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Annual and monthly patterns in recoveries of beach-wrecked Procellariiformes from Southland, New Zealand 1990-2000

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Abstract Recoveries of dead Procellariiformes made during 434 patrols along beaches in Southland, New Zealand, 1990 – 2000, were analysed to identify long-term trends and monthly patterns in recovery rates. Thirty-one species were recovered. Of 16 species for which >10 specimens were retrieved, there was evidence of between-year variation in recovery rates for six, and between-month variation for ten. Trends in annual recovery rates are suggestive of population changes. Trends in monthly recovery rates for most species were similar to those observed on a national scale, and can be explained by known seasonal movements of the species.

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INTRODUCTION

The New Zealand Beach Patrol Scheme was established by the Ornithological Society of New Zealand in October 1951. The scheme provides a formalised way of recording and collating seabirds found dead on the New Zealand coastline, to determine variation in annual and monthly patterns of mortality. A detailed account of the aims and methodology of the scheme is given by Powlesland & Imber (1988). For purposes of comparing records from different areas of New Zealand the coastline has been divided into 15 beach patrol districts. In this paper I examine Procellariiform recoveries during 1990 to 2000 from the southernmost district, Southland, by evaluating annual trends in recovery rates over the 11-year period and establishing the presence of monthly patterns.

The Southland beach patrol district incorporates about 680 km of mainland coastline, from Puysegur Point in the west to Nugget Point in the east, as well as the 700 km coastline of Stewart Island (Hare *et al*. 1990), and other smaller islands in Foveaux Strait (Powlesland & Imber 1988) (Fig.1). The most commonly patrolled sector of coastline, from Te Waewae Bay to Bluff, is characterised by wide, gently sloping, south-west facing sandy shores separated by rocky headlands. The movement of surface seawater along the coast is controlled by the Southland current, a branch of the Tasman current that originates south-west of Stewart Island (Chiswell 1996), flows eastwards through Foveaux Strait (Heath 1972) and then north-eastwards along the South Island's east coast. The current is driven by prevailing westerly winds (Ministry of Transport 1982).

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METHODS

This paper examines data from 434 beach patrols carried out in Southland from 1 January 1990 to 31 December 2000. Patrols were done in every month during the entire period except January, June and July 1990, March, April, May and June 1991, July and August 1992, January 1994, and January 1996. In most months more than two patrols were completed; overall, most patrols were completed during October (57), and the least number in January (22). Most patrols were carried out on Oreti Beach (Table 1), due to its proximity to Invercargill and the regular occurrence of beach-wrecked seabirds there.

Records of Procellariiform recoveries were extracted from beach patrol cards and entered into a computer spreadsheet. Mean recovery rates (birds per kilometre of beach covered) for each species in each month of each year were calculated. The mean recovery rates were adjusted to a log scale by using:

$$\text{Log}_{10}\text{ (mean recovery rate + 0.0001)}$$

0.0001 was added to the mean recovery rate so that a numeric value was obtained where the recovery rate was zero; 0.0001 was chosen as an arbitrary value less than 10% of the lowest mean recovery rate above zero.

To analyse for annual and calendar month trends in recovery rates of common species (more than 10 individuals per species), Minitab v.12.1 was used to fit a general linear model to the data, with year and month as factors. This method was chosen as a robust way of dealing with the

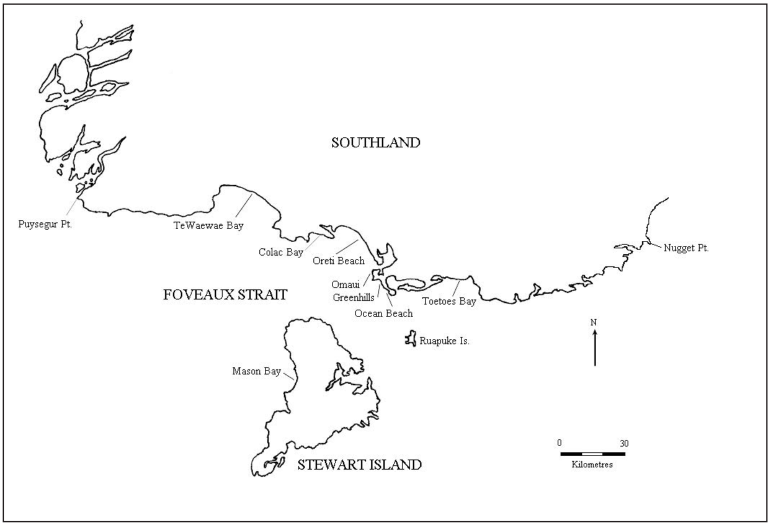


Figure 1 Southland coastline showing beaches where patrols were carried out, 1990-2000.

