Action Plan for Seabird Conservation in New Zealand

Part B: Non-Threatened Seabirds

THREATENED SPECIES OCCASIONAL PUBLICATION NO. 17

Department of Conservation
Te Papa Atawhai

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Published by
Biodiversity Recovery Unit
Department of Conservation
PO Box 10-420
Wellington
New Zealand

Illustrations

Front cover: Northern diving petrel, North Brothers Island, 1998
Inside front cover: Brown skua, Campbell Island, 1986

Source of illustrations
All photographs were taken by the author unless stated otherwise.

ISSN 1170-3709
ISBN 0-478-21925-3

Cataloguing in Publication
Taylor, Graeme A.
Action plan for seabird conservation in New Zealand.
Part B, Non-threatened seabirds / by Graeme A. Taylor.
Wellington, N.Z. : Dept. of Conservation, Biodiversity
Recovery Unit, 2000.

1. v. ; 30 cm. (Threatened Species occasional
publication, 1170-3709 ; 17.)

Cataloguing-in-Publication data. - Includes bibliographical
references.

ISBN 0478219253

1. Sea birds— New Zealand. 2. Rare birds—New Zealand.
I. New Zealand. Biodiversity Recovery Unit. II. Title.
Series: Threatened species occasional publication ; 17.

CONTENTS

PART A: THREATENED SEABIRDS

13. Introduction to Part B

Part A of *Action Plan for Seabird Conservation in New Zealand* dealt with the conservation needs of threatened seabird taxa. Part B covers those taxa that are not listed as threatened using IUCN criteria (see Appendix 1). The seabird taxa in Part B are arranged in alphabetical order on their scientific names. An index of scientific and common names is provided at the back of this document to help locate the text about each seabird taxon. These remaining seabird taxa fit into four distinct groups.

The first group (Table 7) includes seabird taxa that are at lower risk of extinction than threatened species but are close to falling into the IUCN Vulnerable category. These taxa are listed as Near Threatened by IUCN criteria. Examples include seabirds which may be declining in part of their range but are stable or increasing elsewhere, or where threatening processes are pushing population size and distribution closer to meeting the criteria listed in Appendix 1.

The second group (Table 8) are those taxa considered locally threatened using Molloy & Davis (1992) criteria, i.e. they have small population sizes or a restricted breeding range in New Zealand. These taxa are at risk of disappearing from New Zealand but have large secure breeding populations elsewhere in the world.

The third group (Table 9) includes taxa that are culturally significant to one or more iwi. While most seabird species are important to iwi (including the species already discussed in Part A), the two species in Table 9 have a long tradition of being used by iwi for harvest of chicks. These are the only species of seabirds currently available for this purpose under the Wildlife Act 1953. Neither species is considered threatened by IUCN criteria.

The fourth group (Table 10) includes all remaining taxa listed as Least Concern by IUCN criteria. These are seabird taxa that have large population sizes, widespread breeding distributions, and no evidence of recent declines. Some of these seabirds may have local populations at risk, especially mainland breeding populations, but in general there is little risk of extinction in the foreseeable future.

Note: taxa with equal IUCN and Molloy & Davis rankings are listed in taxonomic order.

TABLE 7. LIST OF 'NEAR THREATENED' SEABIRD TAXA

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Macronectes halli	Northern giant petrel	Near Threatened	Category C
Sterna caspia	Caspian tern	Near Threatened	Category O
Thalassarche melanophrys	Black-browed albatross	Near Threatened	not listed
Puffinus carneipes	Flesh-footed shearwater	Near Threatened	not listed
Eudyptula minor iredalei	Northern blue penguin	Near Threatened	not listed
Eudyptula minor variabilis	Cook Strait blue penguin	Near Threatened	not listed
Eudyptula minor minor	Southern blue penguin	Near Threatened	not listed
Eudyptula minor chathamensis	Chatham Island blue penguin	Near Threatened	not listed

TABLE 8. LIST OF 'LOCALLY THREATENED' SEABIRD TAXA

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Pelecanoides georgicus	South Georgian diving petrel	Least Concern	Category B
Anous stolidus pileatus	Brown noddy	Least Concern	Category O
Gygis alba candida	White tern	Least Concern	Category O

TABLE 9. LIST OF CULTURALLY IMPORTANT SEABIRD SPECIES (NOT THREATENED UNDER IUCN CRITERIA)

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Puffinus griseus	Sooty shearwater	Least Concern	not listed
Pterodroma macroptera gouldi	Grey-faced petrel	Least Concern	not listed

TABLE 10. LIST OF NON-THREATENED SEABIRD TAXA (LEAST CONCERN)

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Puffinus pacificus	Wedge-tailed shearwater	Least Concern	not listed
Puffinus gavia	Fluttering shearwater	Least Concern	not listed
Puffinus assimilis elegans	Subantarctic little shearwater	Least Concern	not listed
Pelecanoides u. urinatrix	Northern diving petrel	Least Concern	not listed
Pelecanoides urinatrix chathamensis	Southern diving petrel	Least Concern	not listed
Pelecanoides urinatrix exsul	Subantarctic diving petrel	Least Concern	not listed
Daption capense australe	Snares Cape pigeon	Least Concern	not listed
Pachyptila turtur	Fairy prion	Least Concern	not listed
Pachyptila desolata banksi	Antarctic prion	Least Concern	not listed
Pachyptila vittata	Broad-billed prion	Least Concern	not listed
Pterodroma nigripennis	Black-winged petrel	Least Concern	not listed
Pterodroma n. neglecta	Kermadec petrel	Least Concern	not listed
Pterodroma lessonii	White-headed petrel	Least Concern	not listed
Pterodroma m. mollis	Soft-plumaged petrel	Least Concern	not listed
Pterodroma inexpectata	Mottled petrel	Least Concern	not listed
Oceanites nereis	Grey-backed storm petrel	Least Concern	not listed
Pelagodroma marina maoriana	New Zealand white-faced storm petrel	Least Concern	not listed
Fregetta t. tropica	Black-bellied storm petrel	Least Concern	not listed
Phaethon rubricauda roseotincta	Red-tailed tropicbird	Least Concern	not listed
Morus serrator	Australasian gannet	Least Concern	not listed
Phalacrocorax carbo novaehollandiae	Black shag	Least Concern	not listed
Phalacrocorax sulcirostris	Little black shag	Least Concern	not listed
Phalacrocorax melanoleucos brevirostris	Little shag	Least Concern	not listed
Stictocarbo p. punctatus	Spotted shag	Least Concern	not listed
Stictocarbo punctatus steadi	Blue shag	Least Concern	not listed
Catharacta antarctica lonnbergi	Brown skua	Least Concern	not listed
Larus d. dominicanus	Southern black-backed gull	Least Concern	not listed
Larus scopulinus	Red-billed gull	Least Concern	not listed
Anous minutus minutus	Black noddy	Least Concern	not listed
Procelsterna a. albivitta	Grey ternlet	Least Concern	not listed

14. Conservation actions required for each non-threatened seabird taxon

This section provides a detailed account of priority conservation actions that are needed for each of the 43 non-threatened seabird taxa breeding in New Zealand. The conservation status, distribution, population size, known and potential threats, and past conservation actions are summarised for each taxon. The future management actions, survey and monitoring needs, and research needs are prioritised for each taxon into categories H, M, and L as described below. Actions and needs within each category are further prioritised, e.g. H1 and H2.

High (H)

This category includes actions that protect seabird taxa from the risk of local extinction or help to define their conservation status. These are important actions that should be initiated within 5 years.

Medium (M)

This category includes actions that help to manage potential threats to lower risk seabird taxa, or improves our understanding of what these threats might be. These are useful actions that should be initiated in the next 10 years.

Low (L)

This category includes actions which improve our knowledge and understanding of seabird taxa, or may contribute long-term conservation benefits. These are desirable actions that could be undertaken in the next 20 years.

15. Non-Threatened Seabird Taxa Profiles

Black Noddy *Anous minutus minutus*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Kermadec Islands (North Meyer, South Meyer, Macauley, Curtis, Cheeseman, and L'Esperance Rock). Elsewhere, black noddies breed on numerous islands off north-east Australia and New Guinea, and tropical and sub-tropical islands in the south-west Pacific Ocean east to the Tuamotu Islands.

Population

The population breeding on the Meyer Islets was considered to be less than 1000 pairs in 1967 (Merton 1970). About 30 pairs nested on L'Esperance Rock in 1970 and there were less than 20 pairs nesting on Cheeseman Island in 1970 (Bell 1970). There were an estimated 50 pairs on Macauley Island in 1988 (Tennyson et al. 1989) and 40 pairs on Curtis Island in 1989 (Tennyson & Taylor 1990a). Elsewhere, large numbers (at least 220,000 pairs) breed on islands off north-east Australia, and there are 1000-10,000 pairs at Norfolk Island (Higgins & Davies 1996).

Threats

Populations on Raoul Island were eradicated by introduced Norway rats, and possibly Pacific rats and feral cats. Pacific rats may restrict the population on Macauley Island to breeding on cliff faces and coastal ledges where rats are scarce or absent (Taylor & Tennyson 1988). Feral goats impacted on colonies on Macauley Island by destroying all trees, which are preferred nest sites. The introduction of new mammalian predators could wipe out populations nesting on these remote islands. Fires may cause temporary losses of nests but are unlikely to impact on the surface-nesting adults. Volcanic activity on Curtis or Raoul Islands could potentially wipe out the colonies nesting on or adjacent to these islands. Human disturbance is unlikely to be a significant threat to this species because the birds nest on inaccessible ledges or in trees.

Previous Conservation Actions

1. Feral goats were eradicated from Macauley Island in 1970.
2. The populations on the Meyer Islets were surveyed in 1966/67 (Merton 1970) and those on Macauley, Cheeseman, Curtis, and L'Esperance Rock were surveyed in 1970, 1988, and 1989 (Bell 1970, Taylor & Tennyson 1988, Tennyson et al. 1989, Tennyson & Taylor 1990a).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the Kermadec Islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

H2. Pacific rats should be eradicated from Macauley Island.

M1. Norway and Pacific rats, and feral cats should be eradicated from Raoul Island.

Future Survey and Monitoring Needs

H1. All islands in the Kermadec Islands should be inspected every 5 years to ensure that rodents and other introduced mammals have not colonised them.

L1. The populations breeding on all islands in the Kermadec Islands should be monitored every 10-20 years. Counts of breeding pairs at each island should be made in November or December.

Research Priorities

L1. The timing of the breeding cycle is poorly known in New Zealand. Information could be obtained from a 1-year study of this species. Monthly visits are needed to the Meyer Islets to record number of birds ashore and number of nests (record if eggs or chicks are present). Nest sites should be marked, and a sample of pairs should be banded to determine if pairs re-nest in the same season.

L2. The diet of the birds at the Kermadec Islands and other Tasman Sea populations is poorly known. Elsewhere, the diet has been studied thoroughly, e.g. Christmas Island, Hawaii. Food samples should be collected and sent to seabird diet specialists (e.g. Dr Mike Imber, DOC, Wellington) whenever the opportunity arises.

L3.The breeding biology of this species has been studied in detail in Australia and elsewhere. The population dynamics of this species (age of first breeding, longevity, survival, and mortality of adults and fledglings) has not been studied, but research is best undertaken on more accessible populations, e.g. islands off Australia. Long-term studies at the New Zealand colonies are not recommended because the populations are small, nest sites are often inaccessible, and the islands are very fragile (dense colonies of burrowing petrels).

Brown Noddy *Anous stolidus pileatus*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: Category O

Distribution

The only New Zealand breeding site is at the Kermadec Islands (Curtis Island). Brown noddies are probably only a recent arrival in New Zealand. Elsewhere, the subspecies breeds on numerous islands, islets, and coral reefs from the Seychelles and Madagascar east to northern Australia, also Polynesia, Hawaii, and Easter Island.

Population

An estimated 25 pairs were nesting on Curtis Island in 1989 (Tennyson & Taylor 1990a).The world population of brown noddies is estimated at 300,000 - 500,000 pairs, mostly subspecies *pileatus* (del Hoyo et al. 1996). At least 100,000 pairs nest in Australian waters (Higgins & Davies 1996).

Threats

Curtis Island is predator-free. Brown noddies are surface nesters and generally choose to nest on inaccessible cliff ledges.Volcanic activity at Curtis Island is the key threat and could potentially wipe out the new breeding colony.The species is vulnerable to predation by feral cats and rats elsewhere in its range and may be at risk if the population expands to other islands in the Kermadec group.

Previous Conservation Actions

1. The population on Curtis Island was discovered in 1989 (Tennyson & Taylor 1990a).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching Curtis Island. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting brown noddies.

L1. Feral cats, Norway and Pacific rats should be eradicated from Raoul Island.

L2. Pacific rats should be eradicated from Macauley Island.

Future Survey and Monitoring Needs

L1. Curtis Island should be monitored every 10 years to determine if the brown noddy population is expanding or stable.

2. Nearby islands (Cheeseman, L'Esperance Rock, Macauley) should be checked every 10 years to determine if the species has colonised these sites.

Research Priorities

L1. Breeding is fairly well known although no major studies have been carried out in the Australasian region. No studies have been conducted on brown noddy population dynamics or social behaviour. Research is not recommended on the New Zealand population because the colony is small and inaccessible, and the island's ground is very fragile (from the dense colonies of burrowing petrels). Studies are best conducted at colonies elsewhere in the breeding range.

Brown noddy, Curtis Island, 1989 (above)

Black noddy, Curtis Island, 1989 (right)

Two species of noddies breed at the Kermadec Islands. Brown noddies only occur at Curtis Island in the New Zealand region. The two species look quite similar. Brown noddies are slightly larger and have a relatively shorter bill compared with black noddies.

Brown Skua *Catharacta antarctica (skua) lonnbergi*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk – Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds in Fiordland (Breaksea Sound, Dusky Sound, Puysegur Point), Solander Islands, Stewart Island and adjacent islands, Chatham Islands (The Sisters, Forty-fours, Mangere, Little Mangere, Pitt, Rangatira, The Pyramid, Star Keys, Rabbit, Murumurus, and Castle), The Snares, Auckland, Campbell, and Antipodes Islands. Elsewhere, breeds on Macquarie, Balleny, Heard, Kerguelen, Amsterdam, St Paul, Crozet, Prince Edward, Marion, South Georgia, Bouvetoya, South Shetland, South Orkney, South Sandwich Islands, and also Antarctica. Birds disperse widely over the Southern Ocean from the pack ice to 30º South.

Population

An estimated 7000 pairs of brown skua occur in the Southern Ocean (Furness 1987). The New Zealand populations are quite small. There are possibly 20-30 pairs around Fiordland and Stewart Island, c.80-90 pairs at The Snares, c.100 pairs at the Auckland Islands, c.100 pairs at Campbell Island, c.50 pairs at Antipodes Island, and c.80-90 pairs at the Chatham Islands (Higgins & Davies 1996, Horning & Horning 1974, Taylor 1986, Young 1994). Populations in the New Zealand region may have declined in the past 50 years. Bailey & Sorensen (1962) referred to hundreds of skuas being in attendance at the rockhopper penguin colonies below Mts Paris and Yvon Villarceau (Campbell Island) in 1942 and many nesting skuas were present around these colonies. The same area had only a few tens of birds present during 1984-87 (G. Taylor unpub.). The vast declines in rockhopper penguins (Cunningham & Moors 1994), albatrosses (Moore & Moffat 1990), and elephant seals (Taylor & Taylor 1989) at Campbell Island since 1942 has presumably affected the food supplies of breeding and non-breeding brown skuas and caused a reduction in their population. Large declines of penguins have also occurred at the Auckland and Antipodes Islands (Cooper 1992, A. Tennyson & G. Taylor unpub.) and these changes may have triggered declines in the brown skua populations although there are no historical counts to determine population trends.

Threats

Brown skuas are an aggressive predatory species. They mostly occur on offshore and outlying islands. There is little evidence that adult skuas are vulnerable to mammalian predators except dogs and feral pigs. Eggs and chicks may be at risk from feral cats, mustelids, and weka. Both domestic and feral cattle and sheep can trample nests, and deer might also damage nests at some locations. Brown skuas are sometimes shot on the Chatham Islands because they scavenge dead sheep and occasionally attack lambs or cast sheep. The large declines in penguin, seal, and albatross populations at some subantarctic islands have possibly caused

declines in skua populations in response to the reduction of their primary food sources. Because skuas are scavengers of carcasses, and are known to consume poison baits, care must be taken to prevent poisoning skua populations during future pest eradication operations.

At sea, brown skuas are occasionally caught on long-lines set for southern blue-fin tuna (Gales et al. 1998), and they may have been killed previously by net-sonde monitor cables used on Russian squid trawlers before these devices were banned in 1992. As a top order, long-lived predator, skuas are potentially vulnerable to accumulating high levels of pollutants such as organochlorine pesticides, PCBs, organic mercury, and cadmium (del Hoyo et al. 1996). There is, however, little evidence as yet that pollutants are having any toxic effect on skua populations in New Zealand. Plastics are sometimes found in pellets regurgitated by skuas. Avian diseases such as avian cholera have killed brown skuas at some colonies overseas and the species is always at risk of avian diseases because they will scavenge eggs, animal corpses, and human refuse.

Previous Conservation Actions

1. Sheep and cattle were removed from Rangatira Island in 1961 and sheep from Mangere Island in 1968.
2. Feral cattle and sheep were eradicated from Campbell Island in 1984 and 1991 respectively.
3. Feral goats were eradicated from Auckland Island in 1995.
4. Feral rabbits, cattle, and mice were eradicated from Enderby Island in 1993 and rabbits from Rose Island in 1993. (This had a temporary negative impact on skua populations because of anticoagulant poisoning but will eventually lead to increased petrel populations on the islands.)
5. The diet and breeding biology of brown skuas were studied on Antipodes Island (Moors 1980).
6. The diet, social organisation, social behaviour, vocalisations, breeding biology, movements, population genetics, and population dynamics of brown skuas have been studied at the Chatham Islands since 1978 by Auckland University researchers (Young 1978, 1994, Young et al. 1988, Hemmings 1989, 1990, Brunton 1982, Flint 1986, Millar et al. 1992, 1994).
7. The distribution of breeding pairs on Campbell Island was mapped and population size estimated in 1984 (Taylor 1986). Pairs associated with rockhopper penguin colonies were colour-banded in 1984-87 (G. Taylor pers. obs.).
8. The taxonomy of brown skuas is still controversial. The New Zealand Checklist (Turbott 1990) and HANZAB (Higgins & Davies 1996) include brown skuas within the species *Catharacta skua*, but recent DNA studies (del Hoyo et al. 1996) have revealed that the northern great skua is more genetically isolated from brown skuas than the three southern hemisphere skua species are from each other. Therefore, Del Hoyo et al. (1996) separate the northern great skua into *Catharacta skua* and place brown skuas within a

southern hemisphere species *Catharacta antarctica* with three separate subspecies.

Future Management Actions Needed

M1. Ongoing advocacy with the Pitt Island community is needed to reduce the incidence of shooting of brown skuas on farmland. The species is currently partially protected by the Wildlife Act. Consideration should be given to raising the protection status to totally protected.

M2. Long-lining techniques need to be improved to reduce the risk to brown skuas by this fishing method.

L1. Norway rats should be eradicated from Campbell Island. (Note: this may cause a temporary reduction in the brown skua population because rats are a food source for skua pairs that breed inland).

L2. Feral pigs and cats should be eradicated from Auckland Island.

Future Survey and Monitoring Needs

H1. The population on Campbell Island should be mapped and counted before any pest eradication operations occur and then be repeated within 5 years of the operation to assess the short-medium term impact of pest removal.

H2. A survey is needed of brown skua populations at the Auckland Islands (especially Auckland, Adams, and Disappointment Islands) to determine distribution of nests and numbers of breeding pairs.

M1.The breeding population on the Chatham Islands should be monitored every 5 years to determine trends in this population.

L1. A survey is needed of brown skua populations in Fiordland and around Stewart Island to determine the distribution and abundance of breeding pairs in this region.

L2. A survey is needed of breeding pairs on Antipodes Islands to accurately estimate the size of this breeding population.

Research Priorities

H1. Research is needed to determine if the populations breeding in each island group or region are genetically isolated from other populations in the New Zealand region. Isolated populations will be slower to recover or at greater risk if pest control operations reduce the number of breeding pairs. Blood should be collected from a sample of birds at each island group to examine the population genetics and extent of population divergence.

M1. The movements of brown skuas outside of the breeding season are poorly known. Populations on Campbell, Auckland, and Antipodes Islands depart to sea during the winter and possibly scavenge food behind tuna long-liners and squid trawlers. The pattern of dispersal of fledgling skuas is unknown. Satellite transmitters (maximum weight 40 g) should be attached to adults and fledglings to determine where they go during the austral winter.

Snares Cape Pigeon *Daption capense australe*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds only at The Snares, Auckland, Campbell, Antipodes, Bounty, and Chatham Islands. Birds have also been observed prospecting at Little Solander Island (Cooper et al. 1986). The distribution at sea is still poorly known owing to the difficulty in separating subspecies *capense* from *australe* at sea. The species forages over seas near New Zealand between 30º and 60ºS but may range further afield in the Southern Ocean.

Population

The total population of this subspecies has been estimated at 5000 to 10,000 pairs (Robertson & Bell 1984). Most of the population breeds at The Snares Islands. There were an estimated 3000 pairs at The Snares Western Chain and 5000 pairs around the main islands of The Snares group in the mid-1980s (Miskelly 1984, C. Miskelly pers. comm. 1999). Imber (1983) estimated a population of 300 pairs at Antipodes Island in 1978. Only a few tens of pairs are considered to breed at each of the Auckland, Campbell, Bounty, and Chatham Islands (Bell 1975, Robertson & van Tets 1982, Clarke 1989, G. Taylor unpub.).

Threats

All New Zealand colonies are on islands free of introduced mammals except those breeding on Campbell and Antipodes Islands. Norway rats are present at Campbell Island, but chicks were reared successfully in 1986/87 on "Folly" Island where these rats also occur (G. Taylor unpub.). Birds nesting on Campbell Island formerly had feral sheep to contend with. Feral cats may have taken a few adults or chicks in the past. Feral cats were formerly present on Campbell Island but may have died out since the mid-1980s (Moore 1997). Mice are present at Antipodes Island but appear to have no effect on Cape pigeon breeding success. Cape pigeons typically nest on steep barren cliff ledges and therefore are not at risk from fires or human disturbance and probably escape the attentions of most mammalian predators.

A few Cape pigeons are caught on southern bluefin tuna long-lines set off New Zealand and in the high seas (Murray et al. 1993, Uozumi 1998). Large numbers of Cape pigeons are attracted to trawlers (Petyt 1995, 1996) but surprisingly few have been reported killed or injured in this fishery (DOC fisheries observer programme unpub.). The species may have benefited overall from the extra food made available from fishing operations. Little is known about the possible effects of pollutants such as plastics, chemical contaminants, and oil spills. The scavenging niche utilised by this species may make it especially vulnerable to pollutants.

Previous Conservation Actions

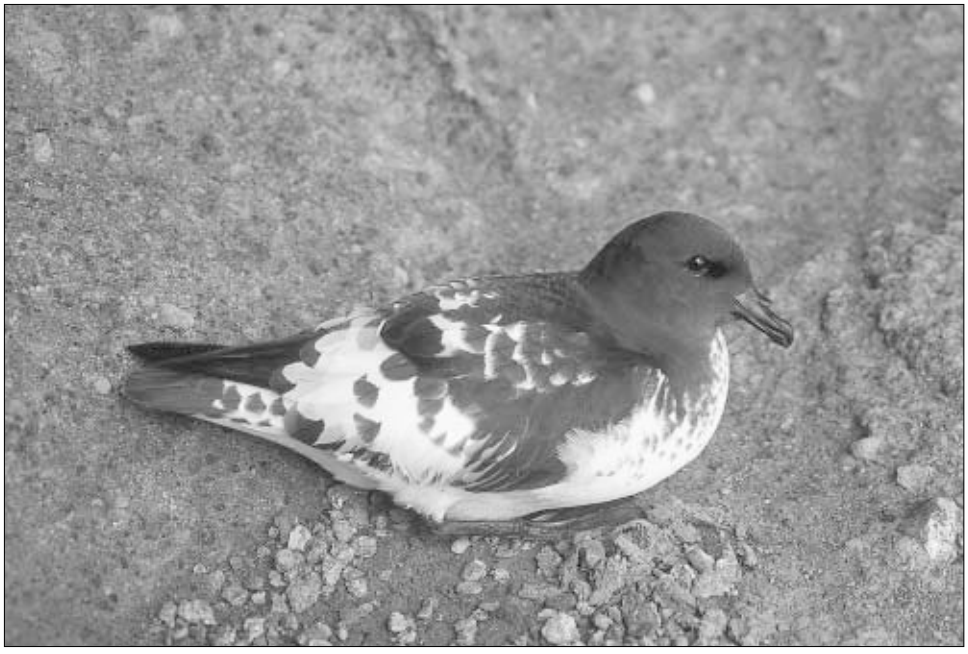
1. A new Cape pigeon colony was discovered at Beacon Rock, Auckland Islands, in 1972 (Bell 1975).
2. The seasonal distribution of Cape pigeons in the Tasman Sea and south-west Pacific Ocean was mapped by Cheshire et al. (1979).
3. The breeding habitat, annual cycle, breeding biology, adult survival rates, and sexual dimorphism of Cape pigeons were studied at The Snares Islands (Sagar 1979, 1986, Miskelly 1984, 1997, Sagar et al. 1996).
4. The population nesting at the Bounty Islands was estimated by Robertson & van Tets (1982).
5. Feral cattle and sheep were eradicated from Campbell Island in 1984 and 1991 respectively. Cape pigeons were observed from the mid-1980s prospecting and/or nesting in caves or on cliff ledges on Campbell Island and adjacent offshore islands (G. Taylor unpub., P. Moore pers. comm. 1999).
6. A population of Cape pigeons was recently discovered breeding at the Forty-Fours and prospecting at The Pyramid (Chatham Islands) (Clark 1989).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

M1. Norway rats should be eradicated from Campbell Island.

M2. Feral pigs and cats should be eradicated from Auckland Island.



Cape pigeon on nest, Campbell Island, 1986

The main breeding ground of subspecies *australe* is at The Snares Islands. About 8000 pairs nested in this group in the mid-1980s. Recently, pairs have begun breeding at the Chatham Islands.

Future Survey and Monitoring Needs

H1. The larger islands with breeding colonies of Snares Cape pigeons should be checked every 5 years to ensure rodents and other introduced mammals have not colonised these islands.

M1. The Snares Island population should continue to be monitored every 5-10 years to establish long-term trends in this population and to collect further information on the population dynamics of this subspecies.

L1. The Forty-Fours, Sisters, and The Pyramid should be checked at 10-year intervals to monitor the establishment of Cape pigeons at the Chatham Islands.

L2. The distribution of Cape pigeons at the Auckland Islands needs further investigation. Currently only one colony is known at Beacon Rock.

L3. A census of Cape pigeon breeding pairs is needed at all islands to give a more accurate assessment of the breeding population in New Zealand.

Research Priorities

L1. The diet of Cape pigeons in the New Zealand region is poorly known. Samples should be collected from birds at breeding colonies whenever the opportunity arises.

L2. When available, satellite transmitters (weighing no more than 10 g) should be attached to breeding birds to determine where they forage during the incubation and chick feeding periods. Transmitters should also be attached to fledglings and adults feeding nearly fledged chicks to determine if these birds leave the New Zealand region after breeding.

L3. The vocalisations of Cape pigeons needs study to determine if sexual and individual differences occur and to describe how these calls function in courtship and nest defence.

L4. The taxonomy of Cape pigeons still needs to be resolved. There are very few differences between the two subspecies, and the birds are not reliably separable except at breeding colonies. A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

Chatham Island Blue Penguin *Eudyptula minor chathamensis*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: not ranked

Distribution

Breeds only at the Chatham Islands (Chatham, Pitt, Rangatira, Star Keys, Mangere, Houruakopara, and Kokope Islands) (Imber 1994). Birds disperse locally near Chatham Islands.

Population

Robertson & Bell (1984) estimated that there were 5000-10,000 pairs of Chatham Island blue penguins. Large numbers breed on Rangatira Island and Star Keys (Imber 1994), but populations on the main islands may be declining.

Threats

Predation by dogs and feral pigs are likely to be the main land-based threat to Chatham Island blue penguins. Unrestrained dogs readily attack and kill adult penguins and chicks in other subspecies (Dann 1998). Feral pigs probably attack penguins when the opportunity arises. Feral cats apparently kill penguins because penguin feathers have been found in cat scats on Chatham Island (Imber 1994). Norway rats may take eggs and small chicks at some nests on Chatham Island. Other rodent species do not appear to be a threat because adult penguins closely guard eggs and chicks. Weka may take eggs and small chicks from some nests on Chatham and Pitt Islands. Possums possibly compete for burrows on Chatham Island. Cattle and sheep could potentially trample a few nests, but usually penguins nest in sites that are not easily damaged (e.g. rock crevices, hollows amongst tree roots). Fires are a risk to penguins especially during the moult (December to February). Chicks are susceptible in some seasons to heavy tick infestations of the inner ear. The chicks are paralysed and eventually killed by the tick infestation (Nilsson et al. 1994).

At sea, most prey items are taken from the sea floor. There is no evidence that commercial or recreational fishing is impacting on penguins directly or affecting prey availability. An oil spill is unlikely at the Chatham Islands but could have a major impact on this subspecies if a spill occurred near the main breeding colonies.

Previous Conservation Actions

1. Sheep and cattle were removed from Rangatira Island in 1961 and sheep were removed from Mangere Island in 1968.
2. Coastal reserves have been fenced from stock on Chatham and Pitt Islands over the past 20 years and have provided more secure nesting habitat for penguins.

3. The social behaviour of Chatham Island blue penguins was studied on Rangatira Island (Waas 1988).

Future Management Actions Needed

M1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

M2. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Dogs pose the greatest risk to blue penguins from dusk to dawn when the penguins move between nests and the sea.

M3. Penguin colonies should be identified as sensitive areas in Tier 1 (site) and Tier 2 (regional) oil spill contingency plans. The plans should contain details of the location and size of all penguin colonies in the area, and the appropriate wildlife response should be planned on this basis.

M4. Ideally, feral cats and weka should be removed from Pitt Island, and feral pigs should be removed from the southern reserves on Pitt Island. These actions will depend on reaching agreements with the local Pitt Island community.

Future Survey and Monitoring Needs

H1. Monitoring of long-term trends is needed at several colonies. Suitable sites include Chatham Island and Mangere Island. Monitoring is best carried out by counting the number of breeding burrows in defined areas. An index of abundance is gained by counting birds coming ashore on beaches at night. Future counts need to be repeated in the same month for comparability of results. Banding and mark-recapture analysis provides a better index of the total numbers of penguins using these landing beaches.

L1. The distribution of Chatham Island blue penguin breeding areas still needs further investigation. All colonies located should be recorded in the National Seabird Colony Register. Priority sites for surveys include most of Chatham and Pitt Islands.

L2. Accurate estimates are needed of the size of Chatham Island blue penguin colonies or numbers of breeding pairs using coastal areas from as many localities as possible. Priority sites include Rangatira, Mangere, and Star Keys.

Research Priorities

H1. The taxonomy of blue penguins is controversial. Six subspecies were described by Kinsky & Falla (1976). However, studies by Meredith & Sin (1988a, 1988b) did not support the separation into subspecies, and their conclusions were adopted by Turbott (1990). Recently the studies by Meredith & Sin have been criticised because they sampled only three of the six subspecies and did not sample penguins over a wide geographic range. A major review of blue penguin taxonomy is needed using modern DNA techniques and a comparison of

plumage, bare part colours, anatomy, body measurements, vocalisations, and body lice.

L1. The breeding biology and breeding cycle of Chatham Island blue penguins are poorly known. Dates of laying, hatching, fledgling, and moult are needed. Information is also needed on aspects of the breeding biology (incubation shifts, incubation period, nestling periods, breeding success) to compare with mainland blue penguin populations.

L2. The diet of Chatham Island blue penguins is unknown. Food samples should be collected whenever the opportunity arises.

Chatham Island blue penguin, Rangatira Island, 1991

Large numbers of Chatham Island blue penguins breed on Rangatira Island and Star Keys but populations on the main islands may be declining. Predation by dogs and feral pigs are likely to be the main land-based threat to Chatham Island blue penguins.

Northern Blue Penguin *Eudyptula minor iredalei*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: not listed

Distribution

Breeds around northern New Zealand from Northland to the Waikato region on the west coast and south to Gisborne on the east coast (Kinsky & Falla 1976). Blue penguins still nest on the mainland coast and on most offshore islands that can be climbed from the sea. The subspecies mainly forages near the coast, but some birds disperse at sea over the continental shelf and slopes.

Population

Robertson & Bell (1984) estimated that there were 5000-10,000 pairs of northern blue penguins. The largest colonies are on the northern offshore islands including Hen and Chickens, Little Barrier, Great Barrier, Mercury, and Aldermen Islands (G. Taylor pers. obs.). The species is susceptible to large mortality events at sea that occur at irregular intervals. Several thousand birds wash up on beaches during these events (Powlesland 1984).

Threats

Predation by mustelids and dogs are likely to be the main land-based threat to northern blue penguins. Ferrets (and probably stoats) take eggs and chicks, and sometimes attack adult blue penguins. Unrestrained dogs have wiped out many blue penguin colonies on the mainland because they readily attack and kill adult penguins and chicks (Dann 1998). Consequently, blue penguin colonies are lost from areas where people with dogs have easy access to the coast. Feral cats may kill adult penguins and chicks. Norway rats could potentially take eggs and small chicks at some colonies. Other rodent species do not appear to be a threat because adult penguins closely guard eggs and chicks. Rabbits and possums may compete for burrows on mainland colonies. Feral pigs may root out burrows and kill nesting penguins at mainland colonies. Cattle, sheep, goats, and deer may trample a few nests but usually penguins nest in sites which are not easily damaged (e.g. rock crevices, hollows amongst tree roots). Fires are a risk to penguins especially during the moult (December to February). The encroachment of coastal settlements on blue penguin habitat is a long-term threat for this species. A few penguins are squashed or injured by cars when crossing roads (Dann 1998).

At sea, blue penguins have frequently been caught in near-shore set nets (Dann 1998, Taylor 1999). The species is unlikely to be captured by trawling or line fishing techniques. Most penguin prey items are taken from the sea floor. There is no evidence that commercial or recreational fishing is impacting on prey availability. Blue penguins mainly eat small shoaling fish such as pilchards and anchovies (Dann 1998). Occasionally there are large ‘wrecks’ of penguins reported on northern beaches (Powlesland 1984). These wrecks appear to be

associated with sustained periods of stormy weather. However, blue penguin deaths could also be associated with temperature related changes which cause spawning failure or die-offs of prey species, biotoxins caused by algal blooms, or increases in land-based viruses such as avian pox or cholera. Little is known about the possible effects of pollutants such as plastics and chemical contaminants. A large oil spill is a key threat to this subspecies. The birds nest in areas with high shipping volume (Auckland, Whangarei, Tauranga) and in close proximity to the oil refinery at Marsden Point. Recent oil spills in Australia (e.g. *Iron Baron* off Tasmania) have shown that blue penguins are the primary victims of oil spills (Hull et al. 1998).

Northern blue penguin, Hen Island, 1987

The subspecies is susceptible to large mortality events at sea that occur at irregular intervals. Several thousand birds wash up on beaches during these events. The cause of these large 'wrecks' of penguins remains unknown.

Previous Conservation Actions

1. Feral pigs were eradicated from Aorangi Island in 1936.
2. Feral cats were eradicated from Cuvier Island in 1964 and Little Barrier Island in 1970.
3. Norway rats were eradicated from the Noises Islands in 1969, 1987, and 1991, Moutohora Island in 1986, Te Haupa (Saddle) Island in 1989, and Rotoroa Island in 1992.
4. Feral goats were eradicated from Cuvier Island in 1961, Moutohora Island in 1977, and Burgess Island in 1973.
5. Rabbits were eradicated from Moutohora Island in 1987, Korapuki Island in 1988, and Stanley Island in 1992.

6. The biology and ecology of northern blue penguins were studied on Tiritiri Matangi Island (Jones 1978).

7. The genetic relationship of northern blue penguins was compared with three other blue penguin populations (Meredith & Sin 1988a). Morphometric comparisons were also made between these penguin populations (Meredith & Sin 1988b).

8. The effect of human disturbance on little blue penguins was studied by Eagles (1998).

Future Management Actions Needed

H1. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Dogs pose the greatest risk to blue penguins from dusk to dawn when the penguins move between nests and the sea. Controlled Dog Areas should be designated at all regionally significant mainland breeding colonies.

H2. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. Restrictions in the use of set nets near blue penguin colonies may be necessary to protect this species.

M1. Penguin colonies should be identified as sensitive areas in Tier 1 (site) and Tier 2 (regional) oil spill contingency plans. The plans should contain details of the location and size of all penguin colonies in the area and the appropriate wildlife response should be planned on this basis.

M2. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

L1. If agreement is reached with the owners, Norway rats should be eradicated from Shoe, Slipper, Mayor, and the Moturua group (near Coromandel). Feral cats, kiore, and pigs should also be removed from Mayor Island.

Future Survey and Monitoring Needs

H1. Monitoring of long-term population trends is needed at several colonies. At least one colony should be monitored in each of the following regions: outer Hauraki Gulf (possibly Lady Alice Island or Hen Island), inner Hauraki Gulf (Tiritiri Matangi), Bay of Plenty (Red Mercury Island or Korapuki Island), and near Gisborne. Monitoring is best carried out by counting the number of breeding burrows in defined areas. An index of abundance can be gained by counting birds coming ashore on beaches at night. Future counts need to be repeated in the same month for comparability of results. Banding and mark-recapture analysis provides a better index of the total numbers of penguins using these landing beaches.

L1. The distribution of northern blue penguin colonies still needs further investigation. All colonies located should be recorded in the National Seabird Colony Register. Priority sites for surveys include small inshore islands in Hauraki

Gulf and Northland, and coastal areas near populated centres. Surveys are best done between June and November.

L2. The size of all northern blue penguin populations is unknown. Accurate estimates are needed from as many breeding localities as possible. Priority sites include northern offshore islands where predators are absent. The populations will need to be sampled using transects and quadrats, banding, and shoreline counts.

Research Priorities

H1. The taxonomy of blue penguins is controversial. Six subspecies were described by Kinsky & Falla (1976). However, studies by Meredith & Sin (1988a, 1988b) did not support the separation into subspecies, and their conclusions were adopted by Turbott (1990). Recently the studies by Meredith & Sin have been criticised because they sampled only three of the six subspecies and did not sample penguins over a wide geographic range. A major review of blue penguin taxonomy is needed using modern DNA techniques and a comparison of plumage, bare part colours, anatomy, body measurements, vocalisations, and body lice.

M1. The foraging ecology and diet of northern blue penguins has not been studied. Movements at sea could be studied using radio transmitters attached to adults during incubation and chick rearing to determine foraging range and dive frequency. Dive depths and dive profiles are unrecorded for this subspecies. Seasonal and annual diet preferences also need research.

M2. The circumstances and possible causes of periodic large die-offs of blue penguins on northern coastal beaches need investigation. Samples of blood and tissues plus freshly dead birds should be autopsied for diseases, viruses, parasites, and toxins.

L1. The breeding cycle and breeding biology has been well studied in other subspecies. Information is needed on the spread of laying, hatching, and fledging dates throughout the geographic range of this subspecies.

L2. Studies on population dynamics are being carried out on other subspecies and are probably not needed on northern blue penguins. Similarly, social organisation and behaviour have been well studied in other subspecies and are a low priority for northern blue penguins.

Southern Blue Penguin *Eudyptula minor minor*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: not listed

Distribution

Breeds on islands and coasts of South Island south of Karamea and Oamaru. Also breeds on Stewart Island and nearby islands in Foveaux Strait. Blue penguins still nest on the mainland at a number of more remote localities and on most offshore islands that can be climbed from the sea. A few protected colonies occur near cities and towns. The species mainly forages near the coast but some birds disperse at sea over the continental shelf and slopes.

Population

Robertson & Bell (1984) estimated that there were 5000-10,000 pairs of southern blue penguins. The only comprehensive survey of this subspecies was carried out in Otago in 1991-92 (Dann 1994). This survey located 2073 breeding pairs between the Waitaki River and Nugget Point. The total population (including immatures) was estimated to be 9300 birds. Comparisons of counts at different areas within the Otago population suggest that penguins have been declining on the mainland except at Taiaroa Head (where regular pest control occurs) (Perriman 1997, Perriman & McKinlay 1995). Populations have also decreased on predator-free islands, and these declines may be linked to events in the marine environment that also impact on numbers of yellow-eyed penguins (Dann 1994).

Threats

Predation by mustelids and dogs are a key threat to blue penguins. Ferrets (and probably stoats) take eggs and chicks and sometimes attack adult penguins. Unrestrained dogs have wiped out many blue penguin colonies. Dogs attack and kill both adult penguins and chicks. Consequently, blue penguin colonies are lost from areas where people with dogs have easy access to the coast (Dann 1998). Feral cats apparently kill adult penguins and chicks. Norway rats apparently take eggs and small chicks at some colonies. Other rodent species do not appear to be a threat because adult penguins closely guard eggs and chicks. Rabbits and possums may compete for burrows on mainland colonies. Feral pigs may root out burrows and kill nesting penguins at mainland colonies. Cattle, sheep, goats, and deer may trample a few nests, but usually penguins nest in sites which are not easily damaged (e.g. rock crevices, hollows amongst tree roots). Fires are a risk to penguins especially during the moult (December to February). Human disturbance is less common at southern blue penguin colonies because this subspecies mostly nests in remote locations. Unfortunately, penguins have been shot near settlements according to media reports. Penguins are most vulnerable when moving between the sea and their burrow. People walking dogs at night in penguin habitat present a risk to this species. A few penguins are squashed or

injured by cars when crossing roads.The encroachment of coastal settlements on blue penguin habitat is a long-term threat for this species.

At sea, blue penguins have frequently been caught in near-shore set nets (Dann 1998). The species is unlikely to be captured by trawling or line fishing techniques. Most prey items are taken from the sea floor. There is no evidence that commercial or recreational fishing is impacting on prey availability. Blue penguins mainly eat small shoaling fish such as pilchards and anchovies (Dann 1998). Little is known about the possible effects of pollutants such as plastics and chemical contaminants. A large oil spill is a key threat to this subspecies. Southern blue penguins nest in areas with moderate-low shipping volume (ports at Timaru, Dunedin, Bluff). Recent oil spills in Australia (e.g. *Iron Baron* off Tasmania) have shown that blue penguins are a primary victim of oil spills (Hull et al. 1998).

Previous Conservation Actions

1. Weka and possums were eradicated from Whenua Hou (Codfish Island) in 1985 and 1987 respectively. Norway rats were eradicated from Ulva Island in 1996.
2. The breeding biology and breeding cycle of southern blue penguins were studied at Otago Peninsula by Gales (1984, 1987). A method of sexing blue penguins by bill measurements was also described (Gales 1988).
3. A comprehensive survey and assessment of the abundance, breeding distribution, and nest sites of southern blue penguins was carried out in Otago in 1991-92 (Dann 1994).This paper also summarises other surveys of breeding blue penguins carried out in the Otago region in the 1980s.
4. The population of blue penguins at Taiaroa Head was monitored to assess number of breeding pairs and breeding success, and to assess the impacts of predation on blue penguin adults and chicks (Perriman & McKinlay 1995, Perriman 1997).
5. Artificial nests have been created for blue penguins at Oamaru and Otago Peninsula. Breeding sites on the Otago Peninsula are partially protected by on-going pest control (primarily for protection of yellow-eyed penguins and northern royal albatross).

Future Management Actions Needed

H1. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Dogs pose the greatest risk to blue penguins from dusk to dawn when the penguins move between nests and the sea. Controlled Dog Areas should be designated at all regionally significant mainland breeding colonies.

H2. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. Restrictions in the use of set nets near blue penguin colonies may be necessary to protect this species.

H3. Regionally important colonies of blue penguins on the mainland should be protected from predators. Artificial nest sites should be provided if the habitat has been modified by human activity.

M1. Penguin colonies should be identified as sensitive areas in Tier 1 (site) and Tier 2 (regional) oil spill contingency plans. The plans should contain details of the location and size of all penguin colonies in the area and the appropriate wildlife response should be planned on this basis.

M2. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

Future Survey and Monitoring Needs

H1. Monitoring of long-term trends is needed at several colonies. Suitable sites include Oamaru, Taiaroa Head, Whenua Hou, and possibly several sites on the West Coast, Fiordland, and Stewart Island. Monitoring is best carried out by counting the number of breeding burrows in defined areas. An index of abundance can be gained by counting birds coming ashore on beaches at night. Future counts need to be repeated in the same month for comparability of results. Banding and mark-recapture analysis provides a better index of the total numbers of penguins using these landing beaches.

L1. The distribution of southern blue penguin breeding areas still needs further investigation. All colonies located should be recorded in the National Seabird Colony Register. Priority sites for surveys include the mainland coasts of West Coast, Fiordland, Southland, and Stewart Island.

