Distribution of Sooty Shearwater *(Puffinus griseus)* breeding colonies along the Otago Coast, New Zealand, with indication of countrywide population trends

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ABSTRACT

Large breeding colonies of Sooty Shearwaters or Titi *(Puffinus griseus)* occur on offshore islands around New Zealand and several smaller colonies occur on headlands and near-shore islands around southern New Zealand; their population trends are unknown. Twelve mainland colonies around Otago had between 11 and 620 burrows in the 1992/93 breeding season. The largest of three near-shore island colonies in Otago had at least 1,050 burrows. Sooty Shearwater burrows have been recorded from 39 mainland sites in the South Island, but only 11 (28%) of these have been checked in the last 40 years; many may now be extinct. OSNZ Beach Patrol data suggest that the overall number of Sooty Shearwaters has changed little over a 26 year period. Methods for monitoring Sooty Shearwater colonies need to be standardised to evaluate population trends in the future.

KEYWORDS: distribution, population abundance, Sooty Shearwater, *Puffinus griseus*, islands

INTRODUCTION

The Sooty Shearwater or Titi *(Puffinus griseus)* is probably the most numerous and has the greatest total biomass of any seabird in the New Zealand region (Warham and Wilson 1982). From October to April, Sooty Shearwaters breed colonially in burrows in the southern hemisphere (Warham 1990, Cooper *et al.* 1991) and then undertake a trans-equatorial migration to the North Pacific and the North Atlantic during the southern winter (Warham *et al.* 1982, Briggs and Chu 1986).

Breeding colonies of Sooty Shearwaters on New Zealand offshore islands have remained large, but many colonies that once existed on headlands of both the North and South Island of mainland New Zealand have disappeared (Jackson 1957). Surviving mainland colonies are thought to be declining because of predation by feral cats *(Felis catus)*, ferrets *(Mustela furo)*, stoats *(M. erminea)* and rats *(Rattus exulans, R. norvegicus, R. rattus)* (Hamilton and Moller 1993, 1995). Other threats to mainland colonies include competition with other burrow-nesting seabirds, habitat alteration leading to burrow collapse, and harvesting of chicks.

Conservation effort in New Zealand is turning increasingly to the restoration and active management of natural habitats on the mainland (Clout 1989). Maintaining Sooty Shearwater colonies in such areas is important for aesthetic, touristic and cultural reasons since these colonies are much more accessible than those found on offshore islands.

The possible establishment of a small sustainable harvest of Sooty Shearwater chicks (muttonbirding) on the mainland may also be of interest to many Maori (Moller unpubl.). This paper:

(i) presents data on the breeding colonies around Otago, south-eastern South Island, during the 1992/93 breeding season; along with the land status, distance offshore (if an island), and total burrow numbers of those colonies;

(ii) reviews the past distribution of island and mainland colonies of Sooty Shearwaters in the southern region around New Zealand; and

(iii) reviews trends in beach-wreck Sooty Shearwater numbers around New Zealand.

METHODS

Surveys of Otago Sooty Shearwater colonies in 1992/93

In this study, a colony was defined as an aggregation of burrows more than 100m away from any other aggregation of burrows. Surveys were carried out during the 1992/93 breeding season on three near-shore islands along the Otago coast and at six locations (12 colonies) on the mainland (Fig. 1). The island colonies were on Green Island, Moturata (Taieri) Island and Tuhawaiki (Jack's) Island. A small area of Tuhawaiki Island (north end) was not searched for burrows due to time constraints. At Green and Moturata Islands there were difficulties in identifying Sooty Shearwater burrows due to the numbers of burrows occupied by Blue Penguins *(Eudyptula minor)*. Severe erosion and, consequently, fragile and easily collapsing burrows also hampered counting on Moturata. Therefore, only a minimal estimate for the confirmed number of burrows occupied by Sooty Shearwaters could be obtained for these two islands (Table 1).

The mainland colonies investigated were chosen because they were known to have been active in the recent past. There were four colonies (>100m apart) at Nugget Point which are referred to as "Nuggets A", "Nuggets B", "Nuggets C" and "Nuggets D". At Taiaroa Head, there were two separate colonies, one within the Nature Reserve ("Reserve"), the other ("Private") on private land.

