THE SOUTHERN OCEAN SEABIRD IRRUPTION TO SOUTH AFRICAN WATERS DURING WINTER 1984

P.G. RYAN[1], G. AVERY[2], B. ROSE[3], G.J.B. ROSS[4], J.C. SINCLAIR[5] & C.J. VERNON[6]

[1]*Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7700, South Africa*
[2]*South African Museum, Box 61, Cape Town 8000, South Africa*
[3]*Sea Fisheries Research Institute, Pvt Bag X2, Roggebaai 8012, South Africa*
[4]*Port Elizabeth Museum, Box 13147, Humewood 6013, South Africa*
[5]*Durban Natural History Museum, Box 4085, Durban 4000, South Africa*
[6]*East London Museum, Box 11021, Southernwood 5213, South Africa*

Received 31 August 1989, accepted 10 November 1989

SUMMARY

RYAN, P.G., AVERY, G., ROSE, B., ROSS, G.J.B., SINCLAIR, J.C. & VERNON, C.J. 1989. The Southern Ocean seabird irruption to South African waters during winter 1984. *Cormorant* 17: 41-55.

Large numbers of Southern Ocean seabirds seldom recorded off South Africa were stranded on South African beaches during late July and August 1984. The most abundant species were Kerguelen Petrels *Pterodroma brevirostris*, Blue Petrels *Halobaena caerulea* and Slenderbilled Prions *Pachyptila belcheri*. Strandings were related to the passage of a series of cold fronts, accompanied by strong, onshore winds, and were recorded over a wide area between Yzerfontein on the western Cape coast and St Lucia, Natal, on the east coast. Observations at sea off the western and southern Cape coasts during July showed that the irruption of Southern Ocean seabirds occurred at least two weeks before the strandings took place. The mortality of irrupted species was much greater than that of closely related species typically found off the South African coast in winter. The irruption followed a year after a major *El Nino*/Southern Oscillation event, and similar irruptions were recorded from Australia and New Zealand during the same period. This suggests that a macro-scale perturbation occurred in the Southern Ocean during 1984. The factors affecting seabird irruptions and strandings are discussed.

INTRODUCTION

Large numbers of seabirds (primarily procellariiforms) that breed at islands in the Southern Ocean winter off the coasts of southern Africa (Ryan & Rose 1989). In addition to these regular migrants are several species which are irregular vagrants to the sub-region from their typically more southerly wintering areas (Clancey 1980, Ryan & Rose 1989) and are referred to as "rare species" here. The known occurrence of these species in southern African waters derives primarily from stranded birds (e.g. Cooper 1979, Clancey 1980, Brooke & Avery 1981, Every *et al.* 1981). Numbers of these scarce seabirds are stranded irregularly during episodic events termed "wrecks", generally associated with stormy, onshore weather conditions (e.g. Cox 1976, Batchelor 1981, Powlesland 1983, Ryan & Avery 1987). However, little is known of the circumstances surrounding seabird wrecks and the conditions that result in displacement of individuals from their normal range (Bourne 1976). In some instances, wrecked vagrants apparently are brought to the region entrained in specific meteorological features (e.g. Cyclone Demoina, Sinclair *et al.* 1986), whereas in other instances it is not clear whether

meteorological events or changes in feeding conditions are responsible for seabird irruptions and strandings (e.g. Cooper 1979, Imber 1984). We examine this question for the macro-scale irruption of Southern Ocean seabirds to South African waters during the winter of 1984, combining at-sea observations with records of strandings.

METHODS

Birds at sea

PGR and BR observed seabirds in continental shelf waters (< 1 000 m deep) from the R.S. *Africana* during the period 4 to 27 July 1984 between the Orange River estuary (28 38S, 16 28E) and Cape Agulhas (34 50S, 20 00E). Counts were made of all birds attending 82 demersal trawls and during 27 hours of transect counts (see Ryan & Moloney 1988), as well as opportunistic observations made while steaming. All sightings of rare species were verified by the Southern African Ornithological Society's Rarities Committee (Sinclair *et al.* 1986). Prions *Pachyptila* spp. that passed close by the ship were carefully examined; only Broadbilled Prions *P. vittata* (*sensu* Cox 1980) were identified (all resembling Antarctic Prions *P. v. desolata*). The scientific names of all species observed are listed in Tables 1 and 2. Numbers of rare species have been recorded by BR during five other hake *Merluccius* spp. stock assessment cruises of the R.S. *Africana* in June-July 1985-1989, and these are compared with the July 1984 counts.

Additional observations of birds at sea during the 1984 irruption were made by R.W. Leslie aboard the R.S. *Chicha Touza* between 19 July and 10 August 1984 in continental shelf waters from Walvis Bay (23 00S, 14 30E) to the Orange River estuary. W. Suter made observations from a commercial trawler off the Cape Peninsula during 19 to 21 July 1984.

Stranded birds

The African Seabird Group conducts patrols for beached seabirds in Southern Africa (Avery 1985). Monthly surveys of beaches were conducted at a number of localities during 1984, and additional surveys were made during the period of the strandings. Beach surveys were split into four geographical regions: the southwestern Cape Province, the Algoa Bay region, the eastern Cape Province, and Natal (Fig. 1). Additional records of stranded birds were obtained from members of the public who delivered live birds or carcasses to wildlife rescue stations and museums. Numbers stranded during the wreck were compared with the results of previous and subsequent beach patrols to emphasize the unusual nature of the wreck.

Birds were identified on plumage and mensural characteristics. Prion taxonomy follows Cox (1980), and is based primarily on bill size and morphology; maximum culmen lengths and widths of most prions collected were measured. However, not all prions were identified, because carcasses either lacked heads or were collected by observers unfamiliar with the differences between taxa. Dead petrels reported by members of the public that were not examined by competent observers were treated as unidentified petrels. Numbers of stranded prions other than Slenderbilled Prions were not recorded in Natal.

