

# Population sizes of shearwaters (*Puffinus* spp.) breeding in New Zealand, with recommendations for monitoring

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**ABSTRACT:** We reviewed population data for the nine taxa of shearwaters *Puffinus* spp. that nest in the New Zealand region. Data for about 350 current breeding colonies were found, and each taxon nested at between three and about 180 localities. We reviewed the information to assess time-series of information for each population and, where possible, to determine trend and total population size. However, few of the species had robust enough information to allow those assessments to be made. We recommend high-priority sites for future monitoring, and encourage other researchers to publish or make available findings from previous work to assist in building a comprehensive picture of the status of shearwater populations.

**KEYWORDS:** New Zealand, shearwaters, *Puffinus*, population sizes, monitoring, review.

## Introduction

Seabirds form an important part of the marine ecosystem, and are responsible for the transfer of a large quantity of nutrients between trophic levels and between marine and terrestrial systems. New Zealand has a high diversity of petrel and albatross taxa (order Procellariiformes), which includes many threatened or rare species, e.g. Chatham Island taiko (*Pterodroma magentae* (Giglioli & Salvadori, 1869)), as well as species that are hugely abundant, e.g. sooty shearwater (*Puffinus griseus* (Gmelin, 1789)) (Taylor 2000a,b).

Marine policy analysts are increasingly turning to indicator species to help them define changes in the well-being of marine systems. For example, Antarctic krill (*Euphausia superba* Dana, 1850) abundance is used as an

indicator of the richness and health of marine systems in the area managed by the Convention for the Conservation of Antarctic Marine Living Resources. Species at high trophic levels in marine systems can be powerful indicators of change, and long-term datasets on their population changes and individual behaviours have been used to indicate important changes in global systems such as ocean energy transfer, circulation and temperature rises. For example, the numbers of breeding emperor penguins (*Aptenodytes forsteri* G.R. Gray, 1844) were a key variable in analyses showing the influence of climate change and sea-ice extent on the Antarctic marine ecosystem (Barbraud & Weimerskirch 2001, 2006; Jenouvrier *et al.* 2009).

Petrels and albatrosses are typically long-lived and many have delayed maturity, breeding for the first time only at

5–10 years of age (Schreiber & Burger 2002). They are superbly adapted to marine environments where resources are sparse, and for using oceanographic features that assist in concentrating food into dense patches. For example, foraging of shearwaters and albatrosses along upwellings, and in relation to movements of top marine predators such as whales and dolphins, is well documented (Evans 1982; Au & Pitman 1986).

However, petrels and albatrosses are less well adapted at responding to rapid – often human-induced – changes in their environment. Such influences may affect them at their breeding sites, for example through predation by introduced mammals or habitat loss; or through interaction with industrial and artisanal fisheries. It is estimated that more than 300,000 seabirds are killed annually in fisheries globally (BirdLife International 2012). For New Zealand, documented mortality in commercial longline and trawl fisheries comprised 2520–4412 individuals in 2008–09 (Abraham & Thompson 2011) of more than 30 species of Procellariiformes (Waugh *et al.* 2008). Climate change and sea water-warming may also affect some seabird populations (e.g. Newman *et al.* 2009).

New Zealand is known for its diversity and abundance of Procellariiformes. This has been explained by the ecological richness of the New Zealand Exclusive Economic Zone. Another explanation has been the large extent of the New Zealand continental shelf, providing a high degree of both ocean productivity and potential niche segregation. The many small islands forming the New Zealand archipelago may be another driver because of the tendency for Procellariiformes to nest near their natal site, with more restricted dispersal to alternative breeding sites than for some other bird groups. New Zealand is one of the nations with the highest number of nesting species and is the country with the greatest number of endemic and threatened taxa (Croxall *et al.* 2012).

We conducted an extensive review of both published and unpublished literature to bring together records of breeding seabirds throughout the New Zealand region, and here present data for the shearwaters (*Puffinus* spp.).

The objectives of this paper are:

- 1 To summarise the data available on breeding distribution and abundance at each breeding site for the nine shearwater taxa nesting in New Zealand.
- 2 To interpret data to provide information on species trends and changes in range, and to better define the state of our

knowledge about each species. However, except in a few cases, data are inadequate to allow these analyses.

- 3 To recommend sites for future monitoring of shearwater populations.
- 4 To encourage researchers to make available unpublished information through subsequent publication or data-sharing to enable an increasingly comprehensive picture of shearwater population status.