At each colony all burrows were mapped and counted. Burrows were examined from the entrance by reaching an arm or a stick (up to 1m long) down the burrow. Burrows that had two entrances were counted as one burrow. Burrows with a single entrance but where the tunnel forked to give two nesting chambers were counted as two separate burrows. The total burrow number for each colony was recorded but occupation rate was not possible to assess.

Past distribution of Sooty Shearwater breeding colonies

Published literature and personal communications from observers of Sooty Shearwaters were obtained to document breeding colonies that have been active in the past. Where data were available, the total number of burrows or the estimated number of "active" burrows (i.e. those being entered by birds) was recorded, as well as the date(s) when the colony was surveyed.

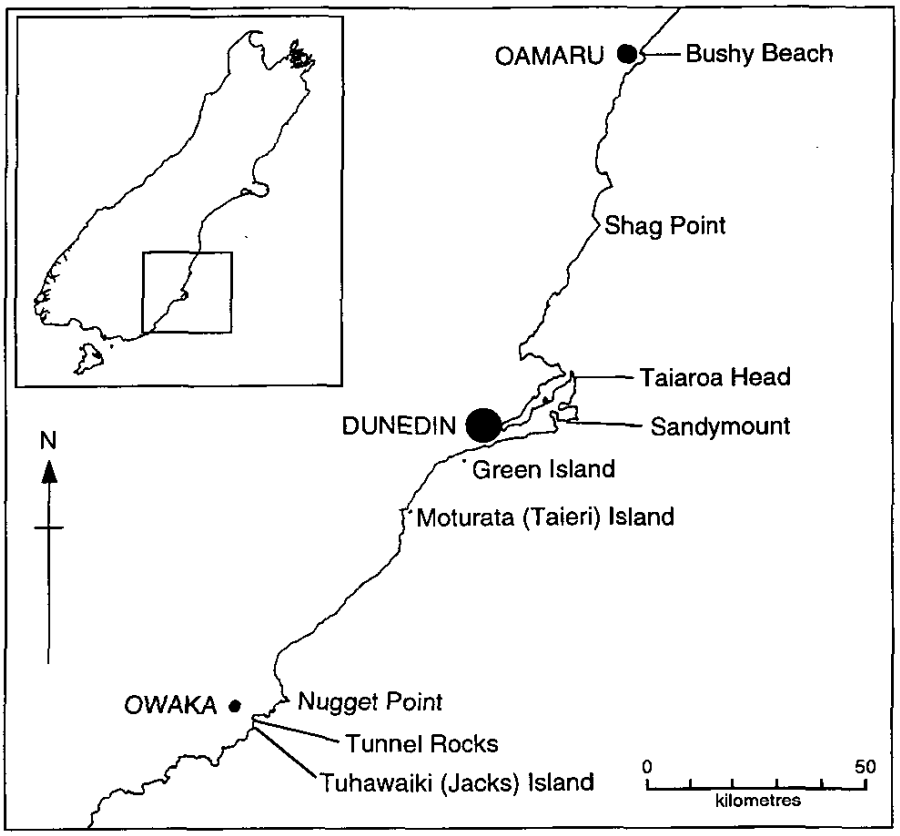

FIGURE 1 – The Otago coastline showing the nine Sooty Shearwater colonies surveyed in 1992/93.

Seasonal and annual trends in Sooty Shearwater numbers washed ashore

The number of dead Sooty Shearwaters (expressed as corpses per km of beach) from 1965 to 1990 were collected from published accounts of the Ornithological Society of New Zealand's Beach Patrol Scheme (Powlesland *et al.* 1993).

The mean number of dead Sooty Shearwaters found per km of seashore patrolled (with 95% confidence intervals) was calculated for each month of the year (N = 26 years, 1965 - 1990). Counts from October to April were averaged to get the yearly variation in the number of adult birds per km which washed up each breeding season from 1965/66 to 1989/90. The Beach Patrol covered most sections of coast in both the North and South Islands for most years.

RESULTS

Distribution of Sooty Shearwater colonies in Otago in 1992/93

All colonies surveyed during 1992/93 were on protected land (Table 1) and all had adult birds present during the season. Most consisted of less than 100 burrows (including both occupied and unoccupied burrows). Taiaroa Head (Private) was the largest colony surveyed (620 burrows) and is possibly the largest mainland colony remaining in New Zealand (Tables 1 & 2). An earlier estimate for the total burrow number at the Taiaroa

TABLE 1 - Sooty Shearwater breeding colonies along the Otago coast surveyed in 1992/93 showing the land status at the colony, position and the total number of burrows at the colony. Adult Sooty Shearwaters were confirmed to be present at all the colonies.

