Conservation of the Jackass Penguin (Spheniscus demersus (L.))

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CONSERVATION OF THE JACKASS PENGUIN (*Spheniscus demersus* (L.))

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ABSTRACT

The jackass penguin Spheniscus demersus (*L.*) *is confined to the coastal waters of southern Africa, and breeds on* 18 *islands predominantly within the region of the cold, nutrient rich Benguella current. Since the early* 1900*s the species' population has declined in numbers of unknown magnitude. The decline appears to be continuing, although the absence of reliable census data precludes an accurate measurement of the rate of change. The initial fall in numbers was undoubtedly due to severe disturbance of nesting birds and excessive commercial exploitation of eggs. The average annual egg crop for the period* 1900–30 *exceeded* 450,000 *eggs from Dassen Island alone. Egg collection has been suspended temporarily, but the species now appears to be threatened by oil pollution, and by competition with a pelagic shoal fish industry. Threats to breeding colonies are posed by harbour developments. These factors are discussed and evaluated. South African marine organisms are considered officially to be an economic resource and are heavily exploited. Legislation governing the control of this resource is the concern of the Ministry for Economic Affairs. There is no provision for any government body to investigate the status and biology of economically insignificant, but yet integral, components of the marine ecosystem. The major priority of conservationists is to safeguard the jackass penguin population at its present level. This includes proclamation of several offshore islands and their surroundings as national nature reserves. We consider current efforts to rescue, clean and rehabilitate oiled seabirds as contributing little to conservation in real terms, even though the activity has an important humanitarian and educational function. Research priorities include a comprehensive census of the jackass penguin and other seabird populations in southern Africa; a study of mortality and recruitment, with particular attention to factors affecting the rates of these processes; a study of the dynamics of the penguin/prey interaction, with special reference to the possible effects of competition with the pelagic fishing industry; an evaluation of the degree of dis-*

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turbance that nesting penguins can tolerate; an investigation into the temporal and spatial patterns of oil pollution incidents, oil slick occurrence and movement, and the development of methods of keeping birds away from oil slicks; and, lastly, an evaluation of the efficacy of rehabilitating oiled penguins as a contribution to maintaining or increasing the current jackass penguin population. The responsibility for these projects rests with the South African government.

INTRODUCTION

The jackass penguin (*Spheniscus demersus* (L.)) is confined to the coastal waters of southern Africa from Lobito (12°S), on the west coast, to Lourenco Marques (26°S) on the east coast (da Franca, 1967; McLachlan & Liversidge, 1970). The species breeds on low-lying offshore islands concentrated mostly along the west coast (Rand, 1963*a*,*b*).

Concern for the future of the species has been expressed by various authors, notably Rowan (1969) and Westphal & Rowan (1971). This was prompted by a series of oil spills off the south-western Cape coast in 1968, when large numbers of penguins were oiled. There followed an assessment of the numerical status of the species, which showed that a decline of unknown magnitude had taken place during this century. As a consequence there was an upsurge of research into jackass penguin biology, and interest in conservation of the species (Verwey, 1971; Reitz, 1972).

The only prior ecologically orientated research that had been carried out were investigations into the impact that jackass penguins and other seabirds, notably the Cape gannet (*Sula capensis* (Lichtenstein)) and Cape cormorant (*Phalacrocorax capensis* (Sparrman)), were having on commercially important pelagic fish stocks (Davies, 1955, 1956; Rand, 1959, 1960*a*,*b*, 1963*a*,*b*; Matthews, 1961). There has been no full review of the problems attending the conservation of the jackass penguin. A review is needed, to relate current research and conservation efforts to those factors thought to be influencing the population status of the species. These factors include the former exploitation of the birds for their eggs, the disturbance of breeding birds through egg and guano collection, oil pollution and competition with the fishing industry (Rand, 1971; Westphal & Rowan, 1971).

THE PAST AND PRESENT STATUS OF THE JACKASS PENGUIN

The jackass penguin currently breeds on a total of 18 islands (and their outliers), extending from Hollamsbird Island (24° 38′S, 14° 31′E) on the west coast to Bird Island (33° 50′S, 18° 20′E) on the south coast (Fig. 1). The largest island, and the most important breeding site for penguins, is Dassen Island (33° 25′S, 18° 05′E).

The species formerly bred on Robben Island (33° 50′S, 18° 20′E), though this colony was extinct by 1800 (Westphal & Rowan, 1971).

Fourteen of the islands lie within the influence of the west coast Benguella current, in a region of high biological productivity (Cushing, 1971). The majority of the islands are low-lying and rock-strewn. Proximity to cold ocean currents and a generally flat coast ensure that rainfall on the islands is low. Insolation is high. Although primarily adapted for life in a cool aquatic environment (Frost *et al.*, 1975), jackass penguins have adapted behaviourally to a hot terrestrial breeding environment (details to be published later). Adaptations include crepuscular activity, and a tendency for nesting birds to burrow or seek other forms of shelter from high incident radiation.

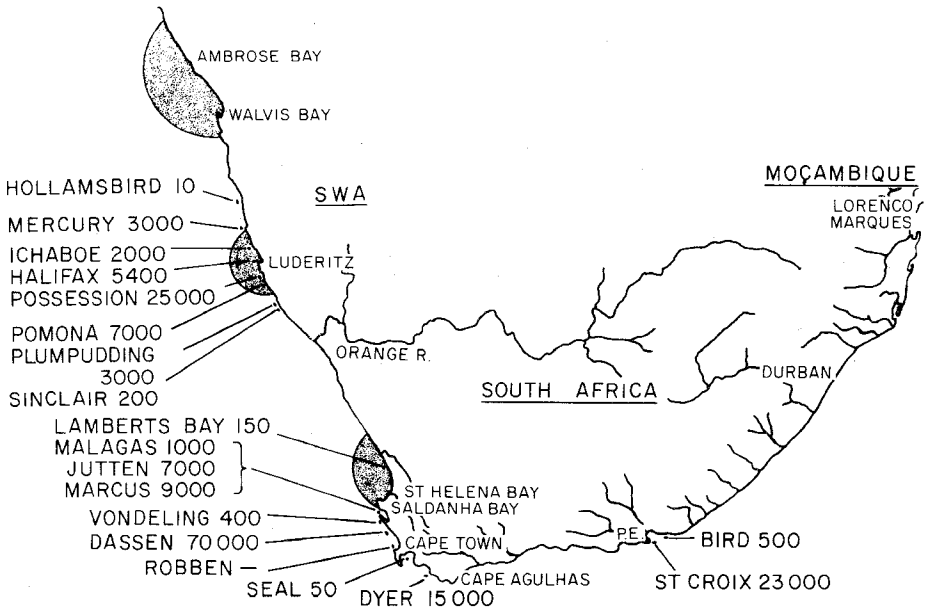

Fig. 1. Distribution of jackass penguin breeding islands, together with current estimated penguin populations. Stippling indicates main areas of commercial harvesting of pelagic shoal fish.