Table 1 Number of beach patrols and length of beaches (km) covered on various Southland, New Zealand beaches 1990-2000.

Beach	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
Oreti	27(192)	24(151)	25(147)	32(182)	24(133)	42(229)	46(231)	41(231)	45(216.5)	60(247.5)	47(210.5)	413(2171)
Colac			1(2)									1(2)
Te Waewae				1(4)					1(2)			2(6)
Mason Bay							1(16)		2(30)	2(28)		5(74)
Ocean Bch									1(1)	1(1)		2(2)
Omaui								2(6)	4(7)		6(13)	
Toetoes Bay								2(10)	1(4)		3(14)	
Ruapuke										2(6)		2(6)
	27(192)	24(151)	26(149)	33(186)	24(133)	42(229)	47(247)	41(231.5)	53(265.5)	70(293.5)	47(210.5)	434(2288)

Table 2 Results of statistical tests (*F*-test) to evaluate yearly and monthly variations in recovery rates of common Procellarformes (>10 specimens) on Southland, New Zealand beaches 1990-2000 (n = number of specimens recovered, F = test statistic, P = probability value). $P < 0.05$ indicates significant between year or between month variation in recovery rate.

		Year		Month	
Species	n	F	P	F	P
Shy mollymawk	45	2.47	0.011	1.26	0.259
Buller's mollymawk	215	2.23	0.022	3.62	<0.001
Sooty shearwater	1445	1.7	0.091	7.9	<0.001
Short-tailed shearwater	620	2.4	0.014	7.47	<0.001
Diving petrel	440	1.53	0.14	7.28	<0.001
Cape pigeon	66	1.88	0.058	0.73	0.705
Antarctic petrel	15	1.07	0.389	1.06	0.398
Antarctic fulmar	65	3.6	<0.001	2.73	0.004
Giant petrel	19	0.98	0.464	0.78	0.656
Fairy prion	338	2.86	0.004	3.02	0.002
Thin-billed prion	21	1.84	0.064	1.08	0.389
Salvin's prion	24	1.85	0.062	0.86	0.579
Broad-billed prion	408	0.92	0.517	4.48	<0.001
Blue petrel	25	1	0.447	1.9	0.048
Mottled petrel	145	1.98	0.044	2.02	0.034
White-headed petrel	12	1.56	0.129	0.129	0.017