L2. Accurate estimates are needed of the size of blue penguin colonies or numbers of breeding pairs in coastal areas from as many localities as possible. Priority sites include Whenua Hou and islands in Foveaux Strait and Fiordland. The populations will need to be sampled using transects and quadrats, banding, and shoreline counts.

Research Priorities

H1. The taxonomy of blue penguins is controversial. Six subspecies were described by Kinsky & Falla (1976). However, studies by Meredith & Sin (1988a, 1988b) did not support the separation into subspecies and their conclusions were adopted by Turbott (1990). Recently the studies by Meredith & Sin have been criticised because they sampled only three of the six subspecies and did not sample penguins over a wide geographic range. A major review of blue penguin taxonomy is needed using modern DNA techniques and a comparison of plumage, bare part colours, anatomy, body measurements, vocalisations, and body lice.

M1. Further research is needed on the impact of mammalian predators on blue penguin populations. In particular, the impacts of mustelids, feral cats, and rodents on blue penguin eggs and chicks should be assessed.

L1.The foraging ecology and diet of southern blue penguins has not been studied. Movements at sea should be studied using radio transmitters attached to adults during incubation and chick rearing to determine foraging range and dive frequency. Dive depths and dive profiles are unrecorded for this subspecies. Seasonal and annual diet preferences also need research. Ideally, studies should be carried out in different parts of their geographic range. Oamaru, Otago Peninsula, Whenua Hou, and Open Bay Islands would be useful sites to study foraging activity.

Cook Strait Blue Penguin *Eudyptula minor variabilis*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: not listed

Distribution

Breeds on islands and coasts of southern North Island from Taranaki and Hawke's Bay south to Wellington. Also breeds on Cook Strait islands and the South Island north of Kaikoura and Karamea (Kinsky & Falla 1976). Blue penguins nest on the mainland at a number of more remote localities and on most offshore islands that can be climbed from the sea. A few breed in Wellington Harbour in an urban environment. The species mainly forages near the coast, but some birds disperse at sea over the continental shelf and slopes.

Population

Robertson & Bell (1984) estimated that there were 5000-10,000 pairs of Cook Strait blue penguins. The largest colonies are found on Motu-o-kura (Hawkes Bay), Matiu/Somes, Mana and Kapiti Islands (Wellington), and islands in the Marlborough Sounds. There are 500-600 pairs on Matiu/Somes Island, and the population has apparently increased since the 1950s (R. Cossee pers. comm. 1998).

Threats

Predation by mustelids and dogs are an important threat to Cook Strait blue penguins. Ferrets (and probably stoats) take eggs and chicks and sometimes attack adult penguins. Unrestrained dogs have wiped out some blue penguin colonies because they readily attack and kill adult penguins and chicks (Dann 1998). Feral cats kill adult penguins and chicks. Norway rats apparently take eggs and small chicks at some colonies. Other rodent species do not appear to be a threat because adult penguins closely guard eggs and chicks. Rabbits and possums may compete for burrows on mainland colonies. Feral pigs may root out burrows on the mainland and kill nesting penguins. Cattle, sheep, goats, and deer may trample a few nests but usually penguins nest in sites which are not easily damaged (e.g. rock crevices, hollows amongst tree roots). Fires are a risk to penguins especially during the moult (December to February). Human disturbance is common at some Cook Strait blue penguin colonies, e.g. Wellington Harbour. People walking dogs at night in penguin habitat present a risk to this species. A few penguins are squashed or injured by cars when crossing roads (Dann 1998).

At sea, blue penguins have frequently been caught in near-shore set nets. The species is unlikely to be captured by trawling or line fishing techniques. Most prey items are taken from the sea floor. There is no evidence that commercial or recreational fishing is impacting on prey availability. Blue penguins mainly eat small shoaling fish such as pilchards and anchovies (Dann 1998). Little is known about the possible effects of pollutants such as plastics and chemical contaminants. A large oil spill is a key threat to this subspecies. Cook Strait blue

penguins nest in areas with moderate-high shipping volume (ports at New Plymouth, Napier, Wellington, Nelson). Recent oil spills in Australia (e.g. *Iron Baron* off Tasmania) have shown that blue penguins are a primary victim of oil spills (Hull et al. 1998).

Previous Conservation Actions

1. Norway rats were eradicated from Titi Island in 1970, Motu-o-kura Island in 1990, and Kapiti Island in 1996. Ship rats were eradicated from Matiu/Somes in 1988.
2. The breeding biology of Cook Strait blue penguins was studied in Wellington Harbour by Kinsky (1960).
3. The genetic relationships of Cook Strait blue penguins was compared with three other blue penguin populations (Meredith & Sin 1988a). Morphometric comparisons were also made between these penguin populations (Meredith & Sin 1988b).
4. A study of blue penguin breeding biology, breeding cycle, productivity, and population dynamics has been carried out on Matiu/Somes Island since 1980 by R. Cossee and M. Wakelin (DOC) and by students from Victoria University (Bullen 1997).
5. Artificial nests have been created for penguins around Wellington Harbour, and breeding sites protected. Publicity and road signs have been used to minimise the number of penguins killed or injured by cars when crossing roads around Wellington Harbour.
6. Sick and injured blue penguins are cared for by an active network of volunteers in Wellington and are released at protected sites.

Future Management Actions Needed

H1. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Dogs pose the greatest risk to blue penguins from dusk to dawn when the penguins move between nests and the sea. Controlled Dog Areas should be designated at all regionally significant mainland breeding colonies.

H2. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. Restrictions in the use of set nets near blue penguin colonies may be necessary to protect this species.

M1. Penguin colonies should be identified as sensitive areas in Tier 1 (site) and Tier 2 (regional) oil spill contingency plans. The plans should contain details of the location and size of all penguin colonies in the area, and the appropriate wildlife response should be planned on this basis.

M2. Secure sites should be established within urban coastal zones to protect blue penguins from human disturbance and predators.

M3. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to

enable a rapid response to any new introductions or events that may cause an introduction.

Future Survey and Monitoring Needs

H1. Monitoring of long-term trends is needed at several colonies. At least one colony should be monitored in each of the following regions: Hawkes Bay (Motu-o-kura), Wellington (Matiu/Somes Island), and Marlborough Sounds (possibly Maud or Titi Islands). Monitoring is best carried out by counting the number of breeding burrows in defined areas. An index of abundance can be gained by counting birds coming ashore on beaches at night. Future counts need to be repeated in the same month for comparability of results. Banding and mark-recapture analysis provides a better index of the total numbers of penguins using these landing beaches.

L1. The distribution of Cook Strait blue penguin breeding areas still needs further investigation. All colonies located should be recorded in the National Seabird Colony Register. Priority sites for surveys include inshore islands in Marlborough Sounds, eastern Wairarapa, and the coast between New Plymouth and Wanganui. Surveys are best done between June and November.

L2. The size of most Cook Strait blue penguin populations is unknown. Accurate estimates are needed from as many breeding localities as possible. Priority sites include Motu-o-kura, Mana, and Kapiti Islands, and islands in the Marlborough Sounds where predators are absent. The populations will need to be sampled using transects and quadrats, banding, and shoreline counts.

Research Priorities

H1. The taxonomy of blue penguins is controversial. Six subspecies were described by Kinsky & Falla (1976). However, studies by Meredith & Sin (1988a, 1988b) did not support the separation into subspecies and their conclusions were adopted by Turbott (1990). Recently the studies by Meredith & Sin have been criticised because they sampled only three of the six subspecies and did not sample penguins over a wide geographic range. A major review of blue penguin taxonomy is needed using modern DNA techniques and a comparison of plumage, bare part colours, anatomy, body measurements, vocalisations, and body lice.

M1. Studies are needed of the homing ability and survival of displaced penguins to develop techniques for recovering penguins after an oil spill.

L1. The foraging ecology and diet of Cook Strait blue penguins has not been studied. Movements at sea could be studied using radio transmitters attached to adults during incubation and chick rearing to determine foraging range and dive frequency. Dive depths and dive profiles are unrecorded for this subspecies. Seasonal and annual diet preferences also need research. The populations on Matiu/Somes, Mana, and Maud Islands would be useful sites to study foraging activity.

L2. The movements at sea of adult blue penguins after the completion of moult (March-May) is unknown. Similarly, the dispersal of fledglings in their first year at sea is unknown. Satellite transmitters (maximum weight 30 g) could be attached to birds to determine long-distance movements during these periods of their life cycle.

Black-bellied Storm Petrel *Fregetta tropica tropica*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Auckland Islands (Adams, Disappointment, and Ewing) and Antipodes Islands. Skeletal remains were found on Dent Island (off Campbell Island) (Robertson 1980). Outside New Zealand limits it breeds at Kerguelen, Crozet, Prince Edward, South Georgia, South Orkney, Signy, Larson, Laurie, and South Shetland Islands. The species disperses widely at sea. In summer, the birds range over Antarctic and subantarctic waters near the breeding colonies, but in winter they move north into subtropical and tropical seas.

Population

The size of the New Zealand populations are poorly known because breeding colonies are cryptic and dispersed in dense vegetation and rocky ground. Robertson & Bell (1984) estimated there were 50,000 to 100,000 pairs in New Zealand. In 1995, 111 birds were captured and banded at Antipodes Island, and the population there appears to be very large, possibly thousands of pairs (M. Imber, G. Taylor & A. Tennyson unpub.). Elsewhere, populations are not considered abundant except at Prince Edward and Elephant Island (South Shetlands).

Threats

Similar to all small petrels, this species is very vulnerable to introduced predators, especially feral cats and rats. Black-bellied storm petrels co-exist with mice at Antipodes Island, but elsewhere they only breed in the absence of introduced mammals. The species was probably extirpated from Auckland Island by feral cats and pigs and possibly from Campbell Island by Norway rats. The main risk to the species today is the chance introduction of mammalian predators to the breeding islands. Fire is a potential risk, especially on Antipodes Island, which can be quite dry during the summer. Visitor impacts on this species are likely to be minimal as all the current breeding grounds are Nature Reserves and have restricted access. The species may be attracted to bright lights on fishing boats, especially on foggy nights (Ryan 1991).

Previous Conservation Actions

1. The species is very poorly known in New Zealand. The only nests with eggs were observed by Edgar Stead at the Auckland Islands in February (Oliver 1955). No studies have been undertaken in New Zealand on this species.
2. The biology of black-bellied storm petrels was studied at Signy Island (Beck & Brown 1971). This study provides details about the breeding cycle, nest sites, calls and social behaviour, and aspects of the breeding biology.

3. Observations of birds seen at Antipodes Island were reported by Warham & Bell (1979) and Imber (1983). A 1995 expedition to Antipodes Island banded 111 black-bellied storm petrels and located concentrations of birds in different areas of the island by nocturnal surveys and spotlighting. No nests were found (M. Imber, G. Taylor & A. Tennyson unpub.).

4. Birds were seen and heard in rocky ground and rock outcrops on Adams Island in 1989 (Buckingham et al. 1991).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the subantarctic islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting black-bellied storm petrels.

M1. Feral cats and pigs should be eradicated from Auckland Island.

L1. Norway rats should be eradicated from Campbell Island.

L2. Mice should be eradicated from Antipodes Island and Auckland Island when appropriate techniques are available.

Future Survey and Monitoring Needs

H1. Each black-bellied storm petrel colony should be checked every 2-3 years to ensure that rodents and other introduced mammals have not colonised these islands. This species is very likely to be eliminated within 3-5 years of predators reaching an island.

L1. A survey is needed on each island of the Auckland Island group to confirm the presence of black-bellied storm petrel colonies and to estimate the size of the breeding populations. Spotlight surveys and tape playback should be used to confirm presence on an island. Ground searches should then be carried out to find nest sites.

L2. A survey is needed of the islands and stacks off Campbell Island between November and March to determine if black-bellied storm petrels breed at the Campbell Islands. (A probable black-bellied storm petrel burrow was found on Monowai Island in 1985 (G. Taylor unpub.).) Methods as for L1 above.

L3. If the opportunity arises, surveys should be carried out on Bollons Island and other small islands off Antipodes Island to confirm if black-bellied storm petrels breed on these islands.

Research Priorities

L1. Black-bellied storm petrels have been poorly studied worldwide and are almost unknown in New Zealand. The breeding cycle is unknown in New Zealand. What months of the year do birds visit the colonies? The laying, hatching, and fledging periods are unknown at all New Zealand sites.

L2. The diet of this species is poorly known throughout its breeding range. There is no information available from the New Zealand region. Samples should be collected whenever the opportunity arises.

L3. The taxonomy of black-bellied and white-bellied storm petrel species is still controversial and needs resolving. In New Zealand the species are fairly distinct and have very separate breeding ranges, but the taxonomy is very confusing in the Atlantic Ocean and Indian Ocean populations.

L4. The breeding biology of this species is unstudied in New Zealand and is poorly known elsewhere. Data are needed on incubation period, incubation shifts, egg sizes, chick growth, and nestling period. Also, the type of nest sites used by this species need investigation.

L5. The population dynamics of this species are unknown. There are no data on age of first breeding, longevity, survival and mortality of adults and fledglings. Antipodes Island is probably the only site in New Zealand where a study of this species could be attempted. However, it would be better to study the species at a site with a permanent base, e.g. at the Antarctic Peninsula colonies or at South Georgia.

White Tern *Gygis alba candida*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: Category O

Distribution

The only New Zealand breeding site is at the Kermadec Islands (Raoul Island). Elsewhere, the subspecies breeds widely on tropical and subtropical islands including islands in the Indian Ocean, Melanesia, central tropical Pacific Ocean, Hawaii, Lord Howe, and Norfolk Islands. Birds disperse widely over tropical and sub-tropical seas.

Population

White terns are apparently scarce at Raoul Island. Two nests were observed in 1966/67 and a maximum of 13 were seen in flight at one time (Merton 1970). Probably less than 50 pairs nest at Raoul Island. Elsewhere, there are 60-100 pairs at Lord Howe Island and 2000-2500 pairs at Norfolk Island. The world population of the species is estimated to be greater than 100,000 pairs with large concentrations at Hawaii, Western Samoa, and the Line and Phoenix Islands (del Hoyo et al. 1996).

Threats

Feral cats kill white terns at Norfolk Island and probably are the main predator at Raoul Island. Norway rats may take eggs and chicks if birds nest near the ground. Pacific rats could potentially remove eggs and chicks from nests in trees and may be a significant threat to this species. Fire would be a major disaster to this species (and the flora of Raoul Island) if it swept through the preferred breeding sites. Volcanic activity could potentially wipe out the species at Raoul Island if a major eruption occurred. Tropical cyclones can cause high breeding failure in some seasons when both eggs and chicks are blown out of trees and onto the ground.

Previous Conservation Actions

1. Feral goats were eradicated from Raoul Island in 1984.

Future Management Actions Needed

H1. Norway and Pacific rats and feral cats should be eradicated from Raoul Island.

H2. Pest quarantine measures are needed to prevent new animal and plant pest species reaching Raoul Island. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential to prevent ship rats establishing on Raoul Island.

Future Survey and Monitoring Needs

H1. A survey of Raoul Island is needed between November and January to estimate the size of the breeding population. Alternatively, a minimum estimate of the total population could be obtained by counting all birds seen in flight on an island-wide census.

Research Priorities

L1. The taxonomy of the *Gygis alba* subspecies still needs further revision. There are four recognised subspecies but del Hoyo et al. (1996) recognises the New Zealand population as part of *G. a. alba* whereas Higgins & Davies (1996) includes it in *G. a. candida*. The New Zealand checklist (Turbott 1990) places the Kermadec Islands birds in subspecies *royana*. Studies using DNA analysis compared with morphology are needed. This work should only be supported if the project involves a major review of the species throughout its range.

L2. The timing of the breeding cycle is poorly known at Raoul Island. Monthly observations are needed to determine which months the species is absent from the islands, dates of return, laying dates, hatching dates, fledging dates, and dates when adults depart.

L3. The social organisation, social behaviour, vocalisations, and moults are not well known from populations breeding in the New Zealand region. Breeding biology has been partly studied but population dynamics are still largely unknown. The New Zealand population would be extremely difficult to study because the population is small, the birds nest in very tall trees, and nest sites are very dispersed on Raoul Island. Research on this species is best undertaken at Norfolk Island or in other populations further afield, e.g. Hawaii.

Southern Black-backed Gull *Larus dominicanus dominicanus*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds widely throughout North, South, and Stewart Islands including numerous offshore islands. The species also breeds at the Chatham, Auckland, Campbell, Antipodes, and Bounty Islands. Birds straggle to The Snares and Kermadec Islands. Elsewhere, breeds in eastern and southern Australia, Macquarie, Heard, Kerguelen, Crozet, Prince Edward, Marion, South Georgia, Falklands, South Shetland, South Orkneys, and South Sandwich Islands, also in Antarctica and South America. Birds disperse over coastal and continental seas, land, lakes, and rivers. Although seldom seen far away from land, the species obviously disperses widely around the Southern Ocean.

Population

There have been no accurate censuses of the total New Zealand breeding population although some breeding colonies are very large (more than 5000 pairs) (Robertson et al. 1984). Robertson & Bell (1984) estimated that there were 1 million+ breeding pairs in New Zealand. Outside of the New Zealand region, the populations are small at most subantarctic islands and in Australia. There are possibly 50,000 to 100,000 pairs in Antarctica, on the subantarctic islands and in South America (del Hoyo et al. 1996). Many New Zealand breeding colonies have been reduced in size by poisoning of birds or through improved management of landfills and disposal of offal. Populations on Canterbury riverbeds have increased markedly in the past 30 years and southern black-backed gulls are now the commonest bird species on some rivers (Maloney 1999).

Threats

Southern black-backed gulls are the only unprotected native bird species in New Zealand. Many gulls are shot, and some colonies are actively controlled by poisoning or egg pricking to limit the impacts of this species on native wildlife or to prevent bird strikes at airports. The species nests on the mainland at beaches, estuaries, sandspits, shellbanks, lake margins, rocky headlands, riverbeds, farmland, roofs of buildings, and mountain-tops. Some colonies occur on predator-free offshore islands. Mustelids (especially stoats and ferrets) and feral cats take eggs and chicks at mainland colonies. Norway rats may also take eggs and chicks at some colonies. Other possible introduced predators include hedgehogs (Sanders 1997). Uncontrolled dogs are a major threat to chicks. Human disturbance is a primary cause of nest failure. Motorbikes and 4WD vehicles on beaches or riverbeds disturb nesting birds and sometimes destroy nest sites (Ell 1999). Flooding of nests by spring tides, storms, and swollen rivers are natural hazards. Some black-backed gulls are caught on recreational fishing

lines, and birds die after swallowing hooks or becoming entangled in the line (Taylor 1996, 1997, 1999). There is no information about the effects of pollutants such as plastics and organochlorines on New Zealand populations of southern black-backed gulls, but chemical residues are likely to be present because birds frequently scavenge food at rubbish tips and sewage outfalls. Avian disease may also be a potential threat to black-backed gull populations.

Previous Conservation Actions

1. The breeding biology, diet, social organisation, behaviour, vocalisations, movements, and aspects of population demography were studied at Matiu/ Somes Island (Fordham 1963, 1964a, 1964b, 1967, 1968, 1970).
2. The social organisation, behaviour, and vocalisations of southern black-backed gulls were studied on Rangitoto Island (Oliver 1973).
3. The vocalisations of southern black-backed gulls were studied by Brunton (1982).
4. The distribution and size of populations nesting on Canterbury riverbeds were surveyed by the New Zealand Wildlife Service (O'Donnell & Moore 1983, Robertson et al. 1983, 1984) and more recently by staff from Project River Recovery (Maloney et al. 1997, Maloney 1999).
5. The movements and status of the populations breeding in the Nelson region were studied in the 1980s by J. Hawkins et al. (results reported in Higgins & Davies 1996).
6. The movements of black-backed gulls in the Bay of Islands and Whangarei region are being studied by the Northland region of OSNZ (D. Crockett pers. comm. 1998).

Future Management Actions Needed

M1. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies.

Note: On-going control of southern black-backed gull populations will probably be needed at a few selected sites to protect populations of threatened species or to reduce the potential impact of gulls prior to species' translocations, e.g. Mana Island.

Future Survey and Monitoring Needs

L1. A national survey of southern black-backed gull colonies is needed. All breeding site records should be stored in the National Seabird Colony Register. Accurate counts of breeding pairs are needed at all localities.

L2. The population trends of southern black-backed gulls should be monitored at several localities. Possible monitoring sites include the Ashburton River, Nelson boulderbank, Matiu/Somes Island, Mana Island, Sulphur Bay (Lake Rotorua), and Rangitoto Island.

Research Priorities

M1. A study is needed to determine the extent of interaction and competition for nest sites between black-backed gulls and other seabirds, especially black-fronted terns and black-billed gulls. In particular, do black-backed gull colonies have negative or beneficial effects on breeding success and availability of nesting habitat of other bird species?

L1. The population dynamics of southern black-backed gulls needs further research. Information is needed on age of first breeding, adult survival rates, juvenile recruitment and survival, natal site fidelity, pair bond fidelity, and species longevity. This research should be carried out in a population living on natural food resources and also on a population where scavenging from human wastes is important. Neither population should be the target of control operations within the next 20 years.

L2. The movements and dispersal of southern black-backed gulls during and after the breeding season needs further attention. Radio transmitters could be attached to breeding adults to determine where they forage during incubation and chick rearing. Attaching transmitters to both adults and their fledglings may also reveal how long fledglings are fed by adults after departure from the nest.

L3. There is much geographical variation in the morphometrics of southern black-backed gull populations within New Zealand. Studies are needed to define any clinal or genetic variation in the populations of this species.

Red-billed gull, Campbell Island, 1986

The red-billed gull has been the subject of a long-term intensive study by Jim Mills at the large Kaikoura colony. This research began in 1964 and has continued until the present day. Large numbers of chicks and adults have been colour-banded at this site, and these banded birds are frequently seen in coastal areas around central New Zealand. (See overleaf.)

Red-billed Gull *Larus scopulinus*

Conservation Status: Endemic species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds widely on offshore islands and coasts of North, South, and Stewart Islands. The species nests inland at Lake Rotorua, North Island. Red-billed gulls also breed at the Three Kings, Chatham, The Snares, Auckland, and Campbell Islands. The subantarctic populations are sometimes considered a separate subspecies *coincidens*. The red-billed gull is often included as a race of the Australian silver gull (*Larus novaehollandiae*). Red-billed gulls disperse over coastal and continental seas and regularly scavenge food from rubbish tips or forage over land.

Population

The distribution and abundance of the breeding populations of red-billed gulls were summarised by Gurr & Kinsky (1965). Colonies were found at 166 sites and Gurr & Kinsky estimated that the total population was about 40,000 breeding pairs. No nationwide survey has been carried out subsequently although the populations at some sites are known to be much smaller than they were in the 1950s and 1960s, e.g. Mokohinau Islands (Hemmings 1988). However, the population at the Three Kings Islands may have increased because 10,000 to 15,000 pairs were thought to be present in 1985 (McCallum et al. 1985) compared with an earlier population estimate of 6000 pairs (Gurr & Kinsky 1965). At the Kaikoura Peninsula, the breeding population increased from 4380 pairs in 1964 to 5678 in 1968 but stabilised at between 5400 and 6400 pairs in the 1970s and 1980s (Mills 1989). Robertson & Bell (1984) estimated that there were 100,000 to 1 million breeding pairs in New Zealand. This estimate now appears too high.

Threats

Red-billed gulls nest on the mainland at sites such as beaches, sandspits, shellbanks, lake margins, and rocky headlands. Many colonies occur on predator-free offshore islands. Introduced predators are an important threat. Mustelids (especially stoats and ferrets) and feral cats take eggs, chicks, and adults at mainland colonies. Norway rats may also take eggs and chicks. Other possible introduced predators include hedgehogs (Sanders 1997). Uncontrolled dogs are a major threat to eggs and chicks. Human disturbance is a primary cause of nest failure. Motorbikes and 4WD vehicles on beaches disturb nesting birds and sometimes destroy nest sites. A few birds may be shot illegally. Recreational activities by people are greatly increasing on the New Zealand coastline. People walking, fishing, sunbathing, swimming or picnicking near red-billed gull nests can also cause nest disturbance and may provide avian predators with the opportunity to take eggs or chicks (Ell 1999). Suitable nesting habitat may have

been limited by the development of seaside resorts on sandspits and coastal headlands. Some red-billed gulls are caught on recreational fishing lines, and birds die after swallowing hooks or becoming entangled in the line (Taylor 1996, 1997, 1999). There is no information about the effects of pollutants such as plastics and organochlorines on red-billed gull populations, but chemical residues are likely to be present because birds frequently scavenge food at rubbish tips and sewage outfalls. Avian disease may also be a potential threat to red-billed gull populations.

Previous Conservation Actions

1. A compilation of red-billed gull breeding colonies was prepared by Gurr & Kinsky (1965).
2. The red-billed gull has been the subject of a long-term intensive study by Jim Mills at Kaikoura. This research began in 1964 and has continued until the present day. Large numbers of chicks and adults have been banded at this site since 1958. The study has examined the breeding biology, social organisation, behaviour, diet, movements, population dynamics, and life-time reproductive biology of red-billed gulls (Mills 1970, 1973, 1979, 1989, Tasker & Mills 1981).
3. The movements and breeding biology of red-billed gulls at Lake Rotorua were studied in the 1960s (Reid & Reid 1965) and in the 1980s (Innes & Taylor 1984, Innes et al. 1999).
4. Observations were reported on the breeding status, aspects of the breeding biology, and diet of red-billed gulls at the Three Kings and Mokohinau Islands (McCallum et al. 1985, Hemmings 1988, Powlesland 1990).
5. Genetic samples were collected for Dr Jim Mills and Dr Alan Baker in 1987/88 from birds at The Snares, Three Kings Islands, Kaikoura, and Australia (Powlesland 1990, C. Miskelly pers. comm. 1998).

Future Management Actions Needed

M1. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Controlled Dog Areas should be designated at all regionally significant mainland breeding colonies.

Future Survey and Monitoring Needs

L1. The population trends of red-billed gulls should be monitored at several sites. Key sites include Kaikoura Peninsula, Nelson boulderbank, Lake Rotorua and Mokohinau Islands. A count of all nesting pairs is needed in November or December.

L2. A comprehensive survey is needed of red-billed gull colonies to compare with the register of colonies prepared by Gurr & Kinsky (1965). All colonies located should be recorded in the National Seabird Colony Register, and estimates made of the number of breeding pairs at each locality.

Research Priorities

L1. The taxonomic status of red-billed gulls is still controversial. Sibley & Monroe (1990) split the New Zealand population into a separate species, but Higgins & Davies (1996) see no justification for this separation and include *scopulinus* as part of *novaehollandiae*. However, *scopulinus* is significantly smaller than *novaehollandiae* in all measurements except toe (Higgins & Davies 1996). Also, specimens from the Chatham Islands have a significantly longer tarsus than mainland birds, and birds from Campbell and Auckland Islands have significantly shorter bills. The subspecies *coincidens* was proposed by Mathews for the red-billed gulls of the New Zealand subantarctic. There is clearly a need to assess geographical variation in this species throughout New Zealand. A review of red-billed gull taxonomy (including *scopulinus*, *novaehollandiae* and *forsteri* on New Caledonia) is also needed using modern DNA techniques and a comparison of plumage, bare part colours, anatomy, body measurements, vocalisations and body lice. (Note: genetic samples were collected in 1987/88 for Alan Baker (Royal Ontario Museum, Canada) from some of these populations.)

L2. The growth rates of red-billed gull chicks have not been assessed. Research is needed to assess the effect of multiple clutches on growth rate and the mechanisms of brood reduction in this species.

Northern giant petrel adult and chick, Campbell Island, 1986

This species often scavenges on corpses in penguin and seal colonies. The birds frequently feed on refuse discarded at sea. Plastic pollution may be an important threat to giant petrels because birds have been found on New Zealand beaches entangled in plastic or starving because of plastic blockages in their gut. (See opposite.)

Northern Giant Petrel *Macronectes halli*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: Category C

Distribution

Breeds at Stewart Island (Nelly Island), Auckland Islands (Enderby, Ewing, Ocean, Disappointment), Campbell Islands (Campbell, Folly Island), Antipodes Island, and Chatham Islands (Forty-Fours, Big Sister, Little Sister). Elsewhere, breeds at Macquarie, Kerguelen, Crozet, Prince Edward, and South Georgia Islands. Birds disperse widely over the Southern Ocean between 30ºS and 64ºS, although most probably forage north of the Antarctic Convergence.

Population

The size of populations in New Zealand is not well known, and estimates are generally based on a single count, some over 30 years ago. There are probably at least 50 breeding pairs at the Auckland Islands (Bell 1975, Taylor 1988), 170 pairs at Campbell Island (A. Wiltshire per P. Moore pers. comm. 1999), 320 pairs at Antipodes Island (Warham & Bell 1979), and about 2000 pairs at the Chatham Islands (Robertson & Sawyer 1994). The current status of the species in New Zealand is uncertain. The recent large counts at the Chatham Islands and the numbers of breeding pairs observed on Campbell Island (higher than any previous estimate) suggest that populations may be stable in spite of substantial declines in their prey species populations, e.g. southern elephant seals (Taylor & Taylor 1989). There were an estimated 7000 - 7500 breeding pairs on the subantarctic islands outside of New Zealand in the 1980s (Croxall et al. 1984).

Threats

There are few land-based threats to northern giant petrels. Feral sheep and cattle possibly disturbed breeding birds on Campbell and Enderby Islands before these pest species were removed from the islands. Northern giant petrels are too large to be affected by rodents. Feral cats possibly kill a few small chicks on Auckland Island and formerly may have killed chicks on Campbell Island. Feral pigs may take eggs or chicks on Auckland Island. Northern giant petrels are sensitive to human disturbance and will sometimes abandon eggs or young chicks if handled or approached too closely by humans (G. Taylor pers. obs.). Brown skuas may then prey on the abandoned eggs or chicks. Fires are a low risk to this surface nesting species, but loss of eggs or chicks could result if fires occurred between September and February.

Small numbers of northern giant petrels have been caught on southern bluefin tuna long-lines set off Australia and New Zealand (Gales et al. 1998, Baird et al. 1998). Birds are also attracted to trawlers when nets are hauled. However, there are no reports of this species being killed by trawler nets or cables (DOC fisheries observer programme unpub.). The large decline of rockhopper penguins and elephant seals at Campbell Island since the 1940s (Cunningham &

Moors 1994, Taylor & Taylor 1989) and also at the Auckland and Antipodes Islands has probably had an impact on food availability for northern giant petrels. This species often scavenges on corpses in penguin and seal colonies, and giant petrel populations would be expected to decline with the concurrent reduction in these animal populations. However, there is little evidence of any decline occurring, which suggests giant petrels were able to locate new food sources. The penguin and seal declines have been attributed to changes in food availability as a result of ocean warming since the 1950s. This same factor may also have had an impact on northern giant petrels. Little is known about the possible effects of pollutants such as chemical contaminants and oil spills. Plastic pollution may be important because several giant petrels have been found on New Zealand beaches entangled in plastic or starving because of plastic blockages in their gut (G. Taylor pers. obs.). The species' scavenging niche may make it vulnerable to pollutants.

Previous Conservation Actions

1. Feral cattle were eradicated from Campbell Island in 1984 and feral sheep were eradicated between 1984 and 1991.
2. Feral goats were eradicated from Auckland Island by 1995. Feral cattle, rabbits, and mice were eradicated from Enderby Island in 1993.
3. Northern giant petrels have been little studied in New Zealand. Nest sites were counted on Antipodes Island in 1969 (Warham & Bell 1979). Chicks and a few adults were banded on Campbell Island between 1960 and 1996 (G. Taylor pers. obs.).
4. The distribution of northern giant petrels on the Forty-Fours was mapped in 1993. A count of nest sites was made in two sample areas and the total population on the island was estimated (Robertson & Sawyer 1994).
5. An opportunistic survey of nesting northern giant petrels was completed on Campbell Island in 1996. The estimate of 173 pairs was the highest count made at this island (A. Wiltshire, P. Moore pers. comm. 1999).

Future Management Actions Needed

M1. There needs to be further development of appropriate mitigation devices or techniques to minimise or eliminate seabird bycatch, especially from long-line fisheries. Liaison with the fishing industry is needed to ensure that incidental bycatch is monitored and to co-ordinate actions to minimise further seabird losses associated with fishing practises.

M2. Feral pigs and cats should be eradicated from Auckland Island.

M3. Norway rats should be eradicated from Campbell Island.

L1. The possibility of establishing a new colony in the Chatham Island group should be considered. Suitable sites might include Mangere Island or the clears on Rangatira Island. Potential establishment techniques would include putting models of giant petrels on these islands, playback of northern giant petrel calls and also transferring chicks to the new colony site. The species has low tolerance

to human disturbance, and sites chosen would need to have restricted access and little human contact.

Future Survey and Monitoring Needs

H1. A census of breeding pairs is needed from all populations in the New Zealand region.

H2. The population on Enderby and Campbell Island should be monitored at 5-year intervals to assess trends in the population. The remaining islands should be censused every 10 years.

Research Priorities

The species has been well studied on subantarctic islands elsewhere in the Southern Ocean and is currently being investigated on Macquarie Island (P. Scofield pers. comm. 1998). However, the biology of northern giant petrels is poorly known in New Zealand.

M1. The diet of northern giant petrels has not been studied at New Zealand colonies although the diet has been studied at Macquarie Island. Seasonal variation in types of foods fed to chicks needs to be determined and also the importance of fisheries waste in the diet. Research is needed to correlate diet with foraging zones (using satellite telemetry) and to determine if there are sexual differences in the type of food items consumed.

M2. The movements of breeding adults should be examined at one or a few New Zealand colonies (Chathams, Campbell?) using satellite telemetry. Research is needed to determine where adults forage during incubation shifts and chick rearing. Sexual differences in foraging range also need to be assessed.

L1. The dispersal of adults, during the non-breeding season, and fledglings still needs further work. This aspect could be studied by satellite telemetry or by banding adults and cohorts of chicks.

L2. The breeding cycle in the New Zealand region is still unknown. Information is needed on laying, hatching, and fledging dates and breeding success at each New Zealand colony. Egg measurements and weights should also be collected. The species' population dynamics have been studied at some other subantarctic islands but have not been determined in New Zealand. A study colony could be monitored on Enderby or Campbell Island to compare adult survival rates at New Zealand colonies with those from other populations.

L3. The vocalisations of northern giant petrels have not been studied in detail. Observations are needed to determine the full range of calls and to identify sexually dimorphic calls or individually recognisable call variations. While this study could be carried out in New Zealand, it is probably best done at an island where southern giant petrels also breed (e.g. Macquarie Island) so that comparisons can be made between the species.

Australasian Gannet *Morus serrator*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds around North and South Islands of New Zealand. Colonies are found at the Three Kings Islands (Hinemoa Rock, Hole-in-the wall, Tutanekai Rock, Arbutus Rock, South west Island), Poor Knights (High Peaks Rocks, Sugarloaf Rocks), Mokohinau Islands (Cathedral Rocks), Great Barrier Islands (Mahuki Island), Coromandel Peninsula/Firth of Thames (Motui Stack, Motukaramarama, Motutakapu, Horuhoru Rock), White Island, North Island west coast (Oaia, Motutara, Muriwai headland, Gannet Island - off Kawhia), Tolaga Bay (Moutara Rock), Cape Kidnappers and Black Rocks, Farewell Spit, Marlborough Sounds (Waimaru Point), and Little Solander Island. Formerly bred in Otago at The Nuggets (B. McKinlay pers. comm. 1998). Elsewhere, the species also breeds at seven colonies in Australia and Tasmania and also at the Norfolk Island group (Phillip, Nepean) (Moore 1999). Birds disperse widely over the continental shelf, including harbours, estuaries, bays, and fiords. Juvenile gannets migrate to Australia and are common off eastern and southern Australia ranging as far west as the Indian Ocean.

Population

The total breeding population was censused in 1980-81 (Wodzicki et al. 1984). There were an estimated 52,664 breeding pairs including 46,004 pairs in New Zealand and 6660 in Australia. The population increased at a mean annual rate of 2.3% between 1946-47 and 1980-81.

Threats

The main threat to mainland gannet colonies is disturbance by dogs and humans. Birds at these mainland colonies become tolerant of humans provided people do not move within the colony. The birds do not appear to be affected by rodents, and there is no information about the impact of feral cats and mustelids on eggs and chicks. Gannets nesting on offshore islands are generally safe from land-based threats although human visitors will sometimes cause the birds to flee nests. When birds stampede, eggs and small chicks are kicked out of nests or taken by gulls. The colony on White Island has to survive periodic volcanic eruptions, and some eggs and chicks are lost in thermal areas. At sea, gannets are sometimes killed in set nets. A few gannets are also caught by line-fishing techniques such as trolling for kahawai. Gannets have been found dead on beaches after swallowing fish hooks or becoming entangled in fishing line (Taylor 1997). The effects of human exploitation of fish stocks are unknown. Gannets tend to take non-commercial fish such as pilchards or small size classes of commercial fish stocks (Marchant & Higgins 1990). Periodic die-offs of pilchards and other fish appear to increase gannet mortality rates. The largest

wreck of gannets on New Zealand beaches was associated with a pilchard die-off event in 1995 (Taylor 1997). Gannets are unlikely to dive into oil spills, but oil can get onto birds resting on the water. Oiled birds transfer the oil to the colony and prevent eggs from hatching. Adults coated with oil also do not survive (del Hoyo et al. 1992).

Previous Conservation Actions

1. The breeding population of this species was censused in 1946-47 (Fleming & Wodzicki 1952) and 1980-81 (Wodzicki et al. 1984).
2. The ecology of this species has been studied extensively in New Zealand at Motukaramarama, Cape Kidnappers, and White Island colonies. The most extensive study was by Waghorn (1982) who looked at diet and energy requirements (Wingham 1985, 1989), social behaviour and vocalisations (Waghorn 1982), breeding biology (Wingham 1984a,b), and population changes at the Motukaramarama colony (Waghorn 1983). The biology of all gannet species is well summarised in Nelson (1978).
3. The population dynamics of this species were studied by Wodzicki & Stein (1958), Wodzicki et al. (1984) and for all gannet species by Nelson (1978). Age of first breeding, natal site fidelity, longevity, adult survival, and chick recruitment are known for this species.
4. The colony at Cape Kidnappers has been monitored to assess the impact of ecotourism on this population. Banding of chicks has been carried out in earlier years (Cossee 1998).
5. The mainland colony at Muriwai Beach (near Auckland) has been fenced to prevent dogs disturbing the colony and to minimise human impacts. This population has been monitored since 1975 with annual counts of breeding pairs taken in October (Greene 1999).
6. Gannets (mainly chicks) are banded at White Island and Farewell Spit to study population dynamics, life expectancy, breeding success, movements, and dispersal patterns in this species (Cossee 1998).
7. Observations were made at the Three Kings Islands gannet colonies in 1985. McCallum et al. (1985) questioned the accuracy of past aerial censuses at the Three Kings because large numbers of nests (>60% on some islands) occurred under dense vegetation. Many of the birds seen on open ground were not associated with nests.
8. An experiment to determine if gannets can be attracted to a new colony location was initiated on Mana Island in 1997. The project uses models and painted bare ground to give the appearance of an active breeding colony. Playback of calls may be trialled in future seasons if visual cues alone do not result in successful establishment of a breeding colony (C. Miskelly pers. comm. 1998).

Future Management Actions Needed

M1. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Controlled Dog Areas should be designated at all mainland breeding colonies.

M2. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. For example, nets set during the day should be attended at all times.

Future Survey and Monitoring Needs

M1. The populations breeding at Muriwai Beach, Cape Kidnappers, White Island, and Farewell Spit should be monitored to assess visitor impacts and to ensure that predators are not having a detrimental impact at these sites. Counts of breeding pairs should be carried out at least every 5 years at the Muriwai and Farewell Spit colonies.

L1. A national gannet census (count of breeding pairs at all colonies) is needed every 20 years. The next census should be carried out in 2000-01 season.

Research Priorities

H1. The current research programme on gannet populations undertaken by Chris Robertson (DOC) should be written up to provide information on population trends and techniques for censusing gannets by photographic means.

L1. Gannets are a well-studied species. Follow-up work could be carried out on banded populations to assess the extent of movements between colonies and for more information on longevity.

L2. The moults of adult and juvenile gannets are insufficiently described. Moult patterns should be studied using banded (known- aged) birds.

L3. Few adult gannets have been weighed. A study of sexual, seasonal, annual, and geographic variation in weights is needed.

L4. The taxonomy of all gannet species still needs further resolving. Australasian gannets are sometimes given specific status as *serrator* and other times considered a subspecies of *bassanus*. The species is also placed in either genus *Morus* or genus *Sula*. A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

Grey-backed Storm Petrel *Oceanites nereis*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Chatham Islands (Rangatira, Mangere, Rabbit, Star Keys, Middle Sister, The Pyramid, Houruakopara, stack and islet east of Houruakopara and possibly Chatham) (Imber 1994), Auckland Islands (Adams, Disappointment, Ewing, Enderby, Ocean, and probably elsewhere), Antipodes Islands (Antipodes and probably all stacks and islands with vegetation), and Campbell Islands (Jeanette Marie, Dent and probably all rodent-free offshore islands and stacks with vegetation). Elsewhere, the species breeds on Macquarie, Kerguelen, Crozet, Prince Edward, South Georgia, Falkland, and Gough Islands. Birds disperse over subantarctic waters but occasionally over warmer sub-tropical waters.

Population

The size of grey-backed storm petrel populations is very difficult to estimate because birds nest under dense vegetation and not in burrows. An estimated 10,000 to 12,000 birds occur at the Chatham Islands with hundreds of pairs on some islands (Marchant & Higgins 1990). No estimates are available from the various subantarctic islands, but there are probably hundreds or perhaps thousands of pairs at each island group. Robertson & Bell (1984) estimated 10,000-50,000 breeding pairs in the New Zealand colonies.

Threats

The species is extremely vulnerable to predation by introduced mammalian predators, especially rats and feral cats. Populations on Campbell Island were presumably extirpated by Norway rats (Bailey & Sorensen 1962, Taylor 1986). Remnant populations on Chatham, Pitt, and Auckland Island are probably restricted to inaccessible sites by feral cats. Browsing mammals also destroy suitable habitat and may crush birds on nests. For example, rabbits and cattle on Enderby Island destroyed tussock grasslands (Taylor 1971), the preferred nesting habitat of this species (Taylor 1988). Grey-backed storm petrels appear to co-exist with mice at Antipodes Island though more observations are needed to determine if mice pose a risk. Recently, Antipodes Island parakeets (*Cyanoramphus unicolor*) were found to kill adult grey-backed storm petrels on the nest (Green 1999). Weka may kill birds attempting to nest on Chatham and Pitt Islands. Grey-backed storm petrels would be very vulnerable to fires both directly and indirectly through loss of nesting habitat. Visitor impacts are likely to be minimal because the birds tend to nest in the centre of dense vegetation, but routine track clearance on some islands (e.g. Rangatira) has exposed nesting birds. The species has been recorded ingesting small plastic pellets when feeding at sea, but it is unknown how this might affect individuals (Imber 1981). The

species may be attracted to bright lights on fishing boats, especially on foggy nights (Ryan 1991).

Previous Conservation Actions

1. Sheep, cattle, and goats were removed from Rangatira Island in 1961, and sheep were removed from Mangere Island in 1968.
2. Studies by Imber (1981) and Plant (1989) at the Chatham Islands looked at the diet and breeding biology (incubation and early chick development).
3. Tennyson (1989) surveyed the distribution and abundance of grey-backed storm petrels on Mangere Island.
4. Rabbits were eradicated from Enderby and Rose Islands in 1993, and cattle and mice were eradicated from Enderby Island in 1993.

Grey-backed storm petrel chick, Rangatira Island, 1991

Grey-backed storm petrels are New Zealand's smallest seabird. They nest in hollow areas under tussock grasses or on the surface under dense shrubby vegetation. Recently, it was discovered that Antipodes Island parakeets kill adult grey-backed storm petrels on their nests.

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore and outlying islands.A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting grey-backed storm petrels.

M1. Norway rats should be eradicated from Campbell Island.

L1. Feral cats and weka should be eradicated from all or part of Pitt Island.

L2. Feral cats and pigs should be eradicated from Auckland Island.

L3. Mice should be eradicated from Antipodes Island and Auckland Island when suitable techniques are available.

Future Survey and Monitoring Needs

H1. Antipodes, Adams, Disappointment, Enderby, Ewing, Rangatira and Mangere Islands should be inspected at least every 3-5 years to ensure that rodents and other mammals have not colonised these islands.

L1. The breeding population on Mangere Island should be monitored at 10-year intervals to determine the status and trends in this population. The methods used should be comparable to those used by Tennyson (1989).

L2. Surveys are needed to determine the distribution and breeding status of this species on all islands and stacks off Campbell Island. Birds may be located by searching for holes into tussock bases, spotlighting at night, listening for calls given from nests or eliciting responses by tape playback of calls.

L3. Surveys are needed to determine the distribution and breeding status of this species on all islands and stacks in the Auckland Island and Antipodes Islands using the methods in L1 above.