Colony	Land status	Position	Total number of burrows
Nuggets A	Scientific Reserve	mainland	122
Nuggets B	Scientific Reserve	mainland	36
Nuggets C	Scientific Reserve	mainland	69
Nuggets D	Scientific Reserve	mainland	60
Taiaroa Head (Private)	Conservation Covenant (private land)	mainland	620
Taiaroa Head (Reserve)	Nature Reserve	mainland	21
Bushy Beach, Oamaru	Scenic Reserve	mainland	56
Shag Point	Recreation Reserve	mainland	11
Sandymount, Otago Peninsula	Recreation Reserve	mainland	49
Tunnel Rocks, Jack's Blowhole	Scenic Reserve	mainland	105
Green Island	Nature Reserve	offshore, 2 km	≥1
Moturata Island, Taieri Mouth	Scenic Reserve	offshore, 1 km	≥3
Tuhawaiki Island, Jack's Bay	Recreation Reserve	offshore, 50 m	1050+

Head (Private) colony was 350-450 burrows (Robertson 1976; Table 2). This means there has been at least a 38% increase in the total number of burrows at this colony in the last 20 years. Excluding Taiaroa Head (Private), colony size (i.e. total number of burrows) on the mainland in 1992/93 averaged 59 burrows (range 11 to 122) (Table 1).

Of the three near-shore islands studied, the largest colony was on Tuhawaiki Island with 1050 burrows recorded. There may be more burrows on the island (Table 1).

Past distribution of Sooty Shearwaters

The colonies known from headlands around the South Island of New Zealand are listed in Table 2. However, of 39 recorded sites, only 11 (28%) have been surveyed in the last 40 years.

Sooty Shearwater colonies occur on offshore islands (≥ 5 km off the mainland coast) around New Zealand and the sub-Antarctic (Table 3) from Three Kings Island (34°S, 172°E) in the north to Macquarie Island (55°S, 159°E) in the south (Warham *et al.* 1982). Of 39 known offshore island colonies, only six (15%) have had burrow numbers recorded (Table 3). The largest known colony is at The Snares where there were an estimated 2,750,000 breeding pairs in 1970-72 (Warham and Wilson 1982). Large concentrations of colonies on the Muttonbird (Titi) Islands around Stewart Island are visited annually for muttonbirding and shearwaters there are abundant (Wilson 1979) but no accurate estimates of their colony size are available.

Colonies also exist or have existed on a number of small near-shore islands (< 5 km off the mainland coast) around the south east coast of the South Island (Table 4). Most of these colonies are probably small with the largest known colony occurring on Tuhawaiki Island. Of ten near-shore island colonies, only five (50%) have been surveyed for burrow numbers (Table 4).

TABLE 2 - Mainland Sooty Shearwater colonies known to exist on the South Island of New Zealand within the last 50 years (NR = not recorded; Total = estimated number of burrows at colony; Active = estimated number of burrows at colony being used by Sooty Shearwaters, presumably by breeding birds).