Shearwaters are one of the most abundant groups of seabirds in the New Zealand region, with populations numbering in the millions of breeding pairs. Although they are not a highly threatened group of species (Croxall *et al.* 2012), there is very poor information on several taxa, and for some there is no recorded quantitative population estimate. Nineteen shearwater taxa are known to occur in the New Zealand region, of which nine breed there (Gill *et al.* 2010). The taxa we discuss fall into three main groups based on geographic spread:

- 1 Those with subtropical breeding distributions (two taxa) – wedge-tailed shearwater (*Puffinus pacificus pacificus* (Gmelin, 1789)) and Kermadec little shearwater (*Puffinus assimilis kermadecensis* Murphy, 1927). The later taxon breeds only at the Kermadec Islands.
- 2 Those breeding in temperate areas (five taxa) – Buller's shearwater (*Puffinus bulleri* Salvin, 1888), flesh-footed shearwater (*Puffinus carneipes* Gould, 1844), fluttering shearwater (*Puffinus gavia* (J.R. Forster, 1844)), Hutton's shearwater (*Puffinus huttoni* Mathews, 1912), and North Island little shearwater (*Puffinus assimilis haurakiensis* C.A. Fleming & Serventy, 1943). These taxa are endemic to New Zealand, except for the flesh-footed shearwater, which also breeds elsewhere in the Pacific and Indian oceans.
- 3 Species found mainly in cool temperate waters and sub-Antarctic waters (two taxa) – sooty shearwater and subantarctic little shearwater (*Puffinus elegans* Giglioli & Salvadori, 1869). The sooty shearwater also occurs in smaller numbers in warm temperate waters and has a southern oceanic distribution, breeding in Chile, the Falkland Islands, Australia and New Zealand. Subantarctic little shearwaters are known to breed only on the Chatham Islands (Aikman & Miskelly 2004) and the sub-Antarctic Antipodes Islands within the New Zealand region, and elsewhere only on a small number of islands in the South Atlantic and Indian oceans (Gill *et al.* 2010).

## Methods and conventions

A literature review was conducted using published scientific studies, some unpublished reports, and the authors' own field diaries. These data were compiled in a database with the aim of making them available to the research community through this paper and online resources. Our review builds considerably on other recent reviews of shearwater colonies (Marchant & Higgins 1990; Hamilton *et al.* 1997; Taylor 2000a,b; Newman *et al.* 2009; Baker *et al.* 2010; Gill *et al.* 2010) but we acknowledge that we have not made an exhaustive review of the literature.

We followed the taxonomy, nomenclature and sequence of species as in Gill *et al.* (2010), with species presented in that order in the text and tables.

Only breeding records were collated, and included 'presence' records (where the occurrence of breeding individuals or progeny was noted) as well as counts or estimates of breeding populations or individuals. The date and methodology of each record was recorded.

We attempted to classify the methodologies according to the guidelines presented by the Species Status and Trends working group of the Agreement on the Conservation of Albatrosses and Petrels (e.g. Agreement on the Conservation of Albatrosses and Petrels 2012). However, this proved problematic, as for most records methodology was not documented. We retained notes in the tables only for those with clearly defined methods and describe these according to the ACAP categorisations, thus: ACAP1 – census with errors estimated; ACAP3 – survey of quadrats or transects of representative portions of colonies/sites with errors estimated; ACAP4 – survey of quadrats or transects without representative sampling but with errors estimated; ACAP5 – survey of quadrats or transects without representative sampling or errors estimated. Surveys without methodological information have been classified as 'unknown'; we have not made any assessment of the reliability of those counts.

All records with reliable information on species identity, location and date were included. Locations that we consider unproven breeding sites were not listed. Even if the precise date and location were unknown, some records were included where they added useful information.

The method used for each observation was assigned to one of three types: ground observation, where no actual count was made or where abundance was estimated to an order of magnitude only; ground count, where an actual figure for abundance, or both maximum and minimum

figures, were given (but even 'counts' are mostly estimates rather than exact numbers); observed from a distance, where counts or observations were made from offshore, e.g. from boats or nearby islands.

We assessed possible trends in population numbers only where two high-quality, recent (post-1990) surveys from major breeding sites were available for comparison. Where possible, we estimated the total numbers of breeding pairs for each taxon.

We followed the guidance of the *New Zealand gazetteer of official geographic names* in describing sites (Land Information New Zealand 2012). Accepted names followed by alternative names in parentheses are used. Dual names are separated by a forward slash. The name of island group is listed first, separated from the island name, or further subdivision, by commas. The singular noun 'Island' is abbreviated to 'I.' and the plural 'Islands' to 'Is'.

## Results

Shearwater species currently nest at about 350 known colonies (extinct colonies not included) around New Zealand, although some records are for generic locations (e.g. an island group). Count data were recorded for only about 190 of these colonies. The greatest number of records were found for sooty shearwater (c. 180 sites), followed by fluttering shearwater (90 sites), North Island little shearwater (30 sites) and flesh-footed shearwater (20 sites). For other shearwaters there were 12 or fewer sites per species.

Tables 1–9 set out the population data in relation to each site. For each species, we summarise the state of information at each site. We note sites that we consider priorities for future monitoring of population trends.