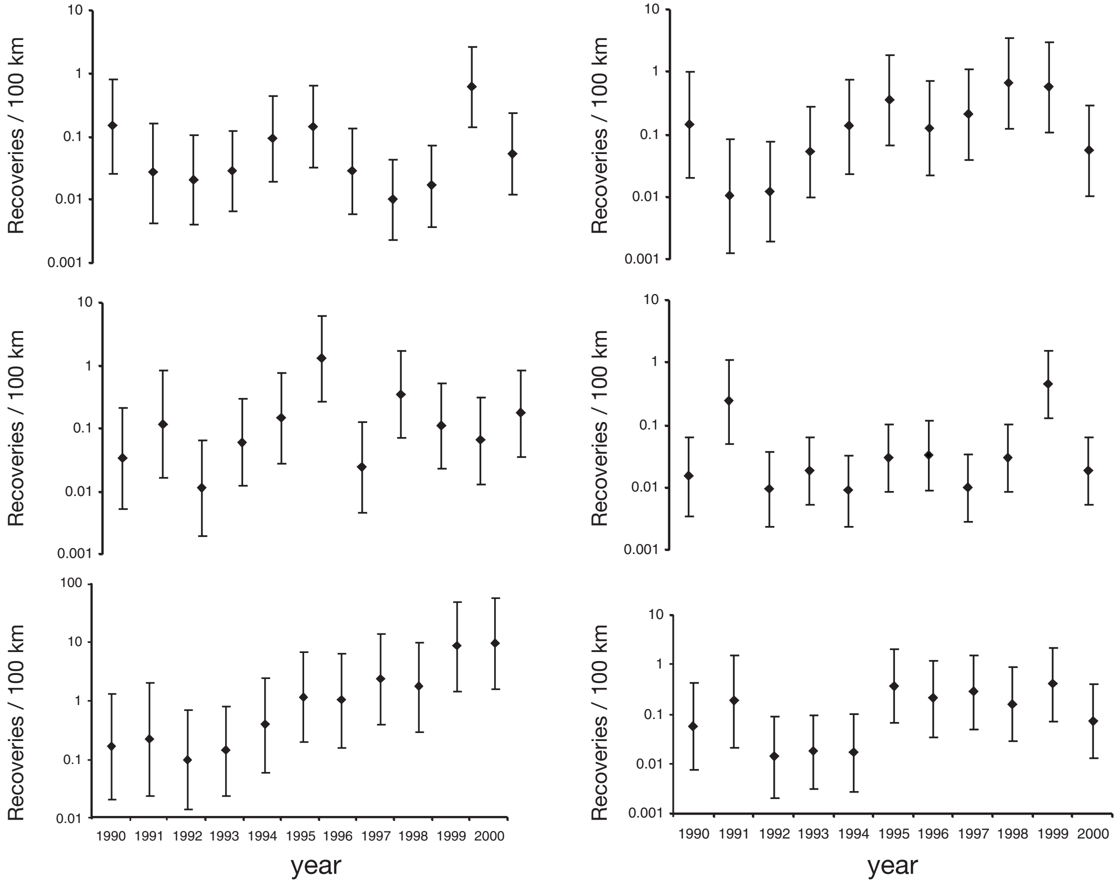


Figure 2 Annual recovery rates for (A) shy mollymawk, (B) Buller's mollymawk, (C) short-tailed shearwater, (D) Antarctic fulmar, (E) fairy prion and (F) mottled petrel from Southland, New Zealand beaches 1990-2000. Data are given as mean with 95% confidence interval.

inconsistent sample sizes per month. Least squares mean recovery rates for each month of each year were calculated for each species. If the analysis showed a significant effect of year on the recovery rate, a linear regression was performed on the least squares means for each year. The potential influence of serial correlation on this regression was assessed using residual plots (Harraway 1993). Annual mean values were calculated as the mean of all patrols carried out in that year, and not the mean value of the monthly means.

In presenting the results, the log recovery rate has been back-transformed to number of birds/100 km. Due to the addition of 0.0001 when converting to a log scale, a back-transformed value of 0.01 birds/100 km is equivalent to no birds being found.

Northern giant petrel (*Macronectes halli*) and southern giant petrel (*M. giganteus*) are grouped as "giant petrel", and northern royal albatross (*Diomedea sanfordi*) and southern royal albatross (*D. epomophora*) are grouped as "royal albatross", because patrollers did not differentiate on many occasions. In the case of giant petrels, this was due to most, if not all, being juvenile, making identification at species level difficult (L. Esler pers. comm.).

Where just the wings of prions were found, these were assigned to either fairy prion (*Pachyptila turtur*) if relatively small, or broad-billed prion (*P. vittata*) which are noticeably larger (L. Esler pers. comm.). This may have the effect of over-representing fairy prion and under-representing the other small prions. However, the effect will be small, as the majority of complete small prions found were fairy prions (pers. obs.).

RESULTS

A total of 3953 birds of 31 Procellariiform species were recovered on 434 beach patrols which collectively covered 2285 km of coastline, thus returning an average recovery rate of 173 Procellariiformes/100 km.

Species for which <10 specimens were recovered
Fifteen species had recoveries of fewer than 10 individuals. These included single specimens of wandering albatross (*D. exulans*), light-mantled sooty albatross (*Phoebetria palpebrata*), fluttering shearwater (*Puffinus gavia*), grey-faced petrel (*Pterodroma macroptera gouldi*), grey-backed storm petrel (*Pelagodroma marina*) and black-bellied storm petrel (*Fregetta tropica*). Multiple specimens of royal albatross (2), Buller's shearwater (*Puffinus bulleri*) (3), Hutton's shearwater (*Puffinus huttoni*) (6), little shearwater (*P. assimilis*) (3), white-chinned petrel (*Procellaria aequinoctalis*) (2), Kerguelen petrel (*Lugensa brevirostris*) (9), Antarctic prion (*Pachyptila desolata*) (6), Cook's petrel (*Pterodroma cookii*) (6), and white-faced storm petrel (*Oceanites nereis*) (8) were retrieved.

Yearly variation in recovery rates for common species
F and *P* values for the effect of year on recovery rates of each species are given in Table 2 while Figure 2a-f illustrates the yearly trends. For 10 species there was no evidence that recovery rates differed significantly between years (Table 2). For the other six species, the year-to-year variation showed a significant 11-year trend only for fairy prion, where a linear regression (r^2 = 0.8852, $P < 0.001$) showed recovery rates to have increased by 57% per year (95% C.I. 39 – 77.7%).