Stranded birds were categorized as live birds, fresh carcasses (carcasses with no sign of terrestrial decomposers), or rotten carcasses (those with terrestrial decomposers). Fresh carcasses were assumed to have died within two days of collection (Cox 1976). Some live birds were weighed, and primary moult and an assessment of fat reserves were recorded for many specimens. The stomach contents of fresh carcasses were examined, but only the contents of the proventriculus were considered to be recent prey items.

RESULTS

Birds at sea

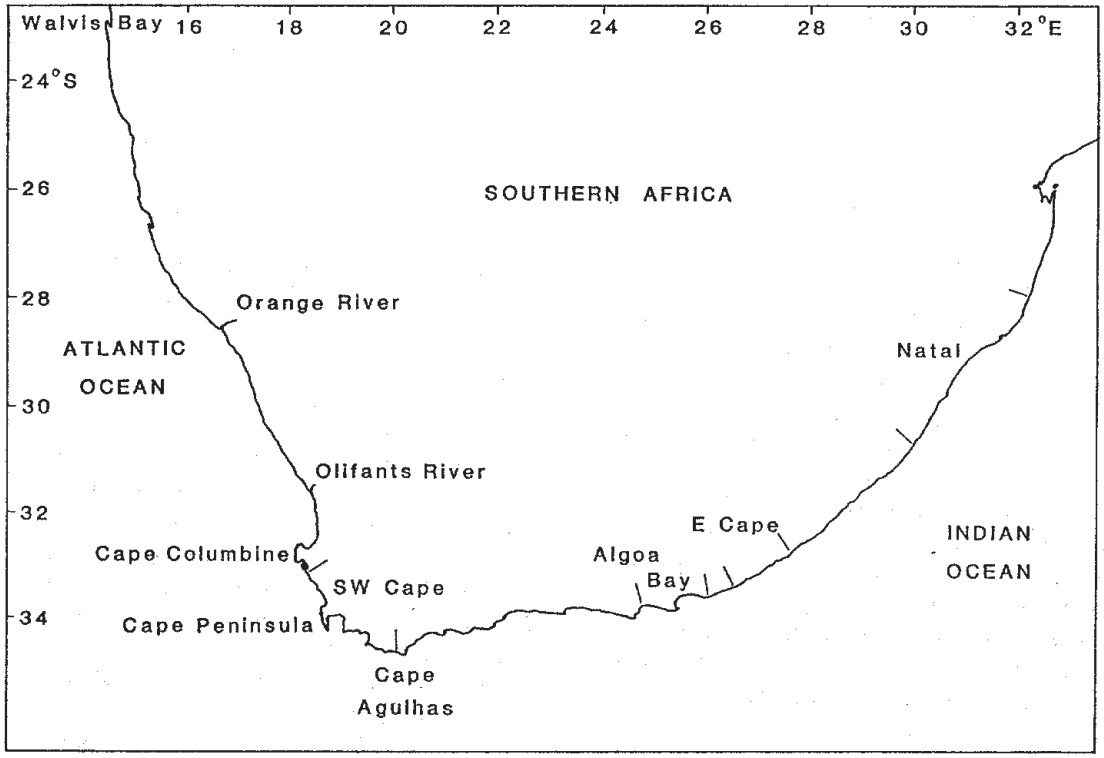

Figure 1

Southern Africa, showing the region where ship-based observations were made, and the four coastal regions where stranded birds were recovered

Two rare Southern Ocean breeding species, Kerguelen and Blue Petrels, were recorded during 1984 but were absent during five other winter hake stock assessment cruises (Table 1). Several other rare visitors from the Southern Ocean were recorded more frequently in 1984 than in other years: Greyheaded Albatrosses, white-phase Southern Giant Petrels (cf. Shaughnessy & Sinclair 1979, Cooper 1980), Antarctic Fulmars (cf. Cooper 1979) and South Polar Skuas (Table 1). All these species were observed by 6 July 1984, and most were seen throughout the cruise. Greyheaded Albatrosses, Antarctic Fulmars and Blue Petrels were seen throughout the study area, although most records were south of the Olifants River estuary. The most northerly records were at 29 11S, 16 26E (Blue Petrel) and 29 40S, 15 05E (Greyheaded Albatross and Antarctic Fulmar). Most Kerguelen Petrels were seen between the Cape Peninsula and Cape Agulhas, with only two single birds farther north (northernmost record at 31 12S, 16 30E). Both white-phase Southern Giant Petrels were seen off Cape Columbine, whereas South Polar Skuas were observed off the Cape Peninsula and farther north at 31 27S, 16 14E. With the exception of Kerguelen Petrels, all rare species seen scavenged fish discarded during trawling operations.

No rare seabird species were observed from the R.S. *Chicha Touza* off southern Namibia during July-August 1984. At least two Greyheaded Albatrosses, one or two Antarctic Fulmars, 10 Blue Petrels and one Grey Petrel were seen from a commercial trawler off the Cape Peninsula between 19 and 21 July 1984. A white-phase Southern Giant Petrel was seen off Port Elizabeth during July 1984 (Ross 1985) and one Kerguelen Petrel was seen south of the Umvoti River mouth, Natal, on 25 August 1984 (Sinclair *et al.* 1986). All the Greyheaded Albatrosses were immatures, with the exception of one adult off the Cape Peninsula.

Dispersion of stranded birds

A total of 398 Southern Ocean seabirds of 14 species was recovered from 284 km of South African beaches patrolled during July and August 1984 (Table 2). An additional 147 specimens (including two additional species) were reported by members of the public, where search area was not quantified, bringing the total number of stranded birds reported to 545 (Table 2).

Approximately 70% of stranded birds were species seldom recorded in southern African waters; the majority were Kerguelen Petrels (n=233, compared to 17 records prior to 1984; Brooke & Avery 1981, Cyrus 1982, Avery 1984) and Blue Petrels (n=76, compared to 26 records prior to 1984, Batchelor 1981, Every *et al.* 1981, Avery 1982, Cooper 1982, Brooke 1983). Between 1984 and 1989, there have been only three and four further records of the two species, respectively (African Seabird Group beach patrols, BR pers. obs.). Other rare species stranded during July-August 1984 included a Sooty Albatross (Jackson 1984, a rare visitor to southern African waters, Ryan & Rose 1989), an Antarctic Petrel (second record for southern Africa, Ryan & Rose 1989) and 70 Slenderbilled Prions (small numbers are stranded in most years, occasionally in larger wrecks, e.g. Avery 1984).