### Wedge-tailed shearwater

In the New Zealand region this species breeds only on the Kermadec Islands. There is a population estimate available for all but one of 10 colonies (Table 1). The three sites with greatest numbers of birds are: Macauley I., where 20,000 pairs were estimated in 1970 and 40,000 pairs estimated in 1988; Meyer Is, where 10,000 pairs were recorded in 1966–67; and Curtis I., which had 2500 pairs in 1989. Numbers at Macauley I. probably increased after goats were eradicated there in 1970 (Veitch *et al.* 2004) but there is no other population trend information. Repeat surveys at these larger colonies are a priority, and Raoul I. should also be monitored

Table 1 Population data for wedge-tailed shearwater, *Puffinus pacificus pacificus*. Sites are listed in roughly north–south order (KMI = Kermadec Islands; – = no data or comments; for sampling protocol, see ‘Methods and conventions’).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Raoul I. (Rangitahau I.)	KMI	1907–08	–	Burrows	Breeding	Ground observation	Iredale 1910
		1964	–	Individuals	Common	Ground observation	Edgar 1965
		1966–67	–	Burrows	Uncommon	Ground observation	Merton 1968, 1970
		2008	<50	Breeding pairs	–	Ground observation	Gaskin 2011
Napier I.	KMI	1966–67	2	Burrows	–	Ground count	Merton 1970
Meyer Is, North and South Meyer Is	KMI	1907–08	–	Burrows	Breeding	Ground observation	Iredale 1910
		1966–67	10,000	Breeding pairs	–	Ground observation	Merton 1970
Meyer Is, North Meyer I.	KMI	1964	–	Individuals	Breeding	Ground observation	Edgar 1965
Meyer Is, South Meyer I.	KMI	1966–67	–	Breeding pairs	–	Ground observation	Merton 1970
Herald Is, Dayrell I.	KMI	1966	–	Burrows	Common	Ground observation	Merton 1970
Herald Is, northern Chanter I.	KMI	1967	3	Burrows	–	Ground count	Merton 1970
Macaulay I.	KMI	1970	20,000	Breeding pairs	–	Ground observation	Veitch <i>et al.</i> 2004
		1988	40,000	Breeding pairs	–	Ground observation	Veitch <i>et al.</i> 2004
L’Esperance Rock	KMI	1970	50	Breeding pairs	–	Ground observation	Veitch <i>et al.</i> 2004
Curtis I.	KMI	1989	2500	Breeding pairs	–	Ground observation	Veitch <i>et al.</i> 2004
Cheeseman I.	KMI	1970	500	Breeding pairs	Up to 500	Ground observation	Veitch <i>et al.</i> 2004

to assess a potential population recovery after the recent eradication of mammals there. The total New Zealand wedge-tailed shearwater population size is in the order of 50,000 breeding pairs.

### Buller’s shearwater

Six of the seven identified Buller’s shearwater breeding localities are in the Poor Knights Is group (Table 2). The state of the information and loose estimates make an assessment of the status of the population and its total size difficult.

Outside the Poor Knights, only a single burrow has ever been reported, on Simmonds I. (Motu Purihi I.). While we consider this to be a one-off record, the status of the species there needs reassessing.

Visits by G.A.T. and others to Aorangi I. in 2011–13 suggest that the island may have similar numbers of burrows to those reported by Bartle (1968), with the largest concentrations on the higher ridges and southern slopes, but only a low density of burrows in most of the island’s interior. Estimates were made in 1943 at Tawhiti Rahi I. of 250,000 breeding pairs and 500,000 individuals, but no repeat count at this site has been made. Tawhiti Rahi and Aorangi I. are the largest islands in the Poor Knights group and provide the most viable population-monitoring localities for this species. There is ongoing work by the authors at Aorangi I.

At a superficial level, the population at the Poor Knights Is seems to have increased from about 100 burrows on Aorangi in 1938 (when there was no estimate for Tawhiti Rahi I.), to hundreds of thousands of pairs on the Poor

Table 2 Population data for Buller's shearwater, *Puffinus bulleri*. NLE = Northland East; – = no data or comments; for sampling protocol, see 'Methods and conventions'.

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Poor Knights Is (7 of 12 islands)	NLE	1963–81	2,500,000	Individuals		Ground observation	Harper 1983
Poor Knights Is, Tawhiti Rahi I.	NLE	1924–25	–	Individuals	Breeding, small colony	Ground observation	R. Falla <i>et al.</i> in Wilson 1959
		1940	–	Burrows	Breeding in large numbers	Ground observation	Buddle 1941; Wilson 1959
		1943	250,000	Breeding pairs	–	Ground observation	Buddle 1946
		1943	100,000+	Burrows	Breeding, well over 100,000	Ground observation	Wilson 1959
		1980	–	Burrows	Breeding	Ground observation	McCallum 1981
Poor Knights Is, Aorangi I.	NLE	1938	100	Burrows	–	Ground observation	Buddle 1941; Wilson 1959
		1940	–	Burrows	Breeding, in large numbers	Ground observation	Buddle 1941; Wilson 1959
		1958	152+	Individuals	More than 152 breeding	Ground observation	Kinsky & Sibson 1959
		1963–64	100,000	Burrows	–	Ground observation	Bartle 1968
		1980s	200,000	Breeding pairs	–	Ground observation	Harper 1983; Taylor 2000b
2010–13	100,000	Burrows	–	Ground observation	G. Taylor & A. Tennyson, pers. obs.		
Poor Knights Is, Motu Kapiti I.	NLE	1940	–	Burrows	Breeding	Ground observation	Buddle 1941
			–	Chicks	Very abundant	Ground observation	R. Parrish <i>in</i> Taylor & Parrish 1992
Poor Knights Is, Archway I.	NLE	1990	1	Burrow	–	Ground observation	R. Parrish <i>in</i> Taylor & Parrish 1992
Simmonds Is, Motu Purihi I.	NLE	1990	1	Adult and chick	Breeding	Ground observation	R. Parrish & B. Waddell <i>in</i> Taylor & Parrish 1991