Westphal & Rowan (1971) have discussed the evidence for an historical decline in the penguin population. This evidence rests largely upon anecdotal accounts together with photographs made by Kearton (1930) on Dassen Island. This material cannot be used to derive absolute figures for the Dassen Island population. However, examination of these photographs, and knowledge of the bird's present

status on Dassen Island, leaves us in no doubt that a marked decline has taken place since 1930. Kearton (1930), who even in the 1920s suggested that the species might be declining, estimated that the island supported 5,000,000 birds. This is considered a gross overestimate and it is likely that during this period no more than 1,500,000 birds inhabited the island (Westphal & Rowan, 1971).

Some support for this latter estimate comes from a consideration of the commercial egg crop (*see* Cott, 1953). Between 1900 and 1930 the average annual egg crop from Dassen Island exceeded 450,000 eggs. Eggs were collected over a period of two to five months each year and represented the annual reproductive commitment of a minimum of 300,000 birds (150,000 pairs, assuming that two eggs comprised a clutch and that half the pairs renested and were exploited again). Since only a part of the island was worked in any one year, the actual number of birds was undoubtedly much higher.

The previous populations of penguins on some other islands can also be inferred from egg crop data (Table 1). The estimated minimum numbers of penguins

TABLE 1

AVERAGE ANNUAL NUMBER OF JACKASS PENGUIN EGGS COLLECTED FROM SELECTED ISLANDS PER DECADE FOR THE PERIOD 1871–1969.* FIGURES IN PARENTHESES REFER TO THE NUMBER OF YEARS FOR WHICH DATA ARE AVAILABLE. DASH INDICATES THAT NO DATA ARE AVAILABLE FOR A PARTICULAR DECADE

Decade	*Dassen*	*Jutten*	*Marcus*	*Vondeling*	*Lambert's Bay*
1870–1879	104,750 (8)	70,714 (7)	5,300 (2)	14,950 (8)	7,675 (8)
1880–1889	—	—	—	—	—
1890–1899	400,000 (2)	—	—	—	—
1900–1909	436,000 (9)	117,310 (9)	29,478 (7)	66,596 (5)	4,067 (3)
1910–1919	465,000 (8)	62,580 (3)	25,260 (3)	44,760 (3)	—
1920–1929	495,000 (10)	—	—	—	—
1930–1939	236,000 (5)	—	—	—	—
1940–1949	161,000 (8)	—	—	—	—
1950–1959	129,000 (7)	—	—	—	—
1960–1969	35,300 (2)	—	—	—	—

* Data from Division of Government Guano Islands Annual Reports; Cott (1953); D. Price (pers. comm.).

required to produce the average annual numbers of eggs collected from Jutten, Marcus, Vondeling and Lambert's Bay islands for the decade 1900–09 are 78,000, 19,500, 44,400 and 2700 birds, respectively. When these figures are compared with the estimated current populations on these islands, totalling 16,550 birds (Fig. 1), a decline of nearly 90% is apparent.

The most reliable total population estimates were those derived from aerial photographs, taken in late 1956 (Rand, 1963*a*,*b*). Westphal & Rowan (1971) commented critically on disparities in the counts and estimates made by Davies (1958) and Rand (1960*a*, 1963*a*) from the same sets of photographs. Close reading of these reports indicates that the figures are not comparable, since the authors were referring to different combinations of islands south of the Orange River. Only Rand

(1963*a*) referred to all the Cape islands when he estimated a population of 196,000 adult penguins. For Dassen Island alone a total of 80,562 penguins was counted, and after allowing for absenteeism an estimate of 145,000 adult birds was made. Similar methods were used in estimating a total of 99,400 adult penguins in the South West African islands north of the Orange River (Rand, 1963*b*).

We are critical of aerial photography as a method for censusing birds which frequently nest in burrows or under boulders. While the penguins do nest in the open on some islands, on others the tendency to burrow is marked. Furthermore, by midmorning most non-incubating birds leave the breeding flats to congregate in beach groups or to go to sea. The diel variation in the numbers of birds visible on the surface of a breeding flat is shown in Fig. 2. Thus, counts made from aerial photographs would result in an underestimate of the actual population.

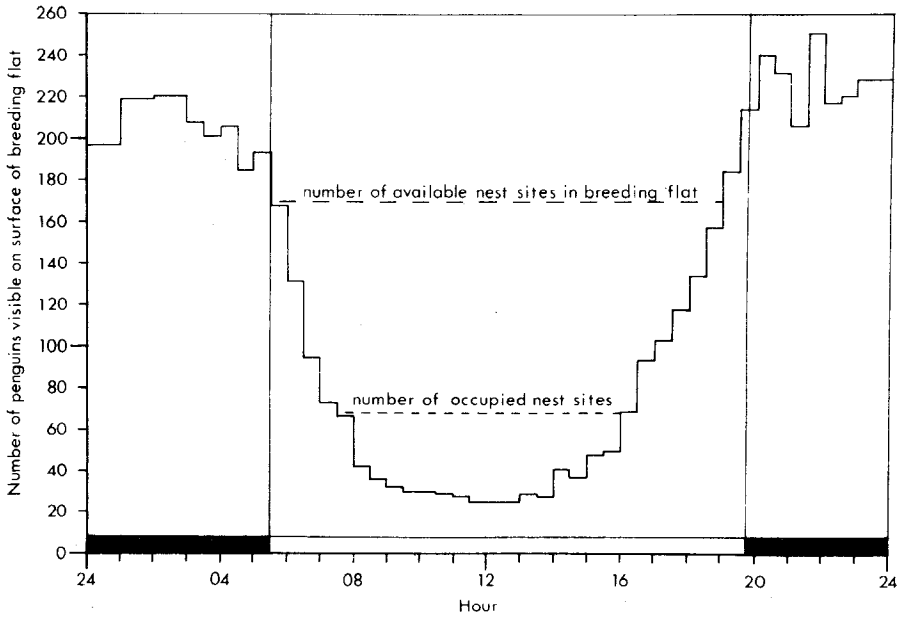

Fig. 2. Numbers of jackass penguins on the surface of a breeding flat at Dassen Island, November 1974. Shaded horizontal bars indicate night and clear bar indicates daylight hours.

Further criticism of past and more recent censuses is that counts made at one time of the year do not take into account birds breeding at other times. On most islands there are peaks of breeding in September and February (Rand, 1960*a*), though on Dassen Island, at least, birds breed throughout the year with only minor peaks in spring and autumn (details to be published later). On St Croix there is

apparently only one peak in breeding each year, in February (G. B. Ross, pers. comm.). Rand (1960*a*) states that individuals breed twice a year, though we do not know if this statement is based on observations of marked birds, or is merely an extrapolation from the occurrence of two peaks of breeding. We believe that the jackass penguin normally does not breed more than once a year, though renesting after an initial failure is quite common. Counts made once a year must lead to an underestimation of absolute population size, though they can provide useful information on relative change in numbers from year to year.

Recent estimates for populations on selected islands are presented in Table 2. The figures provided by the Government Guano Islands Administration are only rough estimates. The other figures are based either on sampling and extrapolation (Ross, 1971; Cooper, 1972 for Dyer Island), or on direct head counts (Cooper, 1972 for Dassen Island; Berry *et al.*, 1974). Total head counts are probably reliable for islands with small penguin populations.