Figure 2 illustrates the culmen dimensions of stranded prions and the taxa to which they were ascribed. The identity of the prion with a culmen width of 11,5 mm (treated here as an Antarctic Prion) is uncertain; Falla (1940) suggested that widths less than 12 mm were Slenderbilled Prions.

Birds were recovered from Yzerfontein on the Cape west coast to St Lucia in northern Natal. No rare species were recovered from Skeleton Coast beaches in northern Namibia during patrols covering 1 161 km in 1984 (African Seabird Group unpubl. data). The density of stranded seabirds was greatest in the southwestern Cape Province and lowest in the Algoa Bay region (Table 3). The low density of birds on Algoa Bay beaches was related to the large proportion of patrols in sheltered bays characterized by few stranded birds (Ross 1985) and several repeat patrols. Densities of stranded Blue Petrels and prions decreased from west to

TABLE 1

NUMBERS OF RARE AND UNCOMMON SOUTHERN OCEAN BREEDING SEABIRDS SEEN DURING THE JULY 1984 HAKE RECRUITMENT CRUISE OF THE R.S. *AFRICANA* COMPARED WITH SIMILAR CRUISES DURING 1985-1989

Species	1984	Other years		
		Mean	SD	Range
Royal Albatross *Diomedea epomophora*	2	1,6	1,9	0-5
Wandering Albatross *D. exulans*	14	11,0	2,6	7-14
Greyheaded Albatross *D. chrysostoma*	15	4,4	2,1	3-8
White-phase Southern Giant Petrel *Macronectes giganteus*	2	0,6	0,5	0-1
Antarctic Fulmar *Fulmarus glacialoides*	6	1,4	2,1	0-5
Kerguelen Petrel *Pterodroma brevirostris*	25	0,0	0,0	0
Softplumaged Petrel *P. mollis*	182	Not counted*		
Greatwinged Petrel *P. macroptera*	9	3,8	5,7	1-14
Blue Petrel *Halobaena caerulea*	22	0,0	0,0	0
Grey Petrel *Procellaria cinerea*	1	0,2	0,4	0-1
Little Shearwater *Puffinus assimilis*	2	1,0	1,0	0-2
South Polar Skua *Catharacta maccormicki*	2	0,2	0,4	0-1

* Exact numbers of Softplumaged Petrels were not recorded in other years

TABLE 2

RECORDS OF SOUTHERN OCEAN SEABIRDS STRANDED ON THE SOUTH AFRICAN COAST DURING JULY-AUGUST 1984. NUMBERS IN PARENTHESES ARE ADDITIONAL BIRDS NOT FOUND ON MEASURED BEACH PATROLS

Species	Region (see text)									
	SW Cape		Algoa Bay		E Cape		Natal		Total	
Shorelength patrolled (km)	90		111		60		24		284	
Shy Albatross *Diomedea cauta*			1						1	(1)
Unidentified mollymawks *Diomedea* spp.	2		1						3	
Sooty Albatross *Phoebetria fusca*		(1)								(1)
Antarctic Petrel *Thalassoica antarctica*	1								1	
Pintado Petrel *Daption capense*	1				1				2	
Softplumaged Petrel *Pterodroma mollis*	4		1		4	(2)		(3)	9	(5)
Greatwinged Petrel *P. macroptera*					1				1	
Kerguelen Petrel *P. brevirostris*	14	(1)	24	(10)	50	(8)	26	(100)	114	(119)
Blue Petrel *Halobaena caerulea*	40	(1)	13		15	(1)	1	(5)	69	(7)
Broadbilled Prion *Pachyptila v. vittata*			1						1	
Salvin's Prion *P. v. salvini*	1		1						2	
Antarctic Prion *P. v. desolata*	63		14		5		*	*	82	
Slenderbilled Prion *P. belcheri*	34	(4)	23		3		1	(5)	61	(9)
Unidentified prions *Pachyptila* spp.	4		17	(1)	17	(3)	*	*	38	(4)
Whitechinned Petrel *Procellaria aequinoctialis*	1		1						2	
Fleshfooted Shearwater *Puffinus carneipes*								(1)		(1)
Sooty Shearwater *P. griseus*	2								2	
Wilson's Storm Petrel *Oceanites oceanicus*	1								1	
Unidentified petrels					9				9	
Subantarctic Skua *Catharacta antarctica*	1								1	
Antarctic Tern *Sterna vittata*			1						1	
Total number of birds	169	(7)	97	(11)	105	(14)	28	(114)	398	(147)