Knights group in the 1940s to 1960s, to 2,500,000 individuals in 1981 (Harper 1983). However, the accuracy of these counts is unclear. Robertson & Bell's (1984) estimate of 50,000–100,000 breeding pairs for the total population conflicts with the information in Harper (1983) and is likely to be an underestimate. Based on limited data, we suggest a more likely figure of 300,000–400,000 breeding pairs. No counts have been done on the other islands of the group since the 1980s.

### Flesh-footed shearwater

From 20 current flesh-footed shearwater nesting localities, 18 colonies have counts and several sites have repeat counts, although the quality of most of the counts prior to 2003 is poor or unknown (Table 3). It appears that small colonies on Hen I. (Taranga I.), Red Mercury I. (Whakau I.), Hongiora I. and Whakaari I. (White I.) have become extinct (Baker *et al.* 2010; this paper). Reports of breeding at Manawatawhi Is (Three Kings Is) (Oliver 1930; Falla 1934)

Table 3 Population data for flesh-footed shearwater, *Puffinus carneipes*. Sites are listed in roughly north–south order (NLE = Northland East; AKW = Auckland West; CDL = Coromandel; BOP = Bay of Plenty; EHC = East Coast, Hawke’s Bay; WTT = West Coast North I. Waikato–Taranaki–Whanganui; MLS = Marlborough Sounds; – = no data or comments; for sampling protocol, see ‘Methods and conventions’).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Marotere Is (Chicken Is), Gunsight Rock	NLE	1939	2	Pairs	Probably this island	Ground observation	McCallum <i>et al.</i> 1984
		1982	1	Burrow	Incubating bird	Ground observation	McCallum <i>et al.</i> 1984
Marotere Is (Chicken Is), Muriwhenua I.	NLE	1939	1	Burrow	–	Ground observation	C. Fleming <i>in</i> Skegg 1964
Marotere Is (Chicken Is), West Chicken I. (Mauitaha I.)	NLE	1982	–	Burrows	Common	Ground observation	McCallum <i>et al.</i> 1984
		1994	4	Burrows	–	Ground count	Tennyson & Pierce 1995
		2008	15	Burrows, occupied	–	Ground count (ACAP5)	Baker <i>et al.</i> 2010
Marotere Is (Chicken Is), Araara I.	NLE	1982	–	Burrows	Several pairs	Ground observation	McCallum <i>et al.</i> 1984
Marotere Is (Chicken Is), Lady Alice I. (Mauimua I.)	NLE	1916	–	Burrows	Present	Ground observation	E. Stead <i>in</i> Skegg 1964
		1939	–	Unknown	Rare	Ground observation	Wilson 1959
		1953	100s	Breeding pairs	–	Ground observation	Chambers <i>et al.</i> 1955
		1962–64	100s	Breeding pairs	–	Ground observation	Skegg 1964
		1982	1000s	Individuals	–	Ground observation	McCallum <i>et al.</i> 1984
		2007–09	2763	Burrows	–	Ground count (ACAP5)	Baker <i>et al.</i> 2010
Marotere Is (Chicken Is), Whatupuke I.	NLE	2008	2941	Burrows	–	Ground count (ACAP5)	Baker <i>et al.</i> 2010
		2008	1210	Burrows, occupied	–	Ground count (ACAP5)	Baker <i>et al.</i> 2010

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remain unverified (Turbott & Buddle 1948). The breeding record for East I. (Whangaokeno I.) (Marchant & Higgins 1990) is considered an error (the record is presumed to refer to fluttering shearwaters) – no flesh-footed shearwaters were present on the island in 2001 (G. Taylor, pers. obs.), although there is an unconfirmed record of this species nesting there in 1931 (Bell & Blackburn 1960). The species was ‘common’ on West Chicken (Mauitaha) I. in 1982, and had an estimate of four burrows in 1994 and 15 burrows in 2008. Coppermine I. had in excess of 10,000 breeding pairs in 1965 (based on extrapolation from representative plots),

fewer than this number in 1992, and 1425 occupied burrows in 2008–09 (a high-quality estimate).

Sites that could be considered for further counts, with one high-accuracy count in the post-2003 period, are: Karewa I. with 2561 occupied burrows in 2010; Atiu I. (Middle I.) with *c.* 3000 breeding burrows in 2003; and Green I. with 74 occupied burrows in 2009. However, these three sites are very fragile. More easily monitored would be Ohinau I. with 2071 occupied burrows in 2009; Titi I. with 337 occupied burrows in 2009; Lady Alice I. (Mauimua I.) with 921 occupied burrows in 2009; Whatupuke I.