L4. Population estimates are needed for Rangatira and Star Keys Islands and also a survey is needed to determine if the species breeds on Little Mangere Island.

Research Priorities

M1. Research is needed to determine the possible impact of Antipodes Island parakeets on the grey-backed storm petrel population at Antipodes Island and also to determine if mice prey on eggs or chicks (and therefore impact on breeding success).

M2. The taxonomy of grey-backed storm petrels is controversial. Formerly included in the genus *Garrodia*, it is now placed in *Oceanites*. The relationship of grey-backed storm petrels with Wilson's storm petrel *Oceanites oceanicus* needs to be assessed using modern DNA techniques and a comparison of anatomy, vocalisations, and body lice.

L1. Research is needed on all aspects of population dynamics (age at first breeding, longevity, survival and mortality of adults and fledglings, natal philopatry, and nest site philopatry). The Chatham Islands are probably some of the most suitable islands to conduct long-term studies on this species. Mangere Island is probably the best site because birds nest under tussocks and their distribution has been mapped by Tennyson (1989).

L2. The breeding cycle and aspects of the breeding biology have been studied. More work is needed, however, to determine the incubation period and chick rearing period, chick growth rates, and adult feeding frequency. No information is currently available on breeding success.

L3. No detailed studies have been done on vocalisations and social behaviour of grey-backed storm petrels. This research could be carried out at the Chatham Islands.

Antarctic Prion *Pachyptila desolata banksi*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Auckland Islands (Auckland, Adams, Enderby, Ewing, Ocean). Elsewhere, breeds at Macquarie, Heard, Kerguelen, Crozet, Scott, South Georgia, South Sandwich, South Orkney, South Shetland, and Elephant Islands. The subspecies may also breed on stacks off Campbell Island, Bouvetoya, and Balleny Islands and on the Antarctic continent. Birds disperse throughout the Southern Ocean in Antarctic and subantarctic water zones between the pack ice and 50º S.

Population

The population at the Auckland Islands was estimated to be between 100,000 and 1 million breeding pairs (Robertson & Bell 1984) although no surveys have been carried out for this taxon. Elsewhere, breeding populations range from a few tens of pairs at the Crozet Islands to 2-3 million pairs at Kerguelen Islands and 22 million pairs at South Georgia (Croxall et al. 1984).

Threats

The introduction of mammalian predators is the greatest threat to prion populations. Feral cats and pigs continue to kill large numbers of prions on Auckland Island (Taylor 1988), and the subspecies is likely to be extirpated from this site in the near future. Norway rats have probably eradicated prions from Campbell Island. On Macquarie Island feral cats, ship rats and weka have had a huge impact on Antarctic prion populations (Brothers 1984). Wild cattle and rabbits on Enderby Island and rabbits on Rose and Macquarie Islands also impacted on this species by crushing burrows and digging out burrows. Prion colonies at the Auckland Islands are usually found on steep banks or under the base of rata trees. Visitors are unlikely to crush burrows in these locations. Large-scale harvest of krill in the Southern Ocean would probably affect prion populations. Prions are easily attracted to bright lights on fishing boats working near breeding colonies. Birds attracted to these boats risk being killed when they hit the superstructure (Ryan 1991).

Previous Conservation Actions

1. Feral goats were eradicated from Auckland Island by 1995, cattle from Enderby Island in 1993, and rabbits and mice from Enderby and Rose Islands in 1993.
2. Cattle and sheep were eradicated from Campbell Island by 1984 and 1991 respectively.

Antarctic prion, Enderby Island, 1988

Feral cats and pigs continue to kill large numbers of prions on main Auckland Island. The status of the New Zealand population is still poorly known. However, the species is not threatened because 22 million pairs breed at South Georgia.

Future Management Actions Needed:

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the subantarctic islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting Antarctic prions.

H2. Feral cats and pigs should be eradicated from Auckland Island.

L1. Norway rats should be eradicated from Campbell Island.

L2. Antarctic prions should be re-established on Campbell Island once Norway rats are eradicated. If populations are found on the offshore stacks, then adults can be lured to the main island using tape play-back of calls. If the species is not found on the islands and stacks off Campbell or the population is tiny, then chicks should be transferred from the Auckland Islands.

Future Survey and Monitoring Needs

H1. All large islands in the Auckland Islands (Adams, Disappointment, Enderby, Ewing) need to be checked at least every 5 years to ensure that rats and other mammals have not colonised these islands.

L1. The distribution of Antarctic prion breeding colonies is still not completely known. All small islands and stacks at the Auckland Islands should be surveyed, and the location of colonies on Auckland and Adams Island should be mapped. The best time to do surveys is during the incubation period (mid-December to mid-January).

L2. All stacks and islands off Campbell Island should be surveyed between November and February if the opportunity arises.

L3. Population estimates are needed from each breeding island but especially from Adams Island.

Research Priorities

L1. The taxonomy of prions needs major revision. The populations breeding at the Auckland Islands have been separated from or lumped with three different subspecies (*alter, macquariensis, banksi*). Some authors have lumped all "broad-billed" prion taxa together (*vittata, salvini, desolata*). All prion species at each group of breeding islands need to be examined by DNA techniques, morphology, anatomy, vocalisations, and lice.

L2. The breeding cycle of Antarctic prions is unknown in New Zealand. The date of arrival back at breeding colonies, spread and peak dates of laying, hatching and fledging, breeding success, and period of absence from breeding colonies need to be determined.

L3. The vocalisations of this species are poorly known. Studies are needed to identify any sexual differences and to determine how birds respond to tape play-back of different types of calls.

L4. The breeding biology of Antarctic prions has not been studied in New Zealand but has been studied at Signy Island by Tickell (1962). The population dynamics are unknown. There are clearly opportunities to study this species at a number of sites with permanent bases outside New Zealand. However, in these large colonies it would prove difficult to get reliable information on juvenile survival and recruitment rates. Enderby Island has a small population of Antarctic prions and may be a suitable site to study the population dynamics of this species.

Fairy Prion *Pachyptila turtur*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breed on numerous islands around New Zealand (including Poor Knights, Stephen's, Trios, Jag Rocks, Sentinel Rock, Brothers, Motunau, Open Bay, Big Solander, Whero, Womens, North [Foveaux Strait], Big South Cape, probably Stage, Kaimohu, Pohowaitai and Tamaitemioko, and other islets and stacks off South Island west coast, Banks Peninsula, Otago Peninsula, and Stewart Island), Chatham Islands (Mangere, Murumurus), The Snares Islands, and Antipodes Island. May breed on stacks or islands off Campbell Island. Elsewhere, breeds on 30 islands and rocks off Victoria and Tasmania (Australia), also Macquarie, Heard, Kerguelen, St Paul, Crozet, Prince Edward, Marion, South Georgia, and Falkland Islands. Birds disperse locally over sub-tropical and subantarctic waters.

Population

Very large numbers of fairy prions breed in New Zealand. Estimates of population size are unavailable for most breeding colonies but about 1 million birds are considered to breed on Stephen's Island (Robertson 1985) and 40,000 pairs on Mangere Island (Tennyson 1989). Robertson & Bell (1984) considered that the total New Zealand population was over 1 million breeding pairs. Elsewhere, the populations vary from a few tens of pairs to tens of thousands of pairs but New Zealand apparently has greater than 50% of the world population (Marchant & Higgins 1990).

Threats

Introduced predators are the greatest threat to fairy prion populations. All remaining colonies in New Zealand are on predator-free islands. However feral cats, pigs, and weka probably extirpated the populations on Chatham and Pitt Islands. Large numbers of fairy prions were killed by cats on Mangere Island, but they quickly recovered once cats died out. Norway rats and cats probably wiped out prion populations on Campbell Island. On Macquarie Island feral cats, weka, and ship rats have extirpated populations from the main island and the species survives only on offshore stacks (Brothers 1984). Weka are having a severe impact on the populations breeding on Open Bay and Big Solander Islands (G. Taylor pers. obs.). Mice appear to have no effect on fairy prions breeding at Antipodes Island. Grazing animals can affect prion populations by crushing burrows. Sheep are farmed on parts of Stephen's Island and may damage shallow burrows on this island. Sheep were formerly grazed on Mangere Island. Rabbits formerly dug out seabird burrows on Motunau Island. Boxthorn (a thorny shrub) ensnares birds at some breeding sites (Cox et al. 1967). Fire is a risk during the breeding season because many colonies are in grassy habitats. On some densely burrowed colonies, trampling of nests is a risk to breeding populations. Visitor

access to breeding sites needs to be strictly controlled to protect birds, especially during October-January. In some seasons, large numbers of dead fairy prions wash up on beaches, apparently the result of severe winter storms or failure of local food supplies (Powlesland 1989).

Previous Conservation Actions

1. Feral pigs were eradicated from Aorangi Island (Poor Knights) in 1936. Harper (1976) carried out research on this population in the 1970s.
2. Richdale (1944c, 1965b) studied the biology of fairy prions nesting on Whero Island.
3. Rabbits were eradicated from Motunau Island in 1962 and boxthorn has subsequently been controlled on the island to prevent birds becoming ensnared. The distribution and abundance of fairy prion burrows were mapped in the 1960s, and large numbers of birds banded (Cox et al. 1967).
4. Grazing areas on Stephens Island have been reduced and areas fenced so that sheep retain open ground for the benefit of tuatara breeding while prion populations are recovering in the ungrazed areas. A study of the relationship between tuatara and fairy prions in different habitat types on Stephens Island was made by Markwell (1998).
5. Sheep were removed from Mangere Island in 1968. Feral cats and rabbits died out on Mangere Island before 1968. Tennyson (1989) studied the breeding biology of fairy prions at Mangere Island.
6. The diet and breeding biology of fairy prions were studied at South Georgia by Prince & Copestake (1990).
7. Large numbers of fairy prions have been banded at Stephen's, Brothers, Motunau, and The Snares Islands between 1960 and 1996 (Cossee 1998).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting fairy prions.

H2. Weka should be eradicated from Big Solander Island.

H3. Ship rats and possibly weka should be eradicated from Big South Cape Island, if the owners of the island are agreeable, and procedures put in place to manage re-invasion risks.

H4. A management plan for the Open Bay Islands should be developed by DOC and the local iwi to address the problem of weka predation on fairy prions (and other species).

L1. Management of weka populations on the Titi (Muttonbird) Islands needs to be discussed with local iwi, especially if there is evidence that fairy prion populations are threatened by weka predation.

L2. Feral cats and weka should be removed from part or all of Pitt Island if suitable agreements are reached with the island residents. Wild sheep, cattle, and pigs should be removed (by fencing?) from areas suitable for establishing seabird colonies.

L3. If safe colony sites are developed on Pitt Island, a tape playback system should be used to lure adult prions to this colony. If necessary, chick translocations may be needed to establish the new colony.

L4. The fairy prion population on the Poor Knights Islands is the only colony known in northern New Zealand. Oliver (1955) stated that the species formerly nested on the Chickens, Great Barrier and Little Barrier Islands. Today, birds are confined to rock crevices on the Poor Knights owing to competition with more aggressive petrel species. A new colony should be established on the Chickens Island (possibly Whatupuke), or perhaps another northern island that has been restored in recent years (possibly Cuvier), by transferring chicks from the Poor Knights and using tape-playback of calls.

L5. New colonies of fairy prions should be restored to former breeding sites or probable breeding sites in the Cook Strait region, e.g. Titi, Mana, Chetwode, Long, Motuara, and Maud Islands using methods as in (L3) above.

Future Survey and Monitoring Needs

H1. Key breeding islands (Poor Knights, Stephen's, Trios, Brothers, Motunau, Mangere, The Snares, and Antipodes) need to be visited at least once every 5 years to check that rodents or other introduced mammals have not established at these islands.

L1. The distribution of fairy prions is still incompletely known in New Zealand. Priority sites for survey are islands and stacks off Stewart Island, coastal Fiordland, west coast of South Island, and coastal cliffs near Dunedin. Fairy prion fledglings with down on their plumage have been caught at Campbell Island in February, strongly suggesting that the species breeds on adjacent rat-free islands and stacks (G. Taylor pers. obs.). These sites should be surveyed in November and December during the fairy prion incubation period. Surveys should also be carried out on the Auckland Islands to determine if this species nests in the group. (It is inexplicable why they are absent here but breed at Snares, Macquarie, Antipodes, and probably Campbell Islands.)

L2. The size of populations breeding at most islands has not been estimated. Quantitative surveys should be carried out at all known colonies to give an accurate estimate of the breeding population.

L3. Monitoring is needed at a few colonies to assess trends in the populations. The colonies on Mangere, Motunau, and North Brothers Islands have had the most accurate surveys carried out in New Zealand. One or all of these sites should be resurveyed every 10 years to determine trends in the breeding populations.

Research Priorities

L1. The ecology of fairy prions is fairly well known. Studies have been done on breeding biology, diet, behaviour, and vocalisations. The population dynamics of this species, however, are still unknown. Information is needed on age of first return, age of breeding, longevity, survival and mortality of adults and juveniles, and natal philopatry. The best sites to collect this information are Motunau Island, Brothers Island, or possibly a small colony on the Otago Peninsula. Potential problems include difficult access to some colonies and difficulty of relocating returning juveniles in the larger colonies.

L2. A taxonomic revision is needed of fairy prion and fulmar prion populations. Confusion has arisen over separation of the species and subspecies in this group based on bill characters, plumage colour, and breeding ecology. A modern analysis is needed using DNA techniques and examination of morphology, plumage, anatomy, vocalisations, and lice from each of the major geographic zones of both fairy prions and fulmar prions.

Broad-billed prion, Rangatira Island, 1992

The largest population of broad-billed prions occurs on Rangatira Island where an estimated 330,000 pairs bred in forested areas in 1990. Broad-billed prions are having a severe impact on the critically endangered Chatham petrel through competition for nesting burrows. (See opposite.)

Broad-billed Prion *Pachyptila vittata*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breed on islands in Fiordland (Wairaki, Hawea and Inner Gilbert in Breaksea Sound; islands in Dusky Sound and Chalky Inlet), Foveaux Strait (Big Solander, Bird, Womens, North, Whero, Whenua Hou [Codfish Island] and adjacent stacks), Stewart Island (Stage, Big South Cape), The Snares Islands (Main Island, Broughton, Alert Stack, Rocky Islet, Toru Islet) and Chatham Islands (Chatham, Pitt, Rangatira, Mangere, Middle Sister, Star Keys, Murumurus, Little Mangere, Kokope, Rabbit, Houruakopara, and Blyth's Stack) (Imber 1994). Elsewhere, breed on Tristan da Cunha and Gough Islands in South Atlantic Ocean. The species feeds over the sub-tropical convergence and disperses northwards in winter.

Population

A common breeding species. The largest population occurs on Rangatira Island where an estimated 330,000 pairs bred in forested areas in 1990 (West & Nilsson 1994, Nilsson et al. 1994). Robertson & Bell (1984) estimated that there were 100,000 to 1 million pairs breeding in New Zealand. The species is considered abundant at Gough Island (Croxall et al. 1984).

Threats

Broad-billed prions are extremely vulnerable to predation by introduced predators. Feral cats, pigs, Norway, ship, and Pacific rats, and weka have destroyed colonies on Chatham Island. Only inaccessible nests on cliffs remain. Feral cats, pigs, and weka have had similar results on the colonies that nest on Pitt Island. Feral cats impacted on the species on Mangere Island, but the population is recovering after the cats died out (Tennyson 1989, 1991). Weka and possibly possums destroyed small colonies on Whenua Hou (E. Kennedy pers. comm. 1996). Broad-billed prion colonies on Solander Island have almost been lost because of weka predation (G. Taylor pers. obs.). Norway rats preyed on the species on Hawea Island before rats were eradicated in 1986 (Taylor & Thomas 1989). Stoats have been observed killing large numbers of adult prions at accessible colonies in Fiordland (B. Thomas pers. comm. 1986), and stoats presumably extirpated formerly large colonies on islands in Dusky Sound that were reported by Richard Henry (Hill & Hill 1987). The impact of ship rats on broad-billed prions at Big South Cape Island has not been assessed but is likely to be catastrophic. Grazing mammals formerly harmed the species by crushing burrows. Cattle and sheep were present on Chatham, Pitt, Mangere and Rangatira Islands. Fire could potentially have a major impact on some colonies especially those on the Chatham Islands. Both Mangere and Rangatira can be very dry in spring or summer. Broad-billed prions visit colonies throughout the year (Nilsson et al. 1994), therefore birds are at risk from fires any time, but are particularly

vulnerable during incubation in September-October. All the large colonies are in very friable soil, and the burrows are easily crushed. Visitor access to these sites needs to be strictly limited to protect the birds, especially during the breeding season (September to December).

Previous Conservation Actions

1. Broad-billed prions were included in a long-term study of seabirds on Whero Island by Lance Richdale. He studied the breeding biology, breeding cycle, and aspects of the species' population dynamics (Richdale 1944a, 1965b).
2. Sheep, cattle, and goats were removed from Rangatira Island in 1961, and sheep were removed from Mangere Island in 1968.
3. Feral cats were eradicated from Herekopare Island in 1970 (Fitzgerald & Veitch 1985).
4. The diet of broad-billed prions at the Chatham Islands was assessed by Imber (1991).
5. Weka were eradicated from Whenua Hou by 1985, and possums were removed by 1987.
6. Norway rats were eradicated from Hawea Island in 1986 (Taylor & Thomas 1989) and Breaksea Island in 1988 (Taylor & Thomas 1993). Prions were banded on Hawea and Inner Gilbert Islands in 1986.
7. The distribution, abundance, and vocalisations of broad-billed prions were studied on Mangere Island (Tennyson 1989).
8. The distribution and abundance of broad-billed prions on Rangatira Island were assessed by West & Nilsson (1994).
9. The breeding cycle, behavioural biology, and nest competition between petrels and prions were studied recently on Rangatira Island by Kerry-Jane Wilson and Nicolette Was (Lincoln University).
10. Pacific rats were poisoned on Whenua Hou in 1998. The success or otherwise of this operation will be known 2 years after the poison operation.

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting broad-billed prions.

H2. Weka should be removed from Big Solander Island.

H3. Ship rats and possibly weka should be eradicated from Big South Cape Island, if the owners of the island are agreeable, and procedures put in place to manage re-invasion risks.

M1. Feral cats and weka should be removed from part or all of Pitt Island if suitable agreements are reached with the residents. Wild sheep, cattle, and pigs should be removed (by fencing?) from areas suitable for establishing seabird colonies.

M2. If safe colony sites are developed on Pitt Island, a tape playback system should be used to lure adult prions to this colony. If necessary, chick translocations may be needed to establish the new colony. These actions may also prove beneficial to the critically endangered Chatham petrels by helping to reduce burrow competition from broad-billed prions on Rangatira Island.

M3. Management of weka populations on the Titi (Muttonbird) Islands needs to be discussed with local iwi, especially if there is evidence that broad-billed prion populations are threatened by weka predation.

Future Survey and Monitoring Needs

H1. Key breeding islands (Rangatira, Mangere, The Snares) need to be visited at least once every 5 years to ensure that no rodents or other introduced mammals have established at these islands.

L1. Monitoring is needed at a few colonies to assess trends in the populations. The colonies on Rangatira, Mangere, and the stack off Whenua Hou have had the most accurate surveys carried out in New Zealand. One or all of these sites should be resurveyed every 10 years to determine trends in the breeding populations.

L2. The distribution of this species is still incompletely known in New Zealand. Priority sites for survey are islands and stacks off Stewart Island and coastal Fiordland. These sites should be surveyed in September and October during the broad-billed prion incubation period. The locations of new colonies should be added to the National Seabird Colony Register

L3. The size of populations breeding at most islands has not been estimated. Quantitative surveys should be carried out at all known colonies to give an accurate estimate of the breeding population.

Research Priorities

H1. The social behaviour and organisation of broad-billed prions are poorly known and need further research to assess the pattern of nocturnal behaviour. In particular, the process by which prions locate and claim burrows needs to be understood to assess the impacts of broad-billed prions on Chatham petrels.

L1. Aspects of the breeding biology (especially incubation period and breeding success) need further study. The population dynamics of broad-billed prions are poorly known. Information is needed on age of first return, age of breeding, longevity, survival and mortality of adults and juveniles, and natal philopatry.

L2. The taxonomy of prions needs major revision. Some authors have lumped all "broad-billed" prion taxa together (*vittata, salvini, desolata*). A modern analysis is needed using DNA techniques and examination of morphology, plumage,

anatomy, vocalisations, and lice from each of the major geographic zones of "broad-billed" prion taxa.

L3. The foraging ecology and movements of broad-billed prions at sea are poorly known. Further work is needed to assess seasonal foraging range and diet preferences.

White-faced storm petrel, Rangatira Island, 1991

The largest colony is on Rangatira Island where an estimated 840,000 breeding pairs nested in the forested parts of the island in 1990. The species is highly vulnerable to introduced predators and several colonies have been lost in the last 100 years. (See opposite.)

New Zealand White-faced Storm Petrel
Pelagodroma marina maoriana

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on a number of islands off North, South, Stewart, Chatham, and Auckland Islands. The species often only breeds on one island in an island group. Colonies are confirmed on Motuopao, Moturoa Islands (Whale), Poor Knights (Aorangi), Mokohinau Islands (Lizard), Noises Islands (Maria), Motuokino and Cow, Little Ohinau, Aldermen Islands (Hongiora), Plate, East, Portland, Sugarloaf Islands (Motumahanga), Cook Strait (Sentinel Rock), Canterbury (Motunau), Foveaux Strait (North, Womens), Stewart Island (Stage), Chatham Islands (Rangatira, Middle Sister, Star Keys, Murumurus, Kokope, Rabbit) (Imber 1994), and Auckland Islands (Ewing and formerly Auckland). The species usually forages over the continental shelf during the breeding season. In the non-breeding season (April to August), birds disperse to the eastern tropical Pacific, with sightings (and a band recovery) between Ecuador and Galapagos Islands (Imber 1994).

Population

This is a very abundant breeding species. Robertson & Bell (1984) estimated there were 1 million+ breeding pairs in New Zealand. The two largest colonies are on Rangatira (840,000 breeding pairs in the forested parts of the island) (West & Nilsson 1994) and Hongiora Islands (10,000 pairs) (G. Taylor & A. Tennyson unpub.). Remaining colonies in New Zealand are smaller. There are only a few pairs at some islands (Plate, Motumahanga, Sentinel Rock), but typically a few hundred to a few thousand pairs at most other breeding sites (Marchant & Higgins 1990, G. Taylor unpub.).

Threats

The species is extremely vulnerable to introduced predators (feral cats, all species of rats, mustelids, dogs, and pigs). Populations have been lost in the past 50 years when predators have reached islands. The subspecies was extirpated from the David Rocks (Noises group) by Norway rats (Cunningham & Moors 1985), Mangere Island by cats (Veitch 1985) and Hamaruru (Cavalli group) by pigs (Millener 1980). The storm petrels have not yet recolonised these islands. The tiny burrows are also very prone to trampling because most colonies are in soft friable soils. Introduction of sheep, cattle, goats, or deer to these islands would prove disastrous. Visitor access to the breeding islands also increases the risk of burrows being trampled or fires occurring. The colonies would be at greatest risk during the pre-laying courtship and incubation periods (September to January). Weeds are considered a problem on some islands. Boxthorn is probably the worst weed problem for small petrels (Cox et al. 1967). On the Chatham Islands, a naturally occurring larval trematode *Distomum filiferum*

picked up at sea sometimes forms shackles on the birds legs that can cause them to become entangled in vegetation on the breeding grounds. In some seasons, thousands of birds have died after being caught in vegetation (Nilsson et al. 1994).The species may be attracted to bright lights on fishing boats, especially on foggy nights (Ryan 1991).

Previous Conservation Actions

1. The subspecies was studied by Lance Richdale on Whero Island in 1940s and 1950s.The breeding timetable and basic breeding biology are reasonably well known (Richdale 1943b, 1965a).
2. Norway rats were eradicated soon after they colonised Maria Island in 1960. This action almost certainly saved this population because on the nearby David Rocks, the population was extirpated by Norway rats (Cunningham & Moors 1985).
3. Sheep, cattle, and goats were removed from Rangatira Island in 1961, and sheep were removed from Mangere Island in 1968.
4. The distribution and abundance of the breeding population on Motunau Island (Canterbury) was mapped and measured in the 1960s but no further work was carried out on population dynamics or breeding biology (Cox et al. 1967). Large numbers of storm petrels were banded from the 1970s onwards.
5. The diet of white-faced storm petrels at the Chatham Islands was assessed by Imber (1981), see also Marchant & Higgins (1990).
6. The movements of white-faced storm petrel populations in the New Zealand region was reviewed by Imber (1984b).
7. Pacific rats were eradicated from Motuopao Island in 1992.This is the only site in New Zealand where white-faced storm petrels and rats were known to co-exist. The storm petrel population on Motuopao Island was surveyed and mapped in 1990-1992 and an estimate made of the breeding population (Pierce & Parrish 1993).
8. Surveys were carried out by West & Nilsson (1994) on Rangatira Island, and the size of the breeding population was estimated.
9. A survey was carried out on Hongiora Island in 1994, and an estimate made of the breeding population (G.Taylor & A.Tennyson unpub.).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore and outlying islands.A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting New Zealand white-faced storm petrels.

M1. Weed control is necessary on several islands with white-faced storm petrel colonies. Boxthorn and mile-a-minute vine need to be eliminated from Maria and Motunau (Canterbury) Islands and pampas from Whale Island (Moturoa group).

L1. Attempts should be made to restore populations of white-faced storm petrels to former breeding islands or to establish new colonies. The subspecies should be easily attracted to tape playback of its own calls because this technique works very well with other storm petrel species (see Podolsky & Kress 1989). Sound units should be set up on headlands and flat ground away from other breeding seabird species. The species could be re-established on David Rocks, Hamaruru and Mangere Islands. New colonies could be considered on islands such as Tiritiri Matangi, Motuora, Stanley, Red Mercury, Middle Chain, Mana, and Pitt Islands. The Pitt Island site will need to be in a predator-proof exclosure to avoid the impacts of feral cats, pigs, and weka.

Future Survey and Monitoring Needs

H1. Each storm petrel colony off northern New Zealand plus Motunau, Rangatira, and Ewing Island should be checked every 2 years to ensure that rodents and other introduced mammals have not colonised these islands. Other islands with storm petrel colonies should be checked every 3-5 years. This species is very likely to be eliminated within 3-5 years of predators reaching an island.

L1. At least one colony in northern New Zealand, Motunau Island (Canterbury), Rangatira Island, and one colony in Foveaux Strait should be monitored every 10 years to determine trends in the populations.

L2. Islands, islets, and stacks in the Foveaux Strait/Stewart Island region need surveying to determine which sites still support storm petrel colonies. Islands with rats, cats, and weka are unlikely to retain storm petrel populations.

L3. Population sizes of most white-faced storm petrel breeding colonies are poorly known. Each island listed above should be surveyed to estimate the size of the breeding population.

Research Priorities

L1. Taxonomy of the white-faced storm petrel group (*P. marina* subspecies) needs further resolving to determine the extent of divergence of the populations breeding in Australia, Kermadec Islands, northern and southern New Zealand, Chatham Islands, and Auckland Islands. If samples are available, the races breeding on Tristan da Cunha, Salvages, and Cape Verde Islands in the Atlantic Ocean should also be included in this analysis. The comparison should preferably use DNA techniques, but a reappraisal of external morphological and skeletal characteristics is also needed. If subspecific characters are revealed by DNA analysis, then samples of the storm petrel bones from Norfolk Island should be tested to determine which subspecies they belong to.

L2. The population dynamics (age at first breeding, longevity, survival, and mortality of adults and fledglings) are unknown in this subspecies. This is best studied at a small colony. A suitable site is Motunau Island (Canterbury) where there is a long history of banding birds. The colony on Maria Island is also accessible and would be suitable for a similar project.

L3. The breeding timetable for white-faced storm petrels needs to be determined in each region because apparently the dates of return to the colony, times of laying, hatching, and fledging chicks varies around the country.

L3. The calls of this species are poorly understood. A study is needed to determine if sexual differences occur and to see which groups of birds respond to tape playback (both sexes? juveniles only?). This will be helpful when establishing colonies of this species by tape attraction techniques.

South Georgian diving petrel, Whenua Hou, 1991

This species formerly nested in sand-dunes in many sites around southern New Zealand. Today, the species is confined to Whenua Hou (Codfish) Island. The total New Zealand population is about 100-200 birds. (See opposite.)

South Georgian Diving Petrel *Pelecanoides georgicus*

Conservation Status: Indigenous species

IUCN rank: Lower Risk -Least Concern

Molloy and Davis rank: Category B for "Codfish Island" population

Distribution

Breeds only at Whenua Hou (Codfish Island) in the New Zealand region. Formerly, the species bred at the Auckland Islands (Enderby, Dundas), Stewart Island, and probably Chatham Islands (Worthy 1998). May also have formerly bred at Campbell and Macquarie Islands. Elsewhere, breeds at Heard, Kerguelen, Crozet, Marion, Prince Edward, and South Georgia Islands. The distribution at sea is unknown owing to confusion with common diving petrels. The species possibly feeds over the edge of the continental shelf.

Population

There were 30-40 breeding pairs at Whenua Hou between 1978 and 1991 (West & Imber 1989, G. Taylor & A. Tennyson unpub.). By 1998, there were 64 burrows in use, indicating an increasing trend (M. Imber pers. comm. 1999). The total New Zealand population is therefore about 100-200 birds. Elsewhere, the breeding populations are very large. There are estimated to be millions of pairs breeding at Kerguelen, Crozet, and South Georgia Islands (Marchant & Higgins 1990).

Threats

The main threat to South Georgian diving petrels at Whenua Hou is human disturbance of the breeding colonies. People walking through the dunes behind Sealers Bay could seriously damage the extremely fragile habitat, and burrows could be collapsed or buried under sand, possibly entombing adult birds. The introduction of mammalian predators would also have a serious impact on the breeding colonies. Feral cats, mustelids, ship rats, and Norway rats could potentially wipe out the colony within 3-5 years because fledglings return to natal colonies at 1-2 years of age and adults visit burrows for 8-10 months of the year (Payne & Prince 1979). Pacific rats occurred until recently on Whenua Hou, but there was no measurement of their impact on South Georgian diving petrels. These rats take both eggs and chicks of common diving petrels and have a serious impact on the breeding success of that species (G. Taylor pers. obs.). The South Georgian diving petrels breed in sand dunes just behind the beach and possibly this habitat was less commonly used by Pacific rats. Prior to their eradication in 1985, weka may have affected South Georgian diving petrels. The first specimens of South Georgian diving petrels in New Zealand were collected from Enderby Island in 1840. Human settlement on Enderby Island last century and the former presence of feral pigs on that island probably had a major impact on the population. Rabbits and cattle may have contributed to the decline by trampling or digging out burrows. The population on Dundas Island apparently was eliminated by the increase in Hooker's sealion populations over the past 100 years (Falla et al. 1979).

At sea, fine mesh monofilament set nets may be a risk to this species if placed near breeding colonies. Oil spills could have a serious impact on this species if they occurred near Whenua Hou or the main feeding grounds. Diving petrels are easily attracted to bright lights and birds have been killed by crashing into brightly lit ships at sea (Warham 1990, Ryan 1991).

Previous Conservation Actions

1. Weka and possums were eradicated from Whenua Hou by 1985 and 1987 respectively.
2. South Georgian diving petrels were only discovered breeding at Whenua Hou in 1978 (Imber & Nilsson 1980) although diving petrels had been recorded nesting in the dunes since 1948. Counts of burrows in 1978 (West & Imber 1989) and in 1991 (G. Taylor & A. Tennyson unpub.) indicated a population of about 30-40 breeding pairs. A recent count in December 1998 found 64 burrows were in use (M. Imber pers. comm. 1999). Access to the dune breeding habitat has been discouraged to minimise impacts to the breeding population.
3. Blood samples, feather lice, and measurements were taken from a small sample of birds in 1991 for taxonomic comparisons with other diving petrel species (A. Patterson pers. comm. 1991).
4. Skeletal bone deposits were excavated at Mason's Bay on Stewart Island. These confirmed the former presence of South Georgian diving petrel colonies on Stewart Island (Worthy 1998). Several bones collected on Chatham Island were also similarly identified to indicate that breeding probably occurred there in the past (Worthy 1998).
5. Pacific rats were poisoned on Whenua Hou in 1998. The success or otherwise of this operation will be known 2 years after the poison operation.

Future Management Actions Needed

H1. A restriction on access to the dunes behind Sealers Bay on Whenua Hou needs to continue to minimise the human impacts on the fragile petrel breeding habitat.

H2. Pest quarantine measures are needed to prevent new animal and plant pest species reaching Whenua Hou. The pest contingency plan for the island will enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting South Georgian diving petrels.

M1. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. Restrictions in the use of set nets near Whenua Hou may be necessary to protect this species. No overnight net-setting is recommended off Whenua Hou.

Future Survey and Monitoring Needs

H1. The population on Whenua Hou needs to be monitored regularly to determine changes in the population following the removal of Pacific rats. The location of each burrow should be marked with a permanent stake and individually numbered.The distribution of burrows in the colony also needs to be mapped so that new burrows can be readily identified. An annual survey is needed to locate any new burrows plus a monitoring programme to determine activity at each known burrow. Burrows should be checked for activity in December (probable time of incubation) and again in February (probable time of chick departure). At the February inspection, the burrow entrance should be lightly fenced and checked for down to confirm if breeding has been successful.

L1. A survey is necessary on Enderby and Dundas Islands (between November and January) to confirm that South Georgian diving petrels are in fact extinct at these sites.All diving petrel burrows should be inspected and birds spotlighted at night.Tape recordings of South Georgian diving petrel calls should be played to ellicit a response.A study of skeletal bone deposits would also be useful at Sandy Bay on Enderby Island to determine the former abundance of breeding seabirds on this island prior to human settlement and the introduction of mammals.

L2. Adams Island needs surveying to determine if South Georgian diving petrels nest at high altitudes as they do on other subantarctic islands. Rock outcrops or rock screes and low fellfield type vegetation, e.g. lichens and moss hummocks, should be searched.

L3. Skeletal bone deposits should be excavated at suitable sites on Campbell Island (e.g. Sandy Bay, Capstan Cove) to determine if South Georgian diving petrels formerly nested on Campbell Island.

Research Priorities

H1.The taxonomy of diving petrels in the New Zealand region still needs to be resolved.The South Georgian diving petrels breeding at Whenua Hou need to be compared with all subspecies of common diving petrels in New Zealand and with the nearest extant populations of South Georgian diving petrels (Heard Island and Kerguelen Islands).A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

L1. Study of the diet and breeding biology of South Georgian diving petrels should not be carried out at Whenua Hou unless there is a substantial increase in their population.The birds nest in very fragile habitat, and inspections of the nest chambers would be very risky. Also the species may be sensitive to handling (especially breeding birds).Therefore, information will need to be collected from the larger populations in the Indian and South Atlantic Oceans. If the Whenua Hou population begins to decline (reduction in breeding burrows), it may be necessary to capture some adults and chicks at burrow entrances to determine if the decline is caused by low adult survival rates or lack of chick recruitment. In the short term, an assessment of the practicality of banding cohorts of chicks could be investigated. Chicks could probably be captured outside burrow entrances in February, just prior to fledging.

Southern Diving Petrel *Pelecanoides urinatrix chathamensis*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on islands around Foveaux Strait and Stewart Island including Little Solander, Big Solander, Whenua Hou (Codfish Island) and adjacent stacks, North, Womens, and Big South Cape. Probably breeds on Stage, Kaimohu, Pohowaitai, and Tamaitemioko. Formerly nested in immense numbers on Herekopare Island, but feral cats and weka extirpated this population (Fitzgerald & Veitch 1985). Similarly, the population on Jacky Lee Island appears to have been lost to weka predation. Small dark feathers and diving petrel size burrows were found on Wharekakahu Island off Otago Peninsula in 1990 (G. Taylor pers. obs.). Possibly diving petrels nest on this island. The subspecies also breeds at The Snares Islands and possibly on The Snares Western Chain. At the Chatham Islands, breeding has been confirmed on Rangatira, Murumurus, Star Keys, Middle Sister, Rabbit, and Houruakopara (Imber 1994). A few diving petrels may also nest on inaccessible ledges on Chatham and Pitt Islands. The dispersal of birds at sea is poorly known, but the subspecies probably stays over continental shelf waters near the breeding colonies.

Population

The total breeding population of southern diving petrels in New Zealand was thought to be between 100,000 and 1 million pairs (Robertson & Bell 1984). The largest population is on Little Solander Island. Cragg and Johnson (in Cooper et al. 1986) estimated there were 250,000 to 300,000 pairs on this 8 ha island based on two plots with burrow densities of 6 burrows per square metre. The subspecies is also abundant on The Snares Islands (probably tens of thousands of burrows) and Rangatira Island where 164,000 pairs were estimated by West & Nilsson (1994). There are no trends known in the total breeding population, but individual colonies are possibly stable if free of introduced predators.

Threats

The main threat to diving petrels is the introduction of mammalian predators at breeding colonies. The subspecies is absent on islands with feral cats, ship rats, and Norway rats and some islands with weka. Diving petrel colonies can be destroyed by predators within 3-5 years because fledglings return to natal colonies at 1-2 years of age and adults visit burrows for 8-10 months of the year (Richdale 1965a). Feral cats extirpated diving petrels from Mangere and Herekopare Islands (Veitch 1985, Fitzgerald & Veitch 1985), and weka have all but eliminated the population on Big Solander Island (Cooper et al. 1986). The fate of diving petrels on Big South Cape Island has not been documented, but the species is quite likely to be extinct there after 30 years of ship rat colonisation.

Pacific rats take both eggs and chicks of diving petrels and have a serious impact on breeding success (G. Taylor pers. obs.). However, a few chicks have been reported fledging from islands that have Pacific rats present. Sheep and cattle probably trampled large numbers of burrows on Rangatira Island prior to their removal. These species plus feral pigs have presumably contributed to populations disappearing from Chatham and Pitt Islands. Human disturbance of breeding colonies can have a serious impact on diving petrels because the burrows are short, shallow and easily damaged. Harvesting muttonbirds on the islands around Stewart Island may have an indirect impact on this species by damaging its burrows. Fire can be a risk because the species visits breeding colonies for most of the year. Rangatira is probably the island at greatest risk of fire damage. Competition for nest sites with other small petrel species (especially fairy prions and broad-billed prions) may have an impact on breeding success (Richdale 1965a). Stewart Island shags have destroyed the vegetation on Whero Island and are doing the same on Wharekakahu Island (Watt 1975, G. Taylor pers. obs.). This may remove all suitable nesting sites on these islands because the loss of vegetation inevitably leads to a loss of soil cover. Fine mesh monofilament set nets may be a risk if placed near breeding colonies. Diving petrels are easily attracted to bright lights, and birds have been reported crashing into brightly-lit buildings near breeding colonies or onto ships at sea (Warham 1990, Ryan 1991).

Previous Conservation Actions

1. Southern diving petrels were included in a long-term study of seabirds on Whero Island carried out by Lance Richdale. He studied the breeding biology, breeding cycle, and aspects of the subspecies' population dynamics (Richdale 1943a, 1945b, 1965a).
2. Sheep, cattle, and goats were removed from Rangatira Island in 1961.
3. Feral cats were eradicated from Herekopare Island in 1970 (Fitzgerald & Veitch 1985).
4. Weka and possums were eradicated from Whenua Hou by 1985 and 1987 respectively.
5. The distribution and abundance of diving petrel burrows on Little Solander Island were estimated by Cragg and Johnson (in Cooper et al. 1986).
6. The distribution and density of burrows on Rangatira Island were surveyed by West & Nilsson (1994).
7. Pacific rats were poisoned on Whenua Hou in 1998. The success or otherwise of this operation will be known 2 years after the poison operation.

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting southern diving petrels.

H2. Weka should be eradicated from Big Solander Island.

H3. Ship rats and possibly weka should be eradicated from Big South Cape Island, if the owners of the island are agreeable, and procedures put in place to manage re-invasion risks.

M1. Access restrictions to Little Solander, The Snares, and Rangatira Islands need to be maintained to minimise the risk of fires occurring during the breeding season and to prevent rodents or other predators establishing on the islands. Limiting visitor access to all islands with large diving petrel populations is desirable to minimise the trampling of burrows.

M2. Management of weka populations on the Titi (Muttonbird) Islands needs to be discussed with local iwi, especially if there is evidence that southern diving petrel populations are threatened by weka predation.

L1. Ideally, feral cats and weka should be removed from part or all of Pitt Island if suitable agreements are reached with the residents. Wild sheep, cattle, and pigs should be removed (by fencing?) from areas suitable for establishing seabird breeding colonies.

L2. Consideration should be given to re-establishing southern diving petrels on Mangere Island. Chicks would need to be transferred to these sites (from Rangatira Island) and tape playback used to lure returning birds to the colony.

Future Survey and Monitoring Needs

H1. Islands with large breeding colonies should be inspected at least every 2-3 years to ensure that rodents and other mammals have not colonised these islands. Other islands should be inspected whenever the opportunity arises but preferably at least once every 5-10 years.

H2. Negotiations should be held with the owners of Big South Cape Island to seek permission for a survey of small burrowing petrels. A survey between July and December would best determine the status of southern diving petrels (and other small spring-nesting seabird species) on this island.

M1. The population on Whenua Hou should be monitored after rat eradication to measure changes in the distribution of colonies and potential impacts on South Georgian diving petrels.

L1. The distribution of southern diving petrels on islands in Foveaux Strait and around Stewart Island is still poorly known. Visits to these islands should occur between July and December. Information needed is confirmation of breeding status of diving petrels, whether weka or introduced mammals are also present, and order of magnitude estimates of diving petrel abundance.

L2. An accurate estimate is needed of the southern diving petrel population on The Snares Islands using transects and quadrats.

L3. The population on Little Solander Island should be reassessed and several transects taken to determine variation in burrow density. Burrow occupancy rates also need to be established. The survey should be done between October and December.

L4. The presence or absence of diving petrels on Wharekakahu Island needs to determined.

Research Priorities

L1. The taxonomy of diving petrels in New Zealand still needs to be resolved. Northern diving petrels and southern diving petrels have recently been combined in the 1990 OSNZ checklist (Turbott 1990) although there are significant differences in measurements between these populations (Marchant & Higgins 1990). Comparisons are also needed with subantarctic diving petrels and South Georgian diving petrels. A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

L2. The population dynamics of this subspecies were studied by Lance Richdale, but further research is needed. The estimates of adult survival obtained by Richdale (1965a) appear to be too low. Information is needed on longevity, adult survival rates, survival and mortality of juveniles, recruitment of chicks, and natal philopatry. Research is best done on Whenua Hou, Rangatira, or possibly a small accessible island off Stewart Island. This subspecies will be very difficult to study because colonies are typically large and nests are in friable soil or burrows are very sparse and difficult to locate.

L3. The diet of southern diving petrels is unknown. Food samples should be collected from birds whenever the opportunity arises. Studies are needed to see whether the populations on islands near Stewart Island and The Snares Islands share a similar diet with birds breeding at the Chatham Islands and whether there are differences in food items delivered to chicks by males or females.

L4. The foraging range and movements of diving petrels at sea could be studied in two ways. If the birds stay within 30-50 km of the colony miniature radio transmitters can be attached and activity monitored from high points near breeding colonies. If the birds move further offshore satellite transmitters will be needed. However, the satellite transmitters must weigh no more than 3-5 g and, once available, should be attached to breeding birds to determine where they forage during the incubation and chick-feeding periods. Transmitters should also be attached to adults feeding nearly fledged chicks to determine where birds disperse to during the annual post-breeding moult.

L5. Some studies have suggested that diving petrels are able to re-lay if an egg is lost early in incubation (Warham 1990). Re-laying does not occur in any other Procellariiforme species, except perhaps storm petrels. This aspect should be studied by a controlled removal of freshly laid eggs from a small discrete breeding colony and monitoring of nests to see if re-laying occurs by the same pair in the same season. The incubation period also needs further study to determine variation in the length of the incubation period and the frequency of temporary egg desertions.

Subantarctic Diving Petrel *Pelecanoides urinatrix exsul*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Auckland Islands (Enderby, Ewing, Rose, Ocean, Disappointment and probably Adams Island); Campbell Islands (Dent, Monowai, and probably other rat-free offshore islands and stacks); and the Antipodes Islands (Antipodes, Bollons, and probably other offshore islands). Elsewhere, breeds at Macquarie, Heard, Kerguelen, Crozet, Prince Edward, and South Georgia Islands. The distribution at sea is poorly known, but flocks of diving petrels seen in the Southern Ocean well east of Antipodes Island in autumn probably are this subspecies.