* No data were available for prions other than Slenderbilled from Natal

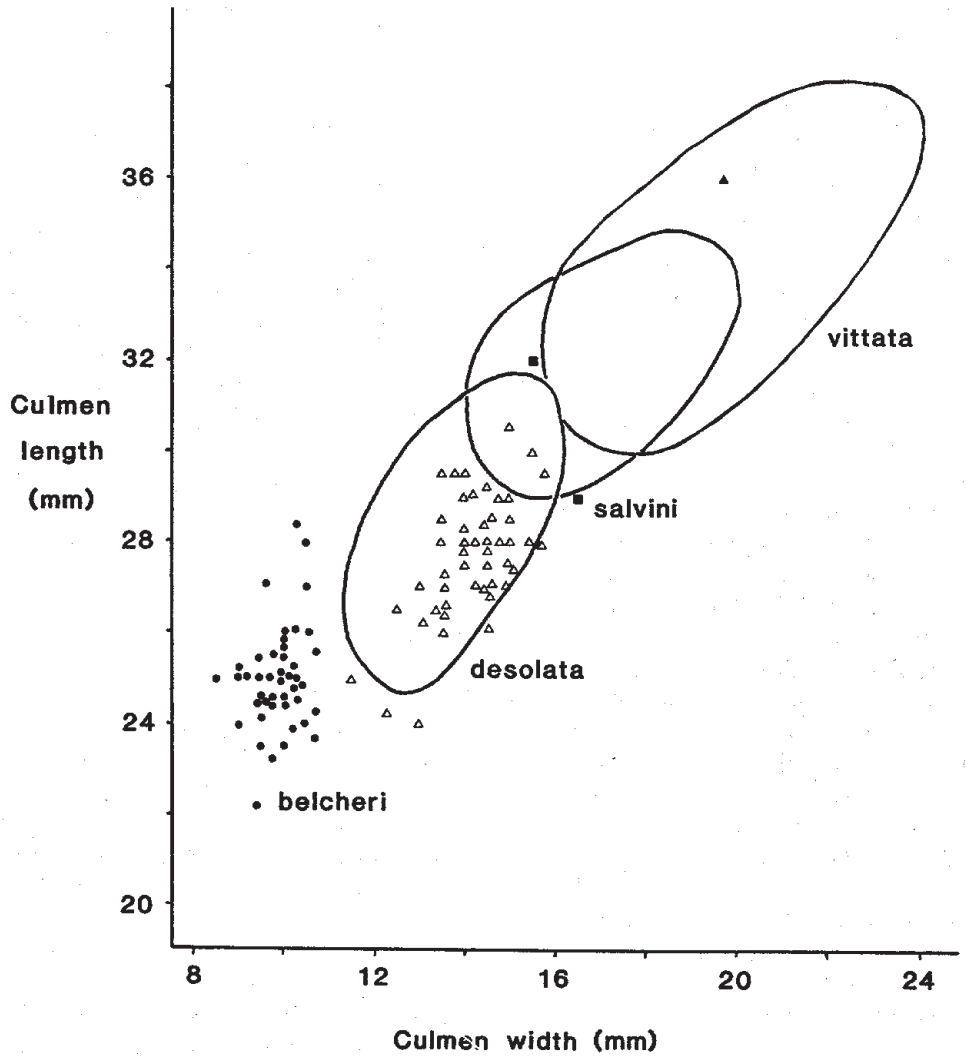

Figure 2

Culmen length-width biplot for prions *Pachyptila* spp. collected during the July-August 1984 seabird wreck. Ovals represent the typical ranges of the *vittata* complex (after Cox 1980)

east, whereas the density of Kerguelen Petrels increased from west to east (Table 3).

Most stranded birds were found between 29 July and 3 August 1984, although a few birds were stranded earlier in July and birds continued to come ashore until the end of August. The wreck was most temporally diffuse in the southwestern Cape Province, where fresh carcasses were found from 20 July until 25 August, with rotten carcasses being found as late as 1 September.

In the Algoa Bay region, prions were recovered ashore on 13, 16 and 23 July, but Kerguelen, Blue and Softplumaged Petrels were only recovered from 29 July onwards (although two Blue Petrels were found on the routine Cape Recife beach survey in June 1984). No fresh carcasses were found after 2 August, but at least four Kerguelen Petrels and three prions came ashore after 3 August. In the eastern Cape Province, no beach surveys were conducted until the first live birds came ashore on 29 July. Again no fresh carcasses were found after 4 August, but repeat surveys on 8 and 10 August found nine birds that came ashore after 3 August (five Kerguelen Petrels, two Blue Petrels and two prions). In Natal, Slenderbilled Prions were found on 16 and 18 July, Blue Petrels on 22 and 25 July, and the Fleshfooted Shearwater on 25 July. However, all Kerguelen and Softplumaged Petrels were collected between 29 July and 3 August, as were additional Blue Petrels and Slenderbilled Prions. No birds were found after 3 August.

Condition and diet of stranded birds

Most stranded birds had very small fat deposits. The mass of 11 fresh Kerguelen Petrels ranged between 170 and 266 g (mean $\pm$ SD 204,3 $\pm$ 29,9 g). The immature female Sooty Albatross found on a building in Rosebank, Cape Town, weighed 1 700 g (Jackson 1984). These values are considerably lower than those recorded for birds at breeding islands in the Southern Ocean; Kerguelen Petrels range between 220 and 451 g (mean 314,3 g; n=213; FitzPatrick Institute unpubl. data), and Sooty Albatrosses range between 2 100 and 3 430 g (mean 2 512 g; n=176; Berruti 1977).

None of the Kerguelen Petrels (n=7), Blue Petrels (n=16) or Slenderbilled Prions (n=20) examined was moulting primary feathers; all had fresh remiges. Three of four Softplumaged Petrels were growing their outer primaries (inner seven new). Two Antarctic Prions of 22 examined were moulting primaries; both were replacing their inner three to five primaries. More than half of the birds stranded in the southwestern Cape Province lacked prey items in their proventriculi (52% empty except for plastic particles, n=66). Other birds contained a variety of prey types, including apparently unusual items such as fragments of prions (1 Kerguelen and 1 Blue Petrel), insects (2 Blue Petrels, 1 Antarctic and 1 Slenderbilled Prion), and seaweed (1 Antarctic Prion).

Estimating differential mortality

Comparison of the abundances of species at sea and stranded during the wreck allows an estimate of the mortality of rare species relative to that of closely related taxa which are regular winter visitors to South African waters. Assuming that the numbers of birds seen at sea off the south and west coasts during July were typical of the period of the wreck, the mortality of Kerguelen and Blue Petrels was proportionately much greater than that of Softplumaged Petrels and prions (Table 4). Similarly, the mortality of Slenderbilled Prions probably was disproportionately large, because this species was not recorded at sea during July, despite considerable attention being given to prion identification. PGR has subsequently seen many hundreds of Slenderbilled Prions at sea off southern Africa.