TABLE 2
NUMBERS OF JACKASS PENGUINS ON SELECTED ISLANDS OF THE SOUTHERN AFRICAN COAST BETWEEN 1956 AND 1972

Island	*Area (ha)*	1956 *counted*[a]	1956 *estimated*[a]	1970 *estimated*[b]	1972	*Change between 1956 estimate and 1970/72*
St Croix	12	7,470	12,000	15,000	23,000[c]	+11,000
Dyer	20	4,982	8,000	15,000	38,000[d]	+30,000
Dassen	220	80,562	145,000	50,000	70,000[d]	−75,000
Marcus	11	5,834	9,500	3,000	9,000[e]	−500
Possession	89	38,552	49,500	25,000	—	−24,500
Halifax	40	8,639	11,000	5,000	5,269[f]	−5,731
All islands		181,796	295,400	137,450	171,710[g]	−123,690

[a] Rand (1963*a*,*b*)
[b] Government Guano Islands, MS
[c] Ross (1971)
[d] Cooper (1972)
[e] Anon. (1973)
[f] Berry *et al.* (1974)
[g] This paper

There is no consistent trend in the figures presented in Table 2. Compared with previous data (Rand, 1963*a*,*b*), some jackass penguin populations apparently have decreased markedly while others apparently have increased. Berry *et al.* (1974) provide the most conclusive data for a decline of more than 45% over 16 years in the population on Halifax Island. A decline of similar magnitude on Dassen Island (Cooper, 1972) is also considered to be reasonably accurate. Apparent declines in populations on Marcus and Possession Islands require verification. Apparent increases on both St Croix and Dyer Islands are more difficult to evaluate. The aerial photographs of St Croix were taken in November, when few birds would be breeding. Furthermore, St Croix is a rocky island so that counts made from aerial photographs could be too low. However, the increase, if real, may be due to

enhanced breeding success following a reduction in disturbance after guano collecting ceased in 1957 (McLachlan, 1974). The 1956 and 1972 estimates for the numbers of penguins on Dyer Island also are not strictly comparable, because counts were made at different times of the year. Furthermore, the 1972 figure is now considered to be an over-estimate, and a more realistic figure is about 15,000 birds.

Clearly it is impossible to be precise when discussing numbers of jackass penguins. A comparison between the 1956 estimates (Rand, 1960*a*,*b*) and the most recent estimates for the total population indicates a decline in numbers of 123,690 birds (Table 2). While this figure may be too high, we conclude that the penguin population certainly is not increasing. Suggestions that the jackass penguin population has increased by 100,000 birds (E. Westphal, quoted by Ripley, 1974) are based on no data at all.

FACTORS IMPLICATED IN THE DECLINE (1900–70)

Egg exploitation

Cott (1953) remarks that the jackass penguin is probably the only species for which accurate egg crop data are available. Exploitation of penguins and their eggs was started soon after the Cape was settled (Rand, 1971; Westphal & Rowan, 1971). Initially no complete records were kept, so the impact of this phase of exploitation is difficult to assess. The penguin colony on Robben Island was extinct by 1800, so we may presume that exploitation was intense. Official records of egg crops commenced in 1871. Commercial egg collecting was confined to the Cape islands, in particular Dassen Island, from where the major portion of the egg crop originated (Table 1, Fig. 3).

The number of eggs collected each year is staggering. Over 13,000,000 eggs were removed in the 30-year period 1900–30. The number of eggs actually collected was probably higher because partially incubated eggs were discarded (W. van Dyk, pers. comm.), and well incubated eggs were deliberately destroyed in order to induce birds to relay. Loss of eggs and young to kelp gulls (*Larus dominicanus* Lichtenstein) was common during egg collecting operations (W. van Dyk, pers. comm.). Only rudimentary attempts were made to manage the breeding birds and to maintain egg production. These measures included the restriction of egg collecting to certain months of the year, and a yearly rotation of areas over which eggs were collected. Despite these efforts the penguins declined. Twenty of the 51 annual reports of the Government Guano Islands Administration available for the period 1890–1950 noted this decline. For Dassen Island, we have little doubt that excessive egg collecting was responsible.

All egg collecting was temporarily suspended in 1969 as a result of increased collecting costs (Rand, 1971). Illegal egg collecting still occurs, though the mag-

nitude of the operation is difficult to assess. Lack of information makes it impossible to assess properly whether the cessation of egg collecting has had any marked influence on the population status of the penguin. However, despite the low level of egg collecting generally throughout the 1960s, the penguin population on Dassen Island apparently has continued to decline.

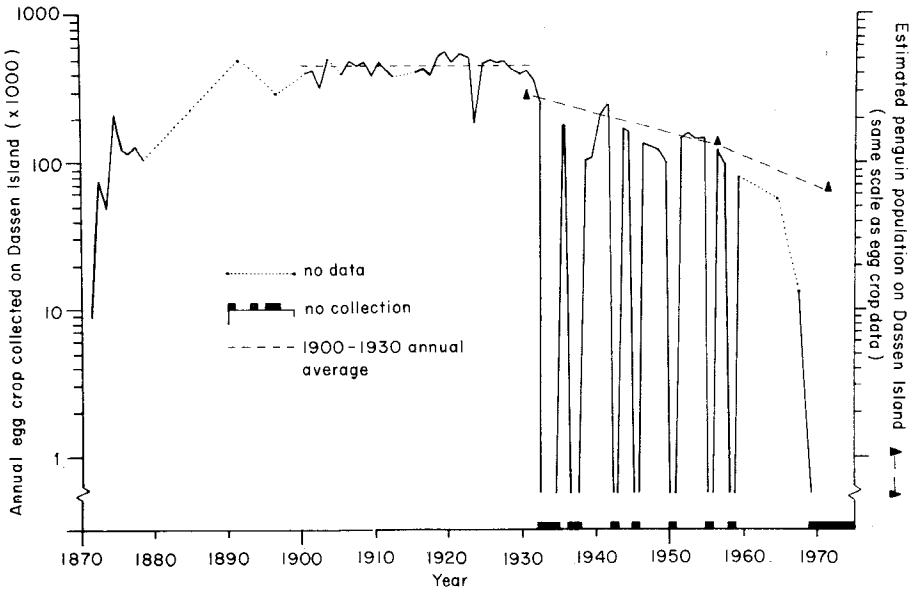

Fig. 3. Annual egg crop taken from jackass penguins at Dassen Island 1870–1970, together with past and present estimates for minimum number of penguins on the island. Data from Cott (1953); annual reports Division of Government Guano Islands, Government Printer, Pretoria; and D. Price (pers. comm.).

Disturbance of breeding colonies

In addition to disturbance caused by egg collecting, breeding was also severely disrupted by the commercial exploitation of guano (Rand, 1950). This was particularly true for the South West African islands where guano exploitation was intensive and largely uncontrolled (Eden, 1846). Indeed, British annexation of these islands in 1861 was a direct consequence of the unruly behaviour of bands of guano collectors.

The major long-term change affecting the penguins was removal of guano accumulations into which they burrowed (Morrell, 1844). This exposed either bedrock or loose sandy subsoils, which precluded penguins from burrowing (Berry *et al.*, 1974). This quite likely affected breeding success. In addition to providing an

equable microclimate, burrows protect nesting penguins from predators. Nesting success is higher in burrows than in the open (Table 3).