Region	Colony location	Number of burrows	Survey date(s)	Source
West Coast	Okarito	NR	NR	Richdale 1944
	Makawhio Head	NR -	NR	K. Smith 1992 (via A.Tennyson pers.comm.)
	Perpendicular Pt	>7 active	1956/57	Jackson 1957
	Twelve Mile Bluff,Greymouth	30	1956/57	Jackson 1957
	One-One,Harihari	16	1956/57	Jackson 1957
	Doughboy Knoll, near Harihari	12-15 total	NR	K. Smith 1992 (via A.Tennyson pers.comm.)
	Near Iota Bluff, South Westland	69 total burrows	NR	A.Tennyson pers.comm.
Banks Peninsula	Stony Bay	NR	NR	G.Tunnicliffe, pers.comm
	Tumbledown Bay	NR	NR	G.Tunnicliffe, pers.comm
	East Le Bons Bay	NR	NR	G.Tunnicliffe, pers.comm
North Otago	Bushy Beach	NR	NR	Lalas, unpublished
	Boatman's Harbour	NR	NR	C. Lalas, pers.comm.
	Bobby's Head	NR	NR	G.Loh, pers.comm.
	Kakanui	NR	NR	P.Sagar, pers. comm.
	Shag Point	5-10 active, no fledging	1980's	C.Lalas, pers. comm.
Otago Peninsula	Mt Charles,	NR	1940-50s	Surveyed by L.E.
	Grassy Point,	NR	1940-50s	Richdale & S. Sharpe
	Highcliff,	NR	1940-50s	(via A. Wright, pers. comm.)
	"Double Bay",	NR	1940-50s	
	The Chasm,	NR	1940-50s	
	Cape Saunders,	NR	1940-50s	
	Titikoraki,	NR	1940-50s	
	Penguin Beach,	NR	1940-50s	
	Ohinepuha	NR		
	Pipikaretu	NR	NR	M. Ellison, pers.comm.
	Victory Beach	NR	NR	G.Loh, pers.comm.
	Taiaroa Head (Reserve)	NR	NR	C.J.R. Robertson
	Taiaroa Head (Private)	350-450 total 150-300 active	NR	1970 A. Wright [in Robertson, 1976] 1982/83 Lalas, unpublished
	Sandymount	NR	NR	A.Wright, pers. comm.
Dunedin	Tunnel Beach area	NR	NR	G.Loh, pers.comm.
	Lawyers Head;	NR	1940-50s	Surveyed by L.E.
	Maori Head	NR	1940-50s	Richdale & S. S.Sharpe (A. Wright, Pers. comm.)
Nugget Point	Colony A	90 active	early	C. Lalas, pers. comm.
	Colony B	120 active	1980s	
	Colony C	40 active		
	Colony D	120 active		
Catlins	Long Point	NR	NR	B. Murphy, pers.comm.
	Wilkie Falls, Cannibal Bay	NR	NR	G. Loh, pers. comm.
	Tunnel Rocks	NR	NR	C. Lalas, pers. comm.

TABLE 3 - Recorded breeding colonies of Sooty Shearwaters on offshore islands (> 5km from the mainland coast) around New Zealand and the sub-Antarctic. Total burrows are all burrows at the colony counted/extrapolated from sample counts. Active burrows are the estimated number of burrows used by Sooty Shearwaters, presumably by breeding adults. NR indicates no record.

Region	Colony location	Number of burrows	Survey date	Source
Northern North Island	Three Kings	NR	NR	Falla 1934 Warham *et al.* 1982
	Cavalli I.	NR	NR	Falla 1934
	Hen I.	NR	NR	Falla 1934
	Mokohinau I.	NR	NR	Falla 1934
	Cuvier I.	NR	NR	Warham & Wilson 1982
	Alderman I.	NR	NR	Falla 1934
Central North Island	White I.	NR	NR	Falla 1934
	Rurima I.	NR	NR	Warham & Wilson 1982
	Motuhora (Whale) I.	NR	NR	Falla 1934
		NR	NR	Imber 1976
		NR	NR	Warham & Wilson 1982
Southern North Island/	Kapiti I.	NR	NR	Warham & Wilson 1982
Cook Strait	Mana I.	NR	NR	Warham & Wilson 1982
	Stephens I.	NR	NR	Warham & Wilson 1982
	The Trios	NR	NR	Warham & Wilson 1982
Fiordland	Open Bay	NR	NR	Warham & Wilson 1982
	Hawea, Breaksea Is	NR	NR	R. Taylor pers. comm.
	Solander Is	NR	NR	Cooper 1984
Canterbury	Motunau I.	80	1960-63	Taylor 1967
Stewart Island/	Starling Head, Stewart I.	NR	NR	C. Challies pers. comm.
Foveaux Strait	Chew Tobacco Bay, Stewart I.	NR	NR	C. Challies pers. comm.
	Codfish I. (Whenua Hou)	NR	NR	West 1990
	Muttonbird (Titi) Is	NR	NR	Wilson 1979
	Whero	400 total	1941	Richdale 1942
Chatham Islands	Chatham I.,	NR	NR	Imber 1994
	South East Island (Rangatira)	ca17,000 total		Nilsson *et al.* 1994
Sub-Antarctic	Antipodes Is	NR	NR	Warham & Bell 1979
	Auckland I.	NR	NR	Clark & Dingwall 1985
	Campbell I.	NR	NR	Warham & Bell 1979
	Macquarie I.	NR	NR	Jones 1980
		1,777 total	1978/79	Brothers 1984
	The Snares	2,750,000 active†	1970/71	Warham & Wilson 1982

[1] Including Pitt I., The Sisters (Big and Middle), Star Keys, Murumurus, Mangere I., Little Mangere I., Kokope I., Rabbit I., Houruakopara

[2]by extrapolation

TABLE 4 - Recorded populations of Sooty Shearwater colonies on near-shore islands (< 5 km from the mainland coast) around the south-east coast of the South Island of New Zealand (NR = not recorded; Active burrows = estimated number of burrows used by Sooty Shearwaters).