Monthly trends in recovery rates for common species
Buller's mollymawk (*Diomedea bulleri*)
There was an effect of month on the recovery rate of Buller's mollymawks (Fig. 3a; Table 2). They were recovered at low rates from November to March, then increased from 0 in February to 0.19 birds/100 km in April and remained relatively constant through to July. Recoveries peaked at 1.85 birds/100 km in September.

Sooty shearwater (*Puffinus griseus*)
There was an effect of month on the recovery rate of sooty shearwaters (Fig. 3b; Table 2). The peak recovery rate was in May (133.1 birds/100 km) before dropping off sharply to a low of 0.02 birds/100 km in August, then rising to a second peak of 17.91 birds/100 km in November.

Short-tailed shearwater (*Puffinus tenuirostris*)
There was an effect of month on the recovery rate of short-tailed shearwaters (Fig. 3c; Table 2). The peak recovery rate was in November (15.2 birds/100 km). The recovery rate then dropped off and short-tailed shearwaters were absent from Southland beaches from June - September (except for one bird found in July 1995).

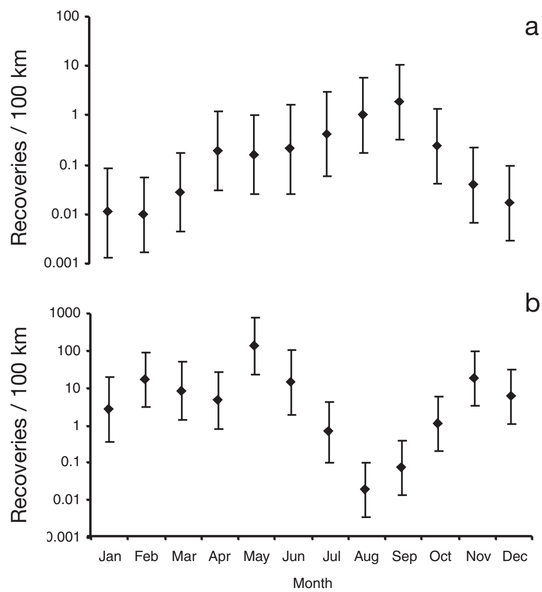
Common diving petrel (*Pelecanoides urinatrix*)
There was an effect of month on the recovery rate of diving petrels (Fig. 3d; Table 2). They were found on Southland beaches in all months of the year, most commonly from August to December, with the peak recovery rate of 32.4 birds/100 km in November, then dropping off with low recovery rates from March - July.

Antarctic petrel (*Thalassoica antarctica*)
There was no evidence of an effect of month on the recovery rate of Antarctic petrels (Fig. 3e; Table 2). Peak recoveries occurred in September with 0.04 birds/100 km.

Antarctic fulmar (*Fulmarus glacialoides*)
There was an effect of month on the recovery rate of Antarctic fulmars (Fig. 3f; Table 2). Recovery rates on Southland beaches were close to 0 throughout the year, but with fulmars found most often from September to December, with monthly recovery rates ranging from 0.12 to 0.14 birds/100 km.

Fairy prion
There was evidence of an effect of month on the recovery rate of fairy prions (Fig. 3g; Table 2). Fairy prions were found in every month of the year, peaking at 21.33 birds/100 km in November and dropping to a low of 0.06 birds/100 km in April.

Thin-billed prion (*Pachyptila belcheri*)
There was no evidence of an effect of month on the recovery rate of thin-billed prions (Fig. 3h; Table 2). Peak recoveries occurred in Oct with 0.06 birds/100 km.