On Lambert's Bay Island the central area was paved with flat stones to facilitate guano scraping (Jarvis & Cram, 1971). This practice further reduced the quality of nesting habitat. In the early 1900s this island supported large numbers of nesting penguins (Green, 1955), whereas today it is inhabited largely by Cape gannets and Cape cormorants. Similar changes in the species composition of breeding seabirds occurred on other guano islands (*e.g.* Ichaboe Island *cf.* Morrell, 1844; Rand, 1963*b*). It is likely that these changes were effected in the period of seabird re-colonisation after the guano 'boom' years 1844–61.

TABLE 3
BREEDING SUCCESS OF JACKASS PENGUINS IN DIFFERENT NEST SITES

Nest site	*No. nests*	*No. eggs*	*Mean clutch*	*% eggs failed before hatching (No.)*	*% chicks failed before fledging (No.)*	*% chicks fledging (No.)*
Burrows	119	231	1·94	24·7 (57)	40·7 (94)	34·6 (80)
Under rocks	198	332	1·68	26·8 (89)	42·8 (142)	30·4 (101)
Exposed	84	158	1·88	32·9 (52)	47·5 (75)	19·6 (31)
				X^2 comparison h_o = no difference		
Burrows compared with Exposed				NS	NS	$p = 0{\cdot}01$–$0{\cdot}001$
Burrows compared with Rocks				NS	NS	NS
Rocks compared with Exposed				NS	NS	$p = 0{\cdot}1$–$0{\cdot}01$

Additional disruption appears to have been caused by the erection of metre-high walls around the central areas of many islands. On Sinclair's Island a wall was built to protect nesting penguins from disturbance by herds of Cape fur seals (*Arctocephalus pusillus* (Schreber)) (Rand, 1949). However, walls were also built on other islands where there were no seal rookeries. On Dassen Island the wall was apparently built so that penguins would nest in greater densities outside, thereby facilitating the collecting of eggs (W. van Dyk, pers. comm.). On other islands the walls were reputed to have been built to increase the breeding space for other guano-producing seabirds such as gannets and cormorants. Whatever the reasons for their construction, the walls must have excluded jackass penguins from much suitable nesting habitat.

Pollution

The most readily apparent source of pollution affecting jackass penguins is petroleum oil. This results from both shipping mishaps and periodic oil slicks originating from bilge and tank washings. The first reported oiling of jackass penguins occurred in 1948 when the tanker *Esso Wheeling* ran aground near Dyer Island (Green, 1955). In 1952, 1200 penguins were recovered near Cape Town, oiled

in a slick of unknown origin (Rand, 1952, 1971). However, the threat posed by this form of pollution did not become apparent until after the closure of the Suez canal in 1967.

The Cape coast, with gale force winds, rough seas and thick fogs, is particularly dangerous to shipping. Approximately 50 shipping mishaps have taken place in South African waters since 1969, the majority of which have occurred close to the Cape coast. Seven vessels have been involved in collisions, while a further 10 have run aground. Fully laden, west-bound tankers, cutting close inshore while rounding the Cape, appear to be most susceptible to accident. Table 4 reports those shipping mishaps that have resulted in significant oiling incidents, as well as periodic oil slicks that have affected numbers of jackass penguins.

TABLE 4
OIL POLLUTION INCIDENTS ALONG THE CAPE COAST AFFECTING JACKASS PENGUINS, AND NUMBERS OF OILED PENGUINS RECOVERED, CLEANED AND RELEASED BY SANCCOB 1968–74

Origin (name of ship) or location of oil spill	*Month and year*	*Oil spilt (tons)*	*Minimum no. penguins oiled*	*No. treated*	*% released*	*(No.)*
Esso Essen	April 1968	15,000	1,700	1,300	73	(950)[a]
Cape point slick	August 1969	—	52	52	94	(49)[b]
Simonstown slick	August 1970	—	51	51	71	(36)[b]
Kazimah	November 1970	200	599	414	64	(264)[b]
Wafra	February 1971	25,000	1,216	1,139	64	(724)[b]
Dassen Island slick	March 1972	—	>2,100	1,706	60	(1020)[b]
Oswego Guardian	September 1972	?	400	400	63	(254)[c]
Oriental Pioneer	July 1974	?	488	488	65	(317)[c]

[a] Westphal & Rowan (1971).
[b] Pearcy *et al.* (1972).
[c] SANCCOB newsletters (undated)—exact numbers released computed from figures for per cent birds released.

At least 6600 oiled penguins were recovered in the eight incidents listed. The number of unrecovered oiled penguins is not known. Tanis & Mörzer Bruyns (1969) estimated that for every oiled seabird recovered eight birds would have perished at sea. Westphal & Rowan (1971) used this factor to suggest that during 1968, oiling incidents might have accounted for 10% of the total population of the jackass penguin. However, the Tanis & Mörzer Bruyns (1969) ratio, originally estimated for flying birds in the North Sea, may not be applicable to the flightless jackass penguin. There have been no reports of large numbers of oiled penguins out at sea, or dead oiled penguins washed ashore, and we suspect that the number of unrecovered and unrecorded birds is lower than generally accepted.

The minimum number of jackass penguins known to have been oiled during the last six years, amounts to approximately 4% of the current estimated total population, and about 5·4% of the estimated population of the Cape islands. The average

annual oiling rate is in the region of 0·7 to 0·9%. This figure is well below the probable annual mortality rate for adults (8·5% used by Jackson *et al.* (in press) in a simulation model of jackass penguin population dynamics). Mean annual adult mortality is 13% in the yellow eyed penguin (*Megadyptes antipodes* (Hombron & Jaquinot)) (Richdale, 1957) and 6–13% for pelagic seabirds in general (Lack, 1966). Consequently, if oiling is to have the magnitude of effect with which it is popularly credited, many more jackass penguins would have to be oiled than current figures suggest. We suspect that oiling alone is relatively unimportant, though together with other factors, oiling may adversely affect the penguin population.

The consequences of oil spills on the seabird population, in particular the jackass penguin, prompted the formation of the South African National Foundation for the Conservation of Coastal Birds (SANCCOB). This organisation has been active in rescuing and rehabilitating oiled birds. The success rate (measured in terms of cleansed penguins released to the wild) has been encouragingly high (Table 4). However, the average release figure of over 60% is not a true test of rehabilitation success. During the past three years 1440 released birds have been marked with flipper bands. To date, 1·8% have been recovered dead. During the same period 5250 penguins were banded on Dassen Island. Less than 1% of these birds have been recovered. This suggests that rehabilitated birds are subject to a slightly higher mortality rate. Current research includes further, more precise, evaluation of rehabilitation success.

Apart from petroleum oil pollution, effluent from a fish factory recently caused extensive mortality among nesting seabirds on Lambert's Bay Island. Large quantities of natural fish oil, mainly anchovy (*Engraulis capensis* (Houttuyn)), were released into the sea, as a result of failure of the oil recovery system in the factory. Heavy seas turned the oil into a thick froth which subsequently surrounded the island. At least 100 penguins, 700 gannets and 7000 Cape cormorants were fatally affected (Percy FitzPatrick Institute, 1974).