Population

Robertson & Bell (1984) estimated that there were between 100,000 and 1 million pairs of subantarctic diving petrels on the New Zealand subantarctic islands. Only small numbers appear to breed on Enderby, Ewing, and Ocean Islands at the Auckland Islands (Taylor 1988). However, given the area of suitable breeding habitat in that group, there could in fact be huge populations on Disappointment and Adams Islands. The species formerly bred on Campbell Island but was extirpated by Norway rats last century (Taylor 1986). The populations on the rat-free islands off Campbell have not been surveyed but could be in the order of thousands or tens of thousands of pairs. Antipodes Island probably has the largest population of this subspecies in the Pacific Ocean sector. It is one of the commonest breeding birds on Antipodes Island and more than 100,000 pairs are likely to be present (G. Taylor, A. Tennyson & M. Imber unpub.). The populations on Crozet and Kerguelen Islands are considered to be very abundant (millions of pairs?) and an estimated 3.8 million pairs breed at South Georgia (Croxall et al. 1984, Marchant & Higgins 1990).

Threats

The main threat to subantarctic diving petrels is the introduction of mammalian predators to their breeding colonies. The species is absent on islands with feral cats, ship rats, and Norway rats. Colonies can be completely destroyed by these predators within 3-5 years because fledglings return to natal colonies at 1-2 years of age and adults visit burrows for 8-10 months of the year (Payne & Prince 1979). Feral cats and feral pigs have probably extirpated subantarctic diving petrels from Auckland Island, and Norway rats eliminated the population on Campbell Island. Prior to their eradication, rabbits and cattle trampled and damaged burrows on Enderby and Rose Islands. Mice appear to have no impact on the survival of diving petrels but may be a vector for disease. Human disturbance of breeding colonies can have an impact on diving petrels because the burrows are

short, shallow, and easily damaged. Fire can be a risk because the subspecies visits the colonies throughout the year. Antipodes and Enderby Islands are probably at greatest risk of fire damage. Diving petrels are easily attracted to bright lights and birds have been killed by crashing into brightly lit ships at sea (Warham 1990, Ryan 1991).

Previous Conservation Actions

1. Rabbits were eradicated from Enderby and Rose Islands in 1993, and cattle and mice were eradicated from Enderby Island in 1993.
2. Cattle and sheep were eradicated from Campbell Island by 1984 and 1991 respectively.
3. There have been no studies of the New Zealand populations of subantarctic diving petrels. Studies have been undertaken on populations breeding at South Georgia (Payne & Prince 1979).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the subantarctic islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting subantarctic diving petrels.

M1. Restrictions on visitor access to Disappointment, Adams, stacks off Campbell and Antipodes Islands should help to protect the breeding colonies of diving petrels.

L1. Norway rats should be eradicated from Campbell Island.

L2. Feral cats and pigs should be eradicated from Auckland Island.

L3. Diving petrels should be re-established on Campbell Island once Norway rats are eradicated. Probably adults can be lured to the main island using tape play-back of calls.

L4. Mice should be eradicated from Antipodes Island and Auckland Island.

Future Survey and Monitoring Needs

H1. Antipodes, Adams, Disappointment, Enderby, and Ewing Islands should be inspected at least every 2-3 years to ensure that rodents and other mammals have not colonised these islands. Other subantarctic islands (>5 ha) should be inspected whenever the opportunity arises but preferably at least once every 10 years.

L1. The distribution of diving petrels needs further assessment at the Auckland Islands. Surveys are needed on Adams Island and on all small offshore islands. Also cliffs and bluffs on Auckland Island should be inspected to determine if relict colonies or pairs continue to breed in these sites.

L2. Surveys are needed on all rodent-free islands off Campbell Island to determine the distribution of diving petrel colonies and estimate the abundance of the species on each island. The subspecies would be best detected by night visits to all these islands, between October and December.

L3. Accurate estimates are needed of all breeding populations at the Auckland and Antipodes Islands. Priority sites are Adams, Disappointment, Enderby, and Antipodes Islands.

Research Priorities

L1. The taxonomy of diving petrels in New Zealand still needs to be resolved. Subantarctic diving petrels need to be compared with the northern and southern diving petrel and also South Georgian diving petrels at Whenua Hou (Codfish Island). A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

L2. The breeding cycle of subantarctic diving petrels is unknown in New Zealand. The date of arrival back at breeding colonies, spread and peak dates of laying, hatching and fledging, breeding success, and period of absence from breeding colonies need to be determined.

L3. The diet of subantarctic diving petrels has not been studied at New Zealand colonies although research has been carried out on other populations. Food samples should be collected from birds whenever the opportunity arises.

L4. The breeding biology has not been studied in New Zealand but has been studied at South Georgia (Payne & Prince 1979) and the Crozet Islands (Jouventin et al. 1985). The population dynamics of this subspecies have not been studied in New Zealand or elsewhere. There are clearly opportunities to research aspects of the subspecies' biology at a number of sites outside New Zealand that have permanent bases. However, in these large colonies, it would prove difficult to get reliable information on juvenile survival and recruitment rates. Enderby Island has a small population of subantarctic diving petrels and may be quite a suitable (and relatively accessible) site to study the population dynamics.

L5. The foraging range and movements of subantarctic diving petrels at sea could be studied in two ways. If the birds stay within 30-50 km of the colony miniature radio transmitters can be attached and activity monitored from high points near breeding colonies. If they move further offshore satellite transmitters will be needed. However, the satellite transmitters must weigh no more than 3-5 g and, once available, should be attached to breeding birds to determine where they forage during the incubation and chick-feeding periods. Transmitters should also be attached to adults feeding nearly fledged chicks to determine where birds disperse to during the annual post-breeding moult.

Northern Diving Petrel *Pelecanoides urinatrix urinatrix*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on islands and small stacks around North Island and Cook Strait. Colonies occur at the Three Kings Islands (Great); Motuopao Island; Moturoa Islands (Moturoa, Green, Sugarloaf, Whale Island, and stacks); Cavalli Islands (Motuharakeke, Te Anaputa, Motutakapu); Poor Knights (Aorangi); Mokohinau Islands (Lizard, Groper and Stack H); Hen and Chickens (North-west Chickens, Sail Rock); Bream Islands; Little Barrier Island (Lots Wife); Great Barrier Islands (Stack south-west of Opakau Island);Wooded Island,Tiritiri Matangi Island;Noises Islands (Maria); Mercury Islands (Middle, Green, Koropuki, Stanley, stacks off Stanley, Double, Red Mercury); Ohinau Islands (Little Ohena, Black Rocks, Needle Rock); Castle Rock;Aldermen Islands (Ruamahuanui, Ruamahuaiti, Hongiora, Half, Ngahoro, and other stacks), Karewa Island; Motuotau Island; Plate Island; Rurima Rocks; Sugarloaf Islands (Motumahanga, Moturoa);The Brothers;Trio Islands and Stephens Island. Elsewhere, breeds on up to 20 Australian islands off Victoria and Tasmania. The dispersal of birds at sea is poorly known, but they probably stay over continental shelf waters near their breeding colonies.

Population

The total breeding population of northern diving petrels in New Zealand was thought to be between 100,000 and 1 million pairs (Robertson & Bell 1984). Surveys of a number of key populations since 1984 suggest there were possibly in the order of 100,000 to 150,000 breeding pairs (G.Taylor unpub.).The largest populations are found at the Three Kings, Moturoa Islands, Motuharakeke, Poor Knights, North-west Chickens, Bream Islands, Middle and Green Islands, Aldermen Islands, Sugarloaf Islands and Trio Islands. These islands (or groups) probably support over 5000 breeding pairs at each site. The Australian colonies are small and none appear to have more than 400 breeding pairs (i.e. there are probably less than 10,000 pairs in Australia). There are no trends known in the breeding populations, but colonies are possibly stable if free of introduced predators.

Threats

The main threat to diving petrels is the introduction of mammalian predators to their breeding colonies. The subspecies is absent on islands with feral cats, mustelids, ship rats, and Norway rats. Diving petrel colonies can be locally extirpated by these predators within 3-5 years because fledglings return to natal colonies at 1-2 years of age and adults visit burrows for 8-10 months of the year (Richdale 1965a,Thoresen 1969). Ship rats and stoats have been recorded killing adult diving petrels on islands within the swimming distance of these predators

(G.Taylor pers. obs.). For example, 1 stoat killed at least 90 adult diving petrels on Motuotau Island (off Mt Maunganui beach) between September and November 1996 (Clifford 1997). Pacific rats take both eggs and chicks and have a serious impact on breeding success (G. Taylor pers. obs.). However, a few chicks have been reported fledging from islands with Pacific rats. Rabbits and feral goats formerly occurred on a few islands with diving petrels and probably trampled or dug out burrows. Human disturbance of breeding colonies can have a serious impact on diving petrels because the burrows are short, shallow, and easily damaged. Fire can be a risk because the species visits the colonies for most of the year and most of the breeding islands are dry at some stage. Competition for nest sites with tuatara and other petrel species (especially fairy prions, fluttering and flesh-footed shearwaters) may affect breeding success. Fine mesh monofilament set nets may be a risk to this species if placed near breeding colonies. Oil spills would probably have a serious impact if they occurred near breeding colonies or the main feeding grounds. Diving petrels are easily attracted to bright lights and birds have been reported crashing into well-lit buildings near breeding colonies or onto ships at sea (Warham 1990, Ryan 1991). In some years, large-scale die-offs of diving petrels have been reported from coastal areas from Northland to Cook Strait (Powlesland et al. 1992). These events are probably caused by natural fluctuations in sea temperatures and ocean currents changing food supplies and leading to starvation of birds or possibly from an increased risk of biotoxin release caused by algal blooms.

Previous Conservation Actions

1. Norway rats were eradicated from Maria Island in 1960.
2. Pacific rats have been eradicated from the following islands with small diving petrel colonies (year of eradication in brackets): Korapuki (1987), Double (1989), Burgess Island (1990), stacks in Mokohinau group (1990), Stanley (1991), Red Mercury (1992), Motuopao (1992), and Tiritiri Matangi (1993).
3. Rabbits were eradicated from Korapuki (1988) and Stanley Islands (1991). Feral goats were eradicated from Burgess Island (1973). In 1996, 1 stoat killed over 90 adult diving petrels on Motuotau Island. It was eventually caught in a trap set (Clifford 1997).
4. The breeding biology, behaviour, calls, and population status of diving petrels were studied at the Mercury Islands (Thoresen 1967, 1969, Thoresen & Thomson 1992).
5. Surveys and estimates of breeding populations have been made on Motuopao (Pierce & Parrish 1993), Mokohinau (de Lange et al. 1995), Cavalli, Mercury, Aldermen, and Sugarloaf Islands (G.Taylor & A.Tennyson unpub.). Banding of adults and chicks has been done most frequently at Mokohinau, Mercury, Motuotau, and Sugarloaf Islands.
6. The size of the breeding population, foraging behaviour, and aspects of the breeding biology were studied at North Brothers Island in 1990 (Gaston & Scofield 1995).

7. An experiment to lure diving petrels to Mana Island using tape playback and artificial burrows attracted 3 non-breeding females between 1993 and 1998. In 1997, 90 diving petrel chicks were transferred to Mana Island from North Brothers Island and Sugarloaf Islands (New Plymouth). A further 100 chicks were transferred in 1998. Ninety-three chicks fledged from Mana Island after hand-feeding for periods of between 1 and 44 days. In 1999, a further 49 chicks were transferred from North Brothers Island. One pair of birds were found nesting at the artificial colony on Mana Island in November 1999, and a chick was raised (G.Taylor unpub.).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be prepared to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting northern diving petrels.

H2. Strict control of visitor access is needed to all islands with large breeding colonies of northern diving petrels. In particular, consultation is needed with the owners of Moturoa and Cavalli Islands to ensure that these petrel colonies are given adequate protection.

L1. Pacific rats should be eradicated from Coppermine, Mauitaha, and Hen Islands.

L2. Attempts should be made to re-establish breeding colonies on islands where the subspecies formerly bred. Suitable sites include Cuvier, Whatupuke, Lady Alice, Middle Chain, Motuora, and Titi Islands. Chicks may need to be transferred to some of these sites (e.g. Cuvier, Motuora) and tape playback used to lure returning birds to the colony. Other islands situated close to large breeding colonies may only need tape playback and artificial burrows to attract birds.

Feeding a northern diving petrel chick after transfer to Mana Island, 1997

Northern diving petrel chicks were transferred to Mana Island from North Brothers Island and Sugarloaf Islands between 1997 and 1999. Chicks were hand-fed for periods of between 1 and 44 days. One pair of birds was found nesting at the artificial colony on Mana Island in November 1999, and a chick was raised.

Future Survey and Monitoring Needs

H1. Islands with large breeding colonies should be inspected at least every 2-3 years to ensure that rodents and other mammals have not colonised these islands. Other islands should be inspected whenever the opportunity arises but preferably at least once every 10 years.

L1. North Brothers Island probably has the most accurately determined population of northern diving petrels.This colony should be monitored every 10 years to assess trends in the breeding population.

L2. Monitoring plots should be established at several islands that have been cleared of Pacific rats to establish the rate of colonisation of diving petrels to these sites. Methods include placing plots in and adjacent to remnant colonies/ breeding sites or opposite offshore stacks with large breeding populations. Motuopao, Burgess, Lady Alice, Tiritiri Matangi, and Stanley Islands are probably best suited for this monitoring project.

L3.The distribution of diving petrel colonies is reasonably well known although surveys are needed of all small inshore islands outside of the likely swimming range of rodents. Islands needing further attention include the Three Kings group, Poor Knights group, Ohinau group, Channel Island, and Square Top Island.

L4.The size of northern diving petrel breeding populations is still poorly known at most colonies.Accurate estimates have only been attempted at a few sites.The larger colonies need to be accurately assessed using transects and quadrat sampling techniques.The ratio of occupied breeding burrows to the total number of burrow entrances per unit area is still unknown for this subspecies and must be determined at several colonies to help assess breeding populations.

Research Priorities

L1. The population dynamics are still poorly known. Information is needed on age of first return to colonies, age of first breeding, longevity, survival and mortality of adults and juveniles, recruitment of chicks, and natal philopatry. Research is best done on Tiritiri Matangi and Wooded Islands or Stanley and the stack north of Stanley or possibly North Brothers Island.This species will be very difficult to study because colonies are typically large and nests are in friable soil or the colonies are very sparse and difficult to locate (e.g. islands that previously had Pacific rats).

L2. The taxonomy of diving petrels still needs to be resolved. Northern diving petrels and southern diving petrels have recently been combined in the 1990 OSNZ checklist (Turbott 1990) although there are significant differences in measurements between these populations (Marchant & Higgins 1990). The Australian birds are considered to be the same subspecies as birds of northern New Zealand but are unlikely to inter-breed. Comparisons are also needed with subantarctic diving petrels and South Georgian diving petrels.A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

L3. The diet of northern diving petrels is poorly known. Food samples should be collected from birds whenever the opportunity arises. Studies are needed to assess whether or not the populations at the northern offshore islands share a similar diet with birds breeding in Cook Strait colonies and whether there are differences in food items delivered to chicks by males or females.

L4. The foraging range and movements of diving petrels at sea could be studied in two ways. If the birds stay within 30-50 km of the colony miniature radio transmitters can be attached and activity monitored from high points near breeding colonies. If they move further offshore satellite transmitters will be needed. However, the satellite transmitters must weigh no more than 3-5 g and, once available, should be attached to breeding birds to determine where they forage during the incubation and chick-feeding periods. Transmitters should also be attached to adults feeding nearly fledged chicks to determine where birds disperse to during the annual post-breeding moult.

L5. Some studies have suggested that diving petrels are able to re-lay if an egg is lost early in incubation (Warham 1990). Re-laying does not occur in any other Procellariiforme species, except perhaps storm petrels. This aspect should be studied by a controlled removal of freshly laid eggs from a small discrete breeding colony and monitoring of nests to see if re-laying occurs by the same pair in the same season. The incubation period also needs further study to determine variation in the length of the incubation period and the frequency of temporary egg desertions

L6. The social behaviour and organisation of this subspecies still needs research. Descriptions are needed of social displays, formation of pair bonds, activity of breeding birds visiting colonies in the pre-laying period (e.g. April to July), and assessment of individual call variations and recognition of calls by breeding partners.

Red-tailed Tropicbird *Phaethon rubricauda roseotincta*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Kermadec Islands (Raoul, North Meyer, South Meyer, Nugent, Dayrell, South Chanter, Macauley, Curtis). Elsewhere, breeds on numerous islands in the south-west Pacific including Norfolk Islands, Lord Howe Islands, and islands of the Great Barrier Reef, Australia. Other subspecies breed on numerous islands in the Indian Ocean, off Indonesia, Central and North Pacific Ocean.

Population:

The population on Raoul Island and adjacent islets was estimated at 50-100 pairs in 1966/67 (Merton 1970). Up to 130 red-tailed tropicbirds were counted in flight over Macauley Island in December 1988 (Tennyson et al. 1989), but there is no estimate of the breeding population at Macauley Island. One dead chick found on Curtis Island in November 1989 is the only evidence of breeding at this site (Tennyson & Taylor 1990a). Elsewhere, there are about 1000 pairs in the Tasman Sea/Great Barrier Reef colonies. Other subspecies have large populations. For example, over 12,000 pairs breed at the Hawaiian Islands (Harrison 1990).

Threats

Humans exploit red-tailed tropicbirds as a food source throughout much of their range (del Hoyo et al. 1992). The populations in New Zealand and Australia are fully protected and are generally safe from human exploitation. Feral cats and dogs are the greatest threat to this surface-nesting species. However, predation on eggs and chicks by Pacific and Norway rats may have an adverse impact on some colonies (Merton 1970). Browsing mammals such as feral goats and rabbits removed vegetation cover or trampled nests at some colonies causing loss of habitat or disturbance during breeding. The introduction of new mammalian predators to the islands off Raoul, or Macauley and Curtis Islands is the key threat to this species in New Zealand. Fires may cause temporary losses in the populations during the breeding season (December - May). Macauley Island is densely covered in grasses and sedges and is most at risk. Volcanic activity on Curtis Island or Raoul Island may have an adverse impact if an eruption occurred during the breeding season. At sea, tropicbirds have been reported colliding with ships at night, apparently confused by bright lights (Harrison 1990).

Previous Conservation Actions

1. Feral goats were removed from Macauley Island by 1970 and Raoul Island by 1984.

Red-tailed tropicbird, Macauley Island, 1988

Red-tailed tropicbirds nest at the Kermadec Islands in the New Zealand region. Known as amokura by Maori, the red-tail feathers of the tropicbird were highly prized by northern iwi who presumably collected birds found washed ashore on northern beaches.

2. The red-tailed tropicbird breeding population on Raoul Island and adjacent islets were surveyed in 1966/67 (Merton 1970).

3. The taxonomic status of red-tailed tropicbirds was examined by Tarburton (1989).

Future Management Actions Needed

H1. Norway and Pacific rats, and feral cats should be eradicated from Raoul Island.

H2. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the Kermadec Islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

M1. Pacific rats should be eradicated from Macauley Island.

Future Survey and Monitoring Needs

H1. All islands (>5 ha) in the Kermadec group should be checked every 5 years to ensure that rodents and other introduced mammals have not colonised these islands.

H2. The breeding populations on Raoul Island and adjacent islets should be re-surveyed prior to rat and cat eradication operations on Raoul Island. The census of breeding pairs should be undertaken in January to compare with the results of the 1966/67 survey.

L1. A census of the red-tailed tropicbird breeding population is needed on Macauley Island during the period January to March.

L2. Curtis, Cheeseman, L'Esperance Rock, and Haszard Islet need surveying to determine if red-tailed tropicbirds nest at these locations (best time is January to May).

Research Priorities

L1. The timing of the breeding cycle is poorly known in New Zealand. Monthly visits could be undertaken to the Meyer Islets to record the number of birds ashore and in flight over the colony. A selection of nests should be marked to record presence of eggs or chicks during each visit. A sample of breeding pairs could also be banded to determine if pairs re-nest in the same season as has been reported at other colonies.

L2. The diet of the birds at the Kermadec Islands and other Tasman Sea populations is unknown. Elsewhere the diet has been studied thoroughly, e.g. populations breeding in the Indian Ocean and North Pacific (Marchant & Higgins 1990). Food samples from New Zealand birds should be collected and sent to diet experts, e.g. Dr Mike Imber (DOC, Wellington), whenever the opportunity arises.

L3. The taxonomy of the tropicbirds is still uncertain. Four red-tailed tropicbird subspecies have been described based on wing and bill dimensions and plumage colouring. The validity of these subspecies has been questioned by researchers working on the species (Tarburton 1989). A taxonomic revision is needed using DNA techniques and examination of morphometric and plumage characteristics. This study should only be undertaken as part of an international programme to review the taxonomy of the tropicbird group.

L4. The breeding biology of this species has been well studied outside New Zealand. The population dynamics of red-tailed tropicbirds are unknown (e.g. age of first breeding, adult survival, chick recruitment etc.). Studies are best undertaken on more accessible colonies in the Pacific Ocean. All New Zealand populations nest on fragile seabird islands, and collecting long-term information about this species would have a significant impact on other seabird colonies.

Black Shag *Phalacrocorax carbo novaehollandiae*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds throughout North, South, and Chatham Islands, but the distribution of colonies is poorly known. The same subspecies also breeds in Australia and Tasmania and occasionally visits New Guinea. Vagrants reach Lord Howe, Norfolk, Snares, Campbell, and Macquarie Islands. Black shags are found on most inland lakes, rivers, streams, and larger ponds. They also occur in estuaries, harbours, and inshore seas close to the coast.

Population

Robertson & Bell (1984) estimated that there were 5000-10,000 pairs of black shags in New Zealand. The species is apparently less abundant than in the past when large numbers were shot by fishers. In Australia, some colonies are as large as 20,000 pairs (Marchant & Higgins 1990).

Threats

Black shags were persecuted for decades by fishers who believed that these birds ate large quantities of brown and rainbow trout (Sim & Powlesland 1995). Subsequent studies found that trout species were infrequent in the diet of black shags, and the birds mainly ate eels, native fish, crustaceans and other invertebrates (Robertson 1985, Marchant & Higgins 1990). Black shags were partially protected in 1986. Occasional birds are still found shot during the duck shooting season (R. Powlesland pers. comm. 1999). Nest sites are usually inaccessible to dogs, pigs, stock, and probably feral cats. The effect of mustelids and rats on this species has not been studied. Possibly eggs and chicks may be vulnerable at mainland colonies. The species is very sensitive to disturbance by humans (Lalas 1993, Sim & Powlesland 1995). Birds leave nest sites when approached closely by people but return once people have gone. They may flick eggs and small chicks from nests when frightened (R. Powlesland pers. comm. 1999). There is very little risk to this species from trawling because shags are generally shy of people/boats. However, a few birds may be caught by fishing techniques such as recreational hand-lines or inshore long-line fisheries. Shags occasionally swallow fish found on snagged lines. If the lines come free, some of these birds are later found dead with the hook penetrating the gut. Others get fouled up at roost sites by lines, sinkers, or other hooks. A few lucky birds are able to regurgitate the lines and hooks (R. Powlesland pers. comm. 1999). Bottom-feeding shag species are sometimes caught in crayfish pots, which may be a slight risk for this species (Sim & Powlesland 1995). Set-netting, especially in estuaries, harbours or small bays, presents a moderate risk throughout the year (Sim & Powlesland 1995, Taylor 1996). The threat of oil spills impacting on this species is

generally low because the majority of the population disperses widely around both islands, and many birds remain in freshwater habitats throughout the year.

Previous Conservation Actions

1. Various studies have been carried out on the diet of black shags (summarised in Marchant & Higgins 1990).
2. The species was partially protected in 1986.
3. The movements and causes of mortality of black shags breeding in the Wairarapa was studied by banding cohorts of chicks (Sim & Powlesland 1995).
4. The status and diet of black shags in coastal Otago was summarised by Lalas (1983, 1993).
5. Population trends of black shags and other waterbirds have been studied at the Rotorua Lakes (Innes et al. 1999) and Wellington Harbour (Robertson 1992).
6. A long-term study of black shag population dynamics and breeding success is being undertaken at a Wellington colony. Chicks have been colour-banded to determine age-related survival and age of breeding (Powlesland & Reese 1996).The breeding cycle and aspects of the breeding biology have also been studied at this colony (Powlesland & Reese 1999).

Future Management Actions Needed

M1.The black shag should be fully protected because there is little evidence that this species interferes significantly with game fish, and the breeding population in New Zealand is possibly threatened. DOC can issue a permit to allow removal of problem birds from certain sites (e.g. trout hatcheries).

M2. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. For example, nets should not be left unattended in estuaries and harbours.

Future Survey and Monitoring Needs

L1. Surveys are needed to locate all breeding colonies of this species. All colony locations should be recorded in the National Seabird Colony Register and estimates made of the number of nests at each site.

Research Priorities

L1.The biology of black shags is well known from work overseas. R. Powlesland is carrying out a long-term project on the population dynamics and breeding ecology of this species in New Zealand. The feeding biology has been studied previously. Further work needed includes a study on the dive profiles (dive depths and frequency of dives) at both freshwater and coastal sites. A telemetry study may also be worthwhile on this species to determine foraging zones and home range during the breeding season.

L2. The taxonomy of black shags should be investigated. The subspecies *novaehollandiae* is sometimes considered to represent a separate species with the Australian population forming one race *carboides* whereas the New Zealand population is included in race *steadi*. A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

Little Shag *Phalacrocorax melanoleucos brevirostris*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk – Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds only in New Zealand. Colonies are dispersed widely around all three main islands at both inland sites (mainly freshwater lakes, rivers, and streams) but also estuaries and offshore islands. Other subspecies breed in Australia, New Guinea, Indonesia, and islands in the south-west Pacific from the Solomons to New Caledonia.

The Australian subspecies *P. m. melanoleucos* apparently formerly bred on Campbell Island (Kinsky 1969).

Population

The total population in New Zealand was estimated as 10,000 to 50,000 pairs (Robertson & Bell 1984). This estimate currently seems to be too high based on the number of recorded breeding colonies and counts of birds at various localities (see Classified Summarised Notes published in *Notornis*, also Marchant & Higgins 1990). The total population may be less than 10,000 individuals if the species disperses widely after breeding on inland lakes.

Threats

Little shags generally nest at remote sites such as islands in lakes or inshore coastal islands. Some also nest on maimais on lakes and estuaries, in trees such as willows on lake margins and in tall podocarps (rimu especially) in river gorges (Potts 1977, Innes et al. 1999, K. Owen pers. comm. 1998). These sites are usually inaccessible to predators such as feral cats, pigs, dogs, and ferrets. Stoats and possums may have some impact on nesting colonies and rats possibly take eggs or chicks, but no information is available on the effects of mammalian predators on this species. Little shags are susceptible to human disturbance and will abandon nests and chicks temporarily allowing red-billed gulls and black-backed gulls opportunities to take eggs and chicks (G. Taylor pers. obs.). There is a small risk to this species from line-fishing techniques, especially the risk of taking fish hooked on snagged lines. Birds might then drown or die from ingesting hooks or get fouled by the line. Bottom-feeding shag species are sometimes caught in crayfish pots, which may be a slight risk for this species. Set-netting, especially in estuaries and inshore bays presents a moderate risk throughout the year. The threat of oil spills impacting on this species is generally low because the majority of the population disperses widely around both islands, and large numbers of birds remain in freshwater habitats throughout the year.

Previous Conservation Actions

1. The diet of little shags has been studied at the Rotorua Lakes (Potts 1977) and other locations (Marchant & Higgins 1990).
2. Social behaviour, calls, displays, and aspects of the breeding biology of little shags were studied in the Manawatu region in 1981-1983 (Matthews 1984, Matthews & Fordham 1986).
3. Courtship and nesting behaviour, breeding seasons, breeding success, and plumages of birds at an Auckland colony were studied by Taylor (1979, 1987) and Dowding & Taylor (1987).
4. Counts of nests and locations of breeding colonies on the Otago coastline were made by Lalas (1993).
5. The numbers and population status of little shags at the Rotorua Lakes was assessed by Innes et al. (1999).
6. Monthly counts of little shags (and other species) on Wellington Harbour (Robertson 1992) and counts of shags at night roosts in the Wellington region are being studied by Wellington OSNZ members (R. Powlesland pers. comm. 1998).The breeding cycle and breeding success of little shags at a colony near Paraparaumu has been studied recently (Powlesland & Luke 2000).

Future Management Actions Needed

M1. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. For example, nets should not be left unattended in estuaries and harbours.

Future Survey and Monitoring Needs

L1. Surveys are needed to locate breeding colonies of this species. The Rotorua Lakes appear to be a key centre for breeding birds.All colony locations need to be recorded on the National Seabird Colony Register and estimates made of number of nests at each site.

L2. Monitoring of seasonal numbers of little shags in defined areas, e.g. Wellington Harbour, Rotorua Lakes, should be carried out at 5-10 year intervals to determine long-term population trends.

Research Priorities

L1.The taxonomy of little shags needs further investigation. Van Tets (in Marchant & Higgins 1990) considered *brevirostris* was sufficiently distinctive (both morphologically and behaviourally) for it to be separated as a full species. A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

L2. The movements and patterns of dispersal of this species in New Zealand needs research. Colour-banding cohorts of chicks at the larger colonies is

necessary to indicate how far birds move from each site and if birds disperse between the three main islands.

L3. The breeding biology of little shags needs further study. The timing of the breeding season (pairs displaying at nests, eggs or chicks present), laying dates (months of year that eggs are laid), clutch size, incubation period and shifts, chick growth rates and nestling period, post fledgling dependence period are poorly known or unstudied.

L4. The population dynamics of little shags are unknown. There is no information available on age of first breeding, longevity, adult mortality rates, chick survival and recruitment, natal philopatry, pair and nest site fidelity. Studies should consider either banding cohorts of chicks with a single colour-band for each year class or individually colour-banding chicks (or adults if they can be captured) so that on-going disturbance at the colony can be minimised.

Little black shags at nesting colony, Lake Rotorua, 1982

The breeding biology and movements of little black shags were studied at Lake Rotorua in the early 1980s. Over 900 shag chicks were banded at the Sulphur Bay colony. Some of these chicks were subsequently recovered between Kerikeri and Wellington Harbour, proving that most North Island birds originated from the central North Island colonies. (See opposite.)

Little Black Shag *Phalacrocorax sulcirostris*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

In New Zealand, breeds only in the North Island (Innes & Taylor 1984). Birds disperse in autumn and winter to coastal areas throughout the North Island and occasionally to the northern half of South Island. Elsewhere, the species breeds in Australia, Indonesia, and New Guinea. The species is a vagrant at Lord Howe, Norfolk, and New Caledonia Island groups. Birds forage mainly over freshwater lakes, ponds, rivers, and shallow inshore coastal bays and estuaries.

Population

The New Zealand population is about 2000-4000 individuals with the majority breeding at the central North Island lakes (G.Taylor unpub.).A colony at Sulphur Bay, Lake Rotorua, in 1982/83 had 980 nesting pairs (Innes & Taylor 1984), but the birds have subsequently shifted elsewhere in the region (Innes et al. 1999). No total population estimates are available from overseas, but surveys in eastern Australia indicated populations exceed 24,000 birds (Marchant & Higgins 1990).

Threats

The species generally nests at remote sites (islands in lakes, or high in trees over freshwater).These sites are usually inaccessible to feral cats, pigs, and dogs. Stoats and possums (on mainland sites) may reach some colonies, but there is no evidence that they have any impact on breeding success. Norway rats are present at some breeding sites but appear to have little impact on breeding success (G. Taylor pers. obs.). The species is susceptible to human disturbance and will abandon nests and chicks temporarily allowing red-billed gulls and black-backed gulls opportunities to take eggs and chicks. However, a study of the breeding colony at Lake Rotorua in 1981-84 found that the birds adjusted to repeated (but infrequent) human visitation and stayed on their nests until closely approached (G.Taylor unpub.). Nesting colonies may be disturbed by low flying aircraft and close approaches from boats (G. Taylor pers. obs.). Possibly commercial rafting activity scared birds away from a former colony site at Okere Falls (K. Owen pers. comm. 1998).There is a small risk to this species from fishing techniques such as line-fishing and trawling. Bottom-feeding shag species are sometimes caught in crayfish pots, which may be a slight risk. However, set-netting, especially in estuaries presents a moderate risk during autumn and winter.The impact of over-fishing has not been assessed for this species. Little black shags are sometimes shot illegally to supposedly protect fish stocks. Occasionally, little black shags are shot under permit to protect trout fingerlings at fish and game hatcheries (K. Owen pers. comm 1998). The threat of oil spills impacting on this species is moderately high because the majority of the population disperses in autumn and winter to coastal inshore bays and estuaries in the Northland, Auckland, Bay of

Plenty, and Wellington regions (Innes & Taylor 1984). Shipping activity is intense in these areas.

Previous Conservation Actions

1. Little black shags are fully protected. Enforcement of this protection order has greatly reduced the impact on the species by people shooting or harassing birds because of their perceived effect on fish stocks.
2. The diet of this species was studied on the Rotorua Lakes (Potts 1977).
3. The breeding biology and movements of little black shags were studied at Lake Rotorua in 1981-84 (Innes & Taylor 1984). Over 900 shag chicks were banded at the Sulphur Bay colony. Census counts of little black shags and other waterfowl were made on the Rotorua Lakes in the 1980s (Innes et al. 1999).
4. Monthly counts were made of little black shags (and other species) on Wellington Harbour (Robertson 1992). These monthly counts are being repeated in 1999-2000 by Wellington OSNZ members.

Future Management Actions Needed

M1. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. For example, nets should not be left unattended in estuaries and harbours.

Future Survey and Monitoring Needs

L1. Surveys are needed to locate breeding colonies of this species. The species formerly nested at Sulphur Bay, Lake Rotorua, but colonies have also been reported from Hamurana and Mokoia Island (Lake Rotorua), Banded Island (Lake Rotomahana), Lake Rotoiti, and Motutaiko Island (Lake Taupo). Little black shags formerly bred at Lake Whangape (Waikato Region), and small breeding colonies have been reported near Auckland, Hawkes Bay, and Wairarapa. All colony locations need to be recorded on the National Seabird Colony Register and estimates made of number of nests present at each site.

Research Priorities

L1. The study at Lake Rotorua in 1982-84 collected information on breeding biology (nest sites, laying dates, clutch size, incubation period, chick rearing period), movements, and dispersal within New Zealand. More work is needed including egg measurements, incubation shifts, chick growth rates, and fledgling dependence period. This information should only be collected if birds nest in an accessible site (preferably on the ground) because chicks are prone to jumping from trees into water once half grown (G. Taylor pers. obs).

L2. The population dynamics of little black shags are unknown. There is no information available on age of first breeding, longevity, adult mortality rates, chick survival and recruitment, natal philopatry, pair and nest site fidelity. Studies should consider either banding cohorts of chicks with a single colour-band for

each year class or individually colour-banding chicks (or adults if they can be captured) so that on-going disturbance at the colony can be minimised. It may be more appropriate to carry out this research in Australia.

L3. The social and courtship behaviour and vocalisations of this species are poorly known and need study. The role of each sex in nest building and care of eggs and chicks is unknown and needs investigation.

Grey ternlet roosting at night, Macauley Island, 1988

Large numbers of grey ternlets nest at the Kermadec Islands, which is the stronghold of this subspecies. On Macauley Island, Pacific rats may take eggs and chicks because grey ternlets are rare on the plateau but common on cliff ledges and coastal margins where rats are scarce or absent. (See overleaf.)

Grey Ternlet *Procelsterna albivitta albivitta*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Kermadec Islands (Raoul, North Meyer, South Meyer, Napier, Nugent, Dayrell, North Chanter, South Chanter, Macauley, Haszard, Curtis, Cheeseman, L'Esperance Rock). The species ranges south to northern New Zealand in summer and has been seen at the Three Kings Islands (West Island, Princes Islands), Poor Knights (The Pinnacles), Mokohinau Islands (Cathedral Rocks), Aldermen Islands (Sugarloaf Rock), and the Volkner Rocks, near White Island. Elsewhere, the subspecies breeds at the Lord Howe Islands, Norfolk Islands, and Tonga. Birds disperse locally near breeding islands and prefer warm sub-tropical seas.

Population

Large numbers of grey ternlets nest at the Kermadec Islands, which is the stronghold of this subspecies. In 1966/67 at least 2000 pairs nested on the Meyer Islets and many thousands were present on Napier Islet. Several hundred or perhaps thousands of pairs nested on the other islets off Raoul Island. The 1967 survey was completed after breeding had finished (Merton 1970). An estimated 10,000 pairs nested on Macauley Island in 1988 and possibly 1000-1500 pairs nested on L'Esperance Rock in 1988 (Taylor & Tennyson 1988). An estimated 5000 pairs of grey ternlets nested on Curtis Island in 1989 (Tennyson & Taylor 1990a). Large numbers nested on Cheeseman Island in 1970 (Bell 1970). The species breeds at the Volkner Rocks (Bay of Plenty) but not every year (Turbott 1990, K. Owen pers. comm. 1998). Two flocks totalling c.200 birds were seen on or around West Island in January 1985 (McCallum et al. 1985). Elsewhere, there are an estimated 100-1000 pairs at the Lord Howe Islands and 1000-10,000 pairs at the Norfolk Islands (Higgins & Davies 1996).

Threats

Feral cats, Norway rats, and Pacific rats probably prey on grey ternlets that continue to nest on Raoul Island. The species is confined to bluffs and cliff ledges on Raoul. On Macauley Island, Pacific rats may take eggs and chicks because the species is rare on the plateau but common on cliff ledges and coastal margins where rats are scarce or absent. On predator-free Curtis Island, grey ternlets nest throughout the island on the plateau, cliffs, and coastal margins. The introduction of new mammalian predators could wipe out the populations nesting on the rodent-free islands. Fires are unlikely to cause much damage to this species because grey ternlets mainly nest on bare ground on cliffs, caves, and beaches. Volcanic activity at Curtis and Raoul Island could potentially devastate the populations nesting on or near these islands. Nest sites are generally located in sheltered sites. The species appears reasonably tolerant of human disturbance

but some eggs or chicks (especially at the back of beaches) would be at risk if there were frequent visitor access to the breeding islands.

Previous Conservation Actions

1. Feral goats were eradicated from Macauley Island by 1970 and Raoul Island by 1984.
2. Observations and counts of grey ternlets were made at Raoul Island and its outliers in 1966/67 (Merton 1970).
3. The grey ternlet populations on Macauley, Curtis, and L'Esperance Rock were surveyed in 1970 (Bell 1970), 1988 and 1989 (Taylor & Tennyson 1988, Tennyson et al. 1989, Tennyson & Taylor 1990a). Measurements were made of eggs, chicks, and adults, and birds were banded at Macauley and Curtis Islands in 1988 and 1989.
4. Birds roosting and feeding around the Three Kings Islands were counted in 1985 (McCallum et al. 1985) and 1989 (Powlesland 1990).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the Kermadec Islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting grey ternlets.

H2. Norway and Pacific rats and feral cats should be eradicated from Raoul Island.

M1. Pacific rats should be eradicated from Macauley Island.

Future Survey and Monitoring Needs

H1. All islands in the Kermadec group should be inspected every 5 years to ensure that rodents and other introduced mammals have not colonised these islands.

L1. The populations nesting on Raoul Island and all of the offshore islands adjacent to Raoul Island need to be surveyed to determine the number of breeding pairs at each site. This should be carried out during September or October.

L2. A survey is needed to determine the number of grey ternlets breeding on Haszard Islet and Cheeseman Island. This should be done in September or October.

L3. The populations nesting on Macauley, Curtis, and L'Esperance Rock should be monitored every 10-20 years. An accurate census of the breeding population should be attempted at each site.

L4. Surveys should be undertaken (when the opportunity arises) on those northern offshore islands listed above where grey ternlets have been recorded previously to determine if the species breeds at those locations.

Research Priorities

L1. The taxonomy of the *Procelsterna* genus is poorly understood. Grey ternlets are variously lumped with blue-grey noddies (*P. cerulea*) or separated into separate species. There are eight described subspecies in the genus. A complete revision of the group is needed using modern DNA techniques and a detailed examination of plumage colouration, morphology and measurements, feather lice, breeding biology, behaviour, and vocalisations.

L2. The movements, breeding biology, breeding success, social organisation, behaviour, vocalisations, and moults of this species are poorly known. Research is needed on all these aspects of the species' ecology. Grey ternlets nest on remote and fairly inaccessible islands. There are probably no populations that are easily studied both within and outside New Zealand. The best site to undertake research is probably on Macauley Island. Here the species can be studied on the shore platform without causing undue disturbance to more sensitive seabird species such as masked boobies and burrow nesting petrels. Grey ternlets breed from August to January.

L3. The diet of this species has been poorly studied in New Zealand. However, the diet of the blue-grey noddy has been studied in detail at Christmas Island and Hawaii. Food samples should be collected and sent to seabird diet specialists (e.g. Dr Mike Imber, DOC, Wellington) whenever the opportunity arises.

L4. The population dynamics of this species are unknown (e.g. age of first breeding, longevity, mortality rate of adults, survival and recruitment of fledglings, natal philopatry, pair and site fidelity). Long-term research is needed on all these aspects of population dynamics. However, this information will be very difficult to obtain at the Kermadec Islands because the populations are very large. Possibly some aspects may be determined from a study at Macauley Island, but the smaller populations nesting at Lord Howe Island may be more suitable for research. Hawaii would be the most suitable site if the taxonomic assessment finds little difference between the populations of *cerulea* and *albivitta*.

Mottled Petrel *Pterodroma inexpectata*

Conservation Status: Endemic species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds only in New Zealand. Breeding sites are known from Fiordland (island in Lake Hauroko, Front Islands, and Shag Islands), Foveaux Strait (Big Solander, Little Solander), islands off Stewart Island (Whenua Hou, Big South Cape, Putauhinu, Kundy, Solomon, and possibly other small islands) and The Snares Islands (Main, Broughton). Formerly nested on the New Zealand mainland (North and South Islands) (Bartle et al. 1993), Chatham Islands and reputedly Auckland, Antipodes, and Bounty Islands (not recorded subsequently at these islands) (Turbott 1990). The species disperses widely in the Pacific Ocean. In winter, birds migrate to North Pacific as far north as the sub-arctic front and Bering Sea (Bartle et al. 1993). In summer, the range extends between the Antarctic pack ice and the sub-tropical convergence, but the species prefers cold waters.

Population

The size of the total breeding population in New Zealand is unknown. Robertson & Bell (1984) estimated there were 10,000 to 50,000 breeding pairs in the early 1980s. The largest breeding colonies are on Whenua Hou (Codfish Island), The Snares and Putauhinu Islands. Mike Imber (pers. comm 1999) estimated that 300,000 to 400,000 pairs were present on Whenua Hou in 1996, and the population is increasing following weka removal in 1984.

Threats

The species declined from the mainland probably as a result of forest clearance, fires, and the introduction of mammalian predators, especially feral cats, Norway rats, and stoats. Weka were introduced to Whenua Hou and caused heavy losses of mottled petrels (Bartle et al. 1993). The populations on Solander Island and possibly some of the Titi islands off Stewart Island are at risk of local extinction because weka have been introduced to these sites. Ship rats invaded Big South Cape Island in 1964 (Atkinson & Bell 1973). Their impact on mottled petrel populations has not been studied but predation on eggs and chicks is likely to be occurring. Pacific rats were present on Whenua Hou and Putauhinu Islands, but these islands recently had rat eradication operations. Pacific rats probably take eggs and small chicks (Imber 1984a). The introduction of new mammalian predators to breeding islands or weka to rodent-free islands is probably the major threat facing this species. Fires are also a risk to the species, especially during the period November to February. Burrows are often shallow and easily crushed in the larger colonies. Some populations are on islands that have regular muttonbird harvests. It is unknown whether or not trampling of burrows or incidental take of mottled petrel chicks occurs on these colonies. Other islands like The Snares have very friable soils and burrows are easily crushed. Visitor access to these sites

should be strictly controlled. The species is exposed to the higher levels of pollutants in the northern hemisphere during the winter migration (Auman et al. 1998, Ludwig et al. 1998). Mottled petrels have not been assessed for levels of contaminants in their tissues or quantities of plastics ingested.

Previous Conservation Actions

1. Aspects of the biology of mottled petrels was studied by Richdale (1964).
2. Vocalisations and breeding biology were studied on The Snares Islands by Warham et al. (1977).
3. Weka were eradicated from Whenua Hou in 1985 and possums were subsequently eradicated in 1987.
4. A sample of burrows was monitored on Whenua Hou from 1983 to 1996 to provide an annual comparison of breeding success (West 1990, W. Cooper pers. comm. 1999). The size of the breeding population on Whenua Hou was estimated in 1996 (M. Imber pers. comm. 1999).
5. The ecology of mottled petrels was studied on an island in Lake Hauroko by W. Cooper (unpub.).
6. Pacific rats were poisoned on Putauhinu Island in 1997 and Whenua Hou in 1998. The success or otherwise of these operations will be known 2 years after poisoning.

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the breeding islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting mottled petrels.

H2. Weka should be eradicated from Big Solander Island.

H3. Ship rats and possibly weka should be eradicated from Big South Cape Island, if the owners of the island are agreeable, and procedures put in place to manage re-invasion risks.

M1. Management of weka populations on the Titi (Muttonbird) Islands needs to be discussed with local iwi, especially if there is evidence that mottled petrel populations are threatened by weka predation.