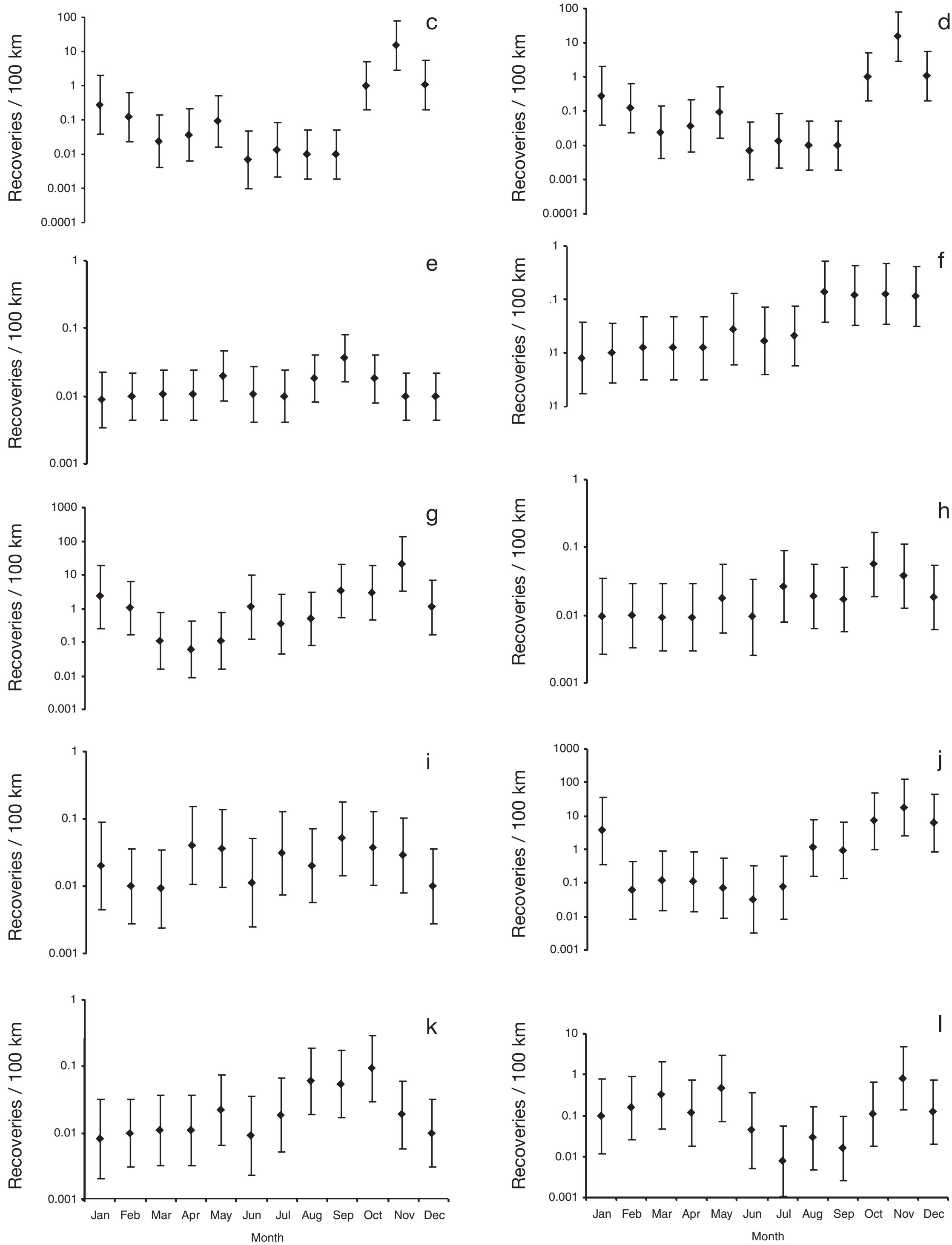


Figure 3 Monthly recovery rates for (A) Buller's mollymawk, (B) sooty shearwater, (C) short-tailed shearwater, (D) common diving petrel, (E) Antarctic petrel, (F) Antarctic fulmar, (G) fairy prion, (H) thin-billed prion, (I) Salvin's prion, (J) broad-billed prion, (K) blue petrel and (L) mottled petrel from Southland, New Zealand beaches 1990-2000. Data are given as mean with 95% confidence interval.

Salvin's prion (*Pachyptila salvini*)
There was no evidence of an effect of month on the recovery rate (Fig. 3i; Table 2).

Broad-billed prion
There was an effect of month on the recovery rate of broad-billed prions (Fig. 3j; Table 2). They were found in every month of the year, with peak recovery rates in November (17.86 birds/100 km).

Blue petrel (Halobaena caerulea)
There was an effect of month on the recovery rate of blue petrels (Fig. 3k; Table 2). Peak recovery rates were from August (0.06 birds/100 km) to October (0.094 birds/100 km).

Mottled petrel (*Pterodroma inexpectata*)
There was an effect of month on their recovery rate (Fig. 3l; Table 2). Recovery rates were relatively high through the year except for a period of fewer recoveries from June to October.

White-headed petrel (*Pterodroma lessonii*)
There was an effect of month on the recovery rate of white-headed petrels (Table 2). Overall, recovery rates were low, with a total of 12 specimens being recovered.

DISCUSSION

A major assumption underlying the interpretation of beach patrol data is that the recovery rate of a species is proportional to its density in the area. Thus, the movement of a species into Foveaux Strait is expected to result in an increase in its recovery rate on Southland beaches. In this way, a change in the monthly recovery rate may indicate a seasonal migration pattern.