DISCUSSION

Factors affecting the wreck

Four factors may be responsible for seabird wrecks: pollution, disease and parasites, food scarcity, and

TABLE 3

MEAN DENSITIES (NO. 100 KM^{-1} BEACH) OF SOUTHERN OCEAN SEABIRDS STRANDED IN LARGE NUMBERS ON THE SOUTH AFRICAN COAST IN JULY-AUGUST 1984. ND = NO DATA

Species	Region (see text)				
	SW Cape 90 km	Algoa Bay 111 km	E Cape 60 km	Natal 24 km	Mean 284 km
Softplumaged Petrel	4,4	0,9	6,8		3,2
Kerguelen Petrel	15,6	21,7	84,0	108,3	41,1
Blue Petrel	70,0	11,8 *	25,2 *	4,2	23,9
Antarctic Prion	70,0	12,7 *	8,4 *	ND	28,9 +
Slenderbilled Prion	37,8	20,8 *	5,0 *	4,2	21,5
All prions	113,1	50,6	42,0	ND	64,8 +
All birds	187,8	87,7	176,5	116,7	140,1

* Underestimates due to large numbers of unidentified prions
\+ Excludes Natal, where no prions other than Slenderbilled recorded

TABLE 4

THE RELATIVE ABUNDANCE OF IRRUPTIVE SOUTHERN OCEAN SPECIES AT SEA AND AMONG STRANDED BIRDS DURING JULY 1984 COMPARED WITH CLOSELY RELATED SPECIES THAT REGULARLY WINTER OFF SOUTH AFRICA. THE MORTALITY FACTOR (B/A) IS THE NUMBER OF TIMES MORTALITY OF IRRUPTED SPECIES EXCEEDS THAT OF REGULAR WINTER VISITORS

Species pairs	Ratios		B/A
	At sea (A)	Stranded (B)	
Kerguelen: Softplumaged petrels	1 : 7,3	3,8 : 1	27,3
Blue: Softplumaged petrels	1 : 8,3	10,3 : 1	84,8
Blue Petrel: prions	< 1 : 100	1 : 2,6	*c.* 40

storm damage (Bourne 1976, Cox 1976). These factors may act in concert to cause strandings, and their effects may be exacerbated during stressful periods such as moult or migration. Pollution is unlikely to have been an important factor during the 1984 wreck, because only one of the birds stranded was oiled (and only slightly), and their populations are characterized by small pesticide and heavy metal loads (Gardiner *et al.* 1985, FitzPatrick Institute unpubl. data). Little is known of the diseases and parasites of Southern Ocean seabirds, but stranded birds did not have unusually large macro-parasite loads, and live birds recovered after being given adequate food (SANCCOB unpubl. data). Also, the wreck involved a number of species, thus contamination on the breeding grounds is unlikely (*cf* Bourne 1976).

Storm damage was directly responsible for many strandings; birds were drowned or were forced ashore and collided with buildings or were killed by cars and pets. However, healthy birds should be able to withstand periods of adverse weather conditions and avoid being trapped on lee-shores (Cox 1976). With the exception of Softplumaged Petrels, few birds were moulting. Thus, starvation probably was the ultimate cause of the strandings; stranded birds had very small fat reserves and their masses were well below average.

All populations contain weak individuals that are likely to die during adverse conditions. Most wrecks occur either when weather conditions are exceptionally bad (in terms of severity, duration, or both) or when a large proportion of the local population is weakened (by disease, parasites, local prey collapses, etc.). Between 28 July and 3 August 1984, the main period of the strandings, a series of frontal systems passed eastwards over the south and east coasts of South Africa, followed by a large high pressure cell south of the continent (Scholtz 1984, Vallance 1984). This resulted in strong onshore winds over the south and east coasts which were the proximal cause of the strandings. However, similar meteorological conditions occur frequently throughout the winter; presumably some other factor was responsible for the exceptional numbers of rare seabirds wrecked. The greater mortality of irrupted species (Kerguelen and Blue Petrels, and Slenderbilled Prions) compared with that of similar species typically found off the southern African coast in winter suggests that irrupted birds were in poor physical condition prior to the storms that caused the strandings.

Comparison with other regions

The Southern Ocean seabird irruption during the winter of 1984 was not restricted to South Africa. During August 1984, large numbers of vagrant seabirds from the Southern Ocean also were wrecked in Australia (Carter 1984) and New Zealand (Powlesland 1986). Again, the most abundant species stranded in these regions were Kerguelen and Blue Petrels. The strandings occurred slightly later than in South Africa, starting on 6 August in Western Australia, 11 August in Victoria (Carter 1984), and 5 August in New Zealand (Millar & Millar 1984). It is possible that similar wrecks also occurred in South America; two Blue Petrels were found alive in southern Brazil during July 1984, the first records for Brazil (Teixeira *et al.* 1985).

The 1984 irruption was the first major wreck of Kerguelen and Blue Petrels recorded from southern Africa, where regular beach patrols have been conducted since 1977 (Cooper 1978, Brooke & Avery 1981, Every *et al.* 1981, Avery 1982, 1984, 1985). Published results of beach patrols for New Zealand are available from 1970 to 1986 (see Fig. 3). A wreck of Kerguelen and Blue Petrels occurred in New Zealand in 1981, with lesser events in 1975 and 1977 (Fig. 3). The 1977 and 1981 events were not detected in southern Africa (Cooper 1978, Avery 1982, *cf* Bourne 1982). However, the 1978 Antarctic Fulmar wreck in South Africa (Cooper 1979) coincided with a large Antarctic Fulmar wreck in New Zealand (Veitch 1982).