Location	Colony name	Estimated size	Survey date	Source
North Otago	Maukiekie	NR	NR	Richdale 1944
		NR	1980s	Lalas, unpublished
South Dunedin	Moturata /Taieri	100 marked (≥24 eggs)†	1943	Richdale 1963
		100 active burrows	1980s	C. Lalas pers. comm.
	Green	150 active burrows (extrapolated)	1983	C. Lalas pers. comm.
Otago Peninsula	Goat	NR	1940/50s	A. Wright pers. comm.
	Quarantine	NR	1940/50s	A. Wright pers. comm.
	Pudding	NR	1940/50s	A. Wright pers. comm.
	Wharekakahu	1 active burrow	1985	C. Lalas pers. comm.
Catlins	Tuhawaiki (Jack's Island)	1406 active burrows	1985	C. Lalas pers. comm.
	Rainbow Isles	NR	NR	Richdale 1944,
		NR	NR	Lalas, unpublished
	Cosgrove	NR	1984	Lalas, unpublished

†Richdale (1963) marked a sample of 100 burrows and at least 24 had eggs laid in them

Numbers of Sooty Shearwaters found washed ashore around New Zealand

The mean number of Sooty Shearwaters washed ashore over 26 years peaked in May and November (Fig. 2). Only the data for October to April (inclusive) were used to analyse the variation in the number of dead "adult" Sooty Shearwaters washed ashore during the breeding season. Data from May were excluded as the counts would then include many fledglings. The mean number of dead "adult" Sooty Shearwaters washed ashore during 25 breeding seasons (October to April) remained fairly constant, with the exception of two catastrophic seasons, 1975/76 and 1978/79 (Fig. 3). There was no significant correlation between the number of Sooty Shearwaters washed ashore from October to April and year, whether the two catastrophic years were excluded ($r^2 = 0.004$, $p>0.1$) or included ($r^2 = 0.000$, $p>0:1$).

DISCUSSION

Persistence of Sooty Shearwater colonies in Otago in 1992/93

All the colonies surveyed in 1992/93 were on secure land tenure (to allow conservation management) and all were visited by adult Sooty Shearwaters during the breeding season. The Taiaroa Head (Private) colony appears to be increasing in size which is most likely due to intense predator control in the general area for the protection of the Northern Royal Albatross *(Diomedea epomophora sanfordi)* and the Yellow-eyed Penguin *(Megadyptes antipodes)* colonies. High numbers of rabbits *(Oryctolagus cuniculus)* in the sand dune habitat at Taiaroa Head may also form the main component of predator diet so that bird predation may be naturally low in the area.