Table 3 Population data for flesh-footed shearwater, *Puffinus carneipes*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Marotere Is (Chicken Is), Coppermine I.	NLE	1962	1000s	Breeding pairs	–	Ground observation	Skegg 1964
		1965	10,000	Breeding pairs	–	Ground count (ACAP5)	Merton & Atkinson 1968
		1982	–	Burrows	Abundant	Ground observation	McCallum <i>et al.</i> 1984
		1992	–	Burrows	Present but fewer than 10,000 pairs	Ground observation	A. Tennyson, pers. obs.
		2008–09	2290	Burrows	–	Ground count (ACAP5)	Baker <i>et al.</i> 2010
		2008–09	1425	Burrows, occupied	–	Ground count (ACAP5)	Baker <i>et al.</i> 2010
Taranga I. (Hen I.)	NLE	1937–54	–	Adults and burrows	Very few	Ground observation	Skegg 1964
		1960–64	0	Burrows	–	Ground observation	Skegg 1964
		1991	0	Burrows	–	Ground observation	Taylor 2000a; G. Taylor, pers. obs.
Te Henga (Bethells Beach), Kawahaia I.	AKW	1990	8	Breeding pairs	–	Ground count (ACAP1)	Taylor 2008; G. Taylor, pers. obs.
		2012	23	Breeding pairs	–	Ground count (ACAP1)	G. Taylor, pers. obs.
Mercury Is, Ariu I. (Middle I.)	CDL	2003	3000	Burrows	–	Ground count (ACAP5)	G. Taylor, pers. obs.
Mercury Is, Green I.	CDL	1966	–	Burrows	Common	Ground observation	Thoresen 1967
		2009	132	Burrows	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010
		2009	74	Burrows, occupied	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010
Mercury Is, Korapuki I.	CDL	1974	2	Adults	–	Ground observation	Hicks <i>et al.</i> 1976
		2003	10	Burrows, occupied	–	Ground count	G. Taylor, pers. obs.
Mercury Is, Kawhitihu I. (Stanley I.)	CDL	1998	1	Burrow, occupied	–	Ground count	G. Taylor, pers. obs.
		2003	1	Burrow, occupied	–	Ground count	G. Taylor, pers. obs.
Mercury Is, Kawhitihu I. (Stanley I.), stack to the north	CDL	1998	1	Burrow, occupied	–	Ground count (ACAP1)	G. Taylor, pers. obs.

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with 1210 occupied burrows in 2008; and Coppermine I. For this species, data are of sufficient quality to provide a reasonable estimate of the total New Zealand population of *c.* 10,000–15,000 pairs breeding annually in 2003–12. The authors are conducting further counts at Lady Alice I. (Mauihua I.), Titi I. and Ohinau I. in 2012–13.

Robertson & Bell's (1984) estimate of 50,000–100,000 breeding pairs and Taylor's (2000a) estimate of 25,000–

50,000 pairs were either overestimates or numbers have declined. Although numbers apparently grew rapidly on Lady Alice I. (Mauihua I.) during the twentieth century up until 1982 (after the cessation of most human activities there) (McCallum *et al.* 1984), more recent counts on other islands, e.g. Coppermine I. and Karewa I., combined with the evidence of extinctions of small colonies noted above, suggest that the overall population is currently in decline.

Table 3 Population data for flesh-footed shearwater, *Puffinus carneipes*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Mercury Is, Double I. (Moturehu)	CDL	1988–90	10	Burrows, occupied	–	Ground count	I. McFadden, pers. comm. 1990
Mercury Is, Red Mercury I. (Whakau I.)	CDL	c. 1930	–	Unknown	Breeding	Ground observation	Falla 1934; Fogarty & Douglas 1972
		1990	0	Burrows, occupied	–	Ground count	G. Taylor <i>in</i> Taylor & Parrish 1992
Ohinau I.	CDL	2009	3883	Burrows	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010
		2009	2071	Burrows, occupied	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010
Ohinauiri I.	CDL	1926–1950s	–	Individuals	Breeding in numbers	Ground observation	R. Falla <i>in</i> Blackburn 1970
The Aldermen Is, Hongiora I.	CDL	1920s	100	Burrows	–	Ground observation	Sladden & Falla 1927, 1928
		1994	0	Burrows, occupied	–	Ground count	G. Taylor & A. Tennyson, pers. obs.
Whakaari I. (White I.)	BOP	Late 19th century	1	Breeding pair	–	Ground observation	Buller 1887–1888
		1980s–2000s	0	–	No recent reports	–	A. Tennyson & G. Taylor, pers. obs.
Karewa I.	BOP	Before 1934	–	Burrows	Breeding	Ground observation	Falla 1934
		1993	6553–8427	Burrows	–	Ground count	McClellan 1996
		1993	2477–4820	Breeding pairs	–	Ground count	McClellan 1996
		2010	5929	Burrows	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010
		2010	2561	Burrows, occupied	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010
Nga Motu (Sugar Loaf Is), Motumahanga I. (Saddleback I.)	WTT	1963	1	Burrow	–	Ground observation	Williams 1964
		1989	100	Burrows	c. 100 breeding	Ground observation	G. Taylor, pers. obs.
		1998	–	Breeding pairs	Small colony	Ground observation	Taylor 2008
Trio Is (Kuru Pongi), Middle Trio I.	MLS	1964	1	Adult and burrow	Rare	Ground observation	Campbell 1967
Titi I.	MLS	2009	2814	Burrows	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010
		2009	337	Burrows, occupied	–	Ground count (ACAP3)	Baker <i>et al.</i> 2010