There is a highly significant correlation between the mean annual densities of Kerguelen and Blue

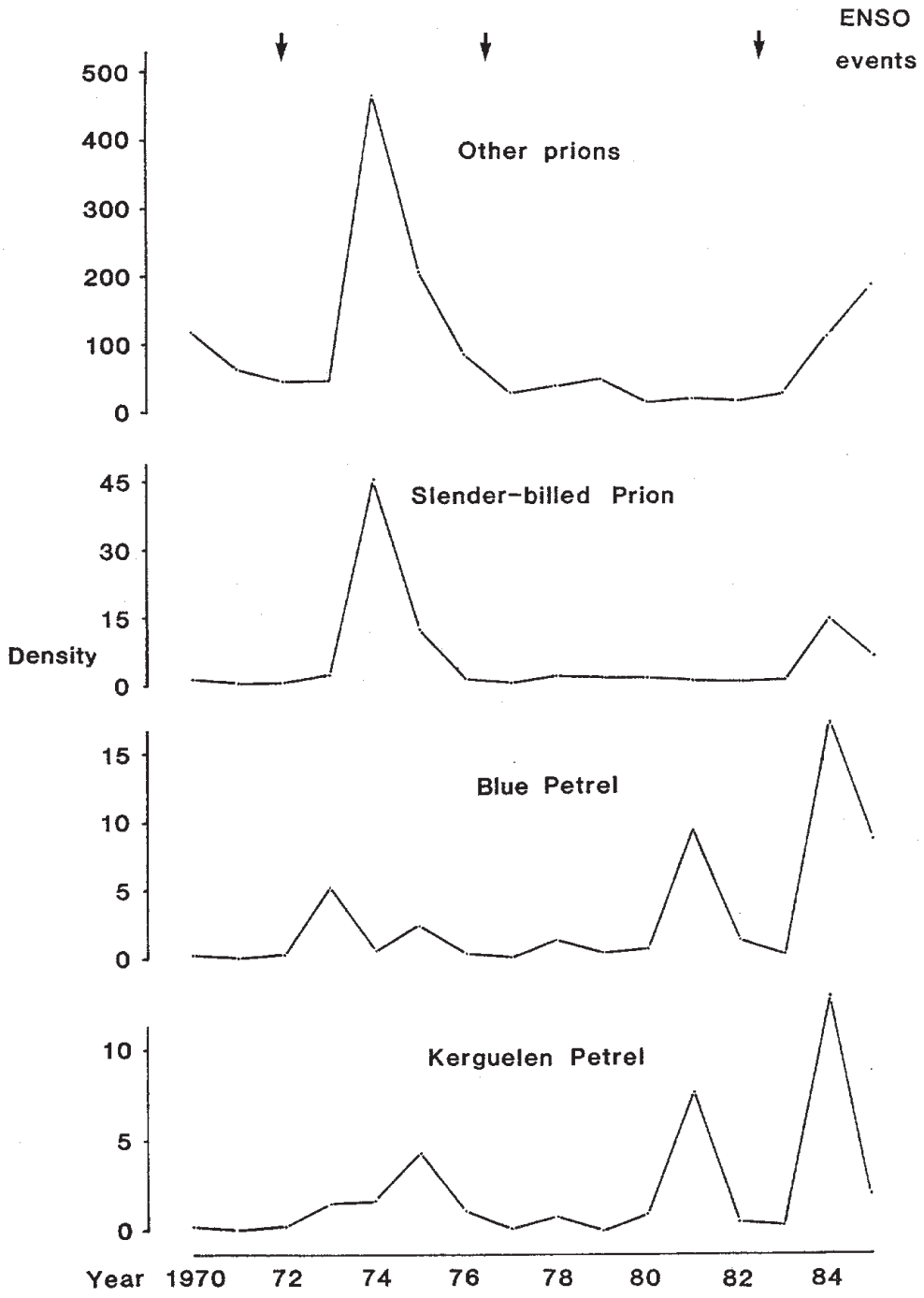

Figure 3
Mean annual densities of selected seabird species (numbers per 100 km of beach patrolled) stranded on New Zealand beaches between 1970 and 1984, and major ENSO events (arrowed) for the same period (from Quinn *et al.* 1978, Duffy in press). Beached bird data are from Veitch (1975-1982) and Powlesland (1983-1987)

Petrels stranded on New Zealand beaches (Fig. 3; $r=0{,}91$; $df=14$; $P<0{,}001$). By contrast, the density of Slenderbilled Prions is correlated with the density of all other prions ($r=0{,}90$; $df=14$; $P<0{,}001$). There are no significant correlations between the densities of stranded Antarctic Fulmars and Kerguelen Petrels, Blue Petrels, Slenderbilled Prions or all prions combined. Neither are there any significant correlations between the densities of Slenderbilled Prions or all prions combined and Kerguelen or Blue Petrels.

These correlations suggest that wintering Kerguelen and Blue Petrels are affected by similar meteorological and/or biological factors which result in periodic irruptions and wrecks on coasts north of their normal ranges. The factors that cause irruptions of Kerguelen and Blue Petrels are either different from those that affect other Southern Ocean species such as Antarctic Fulmars, or affect different geographical regions; Antarctic Fulmars normally occur farther south than do Kerguelen and Blue Petrels (Watson 1975).

Causes of the 1984 irruption

Imber (1984) discussed the factors influencing the eastward movement of Kerguelen Petrels wrecked in New Zealand in 1981. He concluded that it was uncertain whether the stranded birds moved into New Zealand waters in search of food, or whether they drifted east with the prevailing winds in an already weakened state and were stranded when they encountered a lee-shore. The observations of birds at sea during July 1984 show that Kerguelen and Blue Petrels were present in South African coastal waters at least two weeks before the first birds came ashore. Similarly, observations off New Zealand during July 1984 showed that Blue Petrels and other Southern Ocean vagrants (but not Kerguelen Petrels) were present offshore three weeks prior to the strandings (Jenkins & Greenwood 1984). These observations indicate that the irruption of Southern Ocean seabirds occurred some time before the weather features which were responsible for the strandings. Although irrupted birds may be in fairly poor condition, they are not so weak as to be stranded immediately on encountering a lee-shore.

What was responsible for the macro-scale irruption of certain Southern Ocean seabirds in 1984? Two mechanisms provide *post hoc* explanations for the northward movement from normal wintering ranges: adverse weather conditions and/or reductions in prey availability. Virtually nothing is known about the non-breeding diets of Southern Ocean seabirds (Croxall 1984), and even less is known about the population dynamics of potential prey species. It is not possible to speculate whether changes in prey availability caused the irruption.

There is little to suggest that abnormal weather conditions caused the irruption; no major anomalies in air pressure, wind speeds, sea-surface temperature or outgoing longwave radiation were detected in the Southern Ocean during the austral autumn and winter of 1984 (Anon. 1984a,b,c,d,e). The storm that lashed the western Cape Province on 16 May 1984 was unusually severe, but was a local event related to the westward extension of the Agulhas Current (Jury *et al.* 1986). Also, if anomalous weather conditions were primarily responsible for the irruption, a more catholic selection of Southern Ocean seabirds might have been expected to be involved.