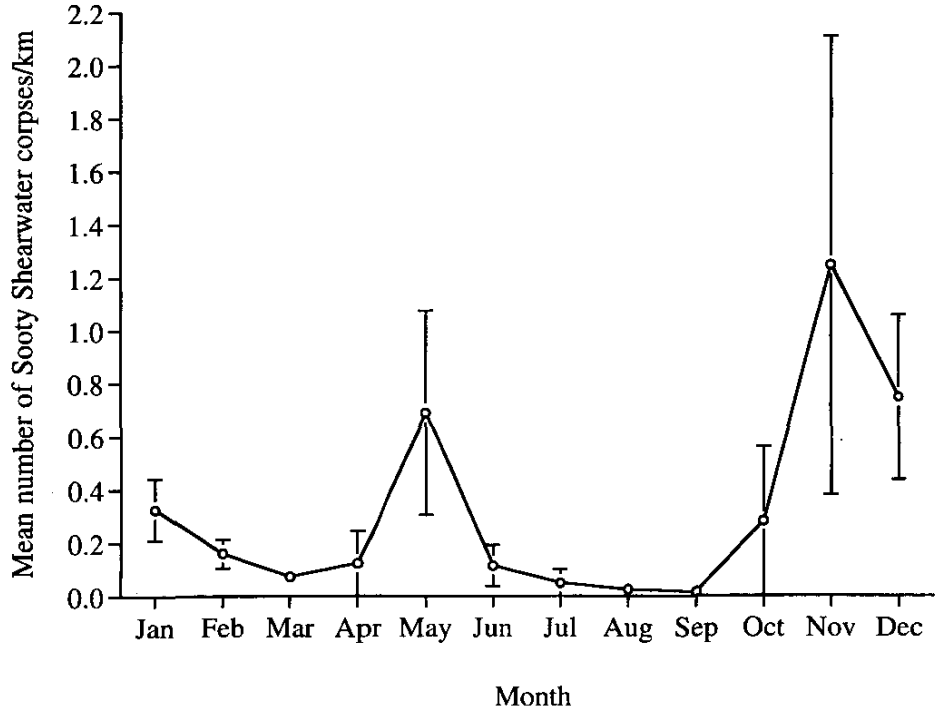

FIGURE 2 – The mean number of Sooty Shearwater corpses washed ashore around New Zealand for 1965 - 1990. Bars indicate the 95% confidence interval.

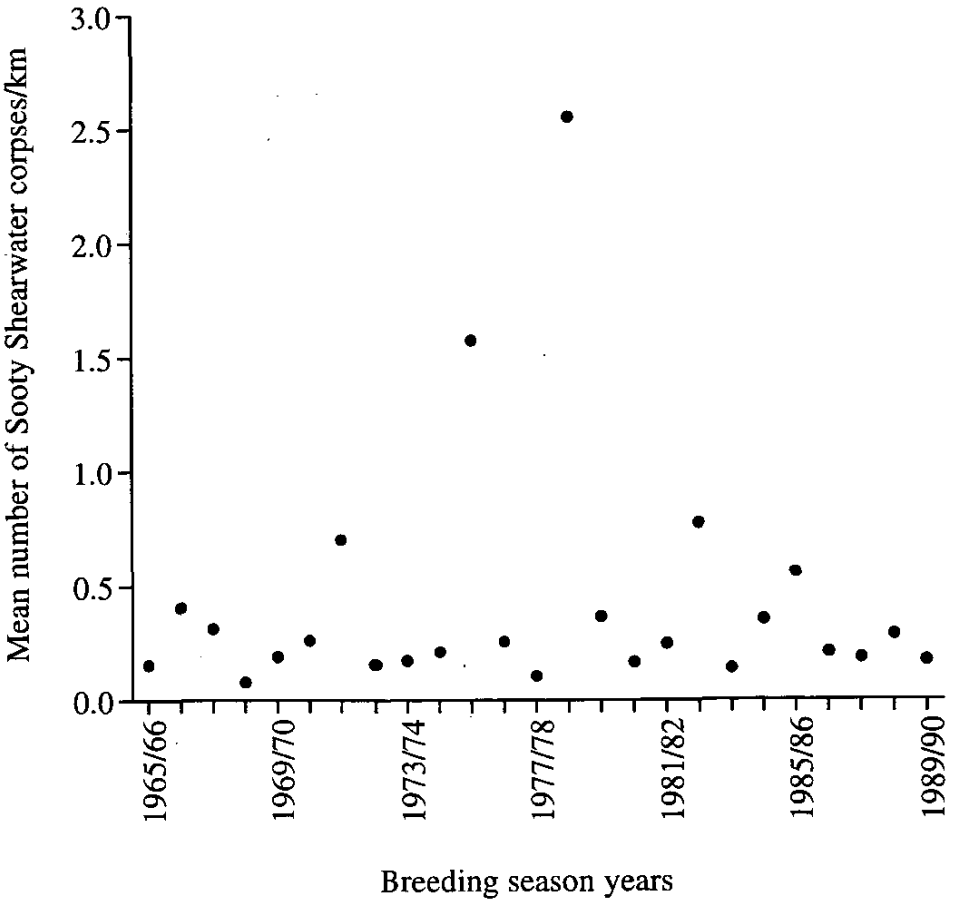

FIGURE 3 –The mean number of Sooty Shearwater corpses washed ashore during each Sooty Shearwater breeding season from 1965/66 to 1989/90.

As the 1992/93 survey covered only colonies which were thought (from anecdotal reports) to be extant, other mainland colonies may have already gone extinct. Simulation models, using the most optimistic estimates for survival rate, age of first breeding, and the frequency of marine food failures, predict that many of the remaining small colonies on the mainland will go extinct over the next 100 years unless predators are controlled (Hamilton & Moller 1993, 1995).