The incident serves to underline the vulnerability of breeding penguins to oiling when slicks surround islands. Birds must swim through the oil when leaving or landing on the island. Dyer Island has twice been affected in this way, once apparently resulting in the oiling of 8000 birds (Westphal & Rowan, 1971, though the original source for this figure is not known). Subsequently some success in preventing oiling has been achieved by fencing off breeding birds from the sea until the oil has been cleared up. The use of playback recordings of killer whale (*Orcinus orca* L.) vocalisations to keep penguins out of oil slicks at sea has been investigated (Frost *et al.*, 1975).

We have no evidence for lethal or sublethal effects of persistent chemical biocides or heavy metal pollutants in South African seabirds. The heavy agricultural use of biocides across the subcontinent might be expected to result in the contamination of the marine food chains. Research is currently underway to gather baseline data.

Competition with the pelagic shoal fish industry

Investigations carried out prior to the peak of commercial fish exploitation indicated that the penguin, gannet and Cape cormorant exploited the commercially important fish stocks of anchovy, pilchard (*Sardinops ocellata* (Pappe)) and maasbanker (*Trachurus trachurus* (L.)) (Table 5). The South and South West African pelagic shoal fish industries are among the largest in the world. The industries were based initially on the exploitation of pilchard and maasbanker stocks. However, with the relative decline in catches of these species, anchovy stocks were increasingly exploited. Currently over 1,000,000 metric tons of pelagic shoal fish are removed annually, of which two-thirds is taken from South West African waters. The trends in these fisheries are illustrated (Figs. 4, 5).

TABLE 5
DIETS OF JACKASS PENGUIN, CAPE GANNET AND CAPE CORMORANT
Data from Rand (1959, 1960*a*,*b*)

Food item	*Jackass penguin* (n = 247)			*Cape gannet* (n = 178)			*Cape cormorant* (n = 204)		
	A	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*
Sardinops	32	20	6–25	51	35	5–25	12	9	1–5
Engraulis	21	24	1–10	12	13	5–13	14	15	1–10
Trachurus	18	26	1–10	20	17	1–15	22	23	1–10
Scomber	3	9		5	7		1	2	
Scomberesox	trace			3	3		nil		
Ammodytes	4	6		3	5		24	15	5–20
Eutrumeus	6	8		nil			4	4	
Cephalopods	5	53		2	19		1	1	
Crustaceans	1	29		nil			1	27	

A % by weight.
B % frequency of occurrence.
C predominant size class in cm.

As was the case with the pilchard fisheries in California (Sette, 1969) and Japan (Nakai, 1960), the South African pilchard industry collapsed in 1964 (Stander & Le Roux, 1968). The South West African pilchard stock declined from an estimated 6·25–7·50 million tons for the period of 1957–66 (Newman, 1970) to 2·1 million metric tons at the end of 1971 (Cram & Visser, 1973). The reduction in size classes and egg production suggests that overfishing was a major factor in these declines. However, under close management the South West African pilchard stocks appear to be exhibiting a slow recovery (Cram, 1974), though the South African pilchard stock remains depleted. Maasbanker catches, which declined 100-fold in 20 years (Fig. 4), similarly show no signs of improving.

Declines such as these must in some way affect the ecology of other marine organisms. The gannet and Cape cormorant appear capable of ranging over a wide area in search of food, to compensate for reduced fish stocks, but flightlessness presumably limits the jackass penguin in extensively extending its feeding range. On the basis of swimming speeds (4–7 km/h) and time away from nest (8–11 h)

(unpublished data), breeding jackass penguins have a foraging area probably not exceeding 1500 km^{-2} (with the nesting island centred on the diameter of a semi-circle). Individual birds cannot forage over this whole area at one time. Assuming that penguins can detect and react to food sources within 500 m (an entirely arbitrary figure) then individual foraging areas probably do not exceed 40 km^{-2} within the limits imposed by the above swimming speeds and foraging time.

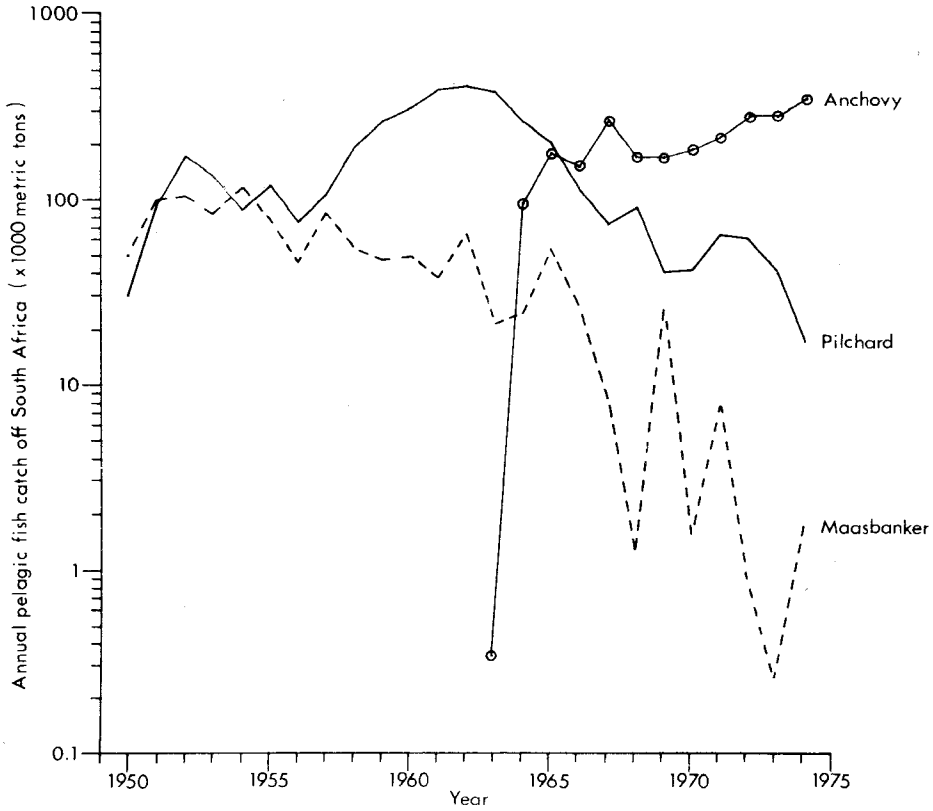

Fig. 4. Annual catch of pilchard, anchovy and maasbanker off South Africa 1950–1974. Data from Stander & Le Roux (1968); annual reports of the Division of Sea Fisheries, Government Printer, Pretoria; and reports in S.A. Shipping News and Fishing Industry Review.

On this basis, penguins must be able to rely on a highly predictable temporal and spatial distribution pattern of prey. Flightlessness in marine birds can have evolved or survived only in areas of high biological productivity where predictable food supplies are found. A major decline in food supplies need not necessarily occur in order adversely to affect the penguin's breeding success. Changes in the distribution

pattern of prey that lower a species' hunting success will ultimately result in an overall decline in survival and reproductive rates.

