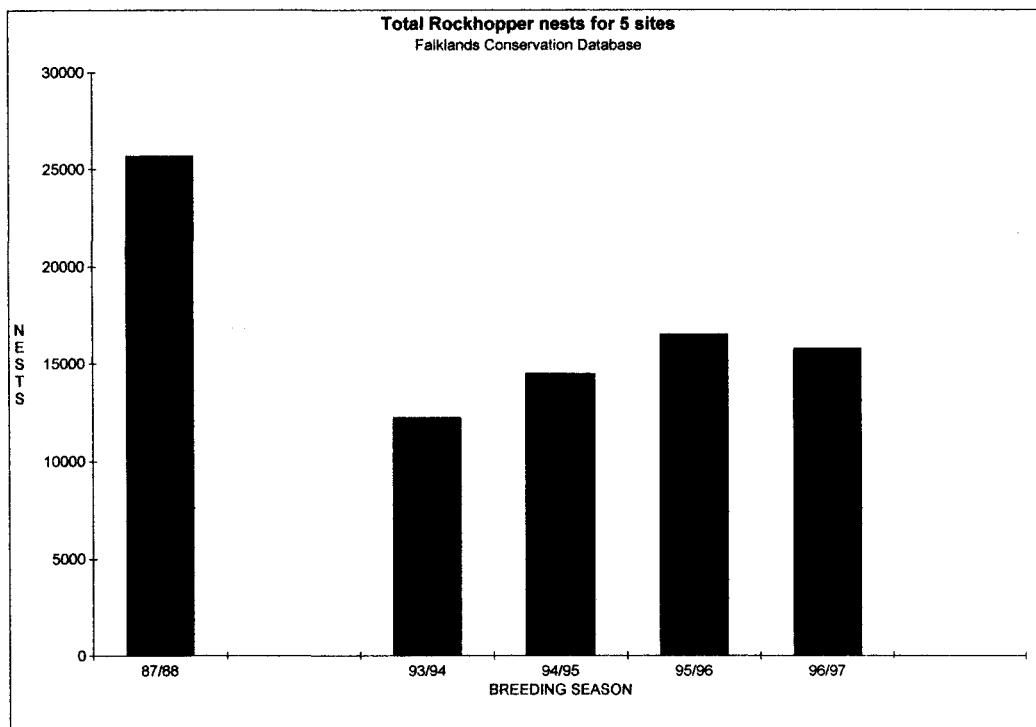


Figure 5. Rockhopper penguin population trends for five sites monitored since 1987/88. Site names and grid references: Berkeley Sound VC4189/VC4791/VC3688/VC3683/VC4382; Fanning Head UC5296/UC5297; Cape Bougainville UD9816; Westpoint Island TD4107/TD4205/TD4202; Saunders Island TD7611/TD6815.

respectively. This is supported by data from more recent site studies, which also suggest that the declines have continued into recent years. Kidney Island's rockhopper population declined from 3000 pairs in 1960/61 to 240 pairs in 1994/95 (Bingham, 1995), rockhopper colonies at New Island declined from >100,000 pairs in 1976/78 to 4000 pairs in 1992 (Thompson, 1993), and at Beauchene Island the colony had declined from 300,000 pairs in 1980 (Lewis-Smith and Prince, 1985) to 71,500 pairs in 1991 (Thompson, 1993). The 1985/86 summer season was especially bad for rockhoppers, with tens of thousands of adults dying from starvation during their annual moult. Analysis of carcasses showed that they had died from starvation, and this was likely to have resulted from food shortages prior to the moult (Keymer, 1988).

It is not easy to account for these declines.

Direct exploitation of penguins has diminished to insignificance. Killing birds to extract oil ceased at the beginning of the 20th century, and collecting of eggs for food has now declined to very low levels.

Commercial fisheries started around the Falklands in the 1960s, expanded greatly during the 1970s and 1980s, and in recent years have been generally stable after the Falkland Islands Government imposed a licensing regime in 1985. There is some evidence that penguin population size and breeding performance are related to food availability around the Falklands (Keymer, 1988; Thompson, 1989, 1993; Bingham, 1995). There is no direct evidence that food availability to penguins has been affected by commercial fishing, but this possibility cannot be ruled out, especially in respect of squid fisheries, larval/juvenile squid being an important element of the diet of both

Table 5. Rockhopper population comparison

Area	1932/33	1995/96
East Falkland	153,500	20,552
West Falkland	24,200	12,973
Kidney & Cochon Islands	12,000	615
Sea Lion Island	150,000	504
Bleaker Island	5,000	700
West Point Island	50,000	4,042
Passage Islands	10,000	392
Pebble Island	6,000	6,702
Jason Islands	2,625,000	149,400
New Island group	130,000	8,972
Saunders & Kepple Islands	3,400	6,949
Beauchene Island	No survey	74,300
Bird Island	No survey	10,600
Total pairs	3,169,000	297,000

Sites are grouped into areas used by Bennett (1933).

rockhopper and gentoo penguins (Thompson, 1994). It should also be noted that the breeding season diet of rockhoppers appears to contain more euphausiids and less commercially fished species than that of the gentoo (Thompson, 1993).

Loss or degradation of breeding habitat has probably occurred at some sites as a result of erosion, fire or other anthropogenic activity. Disturbance from humans and stock may also have been (and remain) a problem in some areas, although there is little firm evidence that this or the current level of tourist visits have any discernible influence. Overall, none of these effects can explain large-scale changes, especially at sites where breeding habitat loss and disturbance have been minimal or non-existent. There is also no evidence of increased impact from introduced predators, and many sites lack any introduced predatory species.

Rockhopper penguins (subspecies *E. c. filiholi*) have declined very substantially in the New Zealand subantarctic islands since the 1940s (Cooper, 1992; Cunningham and Moors, 1994). At these sites also there was no evidence that land-based influences were responsible. It was therefore suggested that changes in the marine environment may have occurred and affected the survival of penguins, either directly through physical factors or, more likely,

indirectly through changes to the food web. There is circumstantial evidence (Croxall, 1992, Fraser *et al.*, 1992) that some broadscale changes in seabird populations may correlate with changes in Southern Ocean marine environments, at least insofar as these are indicated by increases in air and sea-surface temperature, which may be linked to changes in the location and/or magnitude of marine productivity. For such effects to have influenced Falkland Islands' penguins, the factors involved must operate to affect both resident inshore-feeding species such as gentoo penguins, and offshore-feeding migratory species such as rockhopper penguins. A very high research priority is to determine where rockhopper penguins forage when breeding and, in particular, where they reside outside the breeding season.

These data would also have great relevance in relation to the potential effects of oil exploration and extraction (the former scheduled to start in 1998), because penguins are highly vulnerable to oil pollution. Studies of distribution and foraging ecology at sea will need to be complemented by breeding population studies ashore, in particular to determine the relative contributions of changes in adult and juvenile survival to the overall population decline.

At a recent international workshop reviewing the status of penguins, it was clear that the large-scale declines in rockhopper penguin populations were of such magnitude as to justify treating the species as globally threatened (Vulnerable), according to the new IUCN criteria. A co-ordinated programme of research on this species at its most important population site, the Falkland Islands, is now long overdue.

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