Past distribution of Sooty Shearwater colonies

Breeding colonies of Sooty Shearwaters have been widespread around the coast of the South Island within the last 50 years. In particular, a number of small colonies existed on the Otago Peninsula. As few colonies have been visited or surveyed, it is not known whether all of these still exist.

The total number of burrows at a colony probably does not give an accurate index of the size of the breeding population because the proportion of burrows occupied varies markedly from colony to colony and from year to year (Hamilton 1993, P. Lyver pers. comm.).

Past surveys in Otago have usually estimated the number of occupied burrows (i.e. those containing nests) by using either the proportion of burrows which smelled of Sooty Shearwaters (C. Lalas pers. comm.) or the proportion of burrows being entered as gauged by barricade knock-down (Warham & Wilson 1982). However, burrows can be entered by pre-breeding as well as breeding birds and work in 1992/93 using a "burrowscope" (a video camera with a fibre-optic cable, Dyer & Hill 1991) found that smell was an unreliable indicator of burrow occupancy (Hamilton 1993). Therefore these historical estimates do not give an accurate index of the size of the breeding population at a colony.

Trends in Sooty Shearwater numbers washed ashore around New Zealand

It is assumed that the numbers of birds cast ashore during and immediately after a storm are related to the numbers present offshore and to their condition and health when the stormy weather strikes (Powlesland & Imber 1988). Accordingly, the OSNZ Beach Patrol information gives a combined index of numbers and condition. The November peak in Sooty Shearwaters washed up probably coincides with the return of birds to breeding colonies after their migration from the northern hemisphere. The large numbers of Sooty Shearwaters washed up in May coincides with the departure of fledglings from colonies (Powlesland & Pickard 1992).

There were two breeding seasons (October to April) of severe adult mortality at sea, in 1975/76 and 1978/79. Simulation modelling shows that these wrecks had an enormous impact on population trajectories (Hamilton & Moller 1993, 1995). Better understanding of their frequency and intensity will be needed for long-term prediction of changes in Sooty Shearwater numbers.

No censuses have been carried out at the large breeding colonies of Sooty Shearwaters on offshore islands around southern New Zealand. It is not known if these are increasing, decreasing or stable. The lack of any general trend in the abundance of

adult Sooty Shearwaters washed ashore in New Zealand since 1965 suggests that the number of Sooty Shearwaters has not changed significantly over the past three decades. However, opposing trends in the numbers and condition of birds operating simultaneously could obscure any general trends. Also, the Beach Patrol scheme can only provide a very approximate index of changes in population size. More detailed surveys of the breeding colonies themselves will give the best measure of long-term population trends.

Need for accurate baseline information

Methods for surveying and monitoring colonies now need to be standardised and surveys undertaken to gather accurate baseline information about the size and productivity of colonies. Preliminary mathematical modelling suggests that some of the small colonies may not be large enough to persist long-term (Hamilton & Moller 1993,1995). Many assumptions were made from fragmentary data as input for these models. More research on population parameters and threats to colony survival are needed so that breeding colonies of this common seabird can be retained and maintained on the mainland. Threats on land include predation, habitat modification and illegal harvesting of small colonies. Threats at sea may include food shortages, storms and entanglement in fishing nets.

As procellariiform seabirds are long-lived and have slow reproduction (Warham 1990) declines in colonies may be gradual and therefore hard to detect. Monitoring population trends will have to be long-term and using a standardised survey method.

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LITERATURE CITED

BRIGGS, K.T.; CHU, E.W. 1986. Sooty Shearwaters off California: distribution, abundance and habitat use. Condor 88: 355-364.

BROTHERS, N.P. 1984. Breeding, distribution and status of burrow-nesting petrels at Macquarie Island. Aust. Wildl. Res. 11: 113-131.

CLARK, M.K.; DINGWALL, P.R. 1985. Conservation of Islands in the Southern Ocean - a review of the protected areas of Insulantarctica. Discussion document for IUCN's Commission on National Parks and Protected Areas. Dept. Lands and Survey, Wellington, New Zealand.

CLOUT, M.N. 1989. Conservation of New Zealand forest birds - the next decade. Pp 59-61 *in* Management of New Zealand's Natural Estate (D.A. Norton, ed.) N.Z. Ecol. Soc. Occasional Publication No. 1.

COOPER, J.; UNDERHILL, L.G.; AVERY, G. 1991. Primary moult and transequatorial migration of the Sooty Shearwater. Condor 93: 724-730.