## Sooty shearwater

For this species, about 180 current breeding sites were identified (Table 4), although we suspect there are many more sites we are unaware of. Among them, about 100 current sites have numerical data on population size, but only about 22 of these had more than one dated count. Most numerical data are from small colonies, whereas most of the birds nest in huge colonies. Listed roughly from north to south, these sites are:

### Northern New Zealand

Lady Alice I. (Mauihua I.), hundreds of individuals were noted in 1962 but only two burrows were seen in 2012. On Kauwahaia I. at Te Henga (Bethells Beach), 45 pairs were noted in 1990, and 27 pairs in 2012.

### Coromandel region

Kawhitihi I. (Stanley I.) had 24 breeding pairs in 1965 and at least five breeding pairs in 1988. Ruamahuanui I. had 12 burrows in the 1920s and 10–100 breeding pairs in 1994.

### Bay of Plenty

Only Moutohora I. (Whale I.) had repeat counts, where less than 12 burrows were estimated in the 1930s and 625 pairs were counted in the 1968–70 period.

### East Coast region

Bare I. (Motu-o-Kura I.) had 100 burrows in 1960, and 5–20 in 1988.

### Wellington

Kapiti I. had 400+ burrows in the late nineteenth century but only 15 burrows in 2006.

### Canterbury

Motunau I. had 80 burrows in 1958 and 230 were noted in 1996. These counts were both of a high accuracy, using the same methodology.

### Westland

Two sites had repeat counts, with Wanganui River Mouth (Mt Oneone) having 16 burrows in 1956, increasing to 50 in the 1994–97 period, and reducing to 17 in 2009. At Taumaka I. in the Open Bay Is, 75 burrows were estimated in 1973 and in 1980.

### Otago

Several mainland sites were identified, such as Bushy Beach (Oamaru), with 56 burrows increasing to 143 between 1992

and 1997. Kakanui had 27 burrows in 1994–96 and 18 in 1997. Shag Point (Matakaka) had 11 burrows in 1992 and in 1997. At Taiaroa Head (Pukekura) a colony on private land increased from 400 burrows in 1970, to 620 in 1992 and 2164 in 1996, then dropped slightly to 2100 in 1997. Similarly, in the reserve area at this locality, numbers of burrows increased from 26 in the 1992–96 period to 70 by 1997. At Sandymount, burrows increased from 49 in 1992 to 62 in 1997. At Taieri I. (Moturata I.), 100+ burrows were marked in 1943 and 100 active burrows were found in the 1980s. At Nugget Point (Tokata), numbers remained fairly stable, with 370 burrows in the early 1980s, 287 in 1992 and 316 in 1997. At Tahuwaiki I. (Jacks I.), numbers remained fairly stable, with 1406 burrows in 1985, 1050 in 1992 and 1192 in 1992–96.

### Southland

Raratoka I. (Centre I.) had 147 burrows in 1975 and 80 in 1989. At Poutama I., 387,508 burrows were estimated in 1994 and 337,732 in 1995.

### Subantarctic Islands

The greatest numbers of sooty shearwaters nest on these islands, but there are very few counts, with the only repeat counts being estimates of 2,750,000 pairs at The Snares Is (Tini Heke Is) in 1969–71 (3,287,000 burrows), and 2,061,000 burrows in 1996–2001, perhaps equivalent to 1,100,000 breeding pairs.

On face value, there appears to be a mix of both increases and decreases for burrow numbers across the range of sites, but it is probably unwise to compare numbers given by different researchers for any one site, as the methodologies used are seldom described. Colonies at Pipinui Point (Wellington), Puangiangi I. (Marlborough) and on Chatham I. have become extinct, presumably due to predation. Many of the mainland Otago colonies listed in this paper became extinct during the late twentieth century (Jones 2000). It is unknown whether the apparent losses of small colonies from northern islands, such as the Cavalli Is, Taranga I. (Hen I.), Cuvier I. (Repanga I.) and Red Mercury I. (Whakau I.), are due to their ephemeral nature or reflect broader population declines. The largest Northland population – on Lady Alice I. (Mauihua I.) – may have decreased in the last few decades but few data are available. At Whero Rock, repeat counts were made (400 burrows in 1941, increasing to 625 in the period up to 1957), but this colony has since been destroyed by an expanding colony of

Stewart Island shags (*Leucocarbo chalconotus* (G.R. Gray, 1843)) (Watt 1975; Peat 2011). At Otago, significant increases in colonies numbering several hundreds of birds have been noted, presumably as a result of predator management. Undoubtedly pest eradications on some island breeding colonies will benefit the species also (Newman *et al.* 2009). The change in numbers at the largest colony, The Snares, is hugely significant, with a likely decrease of *c.* 37% at the site in 27 years (Scott *et al.* 2008). Other indicators support the decline in numbers of birds at The Snares (Scofield & Christie 2002; Scott *et al.* 2008; Newman *et al.* 2009) and at six other southern islands (Moller *et al.* 2009).