L1. New colonies should be established in safe sites (restored islands now free of introduced mammals and weka) within the former breeding range. Possible sites include Breaksea Island in Fiordland and islands on inland lakes in South Island. There may also be a case to re-establish mottled petrels on the Chatham Islands though possible impacts on Chatham petrel and Chatham Island taiko would need to be considered. New colony establishment will require the transfer of chicks and the use of a tape-playback system to lure adult birds.

Future Survey and Monitoring Needs

H1. All islands in The Snares group should be visited at least once every 5 years to ensure rodents and other introduced mammals have not colonised them.

M1. Suitable colonies (islands?) are needed to monitor the population trends. These should include mapping burrows in small colonies to assess changes at 5-10 year intervals and banding birds at each monitoring site.

M2. A population census is needed to estimate the size of the populations breeding on Whenua Hou and Snares Islands using quantitative methods that can be repeated in the future.

L1. The distribution of mottled petrel breeding colonies is still poorly known. A thorough survey, in particular, is needed of all islands around Stewart Island/ Foveaux Strait and in Fiordland. Landings may not be necessary in the first instance because the birds are very vocal, and nocturnal display flights occur over each breeding island. Potential colonies might be located by anchoring offshore from each island at night during the period November to February and listening for birds calling in flight.

L2. Once potential colonies are located, a ground survey is needed on each island to estimate the size of the breeding population.

Research Priorities

M1. The population dynamics of mottled petrels are unknown. There is no information on age of first return to colonies, age of first breeding, longevity, mortality and survival of adults, recruitment of chicks, emigration rates, natal philopatry, nest and mate fidelity. Aspects of this information may be collected on Whenua Hou because chicks have been banded at study burrows in one colony since 1983. However, the large size of the Whenua Hou population makes this site less suitable for studying population dynamics of mottled petrels. Ideally a small, accessible predator-free colony should be located and used to obtain this information (possibly an islet off Stewart Island or in Fiordland).

L1. The ecology and breeding biology of this species is only partly known. Timing of return to each geographic zone needs to be determined (e.g. Fiordland, Stewart Island, The Snares Islands). Timing of courtship, spread of laying dates, peak laying, spread of hatching dates, peak hatching, fledging dates and peak fledging, and final departure from the islands need to be determined. Whenua Hou would be the most suitable site to carry out research on the breeding cycle.

L2. The breeding biology of this species was studied at The Snares Islands (Warham et al. 1977). Good information was obtained about the incubation period but chick growth rates, feeding frequency, diet, nesting period, and breeding success need further investigation there.

L3. When available, satellite transmitters (weighing no more than 8-12 g) should be attached to breeding birds to determine where they forage during incubation period and when feeding chicks. Transmitters should also be attached to adults feeding nearly fledged chicks in late April to determine the migration flight path and foraging zone during the non-breeding season.

White-headed Petrel *Pterodroma lessonii*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on Antipodes Islands (Antipodes and Bollons Islands) and Auckland Islands (Adams, Disappointment, Enderby, Ewing, Rose, and Ocean Islands). Elsewhere, breeds on Macquarie, Kerguelen, and Crozet Islands. The species disperses widely over the Southern Ocean. Some birds feed near Antarctica in summer and others range north of the sub-tropical convergence in winter.

Population

A stronghold for this species is in the New Zealand subantarctic islands. Very large breeding populations are present at the Auckland Islands (Taylor 1988) and Antipodes Islands (Imber 1983). At least 100,000 pairs are likely to breed at each island group (G.Taylor unpub.). Earlier estimates were 50,000 to 100,000 breeding pairs in New Zealand (Robertson & Bell 1984). Elsewhere, there were an estimated 7850 breeding pairs at Macquarie Island (Brothers 1984), tens of thousands of pairs at the Kerguelen Islands, but only a few hundred pairs at the Crozet Islands (Marchant & Higgins 1990).

Threats

Introduced mammals are the greatest threat to this species. On Auckland Island, the former population was extirpated by feral cats and pigs. The species was not known to have occurred at Campbell Island but could have been eliminated last century by feral cats and Norway rats. At Macquarie Island large numbers are killed annually by feral cats, but ship rats also prey on eggs and chicks, and weka formerly impacted on this species (Brothers 1984, Jones 1977). Cattle may have crushed burrows on Enderby Island prior to their removal and rabbits are likely to have competed for nesting burrows on the same island and nearby Rose Island before these species were eradicated in 1993. Fire may be a threat on Antipodes Island but because the species nests in all habitat types and breeds widely over the island, it is unlikely that more than a portion of the island would be burnt in one event. Some birds on Antipodes and Disappointment Islands nest in shallow burrows that are easily crushed. Visitor access should be strictly controlled on these densely burrowed islands. The risks to white-headed petrels at sea are poorly known. However, the closely related grey-faced petrel does occasionally follow ships and birds are sometimes killed in fishing operations (G. Taylor unpub.). White-headed petrels could also be vulnerable to fishing interactions in the high seas, but the risks appear slight.

Previous Conservation Actions

1. Rabbits were eradicated from Enderby and Rose Islands in 1993, and cattle and mice were eradicated from Enderby Island in 1993.

2. Observations on the distribution, breeding cycle, adult measurements, and vocalisations of white-headed petrels at Antipodes Island were made in 1969, 1978, and 1995 (Warham & Bell 1979, Imber 1983, G. Taylor, A. Tennyson & M. Imber unpub.).

3. Surveys were undertaken in 1988 and 1993 to assess the distribution of breeding colonies and to estimate size of breeding populations on some islands of the Auckland Islands group (Taylor 1988, K. Walker pers. comm 1993).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the subantarctic islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

M1. Feral cats and pigs should be eradicated from Auckland Island.

L1. Norway rats should be eradicated from Campbell Island.

L2. Establishment of a new colony of white-headed petrels on Campbell Island could be considered once Norway rats are eradicated. This would require translocation of chicks (probably from Auckland Islands) and the use of a tape-playback system to help lure these birds to the colony.

Future Survey and Monitoring Needs

H1. Antipodes, Adams, Disappointment, Enderby, and Ewing Islands should be inspected at least every 5 years to ensure that rodents and other mammals have not colonised them.

L1. Monitoring is needed to determine long-term trends in the white-headed petrel populations on New Zealand subantarctic islands. Permanent plots and burrow transects should be established on Enderby Island and monitored at 10-year intervals.

L2. The distribution of white-headed petrels needs further assessment at the Auckland Islands. Surveys are needed of all small offshore islands, and cliffs and bluffs on Auckland Island to determine if relict colonies or pairs continue to breed in these sites.

L3. Accurate estimates are needed of the breeding populations on all islands in New Zealand region. Priority sites are Enderby, Disappointment, Antipodes, and Adams Islands.

L4. Surveys are needed on the larger rodent-free islands off Campbell Island (Dent, Jacquemart, Jeanette-Marie, and Monowai Islands) to determine if remnant populations of white-headed petrels breed at the Campbell Islands. The species would be best detected by night visits to all these islands, between October and January.

Research Priorities

H1. The behaviour, social organisation, breeding dispersion, and vocalisations of white-headed petrels have been partly studied by Warham (1967) but needs re-investigation to assist in the recovery of the closely related (critically endangered) Chatham Island taiko. In particular, are there sexual differences in calls and how do birds respond to tape playback?

H2. The diet of white-headed petrels has not been studied in New Zealand. The range of food items taken needs research. This will provide a helpful comparison with the diet of the Chatham Island taiko. Food samples should be collected at both Auckland and Antipodes Islands and compared.

L1. The population dynamics of this species have not been studied. Information is needed on age of first breeding, mean age of first breeding, adult survival, longevity, chick survival and recruitment, emigration rates, natal site fidelity, pair and nest fidelity. This information could be collected at the Kerguelen Islands, but the information is unlikely to be reliable at Macquarie Island owing to predation by cats and rats. In New Zealand, the best locations to study population dynamics are the small colonies nesting on Enderby, Rose, Ewing, and Ocean Islands at the Auckland Islands. Other localities are not suitable because the colonies are too large.

L2. The breeding cycle of white-headed petrels has not been studied in New Zealand. This is probably best done on either Enderby or Antipodes Islands. Information needed includes date of first return to islands, courtship period, laying period and peak laying date, hatching period and peak hatching date, fledging period and peak fledging date, and occurrence of non-breeding season visits.

L3. The movements of white-headed petrels are poorly known. Satellite transmitters (weighing no more than 20 g) should be attached to breeding birds to determine where they forage during the incubation period and when feeding chicks. Transmitters should also be attached to adults feeding nearly fledged chicks in late April to determine patterns of dispersal and foraging zone during the non-breeding season.

L4. Comparisons are needed of morphometrics and weights between each breeding region. Currently it appears that the birds at Kerguelen Islands are larger than New Zealand birds, but this may be a consequence of sampling timing. Further investigation is needed.

L5. The breeding biology of this species has been studied at Macquarie Island, but information is still needed on incubation period and incubation shifts, chick growth rates, chick feeding frequencies, nestling period, and breeding success. This is probably best done at Enderby or Antipodes Islands or at other subantarctic islands.

Grey-faced Petrel *Pterodroma macroptera gouldi*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on islands, stacks, and headlands from the Three Kings group in the north to Omata (near New Plymouth) on the North Island west coast and a headland between Gisborne and Mahia Peninsula on the North Island east coast. The species breeds on the majority of offshore islands (more than 2 km from mainland) in the Hauraki Gulf and Bay of Plenty and also quite a few inshore islands (within 2 km of the mainland). The species is usually absent on islands where feral cats, mustelids, or Norway rats are present. However, small populations persist on the mainland in Taranaki, west Auckland, Hokianga, Cape Maria van Diemen, Mount Maunganui (Mauao), Ohope, and several sites in the East Cape and Gisborne regions. At sea, grey-faced petrels forage widely in the south-west Pacific Ocean and Tasman Sea between 25-50º S. They feed over deep pelagic water beyond the continental shelf and are seldom seen in inshore waters except near the breeding grounds.

Population

Robertson & Bell (1984) estimated that there were between 100,000 and 1million breeding pairs in New Zealand. Recent estimates of numbers on the major breeding islands suggest the population is about 200,000 to 300,000 breeding pairs, indicating a total population in excess of a million birds (G. Taylor unpub.). The two largest colonies appear to be on Moutohora and Hongiora Islands. These have between 20,000 and 50,000 breeding pairs (Imber 1976, G. Taylor & A. Tennyson unpub.). Islands likely to have more than 5000 breeding pairs include Hen, Lady Alice, Whatupuke, Burgess, Fanal, Red Mercury, Stanley, Double, Ruamahuanui, Ruamahuaiti, Plate, and White Islands. Most other colonies would only have a few tens or hundreds of breeding pairs (G. Taylor unpub.).

Threats

Introduced mammals are the greatest threat to this species. On the North Island mainland, colonies only persist on steep bush-clad slopes or cliff-tops adjacent to the sea. Feral cats and uncontrolled dogs can kill adult birds and chicks (Cooper & Fourie 1991, Cooper et al. 1995, G. Taylor pers. obs.). Feral pigs can potentially kill adults and dig up burrows, eggs, and chicks. Mustelids possibly kill adult grey-faced petrels and take eggs and chicks, although there was no evidence of predation on this species during a recent stoat invasion on Motuotau Island, Bay of Plenty (Clifford 1997). Norway rats and ship rats take eggs and chicks on mainland colonies, and also inshore and offshore island colonies such as Moutohora where very little recruitment of juveniles into the adult population took place for many years (Imber 1976, Harrison 1992). Pacific rats also take eggs and small chicks, but the impact on breeding success is less severe than that

caused by the other two species of rats (G. Taylor pers. obs.). Maori still legally harvest grey-faced petrel chicks at a few Bay of Plenty and Hauraki Gulf islands. Feral goats and cattle trample burrows on some islands and mainland colonies. Rabbits and possums compete for burrows on a few mainland colonies and have affected breeding success on offshore islands prior to their eradication. Fires may be a threat on some of the drier offshore islands, but because the species nests in winter and birds are largely absent from January to March, fires are unlikely to impact on this species. Burrows are easily crushed on some of the larger colonies, e.g. Hongiora and Plate Islands. Visitor access to islands with grey-faced petrel colonies should be managed on an island-by-island basis. In general, access should be strictly controlled on densely burrowed islands with friable soil. Birds have been reported entangled and killed by hip-chain cotton at one mainland colony (Woolley 1998). This product should be used with care when carrying out surveys in seabird colonies. Symptoms of avian pox virus have been observed in this species, and avian diseases may contribute to adult and chick mortality in some seasons. Grey-faced petrels occasionally scavenge behind fishing boats. Birds have been caught on long-lines set for tuna (G. Taylor unpub.) All seven birds caught in a sample autopsied in April 1998 were males (G. Taylor unpub.). If males are more at risk than females, then this may affect sex ratios on the colonies. A few birds are also killed in trawler fisheries (DOC fisheries observer programme unpub.).

Previous Conservation Actions

1. Rats have been eradicated from a number of grey-faced petrel colonies in the past 15 years. These include Moutohora, Burgess and adjacent islands in Mokohinau group, Motuterakihi, Motuopao, Lady Alice, Whatupuke, Korapuki, Double, Stanley, Red Mercury, Cuvier, Tiritiri Matangi, Saddle, Goat, East, and Kauwahaia.

2. Rabbits have been eradicated from Moutohora, Korapuki, and Stanley Islands. Feral goats have been eradicated from Burgess, Cuvier, and Moutohora Islands. Feral cats were eradicated from Cuvier and Little Barrier Islands.

3. The biology and ecology of grey-faced petrels have been studied on Moutohora (Whale) Island from 1968 to the present. Studies included documentation of the breeding cycle and breeding biology (Imber 1976, Johnstone & Davis 1990), diet (Imber 1973), methods for sexing birds (Johnstone & Niven 1989), evolutionary relationships with other petrels (Imber 1985), and behaviour (Imber 1975). Population changes following eradication of goats, rabbits, and Norway rats have been monitored by Harrison (1992). Large numbers of grey-faced petrel adults and chicks were banded between 1968 and the mid-1990s.

4. Population surveys, and banding of adults and chicks have been undertaken in the Mercury Islands by OSNZ members and DOC staff between 1987 and 1998 (Tennyson & Taylor 1990b, G. Taylor unpub.). Monitoring plots were set up on Stanley Island in 1993 to measure changes in the breeding population following the eradication of rabbits and Pacific rats. These were resurveyed in 1998.

Grey-faced petrel, Double Island, Mercury Islands, 1988

Known as the northern muttonbird, Maori still harvest grey-faced petrel chicks at a few Bay of Plenty and Hauraki Gulf islands. The largest populations occur on Moutohora (Whale Island) and the Aldermen Islands. A few remnant colonies persist on coastal cliffs and headlands around northern New Zealand, but introduced predators are a threat to these populations.

5. The behaviour of birds responding to war-whoops was studied by Tennyson & Taylor (1990b) This method was used to locate new grey-faced petrel colonies in Taranaki, west Auckland, and on Great Barrier Island.

6. The breeding cycle, breeding biology, population dynamics, movements, social behaviour, and vocalisations of grey-faced petrels have been studied since 1989 at two colonies on the Auckland west coast (Bethells Beach) (G. Taylor unpub.). Large numbers of adults and chicks have been banded.

7. The status, population size, and impacts of predators have been studied since 1991 at Mount Maunganui (Mauao) and Motuotau Island by OSNZ members from Waikato Region. This study has monitored breeding success, mapped burrows, estimated breeding populations, and banded adults and chicks (H. Clifford unpub.). Management of the Mauao population is taking place whereby predators are being controlled annually in a collaborative programme involving DOC, Tauranga District Council, Environment Bay of Plenty, and local community assistance. Since pest control started, the number of fledglings produced has increased annually.

8. DOC staff have carried out surveys of breeding sites and banded adults at colonies on the Taranaki coastline (B. Williams pers. comm. 1998).

9. The status and movements of grey-faced petrel populations in the inner Hauraki Gulf (Tiritiri Matangi, Motutara, Te Haupa, and Motuora Islands) is being studied by OSNZ members from Auckland region.

10. Studies of grey-faced petrels have been carried out as analogous research for learning more about the critically endangered Chatham Island taiko. Studies to date include captive rearing trials at National Wildlife Centre (incubating eggs and rearing chicks for release into the wild) (G. Taylor, S. O'Connor, & H. Gummer unpub.), assessment of transmitter attachment methods (G. Taylor

unpub.), blood sampling for DNA studies on sex and relationships (D. Lambert, C. Millar & G. Taylor unpub.), and maximum diving ability tests (G. Taylor unpub.).

11. The diet of grey-faced petrel chicks and adults was analysed for nutrient composition (lipids, proteins, fatty acids, trace elements) and energy levels to help formulate artificial diets for hand-rearing petrel chicks (Hendriks et al. 2000).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

M1. Further pest eradications are needed. These include removal of Pacific rats from Mauitaha, Hen, and Ohinau Islands. Norway rats should be eradicated from Shoe and Slipper Islands. Ship rats should be eradicated from Saddle Island (off Great Barrier Island).

M2. Local communities should be encouraged to undertake management and protection programmes to secure the viability of mainland grey-faced petrel colonies, with Mauao, Tauranga, as a guiding example. This will require a period of pest control to protect adults in some sites and ensure successful rearing of chicks at all sites. Management of the Mauao population should continue, and sites in North Taranaki should also be considered for protection.

M3. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Controlled Dog Areas should be designated at all regionally significant mainland breeding colonies.

M4. The impact of cultural harvesting on grey-faced petrel populations should be assessed. This will require consultation with the relevant iwi to determine current harvest levels and to establish guidelines for sustainable harvests at each site.

Future Survey and Monitoring Needs

H1. All large colonies of grey-faced petrels (>5000 pairs) should be inspected every 5 years to ensure that rodents and other introduced mammals have not colonised these islands.

M1. Monitoring of breeding populations should continue at the west Auckland, Motuotau, and inner Hauraki Gulf colonies. The permanent plots and burrow transect established on Stanley Island should be monitored at 5-year intervals.

L1. The distribution of grey-faced petrel colonies is reasonably well known. There are probably colonies on the mainland that have not yet been recorded and others that have not been visited for 10-30 years. There also likely to be small colonies on close inshore islands that have been overlooked in the past. All colonies located should be recorded on the National Seabird Colony Register

once it is established. Mainland colonies should be monitored every 5 years to determine population trends.

L2. Accurate population assessments have only occurred at a few colonies. Quantitative surveys are needed on most islands with grey-faced petrel colonies.

Research Priorities

M1. The presence of mainland colonies, especially in Taranaki and the Bay of Plenty, provides an opportunity for the general public to view petrel colonies. All mainland colonies are in decline, and their continued existence probably depends on immigration from offshore island populations. Research is needed to develop techniques to retain mainland colonies and to develop cost-effective predator management programmes. Research is also needed to investigate whether or not reintroductions are viable for this species on the mainland of New Zealand and how this might be undertaken.

L1. Satellite transmitters (weighing no more than 15-20 g) should be attached to breeding birds to determine where they forage during the incubation period and when feeding chicks. Transmitters should also be attached to adults feeding nearly fledged chicks in late November to determine the foraging zone of grey-faced petrels during the non-breeding season.

L2.The growth of chicks from hatching to fledging has not been studied in detail. Descriptions of plumage development, growth curves, frequency of feeds by each adult, and meal sizes need to documented.

Soft-plumaged Petrel *Pterodroma mollis mollis*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

The species breeds only on Antipodes Island in the New Zealand region. Elsewhere, breeds at the Tristan da Cunha group and Gough Island in the South Atlantic Ocean and possibly on Maatsuyker Island, off Tasmania. The closely related subspecies *P. m. dubia* nests on Amsterdam, Kerguelen, Crozet, Prince Edward, and Marion Islands, and possibly Macquarie Island. Birds disperse widely in the Southern Ocean, occurring over Antarctic, subantarctic, and subtropical seas.

Population

Soft-plumaged petrels were first discovered in New Zealand in 1969 when birds were caught near an expedition campsite at Antipodes Island (Warham & Bell 1979). Birds were found in burrows in November 1978, and the population was estimated at 50-100 pairs (Imber 1983). In 1995, surveys on Antipodes Island found three separate colonies.The population was estimated at several thousand pairs. The species is apparently expanding into new habitats and increasing at Antipodes Islands (M. Imber, A. Tennyson & G. Taylor unpub.). Elsewhere, populations vary from tens of pairs to tens of thousands of pairs (Marchant & Higgins 1990).

Threats

At Antipodes Island, mice are the only introduced species of mammals. They appear to have no obvious impact on breeding success since the population is expanding at that location. Elsewhere, feral cats and rats have devastated populations (Cooper et al. 1995, Marchant & Higgins 1990). Introductions of rats and other introduced mammals to breeding islands are the greatest risk to this species. Fire is also a risk at Antipodes Island because the island is dry in the summer and soft-plumaged petrels nest under tall tussocks, ferns, and low shrubs near the coast. A fire between October and February would have the greatest impact. Breeding burrows are in very dense tall vegetation and are unlikely to be affected by visitor trampling. Brown skuas prey on birds that attempt to nest in open ground away from the valleys and dense areas of vegetation (Moors 1980). Skuas may eventually limit the spread of soft-plumaged petrels on Antipodes Island.

Previous Conservation Actions

1. The species was discovered on Antipodes Island in 1969, and birds were found occupying burrows in 1978 (Warham & Bell 1979, Imber 1983).

2. The calls of soft-plumaged petrels were described by Warham (1979). Bretagnolle (1995) carried out a taxonomic review of soft-plumaged petrel populations. He used call structure as a taxonomic tool to separate populations.

3. Preliminary surveys were carried out on Antipodes Island in 1994 and 1995. Two new colony sites were located. The boundaries of the camp valley colony were surveyed and mapped. Birds were banded, measured, and weighed (M. Imber, A. Tennyson & G. Taylor unpub.).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the subantarctic islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction.

L1. Mice should be eradicated from Antipodes Island.

Future Survey and Monitoring Needs

H1. Antipodes Island should be visited at least once every 5 years to ensure that rats and other introduced mammals have not colonised the island.

L1. One sub-colony on Antipodes Island should be monitored every 10 years to determine the rate of expansion of the colony.

L2. A thorough survey is needed to map all breeding colonies on Antipodes Island and to obtain an accurate estimate of the size of the breeding population. Sample quadrats and banding will be necessary to estimate population size.

L3. Surveys could be carried out on Adams and Disappointment Islands (Auckland group) every 10 years to determine if soft-plumaged petrels have colonised the Auckland Islands. The very distinctive flight call should be easily detected by nocturnal observations between October and January.

L4. A colonisation at the Chatham Islands is possible and should be recognised.

Research Priorities

L1. The breeding cycle is still poorly known at the Antipodes Islands. Information is needed on dates of return to colony and laying, hatching, and fledging dates.

L2. The taxonomy of soft-plumaged petrels is still controversial (Bretagnolle 1995). The status of the two subspecies needs determination. This would require study of all extant populations including DNA analysis and close examination of morphology, anatomy, and vocalisations.

L3. The breeding biology and diet of this species have not been studied in New Zealand. However, the diet has been sampled at other colonies and vocalisations have been studied elsewhere. Breeding biology has been partly studied at Marion Island but further information is needed on the incubation period and incubation shifts. Research is also needed on chick growth rates and breeding success.

Aspects of the breeding biology could be studied at Antipodes Island, but better opportunities are available at other subantarctic island colonies.

L4. Population dynamics (age at first breeding, longevity, survival and mortality of adults and chicks) are unknown for this species. These parameters could be studied at Antipodes Island but would require a long-term commitment and regular visits to the island. Population dynamics should be studied at other subantarctic islands with permanent bases.

Kermadec petrel, Macauley Island, 1988

The Kermadec petrel is a very polymorphic species. That is, it has a full range of plumages from white-breasted forms to totally dark birds. Some birds have pink legs and others have black legs. A huge population once nested on Raoul Island, but the species was wiped out by cats and rats between 1920 and 1967. (See opposite.)

Kermadec Petrel *Pterodroma neglecta neglecta*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breed at the Kermadec Islands (islands off Raoul Island including North and South Meyer Islets, Napier, Nugent, Dayrell, North and South Chanter Islands; Macauley and Haszard Islet). Formerly bred on Raoul Island. Elsewhere, a few breed at the Lord Howe Islands (Balls Pyramid), Norfolk Islands (Philip Island); Tuamotu, Austral, and Easter Islands; and Pitcairn Islands (Ducie, Oeno, and Henderson). The subspecies disperses over tropical and sub-tropical seas throughout the Pacific Ocean.

Population

The largest populations in the south-west Pacific occur on North and South Meyer Islands where in 1966/67 there were an estimated 5000-6000 pairs (Merton 1970). Other islets off Raoul Island had populations of a few pairs to perhaps hundreds of pairs. The population on Macauley Island was estimated to be no more than 50 pairs in 1988 (Taylor & Tennyson 1988, Tennyson et al. 1989). There were an estimated 40,000 pairs nesting at the Pitcairn Islands in 1991 (Brooke 1995).

Threats

Kermadec petrels are a surface-nesting species. This makes them extremely vulnerable to predation by large predators such as feral cats, dogs, and pigs. Norway rats also have a severe impact on this species taking both eggs and chicks. In 1908, it was estimated that the Kermadec petrel population comprised half a million individuals on Raoul Island alone. Over the next few decades the population was totally wiped out on Raoul Island by predation by the two species of rat and feral cats (Merton 1970). Recent studies at the Pitcairn Islands have revealed that Pacific rats kill most of the chicks soon after hatching (Brooke 1995). Roy Bell recorded similar high losses in some seasons before Norway rats reached Raoul Island (Merton 1970). The small population on Macauley Island may also be at risk from Pacific rat predation. Trampling by feral goats probably impacted on the populations on Raoul and Macauley Islands before the goats were eradicated. Fire is a possible threat on the Meyer Islets but is more of a risk on Macauley Island with its dense sward of sedges. Volcanic activity at Raoul Island is a potential threat but possibly surface-nesting species are more likely to escape ash deposits than burrow nesting species. Little is known about the possible effects of pollutants such as plastics, chemical contaminants, and oil spills. However, because this species forages in the North Pacific, it may be at greater risk from pollutants than some other New Zealand breeding species.

Previous Conservation Actions

1. Populations were surveyed on the Meyer Islets and other stacks off Raoul Island in 1966/67. Population sizes were estimated on the larger islands and laying dates observed. There were 944 Kermadec petrels banded during this expedition (Merton 1970).
2. Feral goats were eradicated from Macauley Island by 1970 and Raoul Island by 1984.
3. Surveys were undertaken in 1970, 1988, and 1989 to locate breeding populations on Macauley and Curtis Islands (Bell 1970, Taylor & Tennyson 1988, Tennyson et al. 1989, Tennyson & Taylor 1990a,b).
4. The annual breeding cycle of Kermadec petrels at the Meyer Islets was described by Veitch & Harper (1998).

Future Management Actions Needed

H1. Norway and Pacific rats and feral cats should be eradicated from Raoul Island as a matter of some urgency.

H2. Pacific rats should be eradicated from Macauley Island.

H3. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the Kermadec Islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Special precautions are needed to stop rodents being moved accidentally between Raoul Island and their New Zealand stronghold on the Meyer Islets.

L1. Kermadec petrels should be re-established on Raoul Island once predators are removed. Initially tape playback of calls and perhaps models of nesting birds should be used to lure adult birds, but transfers of chicks from the Meyer Islets may also be necessary.

Future Survey and Monitoring Needs

H1. All large islands (>5ha) in the Kermadec Islands should be inspected every 5 years to ensure that rodents and other introduced mammals have not colonised these islands.

H2. A survey should be undertaken on North Meyer Islet within 5 years to locate any birds banded during 1966/67 expedition. These will provide a useful estimate of adult survival and longevity in this species.

H3. A survey is needed to determine the size of the population on Macauley Island. Previous surveys were carried out in August, September, November, and December. Visits should occur between January and March to determine if autumn and winter nesting populations also breed on this island.

L1. The population on the Meyer and Herald Islands should be re-censused within the next 5 years to calculate trends in the breeding populations over the past 30 years. This census will also be useful as a baseline if pest mammals are eradicated

from Macauley and Raoul Islands and Kermadec petrels start to colonise these islands.

L2. A survey is needed on Curtis, Cheeseman, Haszard, and L'Esperance Rocks during February to May to establish if autumn and winter nesting populations of Kermadec petrels breed on these islands.

Research Priorities

H1. The taxonomy of the species should be reappraised; in particular, relationships between summer and winter nesting populations.The species has a complex array of plumage morphs and colour phases. Studies are needed to examine how these morphs are derived from various combinations of mated pairs. DNA analysis would also help to investigate the taxonomic relationships between the two subspecies of Kermadec petrel and closely related species, e.g. Trinidade, Herald, Henderson, and Phoenix petrels.

L1.The breeding biology of this species was studied in 1908 by Oliver and Iredale on Raoul Island (see Oliver 1955). Recently the species has been studied at the Pitcairn Islands (Brooke 1995). Kermadec petrels have a very complex breeding cycle with peak laying in spring-summer (October - December) and autumn (February-March). The populations on Macauley Island appear to be summer nesters (as were the populations formerly on Raoul Island) whereas those on the Meyer Islets and breeding colonies elsewhere in the Pacific are mainly autumn/ winter nesters (Veitch & Harper 1998). Further work is needed on the spread of laying dates at the Kermadec Islands, especially at Macauley Island, and to establish if individual birds nest only in the same period each year. Research is also needed on basic breeding biology parameters (incubation period, incubation shifts by each partner, chick guard period, chick growth curves and nestling period, breeding success etc.).

L2. The population dynamics of Kermadec petrels are unknown. Information is needed on age at first breeding, frequency of breeding, survival and mortality of adults and fledglings, natal and site fidelity.The Meyer Islets has one of the more accessible populations and should be considered for a long-term study.

L3. The diet of the New Zealand populations is unknown. Recent studies at Henderson Island have provided some insights into the diet in the central Pacific (Imber et al. 1995). Diet samples should be collected whenever the opportunity arises during visits to the Kermadec breeding colonies.

L4. The voice of Kermadec petrels is unusual and complex. A study is needed to determine the variety of calls and whether individual and sexual differences exist.

L5. When available, satellite transmitters (weighing a maximum of 15-20 g), should be attached to adults feeding nearly fledged chicks to determine where the New Zealand populations migrate to and spend their non-breeding season. Are there differences between summer and winter nesting birds in their non-breeding distribution? The foraging range of birds while nesting during summer or winter at the Kermadec Islands would also be worthwhile investigating to find any differences between these two groups of petrels.

Black-winged Petrel *Pterodroma nigripennis*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Kermadec Islands (Raoul, North Meyer, South Meyer, Napier, Dayrell, North Chanter, South Chanter, Macauley, Haszard (?), Curtis, Cheeseman, L'Esperance Rock), Three Kings Islands (Great, South-west), Motuopao, Matapia, Simmonds, Piercy (also known as Motukokako), East and Portland Islands, and Chatham Islands (Rangatira, Mangere, and possibly Star Keys). Black-winged petrels appear to be expanding their breeding range, and prospecting has been recorded at a number of sites including Cape Maria Van Dieman, North Cape, Poor Knights and Cuvier Islands, also Pitt Island and Forty-Fours at the Chatham Islands (Jenkins & Cheshire 1982, Tennyson 1991, Imber 1994). Elsewhere, breeds at the Norfolk Islands (Norfolk, Philip), Lord Howe Islands (Lord Howe, Balls Pyramid), islands off New Caledonia, Rarotonga, islets in Tonga, and islets off Rapa Island. This species only breeds in the south-west Pacific Ocean and Tasman Sea and in summer forages over sub-tropical seas between 25º- 47ºS. After breeding the entire population migrates to the central and North Pacific Oceans (Jenkins & Cheshire 1982).

Population

The stronghold of this species is at the Kermadec Islands. An estimated 2-3 million pairs breed on Macauley Island (Tennyson et al. 1989) and 300,000 pairs on Curtis Island (Tennyson & Taylor 1990a,b). There are also thousands of pairs on the Meyer Islands (Merton 1970). The remaining populations are smaller and are generally a few tens of pairs or hundreds of pairs (Tennyson 1991). McCallum et al. (1985) estimated that less than 1000 black-winged petrels occurred at the Three Kings Islands in 1985. The population in the New Zealand region appears to be increasing because new colonies have established in the past 30 years and prospecting birds have been observed at many sites around northern New Zealand and the Chatham Islands (Jenkins & Cheshire 1982, Tennyson 1991).

Threats

The population on Raoul Island has been all but eliminated by feral cats, Norway rats, and Pacific rats. Pacific rats are also on Macauley Island but don't appear to have a measurable impact on this enormous breeding population. Feral goats probably had a major impact on both Raoul and Macauley Island in the past by trampling burrows. The introduction of new mammalian predators or browsers to the breeding colonies, especially the large Kermadec colonies, would pose the greatest risk to the species. Fire is another risk. Both Macauley and Curtis are covered in dense sedges and grass that would burn extensively in summer. A fire between November and March would cause the greatest damage to the breeding population. Other breeding islands are also at risk from fire, especially the Three

Kings and Motuopao. The nesting colonies on the Kermadec Islands are in extremely friable soil, and the burrows are extremely vulnerable to crushing by visitors.

Volcanic eruptions at Curtis Island or Raoul Island could have an adverse impact if eruptions occurred in summer or autumn. The populations on the Chatham Islands are struggling to establish owing to intense competition for nests with broad-billed prions, fairy prions, and sooty shearwaters, and from severe predation by brown skuas on prospecting birds (Tennyson 1991, Imber 1994). Feral cats kill birds prospecting on North Island headlands, and on Pitt, Norfolk, and Lord Howe Islands.

Previous Conservation Actions

1. Feral goats were eradicated from Great Island in 1946, Macauley Island by 1970, and Raoul Island by 1984.
2. The distribution of black-winged petrels was surveyed on Raoul Island and adjacent islets in 1966-67 (Merton 1970) and on the southern Kermadec Islands in 1970 (Bell 1970).
3. The establishment of black-winged petrels on Portland Island was reported by Eagle (1980).
4. The seasonal distribution and abundance of black-winged petrels at sea, and the location of breeding colonies is reviewed by Jenkins & Cheshire (1982).
5. Breeding of black-winged petrels at the Chatham Islands was confirmed by Merton (1984).
6. The distribution and status of the Three Kings Islands populations were surveyed by McCallum et al. (1985).
7. Aspects of the breeding cycle and breeding biology, morphometrics, behaviour, and vocalisations were studied on Mangere Island in 1987-88 (Tennyson 1989, 1991, Marchant & Higgins 1990).
8. The size of the breeding populations on Macauley and Curtis Islands were estimated by surveys in 1988 and 1989 (Tennyson et al. 1989, Tennyson & Taylor 1990a,b). Birds were banded, and measurements and weights taken (Marchant & Higgins 1990).
9. Pacific rats were eradicated from Motuopao Island in 1992.
10. The black-winged petrel population on Motuopao Island was surveyed and mapped in 1990-1992 and an estimate made of the breeding population (Pierce & Parrish 1993).
11. Pacific rats were poisoned on East Island in 1997.The success or otherwise of this operation will be known 2 years after poisoning.

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore and outlying islands.A pest contingency plan should be

available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting black-winged petrels.

H2. Feral cats, Norway rats, and Pacific rats should be eradicated from Raoul Island.

M1. Access to all the large Kermadec Island colonies should be strictly controlled to minimise damage by visitors to the breeding grounds.

M2. Pacific rats should be eradicated from Macauley Island.

L1. A colony could be re-established on Raoul Island once predators are removed. Although prospecting birds already visit the island and sometimes breed, the use of a tape-playback system will help lure birds into a defined colony site. This new colony site should be situated near the coast to maximise the chance of non-breeding adults hearing the tape when flying past Raoul Island.

Future Survey and Monitoring Needs

H1. All large islands (>5ha) in the Kermadec Islands, Three Kings Islands, and Motuopao Island should be inspected every 5 years to ensure that rodents and other introduced mammals have not colonised these islands.

L1. The colonisation of black-winged petrels on Rangatira and Mangere Islands should be monitored at 5-year intervals to determine if the colonies are expanding there.

L2. The breeding colony on Motuopao Island should be monitored at 10-year intervals to map changes in the breeding colony and to estimate the number of breeding pairs.

L3. Accurate quantitative surveys are needed on all islands in the Kermadec Islands and Three Kings Islands to calculate the size of breeding populations. Estimates to date have been based on burrow counts and burrows per unit area. The variation in burrow counts within different habitats needs assessment, and visits are necessary during the incubation period to determine the proportion of breeding pairs per area compared with burrow entrances per area. Sampling is needed in priority on Macauley, Meyer, Curtis, and Great Islands.

L4. The status of black-winged petrels on the smaller islands at the Three Kings Islands, Poor Knights, East, Star Keys, and Forty-Fours needs to be determined including confirmation of breeding. Visits are best timed between mid-January and mid-March.

Research Priorities

L1. The ecology of black-winged petrels is still poorly known. Detailed study is needed on the breeding cycle to determine dates of first return at colonies south of the Kermadec Islands, also laying, hatching and fledgling periods, incubation period, chick growth rates, frequency of feeds and meal size delivered by adults, breeding success and breeding frequency. In particular, breeding success should be determined at colonies where predation and interspecific burrow

competition is absent and compared with sites such as Macauley, Mangere, or Rangatira Islands where these factors may affect breeding success.

L2. The diet and foraging ecology of black-winged petrels is poorly known. Food samples should be collected from birds at a range of geographic locations (Kermadecs, colonies off North Island, Chatham Islands) to compare diet. Seasonal and sexual differences in diet also need examination.

L3. The population dynamics of this species are still unknown. Information is needed on age of first return to colonies, age of first breeding, longevity, survival and mortality of adults and juveniles, recruitment of chicks, and natal philopatry. The best site to collect this information is Portland Island. The populations on Mangere, Rangatira, and Motuopao Islands may also be useful as study colonies. Potential problems include difficult access to some colonies, burrows being in soft friable soils, and difficulty in relocating returning juveniles in the larger colonies.

L4. Further work is needed on social behaviour, in particular the age and sex of birds prospecting at new colony locations. Research is also needed on vocalisations to determine if sexual differences are present in the calls and the extent of individual variation and recognition of calls. Courtship behaviour and displays need description.

L5. When available, satellite transmitters (weighing no more than 4-7 g) should be attached to breeding birds to determine where they forage during incubation period and when feeding chicks. Transmitters should also be attached to adults feeding nearly fledged chicks in late April to determine the migration flight path and foraging zone during the non-breeding season.

Subantarctic Little Shearwater *Puffinus assimilis elegans*

Conservation Status: Indigenous subspecies

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Chatham Islands (Star Keys and possibly Little Mangere Island) and Antipodes Islands (Bollons and Archway Islands, probably other islets and stacks off Antipodes Island). Elsewhere, breeds on Gough and Tristan da Cunha Islands in the South Atlantic Ocean. The subspecies disperses widely in cold waters between the subantarctic and Antarctic convergence zones. Some birds from the Antipodes population may disperse east to the Chilean coast during the non-breeding season.

Population

An estimated 100,000 pairs breed on Bollons and Archway Islands and other islets off Antipodes Island (Imber 1983).The population at the Chatham Islands is small, possibly 100+ pairs (Marchant & Higgins 1990).

Threats

All the New Zealand populations currently breed on predator-free islands. The introduction of predators (feral cats, pigs, weka, Norway and ship rats) probably extirpated the subspecies from the larger islands in the Chatham group, although little shearwaters are surprisingly absent from some apparently suitable islands, e.g. Rangatira. Similarly, there are no obvious reasons why little shearwaters do not nest on main Antipodes Island. The known breeding colonies are all remote locations and have a very low risk of predator introductions. Crushing of burrows by fur seals is a potential threat at the Star Keys colony. Human disturbance is minimal at all sites. Perhaps the subspecies is restricted to small islands by competition for burrows with more aggressive species such as broad-billed prions and sooty shearwaters at the Chatham Islands.

Previous Conservation Actions

1. Very little study has been done on this subspecies. Estimates were made of populations breeding on the islands off Antipodes Island in 1978 (Imber 1983) and on the Star Keys in the 1980s (Marchant & Higgins 1990).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an

introduction. Rodent quarantine measures are essential for protecting subantarctic little shearwaters.

L1. A new colony could be established on Mangere Island or Pitt Island if predators (feral cats, weka, and pigs) are removed from some part or all of the island. Otherwise the new colony would need to be protected by a predator-proof fence. Chicks could be transferred to the new colony site from the Star Keys and a tape-playback system will be needed to lure in adult birds. The new colony should be developed on steep ground near the sea because the subspecies appears to prefer sites with easy sea access.

Future Survey and Monitoring Needs

M1. Visits should be made to Star Keys and Bollons Islands once every 5-10 years to ensure that rodents and other introduced mammals have not colonised these islands.

L1. The current status of little shearwaters on Little Mangere Island and small islets off Antipodes Island needs confirming. In particular, does the subspecies breed at these sites and if so, how many breeding pairs are present (estimate only required)?

L2. Seabird biologists need to visit Adams and Disappointment Islands between August and November to determine if small populations of this subspecies nest on the Auckland Islands. (The subspecies is commonly seen in the bays and inlets of this group in winter.) A visit to Little Solander Island should also be made during the same period to survey for this subspecies. (There are several records of little shearwaters heard in flight or found dead at the Solander Islands (Cooper et al. 1986).)

L3. An accurate census should be undertaken on Bollons Island to determine the size of the breeding population and confirm the validity of the 1978 estimate.

Research Priorities

L1. Taxonomy of the little shearwater group (P. *assimilis* subspecies) needs further resolving to determine the extent of divergence of the populations breeding on the Kermadec Islands, Norfolk and Lord Howe Islands, Australia, and islands off New Zealand. Research should include DNA analysis and a detailed study of morphology, anatomy, and vocalisations.

L2. More precise information is needed on the basic breeding timetable (months birds visit the colony, laying period, hatching period and peak of hatching, fledging period and peak of fledging). This information can be obtained either by a study on Star Keys or sampling activity in at least 30 little shearwater burrows on each visit made by seabird biologists to Bollons Island.

L3. Research could be undertaken to examine the diet of this species and to determine the extent of foraging movements near the breeding colonies.

L4. When available, satellite transmitters (weighing no more than 7-10 g), should be used to determine if fledglings and/or non-breeding adults from Antipodes Islands disperse east to seas off Chile.

L5. Studies of population dynamics (age of first breeding, longevity, survival and mortality of adults and fledglings) are probably best undertaken on the closely-related *haurakiensis* subspecies.

Flesh-footed shearwater chick, Kauwahaia Island, 1991

Flesh-footed shearwaters form the largest percentage of petrels caught off eastern Australia by tuna long-liners. Immature males are regularly taken in April, and adults returning from migration are caught in September. The species is commonly hooked by recreational fishers around northern New Zealand. The impact of these fisheries on local breeding populations is currently unknown. (See opposite.)

Flesh-footed Shearwater *Puffinus carneipes*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: not listed

Distribution

Breeds on islands around North Island and Cook Strait including Hen & Chickens Islands (Lady Alice, Whatupuke, Coppermine, Mauitaha, Hen), Mercury Islands (Middle, Green, Korapuki, Stanley, stack north of Stanley, Double, and possibly Red Mercury), Ohinau, Karewa, East, Kauwahaia, Motumahanga, Middle Trio, and Titi Islands. Elsewhere, breeds on Lord Howe Island, in South Australia (Smith Island), at least 21 islands off southern coast of Western Australia and at Ile St Paul (Indian Ocean). The species forages over continental shelves north of the sub-tropical convergence during the summer and the New Zealand population migrates to the North Pacific Ocean between May and September. Birds are mostly absent from the New Zealand region during winter.

Population

The size of the New Zealand breeding population was estimated by Robertson & Bell (1984) as between 50,000 and 100,000 pairs. This figure now seems too high based on recent visits to breeding colonies.The largest colonies (more than 1000 pairs) are on Lady Alice, Whatupuke, Coppermine, Middle, Green, and Karewa Islands.The current New Zealand population is probably about 25,000 to 50,000 pairs.There are an estimated 20,000 to 40,000 pairs on Lord Howe Island and 600 pairs on Ile St Paul (Marchant & Higgins 1990). The colonies off southern and western Australia are thought to number 100,000 to 200,000 pairs (Ross et al. 1996 cited in Onley & Bartle 1999). The current status of New Zealand populations is uncertain. The species is increasing on some islands (e.g. Kauwahaia Island, Motumahanga Island) but no longer breeds at the Aldermen group and has not been seen in recent years at Hen Island or Red Mercury Island (G.Taylor unpub.).

Threats

Introduced mammals are a potential threat to flesh-footed shearwater colonies. The largest colonies in New Zealand occur on islands free of ship rats, Norway rats, and mustelids.The birds can rear chicks on islands with Pacific rats although there have been no studies as to whether or not breeding success is affected by these rodents. Ship rats may not be a significant threat because flesh-footed shearwaters breed successfully on Lord Howe Island where ship rats are present. Norway rats occurred on Titi Island in the past, but their impact on breeding success was not assessed. Rabbits probably compete for burrows or disturb nesting birds on Ohinau Island. Competition for burrows between the winter nesting grey-faced petrel and summer nesting flesh-footed shearwater has a significant impact on breeding success on islands where both species are common. Chicks are killed and evicted by the other species reclaiming its

burrow (G. Taylor pers. obs.). Fires may cause temporary losses in the populations, especially during incubation (December to February). Flesh-footed shearwater colonies on small rodent-free islands mostly occupy sites with very friable soils that are easily collapsed by people. Visitor access to these islands needs to be strictly limited to protect birds especially during the courtship and incubation periods (October to February).The species was formerly harvested by iwi, and there has been interest in resuming harvests of this species at Karewa Island in recent years.