COOPER, W. 1984. Solander Island Birds. Notornis 31: 182-183.

DYER, P.K.; HILL, G.J.E. 1991 A solution to the problem of determining the occupancy status of Wedge-tailed Shearwater *Puffinus pacificus* burrows. Emu 91: 20-25.

FALLA, R.A. 1934. The distribution and breeding habits of petrels in northern New Zealand. Auckland Institute & Museum Records 1(5).

HAMILTON, S.A. 1993. Mainland and near-shore islet colonies of Sooty Shearwaters *(Puffinus griseus)* in Otago. Unpublished MSc thesis, University of Otago, Dunedin.

HAMILTON, S.A.; MOLLER, H. 1993. Population Viability Analysis of Sooty Shearwaters *(Puffinus griseus)* for efficient management of predation control, harvesting and long-term population monitoring. Pp 621-626 *in* Proceedings of International Congresss on Modelling and Simulation, December 1993, University of Western Australia, Perth, Australia (M. McAleer and A. Jakeman, eds.).

HAMILTON, S.A.; MOLLER, H. 1995. Can PVA models using computer packages offer useful conservation advice? Sooty Shearwaters in New Zealand as a case study. Biological Conservation 73: 107-117.

IMBER, M.J. 1976. Breeding biology of the grey-faced petrel *Pterodroma macroptera gouldi*. Ibis 118: 51-64.

IMBER, M.J. 1994. Seabirds recorded at the Chatham Islands, 1960 to May 1993. Notornis (Supplement) 41: 97-108.

JACKSON, J.R. 1957. Mortality among nesting muttonbirds near Greymouth. Notornis 7: 184-186.

JONES, E. 1980. A survey of burrow-nesting petrels at Macquarie Island based upon remains left by predators. Notornis 27: 11-20.

NILSSON, R.J.; KENNEDY, E.S.; WEST, J.A. 1994. The birdlife of South East Island (Rangatira), Chatham Islands, New Zealand. Notornis (Supplement 41: 109-125.

POWLESLAND, R.G.; IMBER, M.J. 1988. OSNZ Beach Patrol Scheme: information and instructions. Notornis 35: 143-153.

POWLESLAND, R.G.; PICKARD, C.R. 1992. Seabirds found dead on New Zealand beaches in 1988, and a review of *Puffinus* species recoveries, 1943 to 1988. Notornis 39: 27-46.

POWLESLAND, R.G.; POWLESLAND, M.H; PICKARD, C.R. 1993. Seabirds found dead on New Zealand beaches in 1990, and a review of *Phalacrocorax, Leucocarbo,* and *Stictocarbo* species recoveries, 1943 to 1990. Notornis 40: 27-43.

RICHDALE, L.E. 1942. Whero: island home of petrels and other birds. Emu 42: 85-105.

RICHDALE, L.E. 1944. The Sooty Shearwater in New Zealand. Condor 46: 93-107.

RICHDALE, L.E. 1963. Biology of the Sooty Shearwater, *Puffinus griseus*. Proc. Zool. Soc. Lond. 141: 1-117.

ROBERTSON, L.N. 1976. Mustelids on the Otago Peninsula. Unpublished Postgraduate Diploma of Science Thesis, University of Otago, Dunedin, New Zealand.

TAYLOR, R.H. 1967. Motunau Island, Canterbury, New Zealand: An Ecological Survey. New Zealand Department of Scientific and Industrial Research Bulletin No.178, 56 pp.

WARHAM, J. 1990. The petrels - their ecology and breeding systems. Academic Press, London.

WARHAM, J.; BELL, B.D. 1979. The birds of Antipodes Island, New Zealand. Notornis 26: 121-169.

WARHAM, J.; WILSON, G.J. 1982. The size of the Sooty Shearwater population at the Snares Islands, New Zealand. Notornis 29: 23-30.

WARHAM, J.; WILSON, G.J.; KEELEY, B.R. 1982. The annual cycle of the Sooty Shearwater *Puffinus griseus* at the Snares Islands, New Zealand. Notornis 29: 269-292.

WEST, J.A. 1990. Codfish Island Petrel Survey: 28 March - 9 April 1990. Science and Research Internal Report No. 85, Department of Conservation, Wellington.

WILSON, E. 1979. Titi Heritage, the story of the Muttonbird Islands. Craig Printing, Invercargill, New Zealand.

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