Owing to the large number of colonies of this species, it is difficult to recommend priority sites for monitoring. Some large populations that should be monitored have only one count available. Therefore, our recommendation includes a mix of sites with existing time-series of information, numerical importance and regional representation. Colonies in the regions of Northland and Coromandel are so small that monitoring would be difficult, but Lady Alice I. (Mauihua I.) and Ruamahuanui I. should be reassessed. Fiordland is presumed to have many nesting sites and possibly significant numbers of birds, but there is virtually no data, so basic surveys are required to determine suitable monitoring sites. We encourage further counts to be focused at the following sites:

- Northern New Zealand – Lady Alice I. (Mauihua I.), Kauwahaia I. and Moutohora I. (Whale I.).
- East Coast – East I. (Whangaokeno I.) and Bare I. (Motu-o-Kura I.).
- Wellington and Cook Strait – Mana I., Kapiti I. and Titi I. At Titi I., Marlborough Sounds, a series of counts is being conducted by the authors.
- Canterbury – Motunau I. and Stony Bay.
- Westland – Wanganui River Mouth (Mt Oneone) and Taumaka I. (Open Bay Is).
- Otago – Kakanui, Shag Point (Matakaea), Taiaroa Head (Pukekura), Nugget Point (Tokata) and Tuhawaiki I. (Jacks I.).
- Southland – Raratoka I. (Centre I.), Omaui I., Bench I., Unnamed I., Dryad I. and Codfish I. (Whenuahou). Poutama I., Putauhinau I. and Taukihepa (Big South

Cape I.) have been the subject of various studies, and further monitoring on these sites would be beneficial.

- Chatham Is – Mangere I. and Rangatira I. (South East I.).
- Subantarctic Is – The Snares Is (Tini Heke Is) and Campbell I. (Motu Ihupuku). The latter site is included as mammal eradications have been achieved and it is likely that a significant population will develop here.

The sooty shearwater is New Zealand's most numerous species of *Puffinus*. Taylor (2000a) estimated the total New Zealand population to be about 5 million pairs (15–30 million birds), while Newman *et al.* (2009) estimated about 4.4 million pairs (19.0–23.6 million birds). These estimates still seem accurate according to our analyses. Newman *et al.* (2009) provides a detailed and important analysis of sooty shearwater numbers, however there are some errors in the paper that should be noted. In particular, reporting of estimates for The Aldermen Is, after Hicks *et al.* (1976), should be for Korapuki I., although Hicks *et al.* (1976) refer to only four birds at the latter site. Similarly, for Araara I. (Hen and Chickens Is), although McCallum *et al.* (1984) noted the species breeding, this tiny stack cannot possibly contain the 5000 pairs listed. The Motumuka citation (5000 pairs) also seems to be an error, as are the Cuvier I. (Repanga I.) numbers (P. Scofield, pers. comm., 2013). Newman *et al.* (2009) report a high number of burrows (225) of this species at Red Mercury I. (Whakau I.), whereas the original reference (Taylor & Parrish 1992) reports only a few pairs, but includes numbers of birds seen offshore (probably migrating south). Newman *et al.* (2009: appendix 1) listed 'Greymouth' as a breeding site, but this is not mentioned in the reference referred to and may instead be Twelve Mile Bluff (see Hamilton *et al.* 1997); also listed are Te Hauturu-o-Toi/Little Barrier I. and Ko Oreao, Chatham I., but we do not consider these to be breeding sites. The same paper lists Open Bay Is. (off Haast, not Fiordland) twice.

During the last few decades, the sooty shearwater is the only shearwater species to have been harvested by people (muttonbirding). Chicks are collected from many southern breeding colonies (e.g. Anderson 1997; Lyver 2000). From the Stewart I./Rakiura area alone, an estimated 360,000 chicks are harvested annually (Newman *et al.* 2009).