At sea, flesh-footed shearwaters form the largest percentage of petrels caught off eastern Australia by tuna long-liners. Immature males are regularly taken in April and adults returning from migration are caught in September (Gales et al. 1998). Only a small number of flesh-footed shearwaters were caught on tuna long-lines set off northern New Zealand between 1988 and 1997 (Baird et al. 1998). Very few flesh-footed shearwaters have been identified as killed in the high seas tuna fisheries (Uozumi 1998). However, a large proportion of the petrels and shearwaters killed in this fishery were not identified by the Japanese observers on these fleets (Uozumi 1998). Flesh-footed shearwaters frequently scavenge behind trawlers and may be at risk from trawl nets and warps (Freeman 1992).Yet there are no reports of this species being killed by trawlers in New Zealand seas (DOC fisheries observer programme unpub.). Recreational fishers often catch flesh-footed shearwaters on hand and reel-lines, and birds with imbedded hooks or tangled in monofilament lines have been found dead on northern beaches (Taylor 1996, M. Imber pers. comm. 1999).The species is less likely to be caught in inshore set nets because they tend to forage away from the coast. However, large numbers of flesh-footed shearwaters were previously killed in drift-nets set in the North Pacific Ocean (Tennyson 1990, Johnson et al. 1993 cited in Gould et al. 1998). Currently, the species may be vulnerable to capture by long-lining and gill-net fisheries in the North Pacific Ocean during the winter migration. Little is known about the possible effects of pollutants such as plastics, chemical contaminants, and oil spills.This species, however, forages in the North Pacific so it may be at greater risk from pollutants than some other New Zealand breeding species. In summer the main breeding colonies occur near areas with active shipping (Whangarei, Auckland, Tauranga, Wellington) or oil prospecting and production (New Plymouth).An oil spill near these breeding colonies could have a major impact on this species' survival in New Zealand.

Previous Conservation Actions

1. Norway rats were eradicated from Titi Island in 1975. Pacific rats were eradicated from Korapuki, Stanley, Double, Red Mercury, Lady Alice, and Whatupuke Islands between 1986 and 1994. Ship rats were eradicated from Kauwahaia Island in 1989. Rabbits were eradicated from Korapuki and Stanley Islands in 1987 and 1992.
2. The size of the flesh-footed shearwater breeding population on Titi Island was surveyed and monitored annually in the late 1980s, in conjunction with sooty shearwater monitoring.This work is ongoing (M.Aviss pers. comm. 1998).

3. Burrow distribution, breeding success, and population changes were monitored on Lady Alice Island in conjunction with a study of tuatara during the 1980s (D. Newman pers. comm. 1999).

4. The size of the population on Motumahanga Island was surveyed in 1989 and 1998 (G.Taylor unpub.).

5. The population breeding on Kauwahaia Island has been studied since 1989. The main studies include determining laying period, breeding success, adult survival rates, and competition for burrows with other petrel species. Birds have been banded, blood samples taken for sexing and studies of genetic relationships, and diving ability has been assessed (G.Taylor unpub.).

6. The population on Karewa Island was monitored for breeding success in the early 1990s. The breeding cycle and breeding biology of flesh-footed shearwaters was studied on Karewa Island in 1994-1995 (Rachel McClellan, Victoria University).

7. Pacific rats were poisoned on Coppermine and East Islands in 1997. The success or otherwise of these operations will be known 2 years after poisoning.

Future Management Actions Needed

H1. There needs to be further development of appropriate mitigation devices or techniques to minimise or eliminate seabird bycatch, especially from long-line fisheries. Liaison is needed with the fishing industry to ensure that incidental bycatch is monitored and to co-ordinate actions to minimise further seabird losses associated with fishing practises.

H2. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting flesh-footed shearwaters.

M1. Pacific rats should be eradicated from Mauitaha and Hen Islands. Pacific rats and rabbits should be eradicated from Ohinau Island once agreement is reached with the owners.

L1. Consideration should be given to establishing flesh-footed shearwater colonies on other northern offshore islands and islands in Cook Strait. Suitable islands include Cuvier Island and possibly more inshore islands such as Motuora and Tiritiri Matangi. Mana Island may be a suitable site in Cook Strait. Chicks would need to be transferred to these sites (probably from Lady Alice or Coppermine Islands) and tape playback used to lure returning birds back to the colony.

Future Survey and Monitoring Needs

H1. The current status and population size of most New Zealand breeding colonies is poorly known. Surveys are needed to estimate the number of breeding pairs, especially at the Chickens Islands, Ohinau Island, and East Island.

M1. Information is needed from observer programmes in the North Pacific Ocean to determine if flesh-footed shearwaters are being caught by long-liners, trawlers, or other fisheries in this area.

L1. The monitoring programme should continue annually on Kauwahaia Island.

L2. The distribution of breeding colonies is fairly well known in New Zealand. Confirmation is still needed on whether or not breeding colonies occur on Hen, Red Mercury, Double, and Little Ohinau Islands. Surveys are also needed on the Mokohinau (especially Fanal), Poor Knights, and Three Kings Islands to determine if the species occurs there. Surveys are best done between mid-October and January.

L3. The populations on Titi and Karewa Islands should be monitored every 10 years to assess changes in the size of breeding populations.

Research Priorities

H1. The population dynamics of this species are still unknown. Information is needed on age of first return to colonies, age of first breeding, longevity, survival and mortality of adults and juveniles, recruitment of chicks, and natal philopatry. The best sites to collect this information are Kauwahaia, Titi, Lady Alice, and Korapuki Islands. Potential problems include difficult access to some colonies, burrows being in soft friable soils, and difficulty in relocating returning juveniles in the larger colonies.

M1. The diet and foraging ecology of flesh-footed shearwaters is poorly known. Food samples should be collected from birds at a range of geographic locations (west coast colonies, colonies off north-eastern North Island, Cook Strait) to compare diet composition.

L1. Aspects of the breeding cycle and breeding biology have been studied in western Australia (Warham 1958) and in New Zealand by R. McClellan and G. Taylor (unpub.). Further work is needed on hatching and fledging dates, incubation and nestling periods, incubation shifts, chick growth rates, frequency of feeds and meal size delivered by adults, breeding success, and breeding frequency. In particular, breeding success should be determined at colonies where predation and interspecific burrow competition is absent and compared with sites where these factors may affect breeding success.

L2. Satellite transmitters (weighing no more than 20-25 g) should be attached to breeding birds to determine where they forage during incubation period and when feeding chicks. Transmitters should also be attached to adults feeding nearly fledged chicks in mid-April to determine the migration flight path and foraging zone during the non-breeding season.

L3. Further work is needed on social behaviour, in particular the age and sex of birds prospecting at new colony locations. Research is also needed on vocalisations to determine if sexual differences are present in the calls and the extent of individual variation and recognition of calls. Courtship behaviour and displays need description.

Fluttering Shearwater *Puffinus gavia*

Conservation Status: Endemic species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on numerous small islands between the Three Kings group and Cook Strait/NW Nelson. A list of known breeding colonies is found in Wragg (1985). The larger colonies occur at the Three Kings Islands (West, South-west, Great), Moturoa Islands, Cavalli Islands (Motuharakeke), Poor Knights, North-west Chickens, Bream Islands, Mokohinau Islands (Lizard), Channel Island, Mercury Islands (Middle, Green, stack north of Stanley), Aldermen Islands (Ruamahuanui), Long Island, and the Trio Islands. Fluttering shearwaters forage over the continental shelf and inshore waters including sheltered bays and harbours. They are usually found north of the sub-tropical convergence. Fledglings and possibly some adults migrate to eastern and southern Australia in February (Bell 1995). However, large numbers of birds remain around the New Zealand coast during autumn and winter.

Population

There are no reliable estimates of the total population size of fluttering shearwaters in New Zealand nor any information on population trends. Robertson & Bell (1984) considered there might be as many as 100,000 to 1 million. Flocks of up to 20,000 birds have been reported in the Hauraki Gulf (G. Taylor pers. obs.) indicating that at least 100,000 individual birds are possible.

Threats

All breeding colonies are on mammal-free islands or islands that only have Pacific rats present. The breeding populations are quite small on islands with Pacific rats. Probably these rats eat eggs and chicks of fluttering shearwaters. The species once bred on Moutohora Island but was extirpated by Norway rats and feral cats (Robertson 1985). Recently a small colony of fluttering shearwaters attempted to nest on the Taranaki mainland after the colony site on a small offshore stack (30 m offshore) was eroded by storms. Most of these birds were killed by predators (probably stoats and feral cats) (B. Williams pers. comm. 1996). The introduction of new mammalian predators on breeding islands is a potential serious risk for this species. Fires may cause temporary losses in the populations, especially during incubation (September-November). Nesting colonies on small rodent-free islands are usually in very friable soil. The burrows on these islands are easily collapsed by people moving about the colonies. Visitor access to these sites needs to be strictly limited, especially during the courtship and incubation periods (August to November). Fluttering shearwaters frequently feed close inshore and dive deeply for food. Consequently, birds have been caught by fishers using hand and reel-lines in inshore waters (Taylor 1997). The birds either swallow hooks or get tangled in the lines. Flocks of shearwaters are occasionally

caught in set nets (Tarburton 1981,Taylor 1999). It is unknown what effect these sources of mortality are having on breeding populations.The long-term impact of over-harvesting of inshore fish species such as kahawai or mackerel has not been assessed either but could have serious consequences for fluttering shearwaters, which often feed in association with these fish species. Most of the large breeding colonies are situated near active shipping lanes (Whangarei, Auckland, Tauranga, Wellington) and the main New Zealand oil refinery is at Marsden Point (near the Bream Islands and North-west Chickens). An oil spill near the breeding islands could have a major impact on this diving species.

Previous Conservation Actions

1. Rodents have been eradicated from a number of fluttering shearwater colonies, or former colony sites, in the past 15 years.These include Moutohora, Burgess and adjacent islands in Mokohinau group, Motuopao, Lady Alice, Whatupuke, Korapuki, Double, Stanley, Red Mercury, Cuvier, Tiritiri Matangi, Titi, Chetwode, and Motuara Islands.
2. Rabbits have been eradicated from Moutohora, Korapuki, and Stanley Islands. Feral goats have been eradicated from Burgess, Cuvier, and Moutohora Islands. Feral cats were eradicated from Cuvier, Little Barrier, and Stephen's Islands, and the feral cat population on Moutohora died out apparently.
3. The comparative biology and taxonomy of fluttering shearwaters and Hutton's shearwaters were studied by Wragg (1985). Aspects of the breeding cycle and breeding biology were also studied by P. Hodum (unpub.) in the late 1980s at Long Island, Marlborough Sounds.
4. The distribution and abundance of breeding colonies were surveyed on the Three Kings Islands in 1985 (McCallum et al. 1985).
5. Translocations of fluttering shearwater chicks from Long Island to Maud Island were carried out in the 1990s to establish a new breeding colony (Bell 1995). Six pairs had formed by 1998 and successful breeding occurred in 1996-97 and 1997-98 (Bell & Bell 1996, 1997, B. Paton pers. comm. 1998).
6. Birds breeding at the Mercury Islands were banded in late 1980s. Information was collected on aspects of the breeding cycle and body measurements were sampled (Marchant & Higgins 1990). The Aldermen Islands were surveyed in 1994 and estimates made of the breeding populations in that group (G.Taylor & A.Tennyson unpub.).
7. Pacific rats were poisoned on Coppermine, Fanal, and Long Islands in 1997. The success or otherwise of these operations will be known 2 years after poisoning.

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the breeding islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are essential for protecting fluttering shearwaters.

H2. Ship rats should be eradicated from Saddle Island (off Great Barrier Island).

M1. Pacific rats should be eradicated from Mauitaha and Hen Islands. If agreement is reached with the land-owners then Pacific rats should also be eradicated from Ririwha (Stephenson) and Ohinau Islands.

M2. Strict control of visitor access is needed on all islands with large breeding colonies of fluttering shearwaters. In particular, consultation is needed with the owners of Moturoa, Ririwha, Cavalli, and Ohinau Islands to ensure that these sites have adequate protection, preferably as reserves (e.g. conservation covenants).

L1. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch.

L2. Attempts should be made to re-establish breeding colonies on islands where the species formerly bred. Priority sites include Cuvier, Moutohora, Middle Chain, Motuora, Mana, Matiu/Somes, and Titi Islands. Chicks may need to be transferred to some of these sites (e.g. Mana, Cuvier, Motuora) and tape playback used to lure returning birds to the colony. Other islands situated close to large breeding colonies or wintering flocks may only need tape playback and artificial burrows to attract birds to these sites.

Future Survey and Monitoring Needs

M1. Monitoring of long-term population trends is needed at several colonies. At least one colony should be monitored in each of the following areas: Hauraki Gulf, Bay of Plenty and Cook Strait. The stack north of Stanley, Ruamahuanui, and Long Islands are suitable locations and perhaps one of the Bream Islands or Wooded Island.

L1. The distribution of fluttering shearwater colonies still needs further investigation. All located colonies should be stored on the National Seabird Colony Register. Priority sites for surveys include small inshore islands in Hauraki Gulf and Northland, and islets off North-west Nelson. Surveys are best done between mid-August and November.

L2. The number of breeding pairs at all fluttering shearwater colonies is poorly known. Accurate estimates are needed from most breeding localities. The populations will need to be sampled using transects and quadrats.

Research Priorities

M1. The diet and foraging ecology of fluttering shearwaters needs further research. Food samples should be collected from birds during different stages of the breeding cycle and from a range of geographic locations (Northland, Bay of Plenty, Cook Strait). Dive depths and dive profiles also need to be determined.

M2. The population dynamics of this species are still unknown. Information is needed on age of first return to colonies, age of first breeding, longevity, survival and mortality of adults and juveniles, recruitment of chicks, and natal philopatry. Potential problems include burrows being in soft friable soils and difficulty in relocating returning juveniles in the large colonies. A small-sized colony should be selected for a population study to increase the chances of recapturing birds.

Possible sites include Wooded and Tiritiri Matangi Islands, stack north of Stanley and Long Islands.

L1. The foraging range at sea could be examined by placing radio transmitters on adults during the incubation period and when feeding chicks. This will determine how far these birds move from the colonies to collect food. The studies would be most practical if carried out in the Marlborough Sounds or Hauraki Gulf. Radio transmitters should weigh no more than 10 g. Another method of determining foraging range may be to colour-dye breeding birds at a colony and collect information on sightings from the boating community.

L2. Aspects of the breeding cycle and breeding biology were studied by P. Hodum (unpub.). Further work is needed on the spread of laying, hatching, and fledging dates (especially comparing colonies in Hauraki Gulf and Cook Strait), egg measurements and weights, incubation and nestling periods, incubation shifts, chick growth rates, frequency of feeds and meal size delivered by adults, breeding success, and breeding frequency.

L3. The social behaviour and social organisation of fluttering shearwaters have received little study. Research is also needed on vocalisations. The types of calls are poorly known and need description. Sexual differences are likely to be present as in the related Manx shearwater (Brooke 1990). The extent of individual variation and recognition of calls also needs research. Courtship behaviour and displays needs description.

L4. Satellite transmitters (weighing no more than 10 g) should be attached to fledglings to determine the migration path and foraging areas off Australia. Adults feeding nearly fledged chicks in late January should also have satellite transmitters attached to determine the foraging zone of adult birds during the non-breeding season. These should be placed on birds from both Hauraki Gulf and Cook Strait colonies.

Sooty Shearwater *Puffinus griseus*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on numerous islands around New Zealand from Three Kings to Stewart Island, also The Snares, Auckland, Campbell, Macquarie, Antipodes, and Chatham Islands. A few colonies are present on coastal headlands on the South Island mainland (e.g. West Coast, Fiordland, Banks Peninsula, Otago Peninsula, Catlins). A list of known breeding colonies is given in Hamilton et al. (1997). Elsewhere, the species breeds on at least 17 islands off Australia, islands off Chile, and at the Falkland Islands. The sooty shearwater is one of the world's most widely distributed seabirds. Birds from New Zealand forage over the South Pacific Ocean and Tasman Sea during the austral summer and are recorded as far south as the Antarctic pack ice. They migrate to the North Pacific Ocean in the austral winter and spread over the entire central and eastern Pacific Ocean. Some birds reach the Arctic Ocean. Birds from South America disperse to seas off South Africa and some migrate to the North Atlantic Ocean in the austral winter. The species is absent only from the equatorial Indian Ocean (Marchant & Higgins 1990).

Population

The size of the sooty shearwater breeding population worldwide (and in New Zealand) has not been estimated. Robertson & Bell (1984) indicated there were at least 1 million breeding pairs in New Zealand. The largest colonies are at The Snares Islands (2.75 million breeding pairs) (Warham & Wilson 1982), islands off Stewart Island, especially the Titi Islands (Big South Cape, Putauhinu, Big, Kundy, Big Moggy etc.), Whenua Hou (Codfish Island) and Bench, Auckland Islands (Adams and Disappointment Islands), Campbell Islands and Chatham Islands (Little Mangere). The total New Zealand population is likely to be in the order of about 5 million pairs (about 15-30 million birds). The Australian populations are all small (each less than 1000 breeding pairs) (Marchant & Higgins 1990) but large colonies (at least 200,000 birds) are present in southern Chile (Clark et al. 1984).

Threats

Introduced mammals are the main threat to sooty shearwater colonies. Feral cats, ferrets, stoats, pigs, and dogs can have a significant impact on breeding colonies (Hamilton 1998b). Norway rats also have a major impact by eating eggs and chicks. Sooty shearwater breeding success on Campbell Island in 1984/85 was reduced to almost 0% by Norway rat predation on eggs and chicks (Taylor 1986). The effect of ship rats on breeding success has not been assessed, but these rodents probably take some eggs and chicks. However, the persistence of sooty shearwaters on Big South Cape and Macquarie Islands (where ship rats are present) compared to their demise on Campbell Island (Bailey & Sorensen 1962)

suggest that ship rats have less impact than Norway rats. Sooty shearwaters can breed successfully on islands with Pacific rats, although the affect of these rodents on breeding success has not been studied. Rabbits probably compete for burrows or disturb nesting birds on a few islands. Weka take eggs and kill chicks at some sites. Cattle, sheep, and goats have damaged burrows on numerous islands. Competition for burrows with other summer nesting petrels (e.g. white-chinned and white-headed petrels) or with the winter nesting grey petrel may be the reason why sooty shearwaters are less common on Antipodes and Auckland Islands than at The Snares Islands. Fires may cause temporary losses in the breeding populations, especially if these occurred during incubation (November to January). Burrows are easily collapsed by people moving about on islands with very friable soils (e.g. Snares, Rangatira, Little Mangere). Visitor access to these easily-damaged sites needs to be strictly limited especially during the breeding season (October to May). Sooty shearwaters are harvested in commercial operations at traditional sites around Stewart Island by descendants of Rakiura Maori. Elsewhere, there are occasional small-scale illegal harvests of sooty shearwater chicks, e.g. at the Chatham Islands and islands in Cook Strait.

At sea, small numbers of sooty shearwaters are caught by commercial long-line fisheries (Baird et al. 1998) and birds are occasionally captured on hand or reel lines by recreational fishers. Sooty shearwaters are one of the commonest species attending trawlers (Petyt 1995). The species is one of the most frequently killed seabirds returned for autopsy from trawl fisheries in the New Zealand EEZ (DOC fisheries observer programme unpub.). Birds have been killed by trawl nets or warps used in the hoki, squid, and scampi fisheries. The species is also at risk from inshore set nets if these are placed near breeding colonies or in areas frequently used by feeding shearwaters (e.g. Otago Peninsula, Catlins, Foveaux Strait, Fiordland) (Taylor 1999). Vast numbers of sooty shearwaters were killed by drift-nets set by fishers in the North Pacific Ocean between 1960 and 1992 (Ogi 1984, King 1984, Tennyson 1990, Johnson et al. 1993 cited in Gould et al. 1998). Sooty shearwaters are still being killed by long-line and gill net fisheries in the North Pacific Ocean during the winter migration (G. Wragg pers. comm. 1998). Little is known about the possible effects of pollutants such as plastics, chemical contaminants, and oil spills. This species, however, forages in the North Pacific Ocean so it may be at greater risk from pollutants than some other New Zealand breeding species.

Previous Conservation Actions

1. Feral cats were eradicated from the following islands (year of eradication in brackets): Stephen's (1925), Kapiti (1934), Putauhinu (year unknown), Cuvier (1964), and Herekopare (1970).
2. Norway rats were eradicated from the following islands (year of eradication in brackets): Titi (between 1970 and 1975), Moutohora (1986), Hawea (1986), Breaksea (1988), Motu-o-Kura (1991), Kapiti and Tahoramaurea Island (1996).
3. Ship rats were eradicated from Kauwahaia Island in 1989.
4. Pacific rats were eradicated from the following islands (year of eradication in brackets): Korapuki (1987), Motuara (1990), Stanley (1991), Red Mercury

(1992), Motuopao (1992), Cuvier (1993), Whatupuke (1993), Lady Alice (1994), and Kapiti Island (1996).

5. Feral sheep and cattle were removed from Rangatira Island (1961), sheep from Mangere Island (1968), Kapiti Island (cattle and sheep in the 1960s, although they were removed from the reserve in the 1930s), and Mana Island (sheep 1978, cattle 1986).

6. Feral cattle and sheep were eradicated from Campbell Island by 1984 and 1991 respectively.

7. Cattle, rabbits, and mice were eradicated from Enderby Island in 1993 and rabbits from Rose Island in 1993. Feral goats were eradicated from Auckland Island in 1995.

8. Feral goats and rabbits were eradicated from Moutohora Island in 1977 and 1987 respectively. Feral goats were eradicated from Cuvier Island in 1961.

9. The breeding biology, population dynamics, and behaviour of sooty shearwaters were studied on Whero Island from 1938 to 1957 (Richdale 1944b, 1945a, 1954, 1962, 1963).

10. The breeding cycle and breeding biology of sooty shearwaters were studied on The Snares by Warham et al. (1982). Estimates were also made of the size of the breeding population on The Snares (Warham & Wilson 1982).

11. Breeding population size has been surveyed on Motunau, Motuopao, Kauwahaia, Titi, Hawea, Rangatira, Mangere, Mana, and Kapiti Islands. Populations on Whenua Hou, and Kauwahaia Islands are monitored annually for breeding success, and adults and chicks are banded at the last two sites and Mana Island.

12. The distribution, abundance, breeding success, and status of sooty shearwater colonies on Otago Peninsula was studied by Sheryl Hamilton, Otago University (Hamilton 1993a,b, 1998a,b, Hamilton & Moller 1995, Hamilton et al. 1997).

13. A long-term study on sooty shearwater population dynamics and the sustainability of cultural harvest has commenced on Otago Peninsula, Whenua Hou, southern Titi Islands and The Snares Islands (H. Moller pers. comm. 1998). A number of PhD students are investigating aspects of the ecology of sooty shearwaters including breeding success in different habitat types, harvest levels, diet, movements of chicks and adults, population trends on different islands, and the influence of climate and fisheries bycatch on annual survival rates and breeding success. The initial results of these studies are presented in a newsletter *Titi Times* produced by Otago University.

14. Dive depths and chick-feeding frequency were studied at the Snares Island (Weimerskirch & Sagar 1996). The mass-related survival rates of chicks banded at The Snares in 1972 was assessed by Sagar & Horning (1998).

15. Pacific rats were poisoned on Centre Island and Putauhinu Island in 1997 and Whenua Hou in 1998. The success or otherwise of these operations will be known 2 years after poisoning.

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching offshore islands. A pest contingency plan should be prepared to enable a rapid response to any new introductions or events that may cause an introduction.

H2. Norway rats should be eradicated from Campbell Island.

H3. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Controlled Dog Areas should be designated at all regionally significant mainland breeding colonies of sooty shearwaters.

M1. Weka should be eradicated from Big Solander Island.

M2. Ship rats and possibly weka should be eradicated from Big South Cape Island, if the owners of the island are agreeable, and procedures put in place to manage re-invasion risks.

L1. Feral cats and weka should be removed from part or all of Pitt Island if suitable agreements are reached with the residents. Wild sheep, cattle, and pigs should be removed (by fencing?) from areas suitable for establishing seabird colonies.

L2. Feral pigs and cats should be eradicated from Auckland Island.

L3. Pacific rats should be eradicated from Bench Island.

Future Survey and Monitoring Needs

M1. Long-term monitoring of population trends is needed at one or two additional colonies near Stewart Island and Chatham Islands. Monitoring should continue or resume at Motuopao, Kauwahaia, Moutohora, Mana, Titi, Motunau, Whenua Hou, and The Snares Islands plus Taiaroa Head (Otago Peninsula).

L1. The distribution of sooty shearwater colonies in New Zealand is reasonably well known. Surveys are still needed on coastal headlands and islands off the West Coast, Fiordland, and Stewart Island. All new colony locations should be added to the National Seabird Colony Register.

L2. Surveys are needed on the stacks off Campbell Island to determine the distribution and abundance of the sooty shearwater colonies.

L3. Accurate estimates are needed of the population size of most sooty shearwater breeding colonies. The priority sites are the islands off Stewart Island, Chatham Islands, and Auckland Islands.

Research Priorities

M1. The population dynamics of this species is partly known but needs more intensive investigation. This aspect is being investigated by the Otago University research project with the support of the Rakiura Titi Committee (H. Moller pers. comm. 1998). Information is needed on age of first breeding, longevity, survival and mortality of adults and juveniles, recruitment of chicks, natal philopatry, and

rates of emigration and immigration. Potential problems include burrows being in soft friable soils, complex burrow systems in dense colonies, and difficulty in relocating returning juveniles in large populations.

M2. The presence of mainland colonies, especially in Otago and on Stewart Island, provide an opportunity for the general public to view petrel colonies. All mainland colonies are in decline and their continued existence probably depends on immigration from offshore island populations. Research is needed to develop techniques to retain these mainland colonies and to develop cost-effective predator management programmes. Research is also needed to investigate whether or not reintroductions are viable for this species on the mainland of New Zealand and how this might be undertaken.

L1. The diet and foraging ecology of sooty shearwaters needs further research. Almost all diet studies have been conducted on birds in the Northern Hemisphere. Food samples should be collected from birds during different stages of the breeding cycle and from birds breeding at different latitudes. Aspects of this work have been studied by the Otago University researchers. Further work is needed on dive depths and dive profiles at various colonies.

L2. Satellite transmitters (weighing no more than 25 g) should be attached to breeding birds to determine where they forage during the incubation period and when rearing chicks. (Satellite telemetry trials commenced in 1999 as part of the Otago University research project.) Transmitters should also be attached to adults feeding nearly fledged chicks in early April and to fledglings to determine the migration flight path and foraging zones during the non-breeding season.

L3. The breeding cycle and breeding biology have been studied by Richdale (1963) and Warham & Wilson (1982). Further work is needed on spread of laying, hatching, and fledging dates at colonies in different geographic zones, frequency of feeds and meal size delivered by adults, breeding success, and breeding frequency. The species is reported to be sensitive to human disturbance during incubation. However, the sooty shearwaters at Kauwahaia and Mana Islands are fairly tolerant of very limited handling (one or two brief checks) during incubation. The use of transponders may overcome these handling problems.

L4. Research is needed on vocalisations. The types of calls are poorly known and need description. Studies are needed to determine if sexual differences are present in the calls and the extent of individual variation and recognition of calls.

Wedge-tailed Shearwater *Puffinus pacificus*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds at the Kermadec Islands (Raoul, Meyer, and Herald Islets, Macauley, Curtis, Cheeseman, and L'Esperance Rock). Elsewhere, the species is very widely distributed in tropical and sub-tropical seas, breeding on islands in the Central and North Pacific, off eastern and western Australia, and numerous islands in the Indian Ocean. New Zealand birds supposedly migrate to the eastern Pacific between June and September but the exact route taken and destination is unknown (Jenkins 1979).

Population

Populations breeding in New Zealand are large. There were an estimated 40,000 pairs at Macauley Island in 1988 (Tennyson et al. 1989) and 2500 pairs at Curtis Island in 1989 (Tennyson & Taylor 1990a). The population on North Meyer Island was estimated at 10,000 pairs in 1967 (Merton 1970). Smaller populations occur on other islands in the Kermadec group (Bell 1970). Elsewhere, populations can be very large with 100,000+ pairs nesting on several islands off the Queensland coast and on Laysan Island (Hawaii) (Dyer & Hill 1992, 1995, Harrison 1990).

Threats

Wedge-tailed shearwaters nest successfully on numerous islands with Pacific rats and appear to nest successfully also on islands with ship rats. However, they are

Wedge-tailed shearwater, Curtis Island, 1989

Large numbers of wedge-tailed shearwaters bred on Raoul Island at the turn of the century. The populations were still common in the 1940s, but by the 1960s there were very few pairs still nesting on Raoul Island. This decline was attributed to predation by Norway rats and feral cats.

extremely vulnerable to Norway rat predation (chicks taken) and feral cats and pigs. Large numbers of wedge-tailed shearwaters bred on Raoul Island at the turn of the century.The populations were still common in the 1940s, but by the 1960s there were very few pairs still nesting on Raoul Island. This decline was attributed to predation by Norway rats and feral cats (Merton 1970). The introduction of these mammalian predators to the current breeding islands is probably the greatest risk to this species in New Zealand. Browsing mammals (mainly goats) formerly impacted on wedge-tailed shearwaters by trampling burrows on Raoul and Macauley Islands. Fire is a high risk during the breeding season, especially during incubation (December to February). Volcanic activity threatens this species. Both Curtis and Raoul Islands have had active periods this century and an eruption could potentially destroy breeding colonies. All New Zealand breeding colonies are in very friable soil. Human access should be strictly limited to avoid burrows being crushed.This species may be vulnerable to fisheries' impacts during the non-breeding season. Wedge-tailed shearwaters were killed in drift-net fisheries in the North Pacific before this fishing method was outlawed in 1992 (King 1984).

Previous Conservation Actions

1. Observations were made by Crockett (1975) on the population breeding on North Meyer Islet. These included an estimate of the size of the breeding population, pre-laying behaviour, and timing of egg-laying.
2. The distribution of breeding colonies in the southern Kermadec Islands was surveyed by Bell (1970) and on islets off Raoul Island by Merton (1970).
3. Feral goat populations were eradicated from Macauley Island by 1970 and Raoul Island by 1984.
4. The seasonal distribution and abundance of wedge-tailed shearwaters in the south-west Pacific was reviewed by Jenkins (1979).
5. Population surveys were carried out on Macauley and Curtis Islands in 1988 and 1989 (Tennyson et al. 1989,Tennyson & Taylor 1990a). Birds were banded on both islands and measurements and weights were taken (Marchant & Higgins 1990).

Future Management Actions Needed

H1. Pest quarantine measures are needed to prevent new animal and plant pest species reaching the Kermadec Islands. A pest contingency plan should be available to enable a rapid response to any new introductions or events that may cause an introduction. Rodent quarantine measures are especially needed to prevent rodents being moved accidentally between Raoul Island and the mammal-free Kermadec Islands.

H2. Norway and Pacific rats and feral cats should be eradicated from Raoul Island.

L1. Pacific rats should be eradicated from Macauley Island.

L2. A new wedge-tailed shearwater colony should be established on Raoul Island once predators are removed. Tape recordings of wedge-tailed shearwater calls should be played-back to lure birds to the new colony site. If necessary, chicks should be transferred from North Meyer Islet.

Future Survey and Monitoring Needs

H1. A survey is needed to determine if wedge-tailed shearwaters still nest on Raoul Island, and if present, an estimate is needed of breeding pair numbers.

L1. The study area on Curtis Island where birds were banded in 1989 should be visited again in October-November to retrap adults and determine survival rates. This should be done at 5-10 year intervals.

L2. Repeat population estimates are needed on North Meyer, Macauley, and Curtis Islands to determine trends in these breeding colonies.

L3. Haszard Islet should be surveyed to determine if wedge-tailed shearwaters nest on the island.

Research Priorities

H1. The taxonomy of wedge-tailed shearwater populations needs investigation. Birds breeding at New Zealand and Norfolk Island colonies are physically larger than other populations of this species (Marchant & Higgins 1990). There is also much variety in plumages with white-breasted birds nesting in the North Pacific colonies and at some Southern Hemisphere locations. Birds at Indian Ocean colonies have pink bills whereas wedge-tailed shearwaters elsewhere have black bills. A taxonomic review should include DNA analysis, study of plumage and bare part morphology, and skeletal characters and vocalisations.

L1. No studies have been made of wedge-tailed shearwater diet in New Zealand or Australasian seas. Food samples are needed from breeding birds and chicks to determine which prey species are important in the local diet.

L2. When available, satellite transmitters (weighing no more than 12-18 g) should be attached to breeding birds in May to determine migration flight paths and foraging zones used in the non-breeding season.

L3. Studies of population dynamics and breeding biology are not needed from New Zealand colonies of wedge-tailed shearwaters. Elsewhere, there are much more accessible colonies, e.g. Norfolk Island, numerous islands off Australia, and on the Hawaiian Islands.

Caspian Tern *Sterna caspia*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: Category O

Distribution

The species breeds throughout the North and South Islands but mainly in coastal areas in Northland, Auckland, Waikato, Bay of Plenty, Wairarapa, Nelson, Canterbury, and Southland regions. Birds nest inland on islands and sandspits at Lake Rotorua (Innes et al. 1999) and on Canterbury riverbeds (Pierce 1984, Maloney 1999). Caspian terns tend to disperse northwards after breeding but can be seen around the entire coastline of New Zealand. A few stragglers have reached the Chatham and Kermadec Islands. Elsewhere, the species breeds in Australia, Asia, Africa, Madagascar, Europe, and North America.

Population

Robertson & Bell (1984) estimated that the New Zealand population was 1000-5000 breeding pairs. A national census in 1973/74 found about 1500 pairs but numbers had reduced to around 1000 pairs in 1992 (B. Bell pers. comm. 1998). Colonies of over 80 pairs regularly occur in the Kaipara Harbour, Mangawhai Estuary, Waikato River Estuary, Tauranga Harbour, and Farewell Spit. Worldwide there are an estimated 50,000 pairs of Caspian terns (del Hoyo et al. 1996). Populations in North America appear to be increasing whereas those in Europe appear to be decreasing.

Threats

Caspian terns nest mostly at mainland sites such as sandspits, shellbanks, shingle banks, and braided riverbeds. A few pairs nest on offshore islands. Southern black-backed gulls are the main predator of Caspian tern colonies, and eggs and chicks are frequently attacked after human disturbance of colonies (Barlow 1995). Introduced predators also threaten tern colonies. Mustelids (especially stoats and ferrets) and feral cats can take eggs, chicks, and sometimes adults (Barlow 1995). Norway rats may also take eggs and chicks at some sites (e.g. Rotorua Lakes). Other possible introduced predators include hedgehogs and possums. Uncontrolled dogs are a major threat to eggs and chicks (Ell 1999). Motorbikes and 4WD vehicles on dunes can also disturb nesting birds and sometimes destroy nests. A few birds may be shot illegally. Recreational activities by people are greatly increasing on beaches and riverbeds. People walking, fishing, sunbathing, swimming, or picnicking near Caspian tern nests can also cause nest failure or abandonment if too much activity occurs near the nests. Caspian terns are apparently very sensitive to disturbance early in the nesting period. Wandering sheep and cattle cause nest losses at some colonies (Barlow 1995). Flooding of nests by spring tides, storms, and swollen rivers are natural hazards but availability of suitable nesting habitat may have been restricted by

the planting of marram or pine plantations on dunes, development of seaside resorts on sandspits, and the infestation of braided riverbeds by weeds.

Caspian terns eat medium-sized fish, and there may be some competition for fish species with recreational and commercial fishing activities, especially in Northland. In particular, purse-seining of shoaling fish may be detrimental to Caspian terns by reducing available fish stocks. The terns are occasionally caught by inshore set nets. Overseas there are concerns that pollutants such as organochlorines are affecting shell thickness and causing nest failures. There is no information from New Zealand populations, but chemical residues may be present in New Zealand birds.

Previous Conservation Actions

1. The populations in Northland have been protected at some key sites in association with the nest protection and warden programmes for fairy terns and New Zealand dotterels (Parrish & Honnor 1997).
2. A study of inland breeding pairs was carried out in Canterbury by Pierce (1984). The density of nesting pairs in the upper Waitaki Basin was surveyed between 1991 and 1994 by Project River Recovery staff (Maloney 1999).
3. The colony at Invercargill Estuary has been studied to assess population trends, threats, breeding success, and movements of adults and chicks (Barlow 1998). A review of nesting habitat throughout New Zealand and causes of nest failure were summarised by Barlow (1995).
4. Birds at Nelson, Palliser Bay, Matakana Island, and Kaipara Harbour have been banded (some colour-banded) to determine movements within New Zealand and to establish natal site fidelity.
5. A national census of Caspian tern pairs was carried out in 1973/74 and 1992 (B. Bell pers. comm. 1998).

Future Management Actions Needed

H1. All large Caspian tern colonies (more than 10 pairs) should be protected by nest fences (when accessible to the public) and signs displayed during the breeding season. Wardens should continue to be employed at the main shorebird colonies.

M1. Pest control should be carried out at the larger Caspian tern colonies in conjunction with protection programmes for other shorebirds.

M2. Dog owners need to be informed and educated about the risks that dogs impose on ground-nesting seabird colonies. Controlled Dog Areas should be designated at all regionally significant mainland breeding colonies.

Future Survey and Monitoring Needs

H1. A national census of Caspian tern colonies is needed within 5 years to determine if the species is in decline in New Zealand. This survey should locate all colonies (including single nesting pairs) and obtain an accurate estimate of the New Zealand breeding population.

M1. The populations in Northland and Auckland that are protected by wardens should be counted each year, and an estimate made of the number of chicks reared at these sites. Ideally, all chicks should be metal banded to provide a known age cohort.

Research Priorities

L1. An assessment of all banding programmes carried out in New Zealand needs to be undertaken to determine patterns of movement in New Zealand, longevity of birds, natal site tenacity, age of first breeding, and survival of known age cohorts.

L2. The breeding biology of Caspian terns in New Zealand has not been studied. Information is needed on colony formation, clutch size, egg laying intervals, incubation period, incubation shifts, brood reduction, nestling period, chick growth rates, breeding success, and post-fledgling attendance by parents.

L3. The diet of birds in New Zealand has not been studied. Food samples should be collected whenever the opportunity arises.

L4. The regional and national dispersal of Caspian terns was studied by marking birds at Invercargill Estuary (Barlow 1998). A new study could be conducted of local movements by attaching radio transmitters to Caspian terns to determine the foraging range and time spent foraging during day, and to assess nocturnal activity including location of roost sites.

L5. Measurements and weights of adult birds are needed from New Zealand birds to compare with overseas populations.There is some evidence that Caspian terns in New Zealand have shorter bills.

Spotted Shag *Stictocarbo punctatus punctatus*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk – Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds only in New Zealand. Colonies are found near Auckland (The Noises, Tarakihi, Ponui Islands, islets off Coromandel, Oaia Island, and Erangi Point), Wellington Harbour (Matiu/Somes and Ward Islands), near Nelson (Cape Farewell to Marlborough Sounds), Motunau Island, Banks Peninsula, Otago (Moeraki to Otago Peninsula) and Southland (Nuggets Point to Te Waewae Bay). The subspecies moves extensively around coasts of both main islands although most birds are found near the breeding colonies. The birds feed in open seas usually within 2-16 km of the coast but they also forage in bays, inlets, and estuaries. Most spotted shags nest in caves or on ledges on vertical sea-cliffs.

Population

The total New Zealand population was estimated by Robertson & Bell (1984) as 50,000 to 100,000 breeding pairs. Populations in the North Island are generally small and are apparently declining (Turbott 1956, Cunningham & Moors 1985). The main concentrations are on Banks Peninsula, Otago Peninsula, and in the Marlborough Sounds.Turbott & Bell (1995) found 9787 breeding pairs in a census of Banks Peninsula colonies in 1960. Doherty & Brager (1997) repeated this census 36 years later in 1996 and found 22,123 pairs. The Otago population fluctuates between 1000 and 2000 pairs (perhaps 2500 breeding pairs) (Lalas 1993). There are no reliable estimates of populations breeding in the Marlborough or Nelson region, or in the North Island. The current New Zealand population is likely to be less than 30,000 breeding pairs.

Threats

Spotted shags are still persecuted by humans. Birds with gunshot wounds are occasionally found dead on beaches (G. Taylor pers. obs.). The species nests on cliffs or on small offshore islands and is probably not at risk from feral cats, dogs, pigs, or stock. Mustelids and rats may have some effect on mainland colonies, but no information is available. Many of the nests on cliff ledges may be out of reach of predators.The species is sensitive to disturbance by humans, but nest sites are usually in safe locations (Lalas 1993).There may be some risk to this species from fishing techniques such as trawling though this needs further study. The species is caught occasionally on lines used for recreational salmon fishing. A few birds may be caught on inshore long-line fisheries. However, set-netting, especially in harbours or near spotted shag colonies presents a moderate risk throughout the year. Lalas (1993) considered that set-nets potentially threaten the viability of the Otago population of spotted shags.The risk of oil spills impacting on this species is moderately high because the majority of the population breeds near major

ports and industrial centres, e.g. Auckland, Wellington, Nelson, Christchurch, and Dunedin. Shipping movements are very active in these areas.

Previous Conservation Actions

1. The location of breeding colonies in the Auckland region, aspects of the breeding cycle, and development of plumage stages were described by Turbott (1956).
2. A census of occupied nests at Banks Peninsula breeding colonies was made in 1960 (Turbott & Bell 1995).
3. Studies were carried out on the breeding biology of spotted shags in Otago (Gales 1984) and on Banks Peninsula (Fenwick & Browne 1975).
4. The populations on Matiu/Somes and Ward Islands have been monitored since 1973. Chicks were metal-banded from 1973 to 1981 and colour-bands were added from 1979 to 1981 (Miskelly & Benfell 1981).
5. The status of spotted shags at the Noises Islands was reviewed by Cunningham & Moors (1985).
6. The population in the Otago region was surveyed between 1977 and 1993 by Lalas (1993). Counts were made of breeding pairs and colony locations noted.
7. A census of occupied nests at Banks Peninsula colonies was repeated in 1996 (Doherty & Brager 1997).

Future Management Actions Needed

M1. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. For example, nets should not be left unattended in estuaries and harbours.

Future Survey and Monitoring Needs

M1. The breeding populations in the Hauraki Gulf and west Auckland should be monitored at all sites every 5 years to determine trends in these populations. (These populations are most vulnerable to impacts from increased recreational boating and fishing activity.) Counts of nests are needed at each colony in early spring (August-October) (see Turbott 1956).

L1. The breeding populations on Matiu/Somes and Ward Island (Wellington Harbour) should be monitored to determine long-term trends in these populations.

L2. Surveys are needed to locate all breeding colonies of this species. All colony locations need to be recorded on the National Seabird Colony Register and estimates made of number of nests at each site.

L3. Monitoring of South Island populations should be carried out during the incubation period. This varies both annually and geographically (Lalas 1993). Counts at Banks Peninsula are best done between mid-October and mid-November (Doherty & Brager 1997). Populations in Otago breed later than colonies further north. Counts are best made in November in most years

although breeding seasons are sometimes late, and counts would be best in December or January in those years (Lalas 1993). A count of all nests in a coastal region in one season is preferable to annual counts at only one colony because the species is quite mobile in its choice of nesting sites.

Research Priorities

M1. The population dynamics of spotted shags are unknown. There is no information available on age of first breeding, longevity, adult mortality rates, chick survival and recruitment, natal philopatry, pair and nest site fidelity. Studies should consider either banding cohorts of chicks with a single colour-band for each year class plus a locality colour-band, or individually colour-banding chicks (or adults if they can be captured) so that on-going disturbance at the colony can be minimised. Matiu/Somes and Ward Islands are probably the most suitable study sites for this work. Tarakihi Island in the Hauraki Gulf may also be suitable as a study site.

L1. The taxonomy of the spotted shag group (spotted shag, blue shag, and Pitt Island shag) needs further assessment. Some authors consider blue shags and spotted shags to be monotypic (Lalas 1993). The blue shag is generally considered to be a weak subspecies and needs more definable characters to separate it from spotted shags. A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

L2. The diet of spotted shags is still poorly known. Research is needed to quantify the diet of birds breeding in the four main breeding zones (Auckland, Wellington/Nelson, Canterbury, Otago). Information is needed on dive profiles (depth and frequency of dives). A telemetry study may also be worthwhile on this species to determine foraging zones and home range during the breeding season.

L3. The movements of spotted shags between each of the four main breeding zones (Auckland, Wellington/Nelson, Canterbury, Otago) are poorly known and need study to determine where winter flocks originate from. This could be determined by colour-banding cohorts of chicks from each area or by satellite telemetry studies.