Duffy (in press) notes that the density of stranded seabirds on New Zealand beaches was greater in years following *El Nino*/Southern Oscillation (ENSO) events. He speculates that this increase is related to increased circulation of the Southern Ocean after the stabilizing high pressure systems, displaced to the south during ENSO events, are removed. The 1984 wrecks followed a year after the major 1982/83 ENSO event, but there is little correlation between recent ENSO events (1972, 1976/77 and 1982/83) and Kerguelen and Blue Petrel wrecks in New Zealand (Fig. 3). A possible influx of Kerguelen Petrels occurred off central Namibia in November 1964 (Becker 1976), the year preceding an ENSO event (Quinn *et al.* 1978).

Whatever the causes of the 1984 irruption, it is likely that the subsequent strandings resulted at least in part from an inability to cope with conditions outside the usual range. This is supported by the very high mortality of some irrupted species compared with similar species that typically winter off southern Africa. However, not all rare species were stranded; Greyheaded Albatrosses and Antarctic Fulmars were more abundant at sea off South Africa in July 1984 than in the five subsequent years, but none was found stranded. This may be related to the use of readily available trawler discards by these species in South African waters (see Ryan & Moloney 1988, Ryan & Rose 1989).

To conclude, the ultimate causes of Southern Ocean seabird irruptions and wrecks are unknown, and only the collection of long time-series may allow elucidation of this problem. However, it appears that some seabird wrecks involving vagrant species result from physical and/or biological perturbations within the normal ranges of the species involved, and far from the region where strandings occur. Such wrecks involve two discrete sets of causative factors: 1) the perturbations which cause irruptions outside the species' usual range (and may weaken individuals), and 2) the inability to adapt to conditions outside the normal range leaves many birds susceptible to stranding during storms associated with onshore winds.

ACKNOWLEDGEMENTS

We thank R.W. Leslie and W. Suter for their observations. J. Augustyn assisted with observations aboard the R.S. *Africana*. The following supplied information about stranded birds: the African Seabird Group, S. Baron, G. Bennett, R. Black, P. Chadwick, J. Colclough, D.P. Cyrus, B. Every, R.G. Jeffery, G.D. La Cock, I. Mellet (Centre for the Rehabilitation of Wildlife), H. McLean, S. McLean, the Natal Parks Board, B. Purden, J. Spearpoint, M. van Heerden and P. White. We are grateful for the cooperation and support of the South African Sea Fisheries Research Institute and the officers and crew of the R.S. *Africana*. Financial support was received from the South African Museum, the Benguela Ecology Programme of the South African National Committee for Oceanographic Research, and the South African Scientific Committee for Antarctic Research.

REFERENCES

ANON. 1984a. Climate diagnostics bulletin, April 1984. Washington: NOAA/National Weather Service. 84(5).

ANON. 1984b. Climate diagnostics bulletin, May 1984. Washington: NOAA/National Weather Service. 84(6).

ANON. 1984c. Climate diagnostics bulletin, June 1984. Washington: NOAA/National Weather Service. 84(7).

ANON. 1984d. Climate diagnostics bulletin, July 1984. Washington: NOAA/National Weather Service. 84(8).

ANON. 1984e. Climate diagnostics bulletin, August 1984. Washington: NOAA/National Weather Service. 84(9).

AVERY, G. 1982. Results of beach patrols conducted in southern Africa in 1981. *Cormorant* 10: 87-96.

AVERY, G. 1984. Results of patrols for beached seabirds conducted in southern Africa in 1982. *Cormorant* 12: 29-43.

AVERY, G. 1985. Results of patrols for beached seabirds conducted in southern Africa in 1983. *Cormorant* 13: 3-15.

BATCHELOR, A.L. 1981. The August 1981 seabird (*Pachyptila* and *Halobaena* spp.) wreck off Port Elizabeth, South Africa. *Cormorant* 9: 105-112.

BECKER, P. 1976. Albatrosse und Sturmvogel an der Kuste Sudwestafrikas. *Beitr. Naturk. Niedersachsens* 29: 7-10.

BERRUTI, A. 1977. Co-existence in the *Phoebetria* albatrosses at Marion Island. M.Sc thesis, University of Cape Town.

BOURNE, W.R.P. 1976. The mass mortality of Common Murres in the Irish Sea in 1969. *J. Wildl. Manage.* 40: 789-792.

BOURNE, W.R.P. 1982. The wrecks of prions, Blue and Kerguelen Petrels in the Southern Ocean in August-September 1981. *Sea Swallow* 31: 39-42.

BROOKE, R.K. 1983. New data on rarely recorded seabirds in southern Africa. *Cormorant* 11: 67.

BROOKE, R.K. & AVERY, G. 1981. Southern African records of the Kerguelen Petrel *Pterodroma brevirostris*. *Cormorant* 9: 27-29.

CARTER, M. 1984. A petrel strike. *RAOU Newsletter* 61: 1.

CLANCEY, P.A. (Ed.) 1980. S.A.O.S. Checklist of southern African birds. Pretoria: Southern African Ornithological Society.

COOPER, J. 1978. Results of beach patrols conducted in 1977. *Cormorant* 4: 4-9.

COOPER, J. 1979. Seasonal and spatial distribution of the Antarctic Fulmar in South African waters. *Cormorant* 7: 15-19.

COOPER, J. 1980. New data on rarely recorded seabirds in southern Africa: Southern Giant Petrel *Macronectes giganteus*. *Cormorant* 8: 102.

COOPER, J. 1982. New data on rarely recorded seabirds in southern Africa: Blue Petrel *Halobaena caerulea*. *Cormorant* 10: 55.

COX, J.B. 1976. A review of the Procellariiformes occurring in South Australian waters. *S. Aust. Ornith.* 27: 26-82.