Seabird movements are governed by the location of nesting grounds and the seasonal distribution of their food (Warham 1990). Three broad patterns of seabird migration were defined by Warham (1990): sedentary species which remain close to nesting areas; trans-equatorial species which migrate vast distances after breeding, mostly from south to north ; and longitudinal species, which, particularly in the southern ocean, move east after breeding, using the prevailing westerly winds (Warham 1990).

Careful consideration must be given when inferring the migration pattern of a species from seasonal recovery rate patterns. There must be a seasonal pattern that is distinct from a peak that occurs when young birds are fledging and may be wrecked in high numbers. I hypothesize that the seasonal pattern of a sedentary species is distinguished by a steady recovery rate throughout the year. The seasonal pattern of a trans-equatorial or longitudinal migrating species can be inferred by a steady increase and decrease in recovery rate over several months, or where adults of that species are absent from beaches for a period of more than two months.

However, other factors e.g., storm events (Kinsky 1968; Reed 1981) and poor condition of birds (Sagar & Horning 1997) can influence the number of birds washed ashore. Also, recovery rates are often higher on beaches where the prevailing wind is onshore, compared with sheltered beaches (Powlesland & Imber 1988). Most Southland data were collected from beaches where the prevailing westerly winds were onshore.

Over longer periods, however, trends in recovery rates can mirror population trends. Population decline in seabirds can reflect factors such as predation (Hamilton *et al*. 1997) or food shortages due to warm sea surface temperatures during *El Niño* (Fromentin *et al*. 1998). Population growth can result from predator control on breeding islands (Veitch & Bell 1990).

Annual variations in recovery rate

The annual recovery rates of shy mollymawk, Buller's mollymawk, short-tailed shearwater, Antarctic fulmar, fairy prion, and mottled petrel varied. However, linear regression analyses of the annual recovery rate means were not significant except for fairy prion where there was a 57% per year increase in recovery rate.

An increase in Buller's mollymawk annual mean recovery rate was only just outside the 5% significance level. The Snares Islands population increased by 78% during 1969-1992, and by a further 8% during 1992-1997. The Solander Island population, which, due to its location in Foveaux Strait is likely to have greater influence on the numbers on Southland beaches, may have stayed the same or decreased 18.7% from 1985-1986 (Sagar *et al*. 1999). However, the results of this study suggest a subsequent increase in population.

Although not a significant linear trend, a general increase in mottled petrel annual mean recovery rates suggests an increasing population and this fits with recent counts of breeding pairs on Whenua Hou where numbers have increased since weka (*Gallirallus australis*) were removed in 1984 (Taylor 2000).

Linear regression of cape pigeon (*Daption capense*) annual mean recovery rates shows a 1.2% annual increase in recovery rate. Studies of cape pigeon colonies suggest that some populations are increasing, with 7.6% annual growth at Harmony Point (South Shetland Islands) from 1965-1989 (Woehler & Croxall 1997) and 2.3% annual growth from 1985-1999 at Pointe Géologie (Terre Adélie) (Micol & Jouventin 2001). However the absence of a significant seasonal pattern in recoveries suggests birds recovered on Southland beaches may be from closer colonies such as at the Snares Islands.

To be sure of these patterns, however, a longer time period must be looked at. On this relatively short scale of 11 years, trends can be hidden by one or two exceptional years. Year was not a significant factor for the recovery rate of sooty shearwater. P. Scofield (pers. comm.) found a 2.6% annual decline in recovery rate of sooty shearwaters from Auckland beaches from 1960 to 2000. A regression of the sooty shearwater recovery rates from Southland showed a decline of 5.2% per year, but over 11 years it is possible that years of large wrecks are hiding the actual population trend. Hamilton *et al*. (1997) examined adult sooty shearwater recovery rates from the whole of New Zealand for the breeding seasons (October - April) from 1965 to 1990, and found no significant correlation between recovery rate and year.

Seasonal variations in recovery rates

Shy mollymawk

Shy mollymawk were found on Southland beaches throughout the year with no significant monthly pattern. Shy mollymawk were described by Serventy (1949) as sedentary, a species which stays in the approximate area of breeding, and this is probably why no monthly pattern is seen in its recovery rates. However, Powlesland (1985) found a significant monthly variation in recovery rates from New Zealand beaches with peaks from May - June and October - December.

Buller's mollymawk

Overall, monthly recovery rates of Buller's mollymawk on Southland beaches reflected their monthly abundance in the Foveaux Strait area (Stahl *et al.* 1998). The only deviance, high recovery rates in August and September, can be explained by wrecks of juveniles after fledging.