L4. The social organisation and behaviour (including vocalisations) of spotted shags are very poorly known and need study.

Blue Shag *Stictocarbo punctatus steadi*

Conservation Status: Endemic subspecies

IUCN rank: Lower Risk – Least Concern

Molloy and Davis rank: not listed

Distribution

Breeds on Stewart Island and nearby inshore islands, also Whenua Hou (Codfish Island), and Centre Island. The subspecies also breeds on the South Island west coast with colonies confirmed at The Steeples, Perpendicular Point, and Open Bay Islands. Birds with plumage characters intermediate between spotted and blue shags occur in the Otago region and coastal Southland (Lalas 1993).

Population

This subspecies is less abundant than the spotted shag. Robertson & Bell (1984) estimated a population of 10,000 to 50,000 breeding pairs. There are no recent population estimates. Lalas (1993) considered earlier population estimates of spotted and blue shags were overestimated by an order of magnitude.

Threats

This subspecies nests on cliffs or on offshore islands and is probably not at risk from feral cats, dogs, pigs, or stock. Mustelids may have some impact on South Island colonies and rats at some Stewart Island colonies. Weka may take eggs or chicks at some colonies, e.g. Open Bay Islands, but no information is available on their effects. The subspecies is sensitive to ongoing disturbance by humans, but nest sites are usually in safe locations. There may be some threat from fishing techniques such as hand-lines and trawling though this needs further study. However, set-netting, especially in harbours or near blue shag colonies presents a moderate risk throughout the year. The threat of oil spills impacting on this subspecies is low because the majority of the population breeds in areas where shipping volume is low.

Previous Conservation Actions

1. The subspecies is poorly known. No studies have been completed on this taxon.

Future Management Actions Needed

M1. An advocacy programme is needed to encourage set net users to adopt practices that will minimise seabird bycatch. For example, nets should not be left unattended in estuaries and harbours.

Future Survey and Monitoring Needs

L1. Surveys are needed to locate all breeding colonies of this subspecies. All colony locations should be recorded on the National Seabird Colony Register and estimates made of nest numbers at each site.

Research Priorities

M1. The taxonomy of the spotted shag group (spotted shag, blue shag, and Pitt Island shag) needs further assessment. Some authors consider the blue shag and spotted shag to be monotypic (Lalas 1993). The blue shag is generally considered to be a weak subspecies and needs more definable characters to separate it from spotted shags (see Marchant & Higgins 1990). A review is needed using modern DNA techniques and a comparison of plumage, anatomy, body measurements, vocalisations, and body lice.

L1. The movements of blue shags in the two main breeding zones (Foveaux Strait, West Coast) are poorly known and need study to determine if these populations overlap and also if blue shags join flocks of spotted shags. This could be determined by colour-banding cohorts of chicks from each area, radio telemetry studies, or satellite telemetry studies.

L2. Studies on the general ecology of blue shags (breeding biology, feeding biology, social organisation, and behaviour) and also population dynamics are best undertaken on the closely related spotted shag. Separate research would be warranted if taxonomic work confirms the validity of the blue shag subspecies.

Black-browed albatross on chick, Campbell Island, 1984

Interbreeding pairs of black-browed and Campbell albatrosses have been observed at Campbell Island in recent years. Black-browed albatrosses prefer to mate with their own species, but some males mate with female Campbell albatrosses suggesting there is a sex imbalance in the population. Large numbers of black-browed albatrosses are killed on long-lines in the Southern Ocean. (See opposite.)

Black-browed Albatross *Thalassarche melanophrys*

Conservation Status: Indigenous species

IUCN rank: Lower Risk - Near Threatened

Molloy and Davis rank: not listed

Distribution

Breeds at Antipodes Islands (Bollons Island), Campbell Island, and Snares Western Chain. Elsewhere, breeds at Macquarie, Heard, Kerguelen, Crozet, South Georgia, and Falkland Islands. The species also breeds on five islands off Chile and Argentina. Disperses widely around Southern Ocean and into temperate seas of the South Atlantic, Indian, and South Pacific Oceans.

Population

This is the commonest albatross species. There are an estimated 682,000 breeding pairs with 80% of this total breeding at the Falkland Islands. The total global population is an estimated 3 million birds (Gales 1998). The New Zealand populations are tiny with c.120 pairs nesting at Bollons Island (Tennyson et al. 1998) and at least 16-25 (c.20) pairs at Campbell Island, which include some pure black-browed pairs and interbreeding pairs of black-browed and Campbell albatrosses (Moore et al. 1997). The New Zealand populations appear to be increasing (Tennyson et al. 1998). However, the population at South Georgia has declined by 6.95% per annum since 1989 (Croxall et al. 1998) and other colonies at Cape Horn and Kerguelen Island are also declining (Weimerskirch & Jouventin 1998). The Falkland Islands population increased during the 1980s but may begin to decline as the effects of new long-line fisheries in the South Atlantic impact on these populations (Croxall & Gales 1998).

Threats

Black-browed albatross in the New Zealand region have few land-based threats. Studies in 1984 showed that Norway rats had no effect on eggs and chicks (Taylor 1986). Disturbance by humans is minimal because few people visit the colonies at the northern end of Campbell Island. Nevertheless, this species is frequently singled out by researchers working at Bull Rock South colony. Bollons Island and the Snares Western Chain are both free of introduced mammals. Fire is a low risk because the climate is very wet on Campbell Island and Bollons Island is very remote. The Snares Western Chain is largely devoid of vegetation. A potential threat to black-browed albatross is avian pox virus (apparently spread by bird fleas and ticks). This virus has caused high chick mortality in some seasons at colonies of shy albatrosses off Tasmania and amongst black-browed albatrosses nesting at the Falkland Islands (Gales 1993). Ticks are common on birds at the Campbell Island colonies. These and Norway rats may also be a vector for diseases such as avian cholera, which has killed rockhopper penguins at Campbell Island. Avian malaria may also be a potential threat because malarial antibodies have been recorded from yellow-eyed penguins on Campbell Island (Graczyk et al. 1995).

At sea, the main threat is long-line fishing. Black-browed albatrosses are frequently caught on southern bluefin tuna long-lines in the New Zealand EEZ (Murray et al. 1993, Baird et al. 1998). 'Black-browed' albatrosses are the commonest seabird caught in the Australian EEZ. Of the adults caught and later identified by experts, 50% were black-browed albatross and the rest were the closely related Campbell albatross (formerly known as New Zealand black-browed albatross). Most birds caught in this fishery were juveniles (Gales et al. 1998). The large numbers caught relative to the size of populations in the New Zealand region implies that birds from other populations are being caught in the Australasian region. Band recoveries from long-lining vessels off Australia were from the Kerguelen and Macquarie Island black-browed albatross populations (Gales 1998). The high capture rate of juveniles on long-lines coincides with a low recruitment rate of juveniles at South Georgia and Kerguelen Islands (Croxall et al. 1998, Weimerskirch & Jouventin 1998) and this may also be a factor at New Zealand colonies. A few birds have been reported injured or killed by trawlers operating in the hoki and squid fisheries (DOC fisheries observer programme unpub.) although none was reported caught by squid trawlers in 1990 (Bartle 1991). Discards from trawlers are probably beneficial to this species (Thompson 1992, Thompson & Riddy 1995). Little is known about the possible effects of pollutants such as plastics, chemical contaminants, and oil spills but because this species forages widely around the Southern Ocean, the birds could be at risk from a wide range of possible pollutants or oil spills.

Previous Conservation Actions

1. Feral sheep were fenced out and removed from the northern half of Campbell Island in 1970 (Dilks & Wilson 1979).
2. The species was first recorded at Campbell Island in 1975 (Robertson 1980). Breeding was confirmed in 1984, and the small population has been banded and breeding attempts monitored since 1987 (Moore et al. 1997). Blood samples were collected in 1996 to determine if there is a sex bias in the population. The early findings suggest that interbreeding pairs of Campbell and black-browed albatrosses mainly had male black-browed albatross partners whereas pure pairs of nesting black-browed albatross had an equal sex ratio (P. Moore pers. comm. 1999).
3. Observations of birds nesting at The Snares Western Chain were reported by Miskelly (1984, 1997).
4. The population breeding on Antipodes Island was first identified in 1978 (Robertson 1985), colony boundaries mapped in 1994 (Clark & Robertson 1996), and censused in 1995 (Tennyson et al. 1998).

Future Management Actions Needed

M1. Further development of appropriate mitigation devices or techniques to minimise or eliminate seabird bycatch, especially from long-line fisheries, is necessary. Liaison is needed with the fishing industry to ensure that incidental bycatch is monitored and to co-ordinate actions to minimise further seabird losses associated with fishing practises.

L1. Norway rats should be eradicated from Campbell Island.

Future Survey and Monitoring Needs

M1. The population on Campbell Island should be surveyed every 5-10 years to locate breeding pairs or individuals and to determine the extent of inter-breeding with Campbell albatross. All birds should be checked for bands, and new birds should be banded to help monitor the growth of this colony.

L1. The breeding population at Bollons Island should be censused every 10 years.

L2. A survey is needed at The Snares Western Chain to confirm if black-browed albatrosses continue to breed at this locality.

Research Priorities

The ecology and biology of black-browed albatrosses have been studied in detail at South Georgia (Tickell & Pinder 1975, Prince et al. 1994, Croxall et al. 1998) and Kerguelen Islands (Weimerskirch & Jouventin 1998). This includes research on breeding biology, social organisation and behaviour, diet, foraging ecology and population dynamics and conservation status. The New Zealand populations need comparative studies with Campbell albatross. These include:

L1. A comparison is needed of the calls and sexual displays of the Campbell albatross and black-browed albatross breeding at Campbell Island to help understand how interbreeding occurs between these species.

L2. The foraging zones and movements of New Zealand breeding black-browed albatross could be studied using satellite telemetry to compare movements with other populations of this species and with Campbell albatross populations.

16. Seabird research and management in New Zealand

The techniques involved in the management, survey and monitoring, and research of seabird populations are discussed in Appendix 4.This appendix aims to give DOC staff an understanding of the activities likely to be carried out by researchers on conservation land and provides helpful suggestions on techniques for monitoring the status of seabird populations.

Seabird research and management is carried out by a diverse range of individuals and organisations including DOC, Manaaki Whenua Landcare Research Ltd, NIWA, regional councils, universities, museums, private consultancy firms, OSNZ group projects, and private individuals. Long-term research projects tend to be carried out by private individuals whereas management is normally the responsibility of DOC.The choice of projects reflects in part the interest of individuals but latterly has become more focused on conservation priorities.

A list of key seabird research and management projects undertaken in New Zealand during the period 1980-1999 is provided in Appendix 5.

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Appendix 1

IUCN RED LIST CATEGORIES AND CRITERIA AT A GLANCE

TYPE OF CRITERIA	MAIN CRITERIA	SUB-CRITERIA	QUALIFIERS	CODES
A. RAPID POPULATION DECLINE	Decline >80% in 10 years or 3 generations (**CR**) *involving either 1 or 2:*	1. Decline which has happened (observed, estimated, inferred or suspected) based on a–e opposite:	a. Direct observation	A1a
			b. Index of abundance	A1b
			c. Decline in extent of occurrence, area of occupancy, and/or quality of habitat.	A1c
	Decline >50% in 10 years or 3 generations (**EN**) *involving either 1 or 2:*		d. Actual or potential levels of exploitation	A1d
			e. Effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites	A1e
	Decline >20% in 10 years or 3 generations (**VU**) *involving either 1 or 2:*	2. Decline likely in near future (projected or suspected) based on b-e opposite:	b. As b above	A2b
			c. As c above	A2c
			d. As d above	A2d
			e. As e above	A2e
B. SMALL RANGE Fragmented, declining, or fluctuating	Extent of occurrence estimated <100km² (**CR**) *with any two of 1, 2 or 3:* Extent of occurrence estimated <5,000 km² (**EN**) *with any two of 1,2 or 3:* Extent of occurrence estimated <20,000 km² (**VU**) *with any two of 1, 2 or 3:* Or Area of occupancy estimated <10 km² (**CR**) *with any two of 1, 2 or 3:*	1. Severe fragmentation or At 1 location (**CR**) At <5 locations (**EN**) At <10 locations (**VU**)	None	B1
		2. Continuing decline (observed, inferred or projected) *in any of a-e opposite:*	a. Extent of occurrence	B2a
			b. Area of occupancy	B2b
			c. Area, extent and/or quality of habitat	B2c
			d. Number of locations or sub-populations	B2d
			e. Number of mature individuals	B2e
	Area of occupancy estimated <500 km² (**EN**) *with any two of 1, 2 or 3:* Area of occupancy estimated <2,000 km² (**VU**) *with any two of 1, 2 or 3:*	3. Extreme fluctuations *in any of a-d opposite:*	a. Extent of occurrence	B3a
			b. Area of occupancy	B3b
			c. Number of locations or sub-populations	B3c
			d. Number of mature individuals	B3d

continued on next page

TYPE OF CRITERIA	MAIN CRITERIA	SUB-CRITERIA	QUALIFIERS	CODES
C. SMALL POPULATION & DECLINING	Population <250 mature individuals (**CR**) *and either 1 or 2* Population <2,500 mature individuals (**EN**) *and either 1 or 2* Population <10,000 mature individuals (**VU**) a*nd either 1 or 2*	1. Decline >25% in 3 years or 1 generation (**CR**) Decline >20% in 5 years or 2 generations (**EN)** Decline >10% in 10 years or 3 generations (**VU**)	None	C1
		2. Continuing decline in numbers of mature individuals and population structure (observed, projected or inferred) *in form of either a or b opposite*:	a. Severe fragmentation: all sub-populations <50 (**CR**) Severe fragmentation: all sub-populations <250 (**EN**) Severe fragmentation: all sub-populations <1,000 (**VU**)	C2a
			b. All individuals in a single sub-population	C2b
D1. VERY SMALL POPULATION	Population <50 mature individuals (**CR**) Population <250 mature individuals (**EN**) Population <1,000 mature individuals (**VU**)	None	None	D1
D2. VERY SMALL RANGE	Area of occupancy <100 km^2 or <5 locations (**VU** only)	None	None	D2
E. POPULATION VIABILITY ANALYSIS	Probability of extinction in the wild is >50% in 10 years or 3 generations (**CR**) Probability of extinction in the wild is >20% in 20 years or 5 generations (**EN**) Probability of extinction in the wild is 10% in 100 years (**VU**)	None	None	E

Appendix 2

INFORMATION SYSTEMS

Seabird colony register

A National Seabird Colony Register is being developed by DOC (Science, Technology and Information Services Division) to enable records to be kept of all seabird colony sites in New Zealand and to store other information such as size and status of seabird populations in each colony. The information will be stored on a computer database that will be made freely available to bonafide seabird researchers and managers. Initially, a search will be made of the relevant literature to locate records of seabird colonies for loading onto the database. Thereafter, new colonies will be entered as they are found, and the information on previously known colonies will be updated after recent visits.

The register will enable all significant seabird sites and habitats to be readily identified for purposes such as statutory planning and resource management hearings along with management and scientific uses. The register will also allow quick access to information on the distribution and status of individual species. People visiting an area can check the database to see if seabird colonies are known from that site and when counts were last made of the populations.

Banding database

Banding of birds started in New Zealand in the 1930s and was carried out by individuals such as Lance Richdale on yellow-eyed penguins and royal albatrosses. OSNZ organised the first national banding scheme in 1950 and supplied bands to registered participants. This scheme was taken over by the New Zealand Wildlife Service in 1967 and eventually by DOC.

The national banding office issues banding permits to bonafide researchers and managers, and members of OSNZ (see Cossee 1998). The banding office supplies individually numbered metal bands and accessories such as colour-bands, banding pliers, Pesola scales, and mist nets. All banding permits require participants to fill in schedules of birds banded and recovered, and these are sent annually to the banding office for central storage and loading of recovery data on a computer database. All band sheets are stored in folders in numerical order in band size categories (each size band has a different alphabetical prefix). The banding office supplies annual summaries of birds banded and total birds banded since the inception of the banding scheme, some recovery data, and totals of birds banded under each permit (see Cossee 1998 for a recent summary). Banding data remains the property of the permit holders. Bird bands that are recovered by members of the public are sent to the banding office who then provide details of the bird to the person who found the band and a copy is sent to the permit holder.

A very large number of seabirds have been banded in New Zealand. The following 12 species have had more than 10,000 individuals banded in New Zealand by 1996: white-flippered penguin, southern royal albatross, New Zealand black-browed mollymawk (= Campbell albatross), grey-faced petrel, fairy prion, sooty shearwater, Australasian gannet, southern black-backed gull, red-billed gull, black-billed gull, white-fronted tern, and sooty tern.

Beach patrol database

The beach patrol database is co-ordinated by OSNZ. It is a computer database and card file system which records details of seabirds found dead on New Zealand beaches (Powlesland & Imber 1988). Beach patrols are carried out by OSNZ members and their friends. Participants fill in cards which record: name of beach, coastal region, date, distance covered, common names of seabirds found dead on the beach, condition of the birds (freshness), and age (adults or juveniles if this can be determined). Cards are stored on the Beach Patrol Database by an OSNZ volunteer and results for each year are published in *Notornis*, the Journal of the Ornithological Society of New Zealand. The beach patrol scheme provides a valuable long-term record of seabird mortality trends in New Zealand that can be compared with changes in the marine environment, population trends of New Zealand breeding populations, and the incidence of catastrophic events affecting seabirds.

Reference texts

The best reference text for New Zealand seabirds is the *Handbook of Australian, New Zealand and Antarctic birds* Vol. 1. and Vol. 3. (Marchant & Higgins 1990, Higgins & Davies 1996). This series covers all New Zealand species and provides a summary of all published (and sometimes unpublished) work on seabirds. Topics covered include field identification, habitat, distribution and population, movements, food, social organisation, social behaviour, voice, breeding biology, plumages and bare part description, moult, measurements, body structure, geographical variation, and references. The *Field guide to the birds of New Zealand* (Heather & Robertson 1996) is more accessible to the general public and provides an excellent summary of the biology of New Zealand seabirds. Another valuable reference is *Seabirds - an identification guide* (Harrison 1983) which illustrates all of the world's seabirds and provides information on their distribution and ecology. Other useful papers and books are listed in the Reference sections.

Appendix 3

KEY BREEDING SITES FOR SEABIRD SPECIES IN NEW ZEALAND

The key breeding sites for seabird species in New Zealand are mostly on offshore and outlying islands. All of the major island groups are listed in 3a. Twenty-five taxa breed on only one island or group of islands in the New Zealand region. Seabird colonies are still present on the mainland and for some species breeding only occurs at mainland sites. The important mainland breeding sites are listed in 3b.

3a. Key island sites

Seabird islands with large colonies (1000+ breeding pairs) are marked with an asterisk (*). Islands or island groups that are underlined are the only New Zealand breeding ground(s) for one or more seabird species.

Kermadec Islands: (Kermadec petrel, wedge-tailed shearwater, Kermadec little shearwater, white-bellied storm petrel, red-tailed tropicbird, masked booby, sooty tern, black noddy). Islands include Raoul* (white tern), Meyer Islets*, Macauley* (white-naped petrel, Kermadec storm petrel), Haszard Islet*, Curtis* (brown noddy), Cheeseman* and L'Esperance Rock*

Islands off North Island:

Three Kings Islands; including Great*, North-east, West, South-west and Princes Rocks*

Islands off Northland; including Motuopao*, Matapia*, Moturoa group*, Cavalli group (Motuharakeke*), Poor Knights* (Buller's shearwater), Hen*, Chickens group (Lady Alice*, Whatupuke*, Coppermine*, Mauitaha, North-west Chickens*), Bream Islands*

Islands off Auckland; including Great Barrier*, Little Barrier* Mokohinau group (Fanal*, Burgess*, Atihau, Lizard Isle*, Trig, Stack H*), Motutara, Moturekareka, Motuora, Noises Island (Maria*), Horuhoru Rock*, Tarakihi, Moturemu, Rat, Oaia, Kauwahaia, Ihumoana

Islands off Waikato; including Cow, Channel*, Mercury group (Red Mercury*, Stanley*, Double*, Korapuki*, Middle*, Green*, Stack north of Stanley*), Black Rocks, Needle Rock, Ohinau*, Ohinauiti*, Centre, Hahei Islands, Castle Rock, Aldermen group (Ruamahuanui*, Ruamahuaiti*, Hongiora*, Middle Chain, Ngahoro, Half), Shoe, Slipper, Penguin, Rabbit, Gannet*

Islands off Bay of Plenty; including Mayor, Karewa*, Matakana, Motuotau, Plate*, Rurima Rocks, Moutohora*, White*

Islands off East Coast; including East*, Portland

Islands off Hawkes Bay; including Bare

Islands off Wanganui; including Sugarloaf group (Moturoa*, Motumahanga*)

Islands off Wellington; including Kapiti, Mana, Matiu/Somes*, Ward, Taputeranga

Islands off South Island:

Islands off Nelson/Marlborough (king shag); including Stephens*, Trios*, Jags, Sentinel Rock, Brothers*, Chetwodes, Duffers Reef, Maud, White Rocks, Motuara, Long, Archway Islets

Islands off West Coast; including Steeples, Open Bay Islands*

Islands off Canterbury; including Motunau*

Islands off Otago; including Taieri, Green, Wharekakahu

Islands off Southland; including Breaksea, Hawea, Solander*, Little Solander*, Whenua Hou (Codfish)* (South Georgian diving petrel), Centre, Northern Titi Islands*, Southern Titi Islands* (Big South Cape*)

Chatham Islands: (Pitt Island shag, Chatham Island shag). Island include Chatham (Chatham Island taiko), Pitt, Rangatira* (Chatham petrel), Mangere*, Pyramid* (Chatham albatross), Sisters*, Forty-fours*, Star Keys*, Rabbit*, Houruakopara, Murumuru group*

The Snares Islands: (Snares crested penguin). Islands include Main Snares*, Broughton*, Alert Stack, Daption Rocks, Rocky Islet, Snares Western Chain*

Auckland Islands: (Gibson's albatross, Auckland Island shag). Islands include Auckland Island*, Enderby*, Rose, Ewing*, Ocean, Adams*, Disappointment*

Bounty Islands*: (Bounty Island shag)

Antipodes Islands: Antipodes* (soft-plumaged petrel), Bollons*, Leeward, Windward, Orde Lees Stack

Campbell Islands: (Campbell albatross, grey-headed albatross, Campbell Island shag): including Campbell*, Dent*, Jacquemart*, Monowai*, Jeanette Marie*, and other offshore stacks*

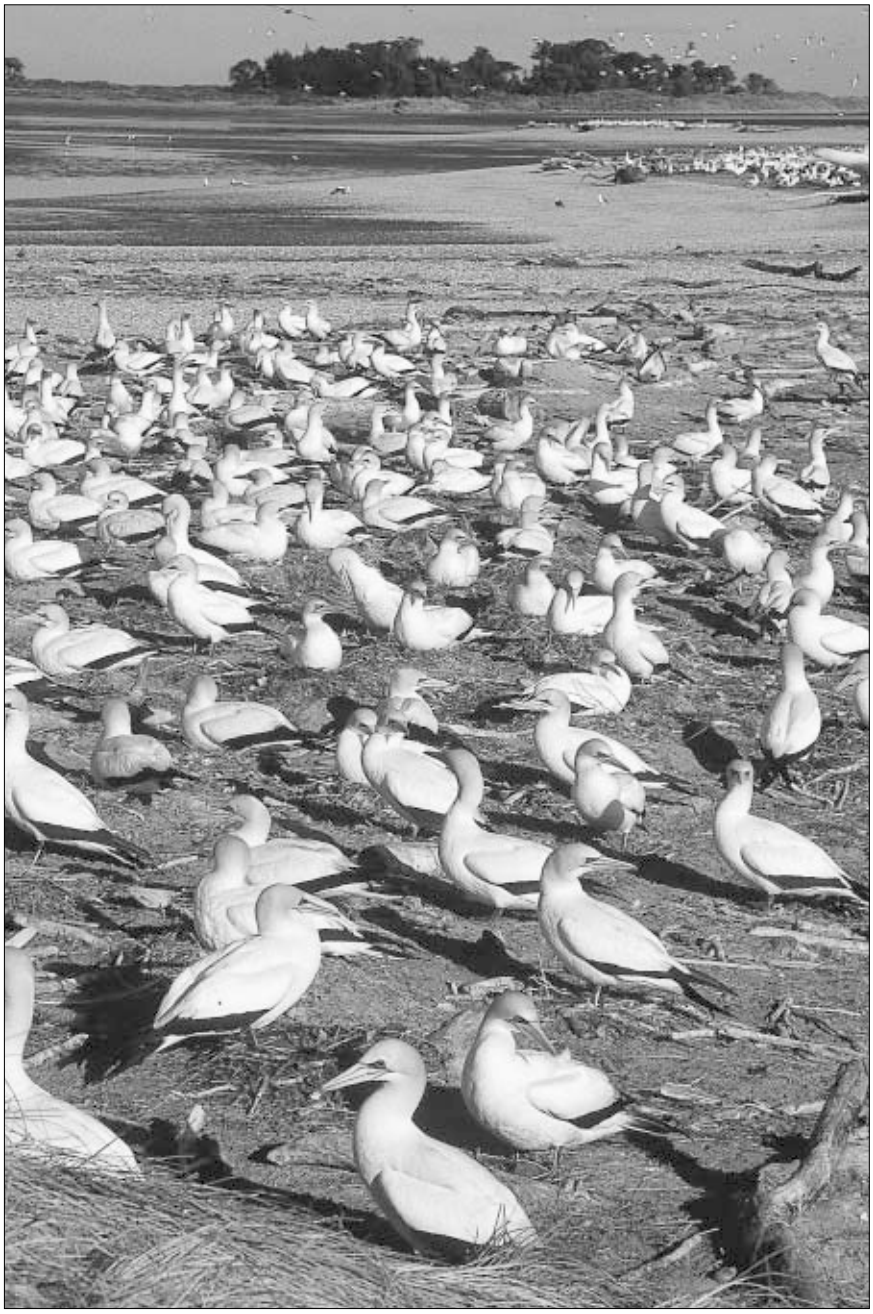
3b. Key mainland sites

Mainland sites with more than a 1000 breeding pairs of seabirds are marked with an asterisk (*). Sites that are underlined are the only New Zealand breeding ground(s) for one or more seabird species. Other than the endemic seabirds that only breed on the mainland, the sites below are important for Fiordland crested penguins, white-flippered penguins, southern blue penguins, Australasian gannets, red-billed gulls, black-billed gulls, southern black-backed gulls, Caspian terns, white-fronted terns, little shags, little black shags, and spotted shags.

North Island: (NZ fairy tern). Sites include Kokota Spit, Waipu Cove, Mangawhai Spit, Kaipara Harbour (Papakanui Spit*, Tapora), Muriwai Beach, Manukau Harbour, Mount Maunganui, Ohiwa Harbour, Waioeka River Mouth, Lake Rotorua*,

Lake Rotoiti*, Mount Tarawera*, Napier/Havelock North Beaches, Cape Kidnappers*, North Taranaki coastline.

South Island: (black-fronted tern). Sites include Farewell Spit, Punakaiki* (Westland petrel), Paringa coastline, Jackson Head, Cascade Point, Yates Point, Wairau River, Seaward Kaikoura Range*(Hutton's shearwater), Kaikoura Peninsula*, Conway River*, Waiau River*, Hurunui River*, Ashley River*, Waimakariri River*, Banks Peninsula*, Rakaia River*, Ashburton River*, Rangitata River, Godley River, Cass River, Tasman River, Tekapo River*, Ohau River, Ahuriri River*, Lower Waitaki River*, Oamaru, Otago Peninsula*, Taiaroa Head*, Catlins, Aparima River*, Oreti River*.



Australasian gannet colony, Farewell Spit, 1985

The New Zealand breeding population of gannets increased at a mean annual rate of 2.3% between 1946-47 and 1980-81. Gannets have recently colonised the end of Farewell Spit. Aerial photographic techniques are commonly used to census gannet colonies.

Appendix 4

SEABIRD CENSUS, MONITORING, RESEARCH AND MANAGEMENT TECHNIQUES

Aerial photography

This technique is best suited for counting surface-nesting colonial seabirds. The preferred cameras to use are single lens reflex cameras with various lens attachment capability. Video cameras suffer from low shutter speeds but can be useful in helping to recall the layout of very large colonies when later compiling a mosaic of photographic film images. The photographs are taken from fixed-wing aircraft or helicopters. Aircraft will disturb most seabird species so there are limits as to how closely the colony can be approached. Generally photographs should be taken at least 300 m above the colony. Oblique photographs taken in a bypass of the colony appear to create less disturbance than flying directly overhead. Fast films are needed (at least 400 ASA) because camera shake will make the images uncountable. The photographs need to be overlapped to ensure that no sections of the colony are missed. Most operators use telephoto lenses 80-300 mm and fast shutter speeds (minimum 1/250 sec). Shadows (in bright sunlight), fog or cloud cover, and wind movement (jarring of aircraft) will frequently restrict the time or days when photographs can be taken.

The variability of the background will affect interpretation of the photographs. Birds that nest on a plain background, e.g. penguins on snow, albatrosses and gannets on bare rock or tussock are generally visible but rock tumbles and shrubs will greatly reduce visibility of the colony and obscure an unknown proportion of birds. In all such aerial surveys, 'ground truthing' is necessary. In many species an unknown proportion of non-breeders or partners may be present on the ground and indistinguishable from breeding birds on nests in aerial photographs. Numbers of these non-breeders varies by season, time of day, and for some species by prevailing weather conditions. The best solution is to count a portion of the colony accurately at the time the aerial photographs are taken. The area counted will need to be marked with flags, paint, or other means that is visible from the air. Alternatively a discreet section of the colony with natural boundaries can be chosen. The number of birds counted in photographs of this area compared to the 'ground truth' census forms a ratio that is then applied over the entire colony. Be aware, however, of club or gam sites where large numbers of non-breeders accumulate and few, if any breeders are present (often on the margin of the colony near a good take-off point or landing site). Photographs are developed and counted using methods such as pin pricking the photo or marking the image of each bird with felt pens etc.

Ground photography

Ground photography has some of the same basic rules as aerial photography except it is usually difficult to see an entire colony from one location. Most

studies use standardised photo points (often with permanent marker pegs) where the photographs are taken each time to allow the identical view to be compared over a series of years (see Moore & Blezard 1999a,b). These sites then become an index of change because only birds that are visible can be counted. They help to show changes such as colony boundary contractions or expansions. A series of well-placed photo points enable reasonable counts of colonies, but the less oblique or vertical the photograph, the greater the chance that birds will be obscured by other birds or surface features such as rocks or shrubs.

Advantages include the opportunity to take photographs with lower ASA film, and shutter speeds can be reduced to 1/60 sec. Also it is possible to take photographs at much closer range using wide angle, standard, or telephoto lens with the camera. If attempting a census, it will be necessary to plan the shoot. Wander around the colony and check out all the angles to determine the best places to take photographs and to ensure that all sections of the colony can be seen from the least number of photopoint sites. Both colour and black/white films are used. Generally, the cheaper black/white is used if large numbers of enlargements are needed and the birds stand out against the natural background. Again, sufficient overlap is needed between each photographic image. Ground truthing is useful but not as essential as in aerial photography because it is often possible to determine non-breeders and partners by their stance, posture, or position relative to nest sites. Counts of images are carried out the same way as outlined for aerial photographs.

Ground counts of surface-nesting seabirds

Ground counts are sometimes used to count flocks of seabirds in the non-breeding season but they are usually undertaken on nesting birds (see Moore 1999, Walker & Elliott 1999). For surface-nesting seabird species, ground counts are probably the most reliable technique for assessing numbers. For most species, counts of the breeding portion of the population are needed. It is extremely difficult to count non-breeders because the proportion of non-breeders ashore at any one time varies according to time of day, season, weather, and tides. Only for the rarest species such as New Zealand fairy tern is it useful to attempt census counts of non-breeding birds. To assess the numbers of non-breeders in seabird species with large populations, the best technique is to band or mark individuals and estimate populations from mark-recapture studies.

Ground counts can be simple if the birds are all together and in small numbers. As the density of nests increase it becomes harder to get accurate counts. Where nests are scattered and obscured by vegetation, it may be easy to overlook nests. Usually nests are counted by teams of people moving through an area systematically and marking nests on the edge of each transect. To assess the accuracy of counts, all nests within an area can be marked with a temporary marker such as raddle or spray paint. Then random line transects are walked back through the area searched and the number of marked to unmarked nests is used to calculate the proportion of nests missed.

In large dense colonies of colonial birds where nests are evenly spaced, e.g. rockhopper penguin colonies, the size of the colony can be calculated by measuring the boundary of the colony with a tape measure or hip chain, and

accurately recording compass directions of each boundary line. The shape of the colony is then drawn to scale on tracing paper and the area calculated using a digital planimeter. If the mean density of nests (pairs per unit area) in the colony was calculated by random plots, it is then possible to calculate the number of pairs nesting in the colony.

Tallying nest sites (bird sitting on eggs or chicks) gives a minimum estimate of the number of breeding pairs at each site. To get a more accurate estimate, the nests should be counted on several occasions, and ideally each site is marked to identify the number of failures since the last count and the number of newly laid nests. To get a very accurate census, it is necessary to count nests daily from just prior to laying to the completion of laying. In some species this will extend over a 1-2 week period, in others over several months. In large colonies, this can be estimated by doing regular counts in a subsampled area and estimating the proportion of nests missed in larger areas on a daily basis (e.g. when doing an census of albatross nests on a large island). In some larger species, e.g. albatrosses, birds are marked with raddle or paint to help determine which nests have been counted. Sometimes the ground on or adjacent to the nest is marked with paint or raddle.

Ground counts of burrow-nesting seabirds

Burrow-nesting species are exceptionally difficult to census. In very small colonies in open terrain, burrow entrances can be directly counted and marked with numbered markers (plastic pegs, metal tags, or trail tape) or sprayed with a temporary marker such as raddle or spray paint. The number of entrances, however, overestimates the size of the breeding population. A proportion of entrances are dual entrances to the same burrow chamber, and some holes are short and unable to be used by petrels (collapsed sites or still being dug). Even good burrows with a chamber are sometimes not used by breeding birds (Dyer & Hill 1992). A one-off nest survey will give a minimum estimate of breeding pairs, but repeated checks are needed to determine nests where egg-laying occurred but failed early, or nests where very late breeding attempts occurred. Note also that some nests will have two or more eggs laid in the chamber and in some species, one entrance will lead to two or more nest chambers. Placing a small row of sticks at the burrow entrance will identify if there is activity in the burrow. However, a disturbed entrance fence may result from visits by non-breeding birds and sometimes other species (or even wind if the fence was not placed securely).

The only way to assess what is happening in burrows is to observe all nest chambers and to determine which contain nesting birds. Methods to assess burrow contents include using a burrowscope to check the tunnels and chamber (Dyer & Hill 1991, Dyer & Aldworth 1998, Seto & Jansen 1997), digging study entrances to observe the nest chamber, or probing with sticks (least reliable technique) (Warham 1990). Other techniques for establishing the presence of birds in burrows includes playback of bird calls to induce vocalisations (James & Robertson 1985, Hamilton 1998a) and using human calls to locate nest chambers or to lure birds from burrows (Warham 1988, Tennyson & Taylor 1990b).

In habitats where a total count is not possible because there are too many burrows, the area is too large to census, or the vegetation cover is too dense to

make counting practical, then sampling will be necessary. A range of techniques is available but generally they include non-random sampling or random sampling.

Non-random sampling is designed to determine habitat use by different species and to get a range of densities in different areas selected by eye. This method can not be used to obtain an accurate estimate of population size but is useful when time is short and a rough ballpark or order of magnitude estimate is required for a seabird population. Non-random techniques include counting burrow entrances within 1-5 m of the observer while moving along a measured transect (counting paces etc.). This method may appear to be a random sampling technique, but the results are affected by observers tending to walk lines that are best for people and not necessarily for birds. Plots are also sampled non-randomly when observers select sample sites in habitat types chosen by eye or pick sites that are convenient for access.

Random sampling techniques work by sampling habitat without a bias as to the terrain, vegetation, substrate, or perceived habitats of the species. Generally, people use prearranged transects/plots selected off maps and using random number tables to select starting locations and compass directions to follow. Examples include starting at a point on the coast and running a transect on a compass line and stopping at pre-determined locations, e.g. every 20 m, 50 m or 100 m. A plot is then done at this point using tape measures or string. Square plots or circular plots are the most popular methods with areas ranging from a few square metres to 400 m^2 being common. Size of plots will depend on terrain, vegetation density, and burrow density. Entrances are counted and put into size classes if more than one species nests on the island. Preferably each burrow should be checked with a burrowscope for occupancy but feathers and calls may also reveal the occupants. On large dense seabird colonies with several species nesting, it may prove very difficult to accurately determine which species breed in the plot, especially as seasonal factors may be important, e.g. some birds nest in winter, others in spring or summer. Enough plots need to be sampled to provide meaningful estimates of population size. Calculation of plot sample variance will provide confidence limits to these population estimates. As a rule of thumb, workers should aim to sample at least 1% of the available habitat. Transect lines can also be used to count all burrows within a specified distance either side of a tape measure. The first method involves counting the number of burrows found within a fixed transect length to give burrows per unit area. Another method involves counting a pre-determined number of burrows and then recording the area searched to reach this number of burrows. Other burrow sampling techniques are described by Dyer & Hill (1995).

Banding/Transponders

The use of individually numbered metal bands is a standard technique for most bird studies. Today, metal bands are made of stainless steel but earlier bands were made from aluminium or monel (an alloy). These lasted from 1-25 years on birds. Stainless steel bands are expected to last the entire life of all seabird species, but they have worn more quickly on some other groups of birds, e.g. wrybills in braided river habitats. Banding is regulated by DOC through the Banding Office in the Science, Technology and Information Services Division (see Cossee 1998).

Permits are issued to experienced operators and beginners are encouraged to start by working on projects with experienced operators. Different band sizes are shown by an alphabetical prefix. Each band has a unique combination of this prefix and a number. All records are stored on schedules and deposited annually with the Banding Office.

Banded birds are a useful technique for sampling population sizes and for providing estimates of total populations. They are particularly useful in species where the population is cryptic, e.g. burrowing seabirds, and where the proportion of breeders and non-breeders is unknown or when the numbers visiting a colony vary on a daily basis. For species such as petrels, the birds are usually caught by hand at night on the surface. Each bird has a band applied. Birds are captured over a series of nights and the proportions of banded to unbanded birds are determined. In a standard search area, a minimum number of birds ashore can be calculated by adding up all the birds caught over the series of nights.

A simple mark/recapture index can also be used to estimate the size of the population visiting the sample area by the formula [n = Ax(C/B)] where n = total population visiting the study area, A = total birds (new + recaptures) caught on the last sampling occasion, B = birds banded previously and recaptured on the last sampling occasion, and C = total number of birds of this species banded at the site prior to the last sampling occasion. This estimate assumes that all birds are able to be retrapped and the total population size is unchanged between trapping sessions, i.e. there has been no mortality, migration, or births. If the samples are done over a period of less than a few weeks then mortality and births are not a problem for most seabirds. However, migration may occur and the ability to retrap birds will be influenced by seasonal factors (breeders spending more or less time on surface, pre-laying exodus, incubation, and chick rearing) and daily factors such as moon phase, weather patterns etc. Some seabird species visit daily or nightly, others only irregularly. To overcome these difficulties samples are best taken over a series of nights (up to 2 weeks) or repeated annually in the same month (and allow for slight effects of births and deaths).

Today, a number of computer models are available to help estimate population size, trends, and survival rates of different age classes of birds. These models will calculate means and variance between the samples which is useful when calculating annual changes in population size and survival rates. Models today allow for uneven sampling effort and can overcome some of the factors that bias results, as discussed above. However, the value of computer model predictions and results depends largely on the quality of the information provided and the skill of the person analysing the results. Unless a well-planned and detailed sampling programme has been carried out, it may be better to use simpler methods to estimate population size and minimum survival rates.

For some studies, coloured plastic bands, normally made of Darvic PVC, are placed on the tarsus in combination with a metal band to allow distant identification of birds without the need to retrap individuals. Colour 'wrap-around' leg bands are the mostly widely used. These allow people working on a species to make up individual band combinations or attach a cohort marker, usually one or two colours to mark an age class or a banding locality. Colour

bands should be glued after attachment with a solvent such as Superglue or an epoxy resin such as Araldite to prevent the band unwinding and slipping over the foot. Colour bands are normally applied to diurnally active species with conspicuous legs such as gulls and terns.

Transponders are small microchips imbedded in a glass capsule. Each transponder has its own unique individual code that can be scanned at close range (usually less than 0.5 m) using an electronic wand. The transponders are applied using a special device to inject the capsule under the skin so that it sits in subdermal fat above the muscle layer. The transponder is inert and sterile, has no power source and lasts indefinitely if applied properly. The main drawbacks are the need to get close to the bird to scan the microchip and the cost: over $1000 per electronic scanning wand (or reader). The price of the transponders varies from $10 a capsule for some models to less than $5 a capsule for other transponder brands. This system may be most effective on penguins where flipper bands are not ideal (e.g. bands may slip off after moult or bands may affect swimming performance and possibly survival) (Fraser 1994).

Translocation experiments

Seabirds are generally very faithful to a colony or section of coastline. This is called natal fidelity and it varies amongst species. It is strongly developed in petrels, albatrosses, and gulls but is weaker in terns. If a seabird colony is lost, it may take a long time for birds to return to that site. Species that are undergoing a population increase are more likely to prospect in new locations than species that have stable or decreasing populations. There are a variety of methods that can be used to encourage seabirds to breed at new location. Surface-nesting seabirds locate breeding colonies by the sight of birds flying over a colony, landing, and displaying. Vocalisations are also important. To mimic this activity, a new colony will need models of seabirds in a variety of postures (displaying, wing spread for take off, and apparently sitting on nests). A continuous tape of seabird calls should also be playing. Clearing ground and painting the soil white to mimic guano was a technique used in an attempt to establish a new gannet colony on Mana Island. These methods have been successfully used overseas to establish new colonies or relocate nest sites in albatrosses, terns, and puffins (Podolsky 1990, Alper 1991).

For nocturnal seabirds such as petrels, the key factors needed to attract birds to a new site are vocalisations and the presence of artificial nest sites and burrows. Where seabirds already visit an area or colonies are nearby, playing tape recordings of seabird calls each night has been sufficient to start new colonies of Leach's storm petrel (*Oceanodroma leucorhoa*) and dark-rumped petrels (Podolsky & Kress 1989, 1992). Trials of this technique have been carried out on Mana Island from 1993 to 1998 using tape recordings of fairy prions, fluttering shearwaters, and northern diving petrels. Three diving petrel adults have been captured by the speakers but no breeding had occurred by 1998 (G. Taylor pers. obs.).

To encourage burrowing petrels to establish at a new site, it may be necessary to translocate chicks to artificial burrows, feed the chicks for a few weeks and let them cue into the new site. This method was trialled initially on black petrels. Between 1986 and 1990, 249 chicks were transferred from Great Barrier to Little

Barrier Island (McHalick 1999, M. Imber pers. comm. 1999). By 1998, only 2 transferred chicks were known to have returned to Little Barrier Island, and another 5-10 chicks were found back on Great Barrier Island (M. Imber pers. comm. 1999). Another trial was conducted on fluttering shearwaters. Chicks were transferred from Long Island in the Marlborough Sounds to Maud Island (Bell 1995). In total, 308 chicks were shifted to Maud Island between 1991 and 1996, and hand-fed an artificial diet of blended fish and supplements (Bell & Bell 1996). In 1996/97, 2 pairs of shearwaters bred on Maud Island, and a chick was reared. In 1997/98, 6 pairs laid eggs and 2 chicks fledged (Bell & Bell 1996, 1997). The colony also has artificial nest sites, and tapes of fluttering shearwater calls have been played throughout winter, spring, and summer. Three unbanded fluttering shearwaters have been captured prospecting at the new site by 1998 (Brian Paton pers. comm. 1998).

In 1997, 90 diving petrel chicks were transferred to Mana Island from North Brothers Island and the Sugarloaf Islands (New Plymouth). A further 100 chicks were transferred in 1998. Over 90 chicks fledged from Mana Island after hand-feeding for periods of 5-40 days (G. Taylor pers. obs.). This project has had to overcome problems with feeding chicks on an artificial diet for long periods prior to fledging. Developing techniques to transfer chicks with minimal losses is an important step that needs to be taken prior to transfers of endangered species. However, the combination of chick transfers, tape recordings, and artificial nests are likely to be the key techniques needed to establish endangered seabirds at new sites and restoring seabird species to islands cleared of predators.