In view of the changes that have presumably resulted from the overexploitation of the fish stocks off southern Africa, it is unlikely that we will ever fully understand the *status ante* of fish shoal size and occurrence. It is possible that prior to exploita-

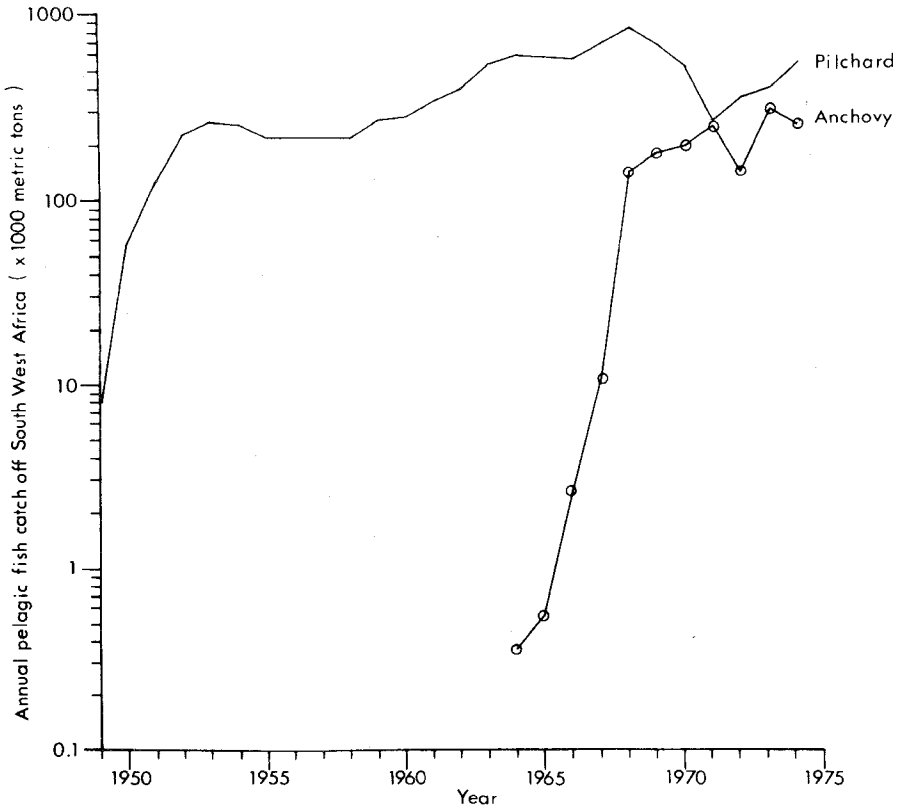

Fig. 5. Annual catch of pilchard and anchovy off South West Africa 1949–74. The figures for the pilchard do not include catches made by factory ships in 1967–68. Data from Newman (1970); annual reports of the Division of Sea Fisheries, Government Printer, Pretoria; and reports in S.A. Shipping News and Fishing Industry Review.

tion the frequency and distribution of shoals was greater than at present. Investigations into pilchard shoal ecology are only just beginning (Cram & Visser, 1973). The occurrence of pilchard shoals appears correlated with conditions of particular water temperature and oxygen concentration between the zones of maximum phytoplankton and zooplankton production (Cram & Visser, 1973; Cram, 1974). There appears to be some predictability of occurrence. It is not known whether

penguins are sensitive to, and respond to, those parameters that appear to determine fish shoal occurrence.

Industrial development schemes

Major development schemes for industrial harbours pose threats to an estimated total of 40,000 jackass penguins. Currently, two projects involve construction of breakwaters from the mainland to Marcus Island, in Saldanha Bay, and to St Croix Island, in Algoa Bay. The scheme at Saldanha Bay is already underway. There are about 9000 penguins on Marcus Island, and another 8000 on two islands nearby. There are no plans for developing Marcus Island for industrial purposes. Plans for St Croix include an ore loading berth capable of accommodating iron ore carriers of 250,000 tons. There are an estimated 23,000 penguins on St Croix (Ross, 1971). The proposed development is likely to displace about 8000 nesting birds and to disturb many others (McLachlan, 1974). Oil slicks and various insidious pollutants pose the greatest long term threats to the penguin populations in Saldanha and Algoa Bays. Furthermore, there is always the risk of catastrophic shipping disasters. We are pessimistic about the future survival of large numbers of penguins in close proximity to these harbour complexes.

Predation and disease

We have no evidence for either predation or disease as major natural sources of jackass penguin mortality. The most significant predators on land are probably kelp gulls which take eggs and chicks (Berry *et al.*, 1974; Cooper, 1974). Feral cats (*Felis* sp.) occur on Dassen Island, but appear to subsist on feral rabbits (*Oryctolagus cuniculus* L.). Cats and rats (*Rattus* spp.) occur on Lambert's Bay Island and possibly on other islands with permanent human habitation. Their effect on the seabird populations on these islands has not been assessed.

Salmonella typhimurium (Loeffler), *Escherichia coli* (Migula) and *Staphylococcus aureus* Rosenbach have been isolated from oiled penguins at a seabird rescue centre (Westphal & Rowan, 1971). *Aspergillus* fungus has been recorded from jackass penguins in captivity (Cooper, 1972). The levels of infection of birds in the wild are unknown. No obvious mortality caused by pathogens has been observed. The real danger, however, is that rehabilitated birds, carrying pathogens, could infect other individuals in the wild. If resistance is naturally low, then epidemics could cause considerable damage. The levels of infection in wild birds should be investigated, and great care taken to ensure that all rehabilitated birds are completely healthy before release.

PRESENT CONSERVATION STATUS OF THE JACKASS PENGUIN

Until recently the responsibility for protecting South African seabirds and seals

rested with the Division of Government Guano Islands of the Department of Industries. The legislation dealing with seabirds and seals provided for the exploitation of products (guano, eggs, sealskins and seal oil) from these islands. The GGI Administration was staffed and funded solely for that purpose.

Currently seabirds are afforded protection by the Sea Birds and Seals Protection Act, 1973, which is administered by the Sea Fisheries Branch, Department of Industries, under the Minister of Economic Affairs. The act provides for 'the control over certain islands and rocks; for the protection and control of the capture and killing of seabirds and seals; and for the disposal of the products of seabirds and seals and for matters incidental thereto; . . .'. The specific provision for conservation is contained in Section II(e) which empowers the Minister to make 'regulations providing for the further conservation or protection of seabirds or seals'. Despite this provision, the emphasis of the present act is largely on the regulation of exploitive activities. In short, the value of marine resources is assessed in terms of economic return, and protection is afforded primarily to increase this return. Officers of the Sea Fisheries Branch live on seven of the 18 islands and public access is strictly controlled. These measures of protection may be insufficient, viewed in relation to the decline of the jackass penguin.

DISCUSSION

We are satisfied that the decline in the jackass penguin population was initiated by prolonged over-exploitation of eggs, together with excessive disruption of breeding birds. These activities have now officially ceased. Factors such as oil pollution, competition with the fishing industry and harbour developments are currently thought to be threatening jackass penguin numbers. It is difficult to establish exact causal relationships between these factors and changes in the penguin population. The immediate objective is to establish whether the penguin population is still declining, as recent census figures seem to indicate. The unreliability of nearly all previous census figures and estimates precludes making specific, quantitative statements regarding the magnitude of change in penguin numbers.