The higher recovery rate around June was also found for New Zealand recoveries (Powlesland 1985) and was explained as marking the movement of adolescents away from breeding colonies and into coastal waters. The similarity in New Zealand recovery patterns and those for Southland is not surprising as Southland had the highest recovery rate of Buller's mollymawk for the period 1960-1983 (Powlesland 1985) and 86% of South Island recoveries between 1970 and 1987 were from Southland (Marchant & Higgins 1990).

Recovery rates for Southland, 1990-2000, peaked in August and September, when chicks at Solander and Snares Islands fledge (Marchant & Higgins 1990). Chicks of the Chatham Island population fledge in June (Heather & Robertson 1996). Wrecks of fledglings/juveniles were common in September. This, together with the banded Buller's mollymawk recovered on Oreti Beach on 8 August 2001 and which had been banded as a chick on Snares Islands on 30 July 1992, suggests that most birds found on Southland beaches are the southern subspecies, *bulleri*. Museum skins from birds wrecked on New Zealand beaches (mostly from Southland) are of *D. b. bulleri* (Powlesland, 1985).

Sooty shearwater

These were the most common procellariiform found on Southland beaches, accounting for 36.6% of all recoveries during 1990-2000, despite records of several large wrecks (1000+ birds) from Mason Bay, Stewart Island, not being included in the data. The abundance of sooty shearwaters reflects the fact that it is probably the most common bird in waters around New Zealand (Warham & Wilson 1982). Sooty shearwater recovery rates decreased after February and peaked in May. Wrecks of juveniles are common on New Zealand beaches after fledging in May (pers. obs.) and in Southland there were wrecks every year. The highest recovery rates in May were of 1098, 544, 508 and 396 birds/100 km recorded in 1992, 1998, 1999 and 1993 respectively. The decrease in recovery rate after May, and peak in November, reflected the post-breeding movement of birds out of the New Zealand region to the north Pacific from March to August, and the return of birds to breeding grounds from September to February (Spear & Ainley 1999).

Short-tailed shearwater

Breeding on islands off southern Australia (Heather & Robertson 1996), this species is uncommon in New Zealand waters from November to May (Marchant & Higgins 1990). However, there are large wrecks in some years and Southland recovery rates were high from October, as birds returned to their colonies from the north Pacific (Marchant & Higgins 1990). Recoveries peaked in November, perhaps reflecting the time of greatest density of returning birds passing through Southland waters. Recovery rates declined thereafter until March and then increased again in April and May. During the latter period birds are leaving their colonies, adults in April, followed by fledglings in May (Marchant & Higgins 1990). Their migration to the north Pacific is seen in Southland beach patrol records as a near absence of this species from June-September.

Common diving petrel

There was a significant monthly effect on recovery rate of diving petrels and this was also found by Powlesland *et al*. (1992a,b) for New Zealand-wide recoveries from 1943 to 1988. On Southland beaches the recovery rate was low in March, and this was also found by Powlesland *et al*. (1992b). The minor peak in December-January New Zealand-wide recoveries (Powlesland *et al*. 1992b) occurs as a major peak in Southland from October-November. This petrel is regarded as a sedentary species (Serventy 1949; Powlesland 1992b), breeding in the Foveuax Strait area and being wrecked on Southland beaches throughout the year.

Cape pigeon
Cape pigeons were found on Southland beaches in all months, with no discernable trends. This reflects the hypothesized recovery pattern for a sedentary species.

Antarctic petrel
Antarctic petrels were found on Southland beaches only during August-October, except for one bird recovered in May 1992. These recoveries of Antarctic petrel indicate that some individuals had moved into waters off Southland at this time. Northwards movement of Antarctic petrels after breeding has been documented (Woehler *et al*. 1990), and is probably related to the northward advancement of sea ice and the polar front during the Antarctic winter. Sea ice reaches its maximum northwards extent in September (Hicks 1973).

Antarctic fulmar
Recovery rates of Antarctic fulmar were low throughout the year except for a slight increase during September-December. Low recovery rates in February and March corresponded to an observed latitudinal distribution of Antarctic fulmar at this time of 67º05’S - 66ºS (Fowler 1973). Northwards dispersion after breeding is recorded by Woehler *et al*. (1990). The increase in recovery rates seen in September to December is probably a result of the polar ice advancement as with Antarctic petrel.

Giant petrel
There was no significant change in recovery rates of giant petrels through the year. They were recovered in every month except April and November. A slight increase in recoveries in May coincides with fledging and dispersal of young. Another slight increase in July may represent high densities of immature birds in local waters at this time, which are often wrecked by winter storms (Marchant & Higgins 1990).