Pest control/eradication

New Zealand has a been a world leader in developing techniques for removing alien mammals from offshore islands (Veitch & Bell 1990). Seabirds are particularly vulnerable to mammalian predators and browsers. The earlier operations concentrated on removing large browsing mammals from islands. The eradication of feral goats from Three Kings Islands in 1946 and Macauley Island in 1970 were significant conservation achievements for seabirds. The removal of sheep and cattle from Rangatira Island in 1961 and sheep from Mangere Island in 1968 also had immediate benefits for seabirds. Later, feral sheep were removed from Campbell Island by 1991. All these operations involved shooting the pest animal. The eradication of feral pigs from Aorangi Island (Poor Knights) in 1936 was another important achievement for seabird conservation. Rabbits were eradicated from Motunau Island by 1962, Moutohora Island by 1987, and Korapuki Island by 1988 by a combination of poisons, traps and shooting. Possums were eradicated from Kapiti Island by 1986 and Whenua Hou (Codfish Island) by 1987 by using a combination of poisons, traps, and dogs.

New techniques to remove predators have been developed over the years and methods are now available to remove both feral cats and rodents from islands larger than 2000 ha. Feral cats have been eradicated from several important seabird islands. These include Stephen's Island in 1925, Cuvier Island in 1964, Herekopare Island in 1970, and Little Barrier Island by 1980. Eradication was achieved using trapping, shooting, poisoning, and dogs. The effective eradication

of rodents from islands has become possible following the development of anticoagulant poisons in the 1940s. In the 1970s, a second generation of poisons such as brodifacoum (Talon), bromadiolone (Ridrat), and flocoumafen (Storm) were developed. These have proved to be highly effective rodenticides. Baits were initially applied in bait stations on a grid system but recently bait has been applied aerially using helicopters with underslung buckets and bait-spinners. This system can spread poison over a 100-200 ha area in 1-2 hours. The use of differential GPS sytems on helicopters now ensures an even spread of poison bait. This will enable larger islands to be cleared of predators in the future. Important seabird islands where rats have been eradicated include Maria Island in 1960, Titi Island in 1975, Lizard Isle in 1978, Moutohora Island in 1986, Korapuki Island in 1987, Breaksea Island in 1988, Stanley Island in 1991, Motuopao Island in 1992, Red Mercury Island in 1992, Cuvier Island in 1993, and Lady Alice Island in 1994.

On some islands the native weka were introduced by sealers or Maori as a food source. These weka populations have had a devastating impact on small island biotas by preying on invertebrates, reptiles, and ground-nesting birds. Petrels and penguins have proved especially vulnerable to weka. Eggs, chicks, and adults have been taken or killed. Weka had a severe impact on Cook's and mottled petrels on Whenua Hou (Codfish Island) (West 1990). Weka were eventually removed from this island in 1984 by a combination of poisoning, trapping, and shooting. Cook's petrel breeding success and population level has increased following the removal of weka (W. Cooper pers. comm. 1998).

Radio telemetry

Radio transmitters with individual frequencies have been available for many years for tracking a variety of animals. Each transmitter emits a pulsed high frequency radio signal that can be detected on an aerial and receiver. The transmitter is a circuit board with small long-life batteries such as lithium batteries. These are cased in epoxy resin and an aerial extends from the transmitter housing. Each signal has its own channel, but there are a limited number of channels available. The pulse rate of the signal can be varied with slower pulses giving the transmitter a longer life but these are harder to locate. With fast flying seabirds, fast transmitter rates are needed (50-100 pulses per minute). Transmitters can also be developed to give stronger or weaker pulses. For far-ranging seabirds or burrow-dwelling species, strong pulses are needed but these reduce the life of batteries.

Transmitters are attached to seabirds by different methods. Transmitters with a base plate and strings can be tied to the central tail feathers, or they can be taped to the tail feathers using strong cloth tapes such as Manco, Danco, or Tessa brands, e.g. Duct tape, Duck tape. Transmitters are also attached to back/rump feathers. Attaching transmitters elsewhere on the body, e.g. the nape, is not recommended for small seabirds because it may change the body profile and increase aerodynamic drag. Transmitters have been glued to back feathers using Superglue, Loctite 401, and Araldite epoxy resin. This method seems to work well with penguins but has not been as successful with petrels because some species rip out the feathers to dislodge the transmitter. Harnesses have been used on a

few seabird species but the birds seem to find the strings uncomfortable and chaffing of feathers occurs. However, when birds are to be tracked for more than a year (e.g. beyond an annual moult cycle), then a harness is the only means of securing a transmitter. In some species of waterfowl, transmitters have been surgically implanted into the body cavity, a method that overcomes drag or feather damage. This technique has not been used on seabirds however, and it requires the services of a skilled veterinarian.

Radio telemetry has been used to track seabirds to locate nesting burrows (Chatham Island taiko) (Imber et al. 1994) or to determine foraging range and location (yellow-eyed penguins) (Moore et al. 1995). If the receiver is connected to a datalogger and battery, visits to and from nest sites can be determined. Radio tracking is mainly used on species that are tracked from land and feed within 50-100 km of the coast. Tracking can be done using hand-held aerials or by setting up a series of permanent tracking stations. These stations have fixed aerials on poles which are able to be turned 360°. The direction of the strongest signal is read on a circular compass, and directions from each tracking station are used to triangulate movements of birds.

Satellite telemetry

When seabirds forage well beyond inshore waters and out over pelagic seas, it is not possible to determine movements using radio telemetry. The availability of the French ARGOS satellite since the 1980s has enabled a new form of telemetry to develop. Transmitters have been developed that send signals to the ARGOS satellite and these are downloaded to receiving stations. The positions can then be sent via telephone to a computer and graphic printouts obtained to show the position of the transmitter (and seabird that is wearing it) (Nicholls 1994). Satellite transmitters were initially quite heavy (several hundred grams) and could only be attached to large albatrosses such as wandering albatross. They have progressively become smaller as electronic componentry has been miniaturised and battery efficiency has improved. However, the current (1998) smallest package is 20 g, and these transmitters have a limited battery life.

Satellite transmitters have been applied to a variety of albatross species and to the larger petrels, e.g. Westland petrel, white-chinned petrel, and short-tailed shearwaters (Freeman et al. 1997, Weimerskirch et al. 1999). The current packages can be used on birds as small as 500-600 g in body weight. The small transmitters can be programmed to give a limited number of fixes per day to extend battery life up to a month. Large packages can give lots of fixes per day or be used to track birds over months or potentially several years. The main disadvantages of satellite transmitters are the size and cost. Each transmitter costs several thousand dollars and downloading of tracking information provided by the satellite costs tens of dollars per day. Therefore, large budgets are needed to track seabirds by satellite telemetry. The method has revealed remarkable movements of albatrosses across the Southern Ocean and provided the first insights into the complex foraging strategies of these seabirds (e.g. Nicholls et al. 1997).

DNA sampling for sex and genetic relationships

Past genetic studies on New Zealand seabirds were primarily involved with sorting out taxonomic relationships between groups of species and subspecies (e.g. Harper 1978, Meredith & Sin 1988a,b). These earlier studies used blood serum proteins to resolve relationships between species. Current taxonomic studies use DNA-DNA hybridization (e.g. Sibley & Monroe 1990) or mitochondrial DNA sequences (the mitochondrial cytochrome-b gene) to determine phylogenetic relationships (e.g. Nunn et al. 1996).

Recent advances in DNA profiling have enabled researchers to isolate sex-specific fragments of DNA and to profile parts of the gene sequence. These techniques enable birds to be sexed from blood or tissue samples and can provide individual unique genetic fingerprints (Lambert & Millar 1995). For most species of seabirds, sexing has been done in the past by measurements with males marginally larger in most species (Warham 1990, Marchant & Higgins 1990). However, overlap in measurement has meant that certainty of sex could not be guaranteed. The new DNA techniques are linked to female specific fragments of DNA. From a tiny sample of blood or sometimes feathers it is now possible to get 100% correct determination of sex for a wide range of seabird species. The fingerprint profiles are able to sort out parent-chick relationships. Chicks will share half the genetic material of their parents. If birds have gene markers not present in one or both parents than this indicates a mix-up in parentage (e.g. extra-pair copulations or egg displacement). The technique will enable degrees of relatedness to be established in species with small populations such as Chatham Island taiko or New Zealand fairy tern.

Burrowscopes

Burrowscopes have only been developed since about 1990 (Dyer & Hill 1991, Dyer & Aldworth 1998). They have taken advantage of the miniaturisation of video camera technology. Basically burrowscopes are a tiny black/white video camera mounted at the end of a long tube such as vacuum cleaner hosing with a coaxial cable running down the tube. The cable is connected to a video monitor powered by a 12-volt gel battery. The video camera is surrounded by a panel of IR LEDs and these are sealed in the tube by glass or polycarbonate cover (Seto & Jansen 1997, Lyver et al. 1998). The burrowscope is inserted into the burrow then twisted and manoeuvred manually or guided using inbuilt cables to reach the nest chamber. The LED lights illuminate the scene but are invisible to the bird. The burrowscope can help identify the species of bird and, by pressing it up to the bird, reveal if an egg or chick is present and sometimes if the bird is banded. These devices have revolutionised the study of burrow-nesting seabirds and now greatly assist the determination of nest contents. However, the system is not fool-proof and errors can be made. Burrowscopes often encounter problems with tree roots or rocks blocking the tunnel, and mud or soil obscuring the view from the camera. Nests may be missed if the burrow is too long, or side tunnels run off at right angles, or the burrow is part of a complex interconnected warren of tunnels and chambers (a situation that arises in some densely packed seabird colonies, e.g. The Snares, Titi Islands) (Hamilton et al. 1998).

IR surveillance/video cameras

Since 1990, time-lapse video cameras have been developed and modified for use in the field. These devices include a video camera placed in a water-proof housing and either LEDs or IR lasers to illuminate a nest or site. Attached to the camera is a time-lapse video recorder which stores one frame per second that can compress 24 hours into 1 hour on a videotape. These devices are used to monitor nest activity and determine causes of predation. An IR video camera has been used to document cat predation at Caspian tern colonies and to determine cause of nest failure in fairy terns (R. Parrish pers. comm. 1998). They are also being used to monitor rare species such as Chatham Island taiko. A disadvantage of the video camera system is the weight of the batteries and the need to regularly recharge batteries (every 1-3 days).

Another device to record activity at nests is a standard SLR camera with either a white light or IR flash. These can be triggered by breaking a light beam at a burrow entrance or using an IR movement detector. The advantage of this system is that it is light and portable, and only images are recorded when some activity is happening. They would not be suitable for monitoring a surface-nesting species where movement would be occurring regularly.

New devices are currently being developed that use electronic sensors or IR detectors to monitor movements in and out of seabird burrows. These devices are connected to small dataloggers that record information about the time of movements at burrow entrances. This can provide a summary of 24-hour activity at a particular burrow and allow information to be collected such as the time that parents feed their chicks.

Fences

Standard stock fences have been used for many years to exclude domestic and feral sheep and cattle from seabird sites. Examples include the fence built on Campbell Island in 1970 and the boundary fence on the Tuku Nature Reserve on the Chatham Islands. A fence at Taiaroa Head was built to prevent people disturbing nesting albatrosses and to stop dogs entering the sanctuary. Predator-proof fence designs are still in their infancy in New Zealand. However, recent trials to develop a predator-proof fence for the Karori Wildlife Sanctuary in Wellington have provided insights into the climbing and jumping abilities of a range of mammalian predators. A fence design has been developed which will exclude all predators and possums. A predator-proof fence was built and installed around the sanctuary in 1999. Predator-proof fences are being planned for the Chatham Islands to provide safe refuges for Chatham Island taiko and Chatham petrels. Other possible applications for new predator-proof fence designs include fencing off small mainland colonies of burrowing petrels such grey-faced petrels in North Taranaki or yellow-eyed penguin nesting colonies on Otago Peninsula.

Captive management options

For most seabirds, captive management is unlikely to be an important option in preserving populations because it is very difficult and expensive to maintain seabirds in captivity (Warham 1996). Overseas, captive populations of penguins

and terns are kept for public display (G. Taylor pers. obs.) and birds sometimes breed in these institutions. In New Zealand, king penguins have been imported for a display at Kelly Tarltons Underwater World in Auckland and breeding has occurred. Some northern royal albatross eggs at Taiaroa Head are placed in brooders at hatching to minimise the incidence of fly-strike. Albatross chicks also have been hand-reared after abandonment or the death of a parent (Robertson & Wright 1973). Fairy tern eggs have been artificially incubated and hatched successfully. Some chicks were returned to new foster parents who successfully reared the chicks (Parrish & Honnor 1997). Recently, fairy tern eggs were artificially incubated and 1 chick was raised to almost fledging size at Auckland Zoo but died prior to fledging. In the 1998/99 season, 2 fairy tern eggs were hatched at Auckland Zoo, and 2 chicks were reared to independance using a diet of live fish (S. Boyd pers. comm. 1999).

In 1995 and 1996, grey-faced petrel eggs were collected in a trial to determine techniques for artificially incubating and hand-rearing petrels. The aim of the project was to develop techniques that would assist Chatham Island taiko or for establishing new petrel colonies on islands. Petrel eggs were successfully incubated, but high losses occurred in the chick-rearing period probably because of contaminated oil and/or a calcium deficiency in the diet. Eventually, 1 chick that hatched from a near fresh egg was hand-reared to fledging and released on Tiritiri Matangi Island (H. Gummer pers. comm. 1996).

Grey-faced petrel eggs in artificial incubator, Tiritiri Matangi Island, 1995

Appendix 5

NEW ZEALAND SEABIRD PROJECTS (1980-1999)

Listed below are projects currently undertaken on New Zealand seabirds or projects that have been completed in the period 1980-1999. The list includes most studies undertaken on New Zealand breeding seabirds that were initiated by New Zealanders, and in general, only includes studies made in the New Zealand region.

A. Conservation status of seabird populations (distribution, census, and monitoring of populations)

Distribution, population size, and status of seabirds breeding at the Kermadec Islands.
Investigators: Graeme Taylor, Alan Tennyson, Dick Veitch, Grant Harper, Colin Miskelly
Taxa: black-winged petrel, white-naped petrel, Kermadec petrel, wedge-tailed shearwater, Kermadec little shearwater, white-bellied storm petrel, Kermadec storm petrel, red-tailed tropicbird, masked booby, sooty tern, grey ternlet, white-capped noddy, common noddy, white tern

Population survey and monitoring of seabirds on Motuopao and Three Kings Islands.
Investigators: Ray Pierce, Richard Parrish
Taxa: black-winged petrel, white-faced storm petrel, northern diving petrel, fluttering shearwater, sooty shearwater, grey-faced petrel

Distribution, population size, conservation status, and movements of Australasian gannets in New Zealand.
Investigator: Chris Robertson
Taxon: Australasian gannet

Distribution and population size of gull and tern colonies in New Zealand.
Investigators: OSNZ, Ralph Powlesland
Taxa: black-billed gull, New Zealand white-fronted tern

Population monitoring and movements of fairy terns in Northland and Auckland.
Investigators: Richard Parrish, Gwenda Pulham, Ray Pierce, DOC - Northland and Auckland Conservancy
Taxon: New Zealand fairy tern

Population size, population monitoring, and movements of gulls and terns in Northland and Auckland regions.
Investigators: Tony Habraken, OSNZ Northland
Taxa: southern black-backed gull, red-billed gull, black-billed gull, New Zealand white-fronted tern, Caspian tern

Distribution, population size, and monitoring of petrels in the Auckland, Waikato, and Bay of Plenty regions.
Investigators: Graeme Taylor, Alan Tennyson, Hugh Clifford, Mel Galbraith, Gwenda Pulham

Taxa: grey-faced petrel, sooty shearwater, flesh-footed shearwater, Pycroft's petrel, Northern diving petrel, fluttering shearwater, North Island little shearwater

Population survey and status of black petrels on Great Barrier Island.
Investigators: Elizabeth Bell, Joanna Sim, Mike Imber
Taxon: black petrel

Population monitoring of grey-faced petrels on Moutohora Island.
Investigators: Malcolm Harrison, Mike Imber
Taxon: grey-faced petrel

Distribution, population size, and movements of gulls and shags at the Rotorua Lakes.
Investigators: John Innes, Graeme Taylor
Taxa: little black shag, red-billed gull, black-billed gull

Distribution and monitoring of petrels on Taranaki coast and Sugarloaf Islands.
Investigators: Bryan Williams, Wayne Hutchinson, Graeme Taylor, Alan Tennyson
Taxon: grey-faced petrel, fluttering shearwater, flesh-footed shearwater, northern diving petrel

Population survey and census of seabirds on Cook Strait Islands, including North Brothers and Titi Islands.
Investigators: Tony Gaston, Paul Scofield, Peter Gaze, Mike Aviss
Taxa: fairy prion, northern diving petrel, sooty shearwater, flesh-footed shearwater

Population monitoring and breeding success of blue penguins in Wellington region.
Investigators: Rod Cossee, Mike Wakelin
Taxon: Cook Strait blue penguin

Distribution, population size, and conservation status of New Zealand king shags.
Investigator: Rob Schuckard
Taxon: New Zealand king shag

Movements of gulls and terns in Nelson, Canterbury, and Southland regions.
Investigators: OSNZ Nelson, OSNZ Canterbury, OSNZ Southland, Maida Barlow
Taxa: southern black-backed gull, black-billed gull, Caspian tern, black-fronted tern

Population trends of Westland petrels at Punakaiki, West Coast.
Investigators: Sandy Bartle, Amanda Freeman, Lynn Adams
Taxon: Westland petrel

Distribution, colony size, population status, and monitoring of Hutton's shearwaters, Kaikoura Ranges
Investigators: Greg Sherley, Richard Cuthbert, Geoff Harrow, Alison Davis, Brian Paton, Faith Barber
Taxon: Hutton's shearwater

Population size, population monitoring, and movements of gulls and terns at Kaikoura Peninsula.
Investigators: Jim Mills, Rod Cossee
Taxa: red-billed gull, New Zealand white-fronted tern

Population survey and monitoring of white-flippered penguins at Motunau Island and Banks Peninsula.
Investigator: Chris Challies
Taxon: white-flippered penguin

Distribution, population size, and status of spotted shags on Banks Peninsula.
Investigators: J. Doherty, S. Brager
Taxon: spotted shag

Distribution and population monitoring of yellow-eyed penguins in Canterbury, Otago, and Southland.
Investigators: John Darby, Bruce McKinlay, Dean Nelson, Peter Dilks, DOC - Southland
Taxon: yellow-eyed penguin

Distribution, population size, and conservation status of gulls and terns in Canterbury.
Investigators: Colin O'Donnell, Richard Maloney, Project River Recovery
Taxa: southern black-backed gull, black-billed gull, Caspian tern, black-fronted tern

Distribution, population size, and conservation status of southern blue penguins in Otago.
Investigators: Peter Dann, Lyndon Perriman, Bruce McKinlay
Taxon: southern blue penguin

Distribution, population size, and conservation status of shags in Otago and Southland.
Investigator: Chris Lalas
Taxa: spotted shag, black shag, little shag, Stewart Island shag

Distribution and abundance of sooty shearwater populations on Otago Peninsula, islands off Otago coast, Stewart Island region, Whenua Hou, and Snares Islands.
Investigators: Henrik Moller, Sheryl Hamilton, Phil Lyvers, University of Otago
Taxon: sooty shearwater

Distribution and population size of Fiordland crested penguins in southern New Zealand.
Investigators: Ian McLean, Rodney Russ, Belinda Studholme, Richard Maloney, John Lyall
Taxon: Fiordland crested penguin

Monitoring of Fiordland crested penguins in South Westland and Fiordland.
Investigators: John Lyall, Graeme Taylor, Martin Abel, Paul van Klink, Megan Hieatt, Daryl Eason
Taxon: Fiordland crested penguin

Population monitoring of mottled petrels at Lake Hauroko.
Investigator: Wynston Cooper
Taxon: mottled petrel

Distribution and population status of petrels on islands in Foveaux Strait including Solander Islands.
Investigators: Wynston Cooper, Colin Miskelly, Graeme Taylor, Alan Tennyson
Taxa: southern diving petrel, broad-billed prion, fairy prion, sooty shearwater, mottled petrel, Stewart Island shag

Population status of petrels on Whenua Hou (Codfish Island).
Investigators: Jill West, Mike Imber, Wynston Cooper, Adrian Patterson
Taxa: South Georgian diving petrels, southern diving petrels, mottled petrel, Cook's petrel

Population monitoring of yellow-eyed penguins at Whenua Hou (Codfish Island).
Investigators: DOC - Southland Conservancy
Taxon: yellow-eyed penguin

Population census and monitoring of Buller's albatross at Solander and The Snares Islands.
Investigators: Paul Sagar, Jean Claude Stahl, Janice Molloy, Alan Tennyson, Graeme Taylor
Taxon: Buller's albatross

Population survey and census of seabirds on The Snares Islands and Western Chain.
Investigators: Colin Miskelly, Alan Tennyson, Paul Sagar, Jacinda Amey
Taxa: Salvin's albatross, black-browed albatross, Chatham albatross, Snares crested penguin, fulmar prion, fairy prion

Distribution of petrels at the Chatham Islands.
Investigators: Mike Imber, Alan Tennyson, Gerry Clarke
Taxa: Snares cape pigeon, fulmar prion, broad-billed prion, fairy prion, southern diving petrel, grey-backed storm petrel, white-faced storm petrel, little shearwater, sooty shearwater

Population survey and monitoring of petrels on Rangatira Island, Chatham Islands.
Investigators: Jill West, Ron Nilsson, Euan Kennedy, Graeme Taylor, Steve Phillipson, Fiona Bancroft, Mike Bell
Taxa: Chatham petrel, black-winged petrel, broad-billed prion, white-faced storm petrel, sooty shearwater, southern diving petrel

Population size and habitats of petrels on Mangere Island, Chatham Islands.
Investigator: Alan Tennyson
Taxa: black-winged petrel, fairy prion, broad-billed prion, sooty shearwater

Location of new burrows of Chatham Island taiko using radio telemetry.
Investigators: Mike Imber, David Crockett, Graeme Taylor, Alan Tennyson, Murray Douglas, Hilary Aikman, Paul Scofield, Reg Cotter
Taxon: Chatham Island taiko

Distribution, population size, and conservation status of Chatham Island shags.
Investigators: Mike Bell, David Bell
Taxa: Chatham Island shag, Pitt Island shag

Population census and monitoring of brown skua at Chatham Islands.
Investigator: Euan Young
Taxon: brown skua

Movements of southern white-fronted terns from the Chatham Islands.
Investigators: Mike Bell, Dave Bell
Taxon: southern white-fronted tern

Population survey and census of seabirds at Bounty Islands.
Investigators: Gerry Clark, Jacinda Amey, Andrea Booth, Sandy King, Frances Schmechel
Taxa: Salvin's albatross, erect-crested penguin, fulmar prion

Distribution and population survey of seabird colonies on Antipodes and Bollons Islands.
Investigators: Mike Imber, Alan Tennyson, Graeme Taylor, Pete McClelland, Andy Grant
Taxa: light-mantled albatross, black-browed albatross, soft-plumaged petrel, white-headed petrel, white-chinned petrel, sooty shearwater, subantarctic little shearwater, fairy prion, black-bellied storm petrel, grey-backed storm petrel, subantarctic diving petrel, Cape pigeon, brown skua

Population census and monitoring of albatross taxa at Antipodes Islands.
Investigators: Kath Walker, Graeme Elliott, Gerry Clark, Jacinda Amey, Gus McAllister, Sheryl Hamilton, Alan Wiltshire, Alan Tennyson, Mike Imber, Chris Robertson
Taxa: Antipodes albatross, white-capped albatross, black-browed albatross, light-mantled albatross

Distribution and population size of crested penguins on Antipodes Islands.
Investigators: Alan Tennyson, Graeme Taylor
Taxa: erect-crested penguin, eastern rockhopper penguin

Distribution and population survey of seabird colonies at Auckland Islands.
Investigators: Graeme Taylor, Kath Walker, Graeme Elliott, Peter Moore, Pete McClelland
Taxa: sooty shearwater, white-headed petrel, white-chinned petrel, subantarctic diving petrel, northern giant petrel, yellow-eyed penguin, Auckland Island shag, brown skua, Antarctic tern

Population census and monitoring of albatross taxa at Auckland Islands.
Investigators: Kath Walker, Graeme Elliott, Chris Robertson, Jacinda Amey, Gus McAllister, Peter Dilks, Graeme Taylor
Taxa: Gibson's albatross, southern royal albatross, white-capped albatross

Distribution, population size, and conservation status of penguins at Auckland and Campbell Islands.
Investigators: Duncan Cunningham, Phil Moors, Graeme Taylor, Peter Moore, Roger Moffat, Wynston Cooper, Jacinda Amey, Pete McClelland
Taxa: eastern rockhopper penguin, yellow-eyed penguin

Distribution of seabird colonies on Campbell Islands.
Investigators: Peter Moore, Graeme Taylor, Roger Moffat, Alan Wiltshire
Taxa: Campbell albatross, grey-headed albatross, light-mantled albatross, sooty shearwater, grey petrel, white-chinned petrel, subantarctic diving petrel, Snares Cape pigeon, northern giant petrel, yellow-eyed penguin, brown skua

Population census and monitoring of albatrosses at Campbell Island.
Investigators: Peter Moore, Roger Moffat, Peter Dilks, Chris Robertson, Jacinda Amey
Taxa: southern royal albatross, Campbell albatross, black-browed albatross, grey-headed albatross, light-mantled albatross.

B. Population demography (breeding success, survival, and recruitment of adults and juveniles)

Effects of predators on breeding success of petrels on Chicken Islands.
Investigators: Ray Pierce, Andrea Booth
Taxa: Pycroft's petrel, North Island little shearwater

Population demography of fairy terns in Northland and Auckland
Investigators: Richard Parrish, Gwenda Pulham, Ray Pierce, Sara Treadgold, DOC - Northland and Auckland Conservancy
Taxon: New Zealand fairy tern

Population demography of petrels in the Auckland, Waikato, and Bay of Plenty regions.
Investigators: Graeme Taylor, Hugh Clifford
Taxa: grey-faced petrel, sooty shearwater, flesh-footed shearwater, Pycroft's petrel, Northern diving petrel

Population demography of black petrels on Great Barrier Island.
Investigators: Elizabeth Bell, Mike Imber
Taxon: black petrel

Monitoring of breeding success of sooty shearwaters on Mana Island.
Investigators: Graeme Taylor, Colin Miskelly, Raewyn Empson, Alan Tennyson, Reg Cotter
Taxon: sooty shearwater

Population demography of Cook Strait blue penguins in Wellington Harbour.
Investigators: Rod Cossee, Mike Wakelin
Taxon: Cook Strait blue penguin

Population demography of shags in the Wellington region.
Investigators: Ralph Powlesland, Peter Reese
Taxa: black shag, little shag

Population demography of Westland petrels at Punakaiki, West Coast.
Investigators: Sandy Bartle, Amanda Freeman, Lynn Adams
Taxon: Westland petrel

Population demography of red-billed gulls at Kaikoura.
Investigator: Jim Mills
Taxon: red-billed gull

Population demography of white-flippered penguins at Motunau Island and Banks Peninsula.
Investigator: Chris Challies
Taxon: white-flippered penguin

The population demography of New Zealand albatrosses.
Investigator: Chris Robertson
Taxa: northern royal albatross, Pacific albatross, Chatham albatross, white-capped albatross

Population demography of yellow-eyed penguins in Otago region.
Investigators: John Darby, Murray Efford
Taxon: yellow-eyed penguin

Population demography and impacts of cultural harvest on sustainability of sooty shearwater populations on Otago Peninsula, islands off Otago, Whenua Hou, Stewart Island region, and The Snares Islands.
Investigators: Henrik Moller, Sheryl Hamilton, Phil Lyvers, Christine Hunter, Paul Scofield, University of Otago
Taxon: sooty shearwater

Population demography (survival, recruitment, breeding success) of Fiordland crested penguins in South Westland.
Investigators: John Lyall, Graeme Taylor, Martin Abel, Paul van Klink, Megan Hieatt
Taxon: Fiordland crested penguin

Breeding success of petrels on Whenau Hou (Codfish Island).
Investigators: Mike Imber, Wynston Cooper, Jill West
Taxa: Cook's petrel, mottled petrel, sooty shearwater

Population demography of Buller's albatross at Solander and The Snares Islands.
Investigators: Paul Sagar, Jean Claude Stahl, Janice Molloy
Taxon: Buller's albatross

Population demography of petrels on The Snares Islands.
Investigators: Paul Sagar, Alan Tennyson, Colin Miskelly
Taxa: Snares Cape pigeon, fairy prion

Population demography of Chatham petrels on Rangatira Island, Chatham Islands.
Investigators: Euan Kennedy, Graeme Taylor, Kerry-Jane Wilson, Phillipa Gardner, Fiona Bancroft
Taxon: Chatham petrel

Population demography of Chatham Island taiko on Chatham Islands.
Investigators: Mike Imber, Graeme Taylor
Taxon: Chatham Island taiko

Population demography of brown skua at Chatham Islands.
Investigators: Euan Young, Craig Millar, Alan Hemmings
Taxon: brown skua

Population demography of albatrosses at Auckland and Antipodes Islands.
Investigators: Kath Walker, Graeme Elliott
Taxa: Gibson's albatross, Antipodes albatross

Population demography of albatrosses at Campbell Island.
Investigators: Sue Waugh, Peter Moore
Taxa: southern royal albatross, Campbell albatross, black-browed albatross, grey-headed albatross

C. Breeding biology, ecology, and behaviour (including displays and vocalisations) of seabird species

Breeding cycle of Kermadec petrels at the Kermadec Islands.
Investigators: Grant Harper, Dick Veitch
Taxon: Kermadec petrel

Breeding biology, ecology, and movements of fairy terns in Northland and Auckland
Investigators: Richard Parrish, Gwenda Pulham, Ray Pierce, Sara Treadgold
Taxon: New Zealand fairy tern

Breeding biology of black petrels on Little Barrier and Great Barrier Islands.
Investigators: Mike Imber, Elizabeth Bell, Joanna Sim
Taxon: black petrel

Population ecology, breeding biology, social behaviour, and vocalisations of *Pterodroma* petrels in northern New Zealand.
Investigators: Graeme Taylor, Alan Tennyson, Mike Imber, R. Johnston, Hugh Clifford
Taxa: grey-faced petrel, Pycroft's petrel, Cook's petrel

Population ecology, breeding biology, and social behaviour of shearwaters in northern New Zealand.
Investigators: Graeme Taylor, Andrea Booth, Ray Pierce, Don Newman, Rachel McClellan
Taxa: flesh-footed shearwater, sooty shearwater, North Island little shearwater

Breeding biology, behaviour, and plumages of little shags in Auckland.
Investigators: Michael Taylor, John Dowding
Taxon: little shag

Breeding biology, ecology, and movements of shags in the Rotorua region.
Investigators: Graeme Taylor, John Innes
Taxon: little black shags

Breeding biology and social behaviour of shags in Manawatu.
Investigator: C. Matthews
Taxon: little shag

Breeding biology, ecology, and movements of shags in the Wellington region.
Investigators: Ralph Powlesland, Peter Reese, Jean Luke
Taxa: black shag, little shag

Breeding biology and ecology of blue penguins in Wellington Harbour.
Investigators: Rod Cossee, Mike Wakelin, L. Bullen
Taxon: Cook Strait blue penguin

Breeding biology of fluttering shearwaters in Marlborough Sounds.
Investigator: Peter Hodum
Taxon: fluttering shearwater

Breeding biology and social behaviour of Westland petrels at Punakaiki.
Investigators: Sandy Bartle, Amanda Freeman
Taxon: Westland petrel

Population ecology, breeding biology, and causes of mortality of Hutton's shearwater, Seaward Kaikoura Ranges.
Investigators: Richard Cuthbert, Alison Davis, Brian Paton, Kath Walker
Taxon: Hutton's shearwater

Breeding biology and ecology of red-billed gulls at Kaikoura.
Investigator: Jim Mills
Taxon: red-billed gull

Breeding biology of white-flippered penguins at Motunau Island and Banks Peninsula
Investigator: Chris Challies
Taxon: white-flippered penguin

The ecology and breeding biology of New Zealand albatrosses.
Investigator: Chris Robertson
Taxa: northern royal albatross, Pacific albatross, Chatham albatross, white-capped albatross

Population ecology, breeding biology, and social behaviour of sooty shearwaters.
Investigators: Henrik Moller, Sheryl Hamilton, Phil Lyvers, Christine Hunter, University of Otago
Taxon: sooty shearwater

Population ecology, breeding biology, and social behaviour of yellow-eyed penguins in Otago.
Investigators: John Darby, Phillip Seddon, Yolanda van Heezik, Peter Moore, Kerri-Anne Edge
Taxon: yellow-eyed penguin

Breeding biology and ecology of blue penguins in Otago region.
Investigators: Rosemary Gales, Lyndon Perriman, Dave Houston
Taxon: southern blue penguin

Breeding biology and behaviour of Fiordland crested penguins in southern New Zealand.
Investigators: Ian McLean, Colleen Cassidy St Clair, Belinda Studholme
Taxon: Fiordland crested penguin

Breeding biology, behaviour, and vocalisations of Buller's albatross at The Snares Islands.
Investigators: Cathy Fitzsimons, John Warham, Paul Sagar
Taxon: Buller's albatross

Ecology, breeding biology, and behaviour of Chatham Island taiko on Chatham Islands.
Investigators: Mike Imber, Graeme Taylor, Rex Williams
Taxon: Chatham Island taiko

Breeding biology of petrels on Rangatira Island, Chatham Islands.
Investigators: Euan Kennedy, Graeme Taylor, Kerry-Jane Wilson, Phillipa Gardner, Nicolette Was, Wendy Sullivan, Fiona Bancroft
Taxa: Chatham petrel, black-winged petrel, broad-billed prion

Vocalisations and breeding biology of petrels on Mangere Island, Chatham Islands.
Investigator: Alan Tennyson
Taxa: black-winged petrel, fairy prion, broad-billed prion, grey-backed storm petrel

Breeding biology of grey-backed storm petrels on Chatham Islands.
Investigators: Mike Imber, Adrian Plant
Taxon: grey-backed storm petrel

Breeding biology and ecology of brown skua at Chatham Islands.
Investigators: Euan Young, Alan Hemmings, Craig Millar
Taxon: brown skua

Breeding biology, ecology, plumages, and behaviour of Antarctic terns on New Zealand subantarctic islands.
Investigators: Paul Sagar, Richard Sadleir, Rowley Taylor, Graeme Taylor
Taxon: New Zealand Antarctic tern

Breeding biology of seabirds at Bounty Islands.
Investigators: Gerry Clark, Jacinda Amey, Andrea Booth, Sandy King, Frances Schmechel
Taxa: Salvin's albatross, erect-crested penguin, fulmar prion

Breeding biology and behaviour of penguins on Antipodes Islands.
Investigators: Alan Tennyson, Graeme Taylor, Colin Miskelly, Lloyd Davis
Taxa: erect-crested penguin, eastern rockhopper penguin

Breeding biology of albatross taxa at Auckland and Antipodes Islands.
Investigators: Kath Walker, Graeme Elliott, Jacinda Amey, Gus McAllister, Sheryl Hamilton, Alan Wiltshire
Taxa: Gibson's albatross, Antipodes albatross

Population ecology, breeding biology, and vocalisations of albatrosses at Campbell Island.
Investigators: Peter Moore, Roger Moffat, Sue Waugh, Graeme Taylor, Jacinda Amey
Taxa: southern royal albatross, Campbell albatross, black-browed albatross, grey-headed albatross, light-mantled albatross.

Breeding biology and behaviour of eastern rockhopper penguins at Campbell Island.
Investigators: Phil Moors, Duncan Cunningham, Graeme Taylor
Taxon: eastern rockhopper penguin

Breeding biology of yellow-eyed penguins at Campbell Islands.
Investigators: Peter Moore, Roger Moffat, Jacinda Amey
Taxon: yellow-eyed penguin

D. Predator control and nest protection management

Nest protection of fairy terns in Northland and Auckland.
Investigators: Richard Parrish, Gwenda Pulham, DOC - Northland and Auckland Conservancy
Taxon: New Zealand fairy tern

Nest protection of petrels on Taranaki coast and Mount Maunganui.
Investigators: Bryan Williams, Wayne Hutchinson, DOC – Tauranga Area Office
Taxa: grey-faced petrel, fluttering shearwater

Protection of nesting Westland petrels at Punakaiki, West Coast.
Investigators: Lynn Adams, DOC - Punakaiki Area Office
Taxon: Westland petrel

Protection of nesting Hutton's shearwaters at Seaward Kaikoura Range.
Investigators: DOC - Kaikoura Field Centre
Taxon: Hutton's shearwater

Project River Recovery habitat restoration and nest protection, McKenzie Basin, Canterbury.
Investigators: Richard Maloney, Kerry Brown, Alicia Warren
Taxa: black-fronted tern, black-billed gull

Protection and monitoring of seabird populations and the management of ecotourism at Taiaroa Head, Otago Peninsula.
Investigators: Chris Robertson, Bruce McKinlay
Taxa: northern royal albatross, sooty shearwater, Stewart Island shag

Protection of nests and habitat for penguins in Otago and Southland.
Investigators: Bruce McKinlay, Dean Nelson, Brian Murphy, Hiltrun Ratz, Nic Alterio, University of Otago
Taxa: yellow-eyed penguin, southern blue penguin

Protection of nest sites and conservation of Chatham Island taiko on Chatham Islands.
Investigators: Paul Johnston, Rex Willams, Andy Grant, Alan Munn, Alison Turner, Mike Ogle
Taxon: Chatham Island taiko

Nest protection and conservation management of Chatham petrels on Rangatira Island, Chatham Islands.
Investigators: Euan Kennedy, Graeme Taylor, Steve Phillipson, Mike Bell, Fiona Bancroft
Taxon: Chatham petrel

E. Feeding studies including diet and foraging movement

Diet of petrels and albatrosses.
Investigator: Mike Imber
Taxa: southern royal albatross, northern royal albatross, Cook's petrel, black petrel, broad-billed prion, grey-backed storm petrel

Movements, diet, and behaviour of black petrels using radio telemetry.
Investigator: Paul Scofield
Taxon: black petrel

Diet of New Zealand shags.
Investigators: Chris Lalas, Derek Brown
Taxa: New Zealand king shag, Stewart Island shag

Movements, foraging behaviour, and diet of Westland petrels using satellite telemetry.
Investigators: Amanda Freeman, Kerry-Jane Wilson
Taxon: Westland petrel

Diet and foraging activity (using radio telemetry) of yellow-eyed penguins in Otago region.
Investigators: Yolanda van Heezik, Peter Moore, Bruce McKinlay, Mike Wakelin, Murray Douglas
Taxon: yellow-eyed penguins

Diet of Fiordland crested penguins in southern New Zealand.
Investigator: Yolanda van Heezik
Taxon: Fiordland crested penguin

Satellite tracking of albatrosses at Chatham Islands and Taiaroa Head
Investigator: Chris Robertson
Taxa: northern royal albatross, Chatham albatross

Movements and diet of Buller's albatross at The Snares and Solander Islands using satellite telemetry and diet sampling.
Investigators: Paul Sagar, Jean-Claude Stahl
Taxon: Buller's albatross

Satellite tracking of Gibson's and Antipodean albatrosses at Auckland and Antipodes Islands.
Investigators: Kath Walker, Graeme Elliott, Jacinda Amey
Taxa: Gibson's albatross, Antipodes albatross

Movements and diet of albatrosses at Campbell Island using satellite telemetry and diet sampling.
Investigator: Sue Waugh
Taxa: Campbell albatross, grey-headed albatross

Diet of eastern rockhopper penguins at Campbell Island.
Investigators: Phil Moors, Duncan Cunningham
Taxon: eastern rockhopper penguin

F. Taxonomy and genetics (morphology, sexing methods, and genetic relationships)

Taxonomy and relationships of albatrosses.
Investigators: Chris Robertson, Gary Nunn, John Warham
Taxa: all species of albatross

Sexing petrels and albatrosses.
Investigators: David Lambert, Craig Millar, Graeme Taylor, Peter Moore
Taxa: grey-faced petrel, flesh-footed shearwater, sooty shearwater, southern royal albatross, black-browed albatross, Campbell albatross, grey-headed albatross, brown skua, Pycroft's petrel, northern diving petrel

Sexing and genetic relationships of New Zealand fairy terns
Investigators: Sara Treadgold, David Lambert, Robin Fordham, Geoff Chambers
Taxon: New Zealand fairy tern

Taxonomy and relationships of Hutton's and fluttering shearwaters.
Investigator: Graham Wragg
Taxa: Hutton's shearwater, fluttering shearwater

Taxonomy of blue penguins in New Zealand.
Investigator: Meredith Meredith
Taxa: northern blue penguin, Cook Strait blue penguin, white-flippered penguin

Taxonomy of yellow-eyed penguins in New Zealand.
Investigators: Sue Triggs, John Darby
Taxon: yellow-eyed penguins

Taxonomy of petrels on Codfish Island.
Investigator: Adrian Patterson
Taxa: South Georgian diving petrel, Southern diving petrel

Sexing and genetic relationships of Chatham Island taiko on Chatham Islands.
Investigators: Graeme Taylor, Craig Millar, David Lambert
Taxon: Chatham Island taiko

Sexing and genetic relationships of brown skua at Chatham Islands.
Investigators: Euan Young, Craig Millar, David Lambert
Taxon: brown skua

G. Restoration projects including seabird translocation

Development of techniques to minimise incidental bycatch of seabirds in fisheries operations.
Investigators: Janice Molloy, Neville Smith
Taxa: albatrosses and petrels susceptible to fisheries bycatch

Translocation of black petrels from Great Barrier to Little Barrier Islands.
Investigator: Mike Imber
Taxon: black petrel

Restoration of seabird communities on Mana Island, including the translocations of diving petrels from North Brother and Sugarloaf Islands to Mana Island.
Investigators: Graeme Taylor, Colin Miskelly
Taxa: northern diving petrel, fairy prion, fluttering shearwater, Australasian gannet

Captive rearing trials for petrels at National Wildlife Centre, Mount Bruce.
Investigators: Graeme Taylor, Shaun O'Connor, Helen Gummer
Taxon: grey-faced petrel

Translocations of fluttering shearwaters from Long Island to Maud Island.
Investigators: Brian Bell, Mike Bell, Elizabeth Bell, Brian Paton
Taxon: fluttering shearwater

Appendix 6

FORMAL NAMES OF PLANT AND ANIMAL SPECIES (OTHER THAN SEABIRDS) REFERRED TO IN THE TEXT

Mammals	
New Zealand fur seal	*Arctocephalus forsteri*
Hooker's sea lion	*Phocarctos hookeri*
Southern elephant seal	*Mirounga leonina*
Possum	*Trichosurus vulpecula*
Hedgehog	*Erinaceus europaeus occidentalis*
Rabbit	*Oryctolagus c. cuniculus*
Pacific rat (kiore)	*Rattus exulans*
Norway rat	*R. norvegicus*
Ship rat	*R. rattus*
House mouse	*Mus musculus*
Domestic dog	*Canis familiaris*
Mustelids	*Mustela spp.*
Stoat	*Mustela erminea*
Ferret	*M. furo*
Feral and domestic cat	*Felis catus*
Feral and domestic pig	*Sus scrofa*
Feral and domestic cattle	*Bos taurus*
Chamois	*Rupicapra r. rupicapra*
Feral goat	*Capra hircus*
Feral and domestic sheep	*Ovis aries*
Deer, e.g. Red deer	*Cervus elaphus scoticus*
White-tailed deer	*Odocoileus virginianus borealis*
Birds	
Kiwi	*Apteryx spp.*
Australasian harrier	*Circus approximans*
New Zealand falcon	*Falco novaeseelandiae*
Weka	*Gallirallus australis*
Buff weka	*Gallirallus australis hectori*
Variable oystercatcher	*Haematopus unicolor*
Kakapo	*Strigops habroptilus*
Kea	*Nestor notabilis*
Antipodes Island parakeet	*Cyanoramphus unicolor*
Australian Magpie	*Gymnorhina tibicen*
Reptiles	
Tuatara	*Sphenodon* spp.

Fish

Pilchard	*Sardinops neopilchardus*
Anchovy	*Engraulis australis*
Southern bluefin tuna	*Thunnus maccoyii*
Trevally	*Pseudocaranx dentex*
Kingfish	*Seriola lalandi*
Jack mackerel	*Trachurus novaezelandiae*
Kahawai	*Arripis trutta*
Snapper	*Pagrus auratus*
Patagonian toothfish	*Dissostichus eleginoides*
Ling	*Genypterus blacodes*
Hoki	*Macruronus novaezelandiae*
Southern blue whiting	*Micromesistius australis*
Arrow squid	*Nototodarus sloanii*
Crayfish	*Jasus edwardsii*
Scampi	*Metanephrops challengeri*
Freshwater eel	*Anguilla* spp.
Brown trout	*Salmo trutta*
Rainbow trout	*Oncorhynchus mykiss*
Quinnat salmon	*O. tshawytscha*

Plants

Russell lupin	*Lupinus polyphyllus*
Broom	*Cytisus scoparius*
Mile-a-minute	*Dipogon lignosus*
Gorse	*Ulex europaeus*
Willow	*Salix* spp.
Boxthorn	*Lycium ferocissimum*
Marram grass	*Ammophila arenaria*
Pampas grass	*Cortaderia* spp.

Index of common and scientific names of seabirds (Part B)