In addition to developing suitable monitoring programmes for seabird numbers, there is a need to evaluate the impact that pollution, the fishing industry and development are having, or will have, on the jackass penguin. The problem of oil pollution has been emphasised frequently (Boyle, 1969; Rowan, 1969; Westphal & Rowan, 1971). In our view the dangers that oil spills pose to the jackass penguin population, as a whole, have been exaggerated. With too much emphasis being placed on the oil pollution aspect, other potentially more serious factors are not being recognised and remain unresearched.

This viewpoint is extremely difficult to put across to the public, who, in the absence of a government-sponsored research programme, have contributed sub-

stantially to supposedly conservation-oriented activities. The rescue, cleaning and rehabilitating of oiled penguins is an activity that finds ready sympathy and support. There is a great humanitarian and educational value in this activity, but this does not gainsay the fact that the programme has limitations, as a contribution to the long-term survival of the species. Funds at present being collected to build a prestigious rehabilitation centre could be put to more effective conservation use. Sponsorship for a detailed survey of the penguin's numerical status, or the adequate protection of birds on their breeding grounds (Bourne, 1970), are more relevant to current conservation needs. The problem is that these are less spectacular and their benefits less readily apparent to the public than is the cleaning of oiled penguins.

The effect of competition with the pelagic shoal fish industry poses possibly the greatest threat to the penguin population. Ainley & Lewis (1974) have related the low population levels of two, formerly numerous, Californian seabirds to the decline in the Californian pilchard industry. A similar situation may be occurring here. We have some data indicating that starvation and desertion of chicks is an important source of mortality, and may be linked to failing offshore food supplies. However, there is no direct evidence that this is a result of pelagic fish exploitation. A study is needed of the diet of the penguin, aimed at determining whether there has been any major change since the study undertaken by Rand (1960*a*). A proposal to this effect was rejected by a public conservation organisation concerned with seabirds, on the grounds that it would not contribute materially to conservation and would offend the general public who supported the organisation.

Little is known of the behaviour of penguins at sea (Siegfried *et al.*, 1975). Until the dynamics of the jackass penguin/pelagic fish interaction are known, no proper evaluation can be made of the impact that declining fish stocks may be having on the penguin population. The technical problems of acquiring the information are great, but they could be overcome.

CONCLUSION AND SUMMARY

In concluding this review we note that not much advance has been made in recent years towards effective conservation of the jackass penguin. This has been largely due to an incomplete appreciation of what constitutes conservation and a failure to identify problems and objectives. Consequently, there has been a lack of direction, poor co-ordination of effort towards achieving stated aims, and a dissipation of financial resources over a spectrum of projects without regard for proper priorities. It is essential that the objectives and problems be clearly defined if progress is to be achieved.

The overall objective is to safeguard, for the future, the number of jackass penguins at or above present level. We recognise two distinct, but complementary, approaches to achieving this objective. The first concerns effective legislation

providing for the creation of viable sanctuaries for the jackass penguin. The second is to investigate those factors that may be adversely influencing the numbers of penguins, and to develop and implement a management programme designed to minimise the effect of those factors. The first aspect is a matter of conservation politics, the second, one of conservation research. Both are essential.

The problem of safeguarding the jackass penguin population must be seen in relation to the official attitude towards the marine ecosystem. The prevailing legislation is inhibiting the development of comprehensive conservation measures. Economic considerations nearly always assume priority.

While the government authorities have co-operated willingly with private organisations and individuals engaged in independent marine research, their own research programmes have been almost entirely dictated by economic forces. Existing policy provides scant consideration for non-economic elements in the system. State departments, which are responsible for protecting and conserving national wildlife resources, also have an obligation to invest some of their time and money in economically insignificant but biologically integral components of an ecosystem. Basic ecological tenets need to be recognised in formulating a balanced approach to the conservation and utilisation of the marine ecosystem.

We understand nature conservation to be the maintenance of a state of dynamic equilibrium through protecting the natural diversity characteristic of an ecosystem. Current policy affecting the marine environment appears to run counter to this principle. Changes of unknown magnitude may be taking place that affect all marine organisms. A change in official attitude is a prerequisite for successful conservation of the marine ecosystem in general and the jackass penguin in particular. Conservationists should work towards promoting such change.

In the short-term we propose that several of the more important offshore islands and their surroundings be proclaimed national nature reserves. Facilities for research and limited tourist activity could be provided. A proposal to this end is detailed in Anon. (1973).

The following research projects, in order of priority, should be considered and implemented as soon as possible.

(a) a complete, and accurate, census of the whole jackass penguin population;

(b) a detailed study of mortality and recruitment, with particular attention being paid to those factors that influence the rate of these processes (*see* Jackson *et al.*, in press);

(c) a study of the dynamics of the jackass penguin/prey interaction with special reference to possible effects arising out of competition with the pelagic shoal fish industry;

(d) an evaluation of the degree of disturbance tolerated by nesting birds (this knowledge being necessary for assessing the impact of development and tourism on breeding success);

(e) an investigation into the temporal and spatial patterns of shipping mishaps

and consequent oil pollution, the drift pattern of slicks, and the development of methods for keeping seabirds out of oil slicks; and

(f) a proper evaluation of the efficacy of rescuing, cleaning and rehabilitating oiled penguins, related to the overall objective of maintaining or increasing the current jackass penguin population.

In the first instance these conservation and research programmes are the responsibility of the national government. The marine ecosystem is a national resource and needs to be exploited judiciously in order to maintain a state of dynamic equilibrium. The jackass penguin is a component of this ecosystem, no more or less important, in terms of ecosystem structure and function, than other components. The organisms comprising an ecosystem have co-evolved through time, and too little is known of their contribution to ecosystem stability. All organisms deserve consideration and conservation.

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REFERENCES

AINLEY, D. G. & LEWIS, T. J. (1974). The history of Farallon Island marine bird populations, 1854–1972. *Condor*, **76**, 432–46.

ANON. (1973). Marcus Island—a new wildlife sanctuary? *Afr. Wild Life*, **27**, 162–4.

BERRY, H. H., SEELY, M. K. & FRYER, R. E. (1974). The status of the Jackass Penguin *Spheniscus demersus* on Halifax Island off South West Africa. *Madoqua, Ser.*, **II:3**, 27–9.

BOURNE, W. R. P. (1970). Oil pollution and bird conservation. *Biol. Conserv.*, **2**, 300–2.

BOYLE, C. L. (1969). Oil pollution of the sea: is the end in sight? *Biol. Conserv.*, **1**, 319–27.

COOPER, J. (1972). *Population dynamics of the jackass penguin. Jan.–Dec.* 1972. Report to SANCCOB, Cape Town, 28 pp. (Mimeographed).

COOPER, J. (1974). The predators of the Jackass Penguin *Spheniscus demersus*. *Bull. Br. Orn. Club*, **94**, 21–4.

COTT, H. B. (1953). The exploitation of wild birds for their eggs. *Ibis*, **95**, 409–49.

CRAM, D. L. (1974). South West African pilchard stock continues to recover. *S.A. Ship. News Fish. Ind. Rev.*, **29**(9), 74–5.