Fairy prion
In Southland, the recovery rate of fairy prions was significantly influenced by month. Powlesland (1989a) also found this for New Zealand beaches. Monthly recovery rates from Southland closely match that for New Zealand (without inclusion of wrecks) (Powlesland 1989a). Peaks in recovery rates for New Zealand occurred in February, July and October (Powlesland 1989a) whereas Southland peaks were slightly displaced to January, June and November. The lowest recovery rates in Southland occurred from March-May and few birds were found on any New Zealand beaches in autumn (Powlesland 1989a). Powlesland (1989a) did not explain the later two peaks in recoveries except to say that there are storms and food shortages at this time of the year. Fairy prions are sedentary (Serventy 1949; Powlesland 1989a) and the fact that they breed in the Foveaux Strait area, e.g., Whero Island (Marchant and Higgins 1990) and are not uncommon on Southland beaches in any month supports this.

Thin-billed prion
Their recovery rate did not change significantly over the year, although no recoveries were made from January-June (except for 1 bird in May 1992). Recovery rates from New Zealand 1960-1986 peaked in July and August (Powlesland 1989a). Recovery rates from Southland 1990-2000 were highest in October. These birds were probably non-breeders because by this time adults have returned to their breeding grounds on islands in the Indian, west Atlantic and east Pacific Oceans (Marchant & Higgins 1990). Thin-billed prions found on New Zealand beaches are usually immature birds from Indian Ocean populations (Marchant & Higgins 1990).

Salvin’s prion
Recovery rates of Salvin’s prion from Southland beaches did not change significantly between months. In contrast, Powlesland (1989a) found significant monthly variation with highest recovery rates in winter, mostly from North Island beaches.

Broad-billed prion
In the New Zealand region, broad-billed prions nest on islands in Foveaux Strait, the Snares Islands, Fiordland, and Chatham Islands (Marchant & Higgins 1990). There was a significant monthly effect on the recovery rate of broad-billed prions. The major peak in Southland recovery rates occurred in November, quite different to the pattern found by Powlesland (1989a) where peaks occurred during June-July, largely as a result of wrecks in 1961 and 1974 (Marchant & Higgins 1990). Even with large wrecks omitted there are peaks in August and October (Powlesland 1989a), probably due to spring gales. Southland recovery rates are high from August - January. This can be explained by the mass arrival of broad-billed prions at breeding islands in July, and their departure and fledging, which at the Snares is from December - January (P. Sagar pers. comm.).

Broad-billed prions are migratory (to Tasman Sea) (Marchant & Higgins 1990), but some birds remain in breeding grounds throughout the year. This is reflected in the Southland beach patrol results by recoveries in each month of the year.

Blue petrel
Recovery rates of blue petrel were significantly influenced by month. High recovery rates were seen on Southland beaches from August - October. This is probably due to the pattern of northern movement of non-breeders into local waters at this time (Marchant & Higgins 1990).

Mottled petrel
Mottled petrel recoveries were affected significantly by month. Mottled petrel is a transequatorial wandering species (Marchant & Higgins 1990). The pattern of Southland recovery rates reflects the movements of this species well.

Mottled petrels breed from November to May on the Snares Islands, Stewart Island and islands in Foveaux Strait, with one small colony on an island in Lake Hauroko, Fiordland (Marchant & Higgins 1990). This is reflected in the recovery rates which are relatively high until late April- early May, when birds leave their breeding grounds (Marchant & Higgins 1990). After May, recovery rates decline, but increase as birds return to Southland waters in early November (Marchant & Higgins 1990). Powlesland (1987) also found an increase in recovery rates as birds arrived back in the New Zealand region in November, but found the national recovery rate to drop off in March, a time when the Southland recovery rate was still relatively high. Perhaps non-breeders remain widespread throughout New Zealand waters during summer and do not congregate in breeding areas until March.

White-headed petrel
White-headed petrel recoveries were significantly influenced by month. Trends in recovery rates in Southland were similar to those reported nationwide by Powlesland (1987), who explained the June peak as due to winter storms.

Conclusions
The monthly trends seen in recovery rates of procellariiform species from Southland, from 1990 to 2000, match the known movements of the species well. A number of species with similar distributions showed similar seasonal patterns. For example, the Antarctic or circumpolar species Antarctic petrel, Antarctic fulmar, blue petrel, Antarctic prion and white-headed petrel were most commonly found from September to December, when the austral winter and advance of sea ice pushes the distributions of these birds further north, into coastal waters of New Zealand.

The seasonal patterns seen in the Southland data closely match national patterns presented by Powlesland (1985, 1986, 1987, 1989a, 1989b, 1992a, 1992b), except that in many cases peak recovery rates were offset by a month or two, possibly due to latitudinal effects.

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