COX, J.B. 1980. Some remarks on the breeding distribution and taxonomy of the prions (Procellariidae: *Pachyptila*). *Rec. S. Aust. Mus.* 18: 91-121.

CROXALL, J.P. 1984. Seabirds. In: LAWS, R.M. (Ed.). Antarctic ecology, Vol 2. London: Academic Press. pp. 533-618.

CYRUS, D.P. 1982. New data on rarely recorded seabirds in southern Africa: Kerguelen Petrel. *Cormorant* 10: 126.

DUFFY, D.C. in press. Seabirds and the 1982-84 *El Nino*/Southern Oscillation. In: GLYNN, P.W. (Ed.). Global ecological consequences of the 1982/83 *El Nino*/Southern Oscillation. Amsterdam: Elsevier.

EVERY, B., HOSTEN, L. & BROOKE, R.K. 1981. The Blue Petrel *Halobaena caerulea* in South Africa. *Cormorant* 9: 19-22.

FALLA, R.A. 1940. The genus *Pachyptila* Illiger. *Emu* 40: 218-236.

GARDNER, B.D., SIEGFRIED, W.R. & CONNELL, A.D. 1985. Chlorinated hydrocarbons in seabird eggs from the southern Atlantic and Indian Oceans. In: SIEGFRIED, W.R., CONDY, P.R. & LAWS, R.M. (Eds.). Antarctic nutrient cycles and food webs. Berlin: Springer-Verlag. pp. 647-651.

IMBER, M.J. 1984. The age of Kerguelen Petrels found in New Zealand. *Notornis* 31: 89-91.

JACKSON, S. 1984. Sooty Albatross. *Promerops* 166: 12.

JENKINS, J.A.F. & GREENWOOD, E. 1984. Southern seabirds in New Zealand coastal waters, July 1984. *Notornis* 31: 325-330.

JURY, M.R., SHILLINGTON, F.A., PRESTIDGE, G. & MAXWELL, C.D. 1986. Meteorological and oceanographic aspects of a winter storm over the southwestern Cape Province, South Africa. *S. Afr. J. Sci.* 82: 315-319.

MILLAR, P. & MILLAR, K. 1984. Seabird wreck on Northland west coast. *OSNZ News* 32(3): 4-5.

POWLESLAND, R.G. 1983. Seabirds found dead on New Zealand beaches in 1981. *Notornis* 30: 125-135.

POWLESLAND, R.G. 1984. Seabirds found dead on New Zealand beaches in 1982 and a review of penguin recoveries since 1960. *Notornis* 31: 155-177.

POWLESLAND, R.G. 1985. Seabirds found dead on New Zealand beaches in 1983 and a review of albatross recoveries since 1960. *Notornis* 32: 23-41.

POWLESLAND, R.G. 1986. Seabirds found dead on New Zealand beaches in 1984 and a review of fulmar recoveries since 1960. *Notornis* 33: 171-184.

POWLESLAND, R.G. 1987. Seabirds found dead on New Zealand beaches in 1985, and a review of *Pterodroma* species recoveries since 1960. *Notornis* 34: 237-252.

QUINN, W.H., ZOPF, D.O., SHORT, K.S. & KUO YANG, R.T.W. 1978. Historical trends and statistics of the Southern Oscillation, El Nino, and Indonesian droughts. *Fish Bull. U. S.* 76: 663-678.

ROSS, G.J.B. 1985. The 1984 seabird wreck: 2) Algoa Bay region. *Bee-eater* 36: 4-5.

RYAN, P.G. & AVERY, G. 1987. Wreck of juvenile Blackbrowed Albatrosses on the west coast of South Africa during storm weather. *Ostrich* 58: 139-140.

RYAN, P.G. & MOLONEY, C.L. 1988. The effect of trawling on bird and seal distributions in the southern Benguela region. *Mar. Ecol. Prog. Ser.* 45: 1-11.

RYAN, P.G. & ROSE, B. 1989. Migrant seabirds. In: PAYNE, A.I.L. & CRAWFORD, R.J.M. (Eds.). Oceans of life off southern Africa. Cape Town: Vlaeberg. pp. 274-287.

SCHOLTZ, E.P. 1984. Weather for the month: August 1984. *S. Afr. Weather Bureau Newsletter* 425: 139-145.

SHAUGHNESSY, P.D. & SINCLAIR, J.C. 1979. White phase Southern Giant Petrels in southern Africa. *Cormorant* 7: 11-14.

SINCLAIR, J.C. & THE SAOS RARITIES COMMITTEE. 1986. SAOS Rarities Committee's annual report. *Bokmakierie* 38: 20-25.

TEIXEIRA, D.M., NACINOVIC, J.B. & NOVELLI, R. 1985. Notes on some Brazilian seabirds. *Bull. Br. Orn. Club* 105: 49-51.

VALLANCE, G.R. 1984. Weer vir die maand. *S. Afr. Weather Bureau Newsletter* 424: 124-129.

VEITCH, C.R. 1975. Seabirds found dead in New Zealand in 1973. *Notornis* 22: 231-240.

VEITCH, C.R. 1976. Seabirds found dead in New Zealand in 1974. *Notornis* 23: 168-178.

VEITCH, C.R. 1977. Seabirds found dead in New Zealand in 1975. *Notornis* 24: 41-49.

VEITCH, C.R. 1978. Seabirds found dead in New Zealand in 1976. *Notornis* 25: 141-148.

VEITCH, C.R. 1979. Seabirds found dead in New Zealand in 1977. *Notornis* 26: 361-368.

VEITCH, C.R. 1980a. Seabirds found dead in New Zealand in 1978. *Notornis* 27: 115-124.

VEITCH, C.R. 1980b. Seabirds found dead in New Zealand in 1970, 1971 and 1972. *Notornis* 27: 369-385.

VEITCH, C.R. 1981. Seabirds found dead in New Zealand in 1979. *Notornis* 28: 41-47.

VEITCH, C.R. 1982. Seabirds found dead in New Zealand in 1980. *Notornis* 29: 41-47.

WATSON, G.E. 1975. Birds of the Antarctic and Sub-Antarctic. Washington: American Geophysical Union.