CRAM, D. L. & VISSER, G. A. (1973). S.W.A. pilchard stocks show first signs of recovery. *S.A. Ship. News Fish. Ind. Rev.*, **28**(3), 56–63.

CUSHING, D. H. (1971). Upwelling and the production of fish. *Adv. Mar. Biol.*, **9**, 255–334.

DAVIES, D. H. (1955). The South African pilchard (*Sardinops ocellata*): bird predators, 1953–54. *Investl Rep. Div. Fish. Un. S.A.*, **18,** 1–32.
DAVIES, D. H. (1956). The South African pilchard (*Sardinops ocellata*) and maasbanker (*Trachurus trachurus*): bird predators, 1954–55. *Investl Rep. Div. Fish. Un. S.A.*, **23,** 1–40.
DAVIES, D. H. (1958). The predation of seabirds in the commercial fishery. *Investl Rep. Div. Fish. Un. S.A.*, **31,** 1–16.
EDEN, T. E. (1846). *The search for nitre and the nature of guano.* London, Groombridge & Sons.
da FRANCA, P. (1967). Sur la presence d'*Arctocephalus pusillus* (Schreber) (Otariidae) et de *Mirounga leonina* (Linné) (Phocidae) au sud de l'Angola. *Mammalia*, **31,** 50–4.
FROST, P. G. H., SIEGFRIED, W. R. & GREENWOOD, P. J. (1975). Arterio-venous heat exchange system in the jackass penguin *Spheniscus demersus*. *J. Zool., Lond.*, **175,** 231–41.
FROST, P. G. H., SHAUGHNESSY, P. D., SEMMELINK, A., SKETCH, M. & SIEGFRIED, W. R. (1975). The response of jackass penguins to killer whale vocalizations. *S.Afr. J. Sci.*, **71,** 157–8.
GREEN, L. (1955). *Panther Head.* London, Stanley Paul.
JACKSON, F., SIEGFRIED, W. R. & COOPER, J. (in press). A simulation model for the population dynamics of the jackass penguin. *Trans. R. Soc. S. Afr.*, **42.**
JARVIS, M. J. F. & CRAM, D. L. (1971). Bird Island, Lambert's Bay, South Africa: an attempt at conservation. *Biol. Conserv.*, **3,** 269–72.
KEARTON, C. (1930). *The island of penguins.* London, Longmans.
LACK, D. (1966). *Population studies of birds.* London, Oxford University Press.
MATTHEWS, J. P. (1961). The Pilchard of South West Africa and the Maasbanker. Bird predators, 1957–1958. *Investl Rep. Mar. Res. Lab. S.W. Afr.*, **3,** 1–35.
McLACHLAN, A. (1974). St Croix—die ander kant van die storie. *Afr. Wild Life*, **28,** 20–3.
McLACHLAN, G. R. & LIVERSIDGE, R. (1970). *Roberts birds of South Africa.* Cape Town, C.N.A.
MORRELL, B. (1844). *Morrell's narrative of a voyage to the South and West coast of Africa.* London, Whittaker & Co.
NAKAI, Z. (1960). Changes in the population and catch of the Far East Sardine area. *Proceedings of the world scientific meeting on the biology of sardines and related species, F.A.O. Rome*, **3,** 807–53.
NEWMAN, G. G. (1970). Stock assessment of the pilchard *Sardinops ocellata* at Walvis Bay, South West Africa. *Investl Rep. Div. Fish. Un. S.A.*, **85,** 1–13.
PEARCY, J. F., WESTPHAL, A. & WESTPHAL, E. O. J. (1972). *The rescue and cleaning of oil polluted seabirds in South Africa, Aug.* 1969–*July* 1972. Report to SANCCOB, Cape Town, 23 pp. (Mimeographed).
PERCY FITZPATRICK INSTITUTE (1974). Fish oil kills sea birds. *Afr. Wild Life*, **28,** 24–5.
RAND, R. W. (1949). Birds observed on Sinclair Island. *Ostrich*, **20,** 130–7.
RAND, R. W. (1950). Birds of the guano islands. *Fmg. S. Afr.*, **25,** 297–301.
RAND, R. W. (1952). Oil contamination—a seabird menace. *Bokmakierie*, **4,** 63.
RAND, R. W. (1959). The distribution, abundance and feeding habits of the Cape Gannet, *Morus capensis*, off the South western coast of the Cape Province. *Investl Rep. Div. Fish. Un. S.A.*, **39,** 1–36.
RAND, R. W. (1960*a*). The distribution, abundance and feeding habits of the Cape Penguin, *Spheniscus demersus*, off the south-western coast of the Cape Province. *Investl Rep. Div. Fish. Un. S.A.*, **31,** 1–28.
RAND, R. W. (1960*b*). The distribution, abundance and feeding habits of the cormorants, *Phalacrocoracidae*, off the south western coast of the Cape Province. *Investl Rep. Div. Fish. Un. S.A.*, **42,** 1–32.
RAND, R. W. (1963*a*). The biology of guano producing seabirds: composition of colonies on the Cape Islands. *Investl Rep. Div. Fish. Un. S.A.*, **43,** 1–32.
RAND, R. W. (1963*b*). The biology of guano producing seabirds: composition of colonies on the South West African Islands. *Investl Rep. Div. Fish. Un. S.A.*, **46,** 1–26.
RAND, R. W. (1971). Some hazards to seabirds. *Ostrich Suppl.*, **8,** 515–20.
REITZ, J. B. de V. (1972). The jackass penguin of South Africa—a threatened species. *Biol. Conserv.*, **4,** 73.
RICHDALE, L. E. (1957). *A population study of penguins.* London, Oxford University Press.
RIPLEY, S. D. (1974). Successful protection of the jackass penguin. *I.C.B.P. President's letter*, **33,** 8.
ROSS, G. B. (1971). The jackass penguin on St Croix: a census. *Eastn Cape Nat.*, **44,** 22–4.
ROWAN, M. K. (1969). Oiling of marine birds in South Africa. *Proc. int. Conf. Oil Pollut., Rome*, 1968, 121–4.
SETTE, O. E. (1969). A perspective of a multispecies fishery. *Rep. Calif. coop. oceanic Fish. Invest.*, **13,** 81–7.
SIEGFRIED, W. R., FROST, P. G. H., KINAHAN, J. B. & COOPER, J. (1975). The social behaviour of the jackass penguin at sea. *Zool. Afr.*, **10,** 87–100.

STANDER, G. H. & LE ROUX, P. J. (1968). Notes on fluctuations of the commercial catch of the South African pilchard (*Sardinops ocellata*) 1950–1965. *Investl Rep. Div. Fish. Un. S.A.*, **65**, 1–14.

TANIS, J. J. C. & MÖRZER BRUYNS, M. F. (1969). The impact of oil pollution on sea birds in Europe. *Proc. int. Conf. Oil. Pollut., Rome*, 1968, 69–74.

VERWEY, J. E. M. (1971). Conservation programmes for coastal birds in South Africa. *Biol. Conserv.*, **3**, 311–3.

WESTPHAL, A. & ROWAN, M. K. (1971). Some observations on the effects of oil pollution on the jackass penguin. *Ostrich Suppl.*, **8**, 521–6.