Table 4 Population data for sooty shearwater, *Puffinus griseus*. Sites are listed in roughly north–south order (TKI = Manawatawhi Is (Three Kings Is); NLW = Northland West; NLE = Northland East; AKW = Auckland West; CDL = Coromandel; BOP = Bay of Plenty; EHC = East Coast, Hawke’s Bay; WWL = Wellington–Wairarapa; MLS = Marlborough Sounds – Nelson/Tasman; CTC = Canterbury Coastal; WSC = West Coast South I.; OTC = Otago Coastal; STC = Southland Coastal; FLD = Fiordland; STW = Stewart I./Rakiura; CIS = Chatham Is; SNI = The Snares Is (Tini Heke Is); ANT = Antipodes Is; AKI = Auckland Is; CBL = Campbell Is; – = no data or comments; for sampling protocol, see ‘Methods and conventions’).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Manawatawhi Is (Three Kings Is)	TKI	Before 1934	12	Burrows	Fewer than a dozen	Ground observation	Falla 1934
Manawatawhi Is (Three Kings Is), Great I./Ohau I.	TKI	1934–46	1	Chick, probably	–	Ground observation	Turbott & Buddle 1948
		1982	–	Adults and eggs	Breeding	Ground observation	McCallum <i>et al.</i> 1985
Manawatawhi Is (Three Kings Is), South West I.	TKI	1985	40	Burrows	–	Unknown	McCallum <i>et al. in</i> Newman <i>et al.</i> 2009
Motuopao I.	NLW	1988–92	20	Burrows	–	Ground observation	Pierce & Parrish 1993
Cavalli Is	NLE	Before 1934	<12	Burrows	Fewer than a dozen	Ground observation	Falla 1934
		1951	0	–	None reported	Ground observation	Sibson 1953; Millener 1980
Poor Knights Is, Aorangi I.	NLE	1958	1	Adult and egg	Breeding	Ground observation	Kinsky & Sibson 1959
Mokohinau Is	NLE	Before 1889	12	Burrows	Fewer than a dozen on three different islands	Ground observation	Sandager 1889; Falla 1934
Mokohinau Is, Burgess I. (Pokohinu I.)	NLE	2011	<50	Individuals	Fewer than 50 individuals	Ground observation	G. Taylor, pers. obs.
Mokohinau Is, Stack D	NLE	1973	–	–	Breeding	Ground observation	McCallum 1980
Mokohinau Is, Maori Bay Is	NLE	1973	–	–	Breeding	Ground observation	McCallum 1980
Taranga I. (Hen I.)	NLE	Before 1934	<12	Burrows	Fewer than a dozen	Ground observation	E. Stead <i>in</i> Falla 1934; Skegg 1964
		1962–63	–	Eggs	Small numbers	Ground observation	J. Bartle <i>in</i> Skegg 1964; P. Harper <i>in</i> Warham <i>et al.</i> 1982
		1991	0	Burrows	Absent	Ground observation	G. Taylor, pers. obs.
Marotere Is (Chicken Is), West Chicken I. (Mautaha I.)	NLE	1982	–	Burrows	Common	Ground observation	McCallum <i>et al.</i> 1984
		1994	3	Burrows	–	Ground count	Tennyson & Pierce 1995

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Marotere Is (Chicken Is), Lady Alice I. (Mauimua I.)	NLE	1953	–	Burrows	In 'numbers'	Ground observation	Chambers <i>et al.</i> 1955
		1962	100s	Individuals	–	Ground observation	Skegg 1964
		1982	–	Burrows	Common	Ground observation	McCallum <i>et al.</i> 1984
		2012	2	Burrows	–	Ground observation	J.-C. Stahl, pers. comm. 2012
Marotere Is (Chicken Is), Araara I.	NLE	1982	–	Burrows	Breeding	Ground observation	McCallum <i>et al.</i> 1984; Tennyson & Pierce 1995
Te Henga (Bethells Beach), Kauwahaia I.	AKW	1990	45	Breeding pairs	–	Ground count (ACAP1)	Taylor 2008; G. Taylor, pers. obs.
		2012	27	Breeding pairs	–	Ground count (ACAP1)	G. Taylor, pers. obs.
Cuvier I. (Repanga I.)	CDL	1974–80	–	Burrows	A few pairs	Ground observation	Bellingham <i>et al.</i> 1981
		2001–08	0	Burrows	Absent	Ground observation	G. Taylor, pers. obs.
Mercury Is, Korapuki I.	CDL	1974	4	Adults	–	Ground observation	Hicks <i>et al.</i> 1976
Mercury Is, Kawhitihi I. (Stanley I.)	CDL	1965	24	Breeding pairs	–	Ground observation	Skegg 1972
		1988	5+	Breeding pairs	Burrows, occupied	Ground observation	A. Tennyson, G. Taylor & P. Scofield, pers. obs.
Mercury Is, Red Mercury I. (Whakau I.)	CDL	1991	2	Adults and burrows	–	Ground observation	G. Taylor <i>in</i> Taylor & Parrish 1992
		2000–10	0	Burrows	Absent	Ground observation	G. Taylor, pers. obs.
Mercury Is, Double I. (Moturehu)	CDL	1988	4	Breeding pairs	4 or more	Ground observation	A. Tennyson & G. Taylor, pers. obs.
Poikeke I.	CDL	1989	1	Chick	–	Ground observation	G. Taylor, A. Tennyson & P. Scofield, pers. obs.
The Aldermen Is, Ruamahuanui I.	CDL	1920s	12	Burrows	Adults incubating	Ground observation	Sladden & Falla 1927, 1928; Falla 1934
The Aldermen Is, Hongiora I.	CDL	1994	10–100	Breeding pairs	–	Ground observation	G. Taylor & A. Tennyson, pers. obs.
Motuotau I.	BOP	1999	<10	Burrows	Fewer than 10	Ground observation	G. Taylor, pers. obs.
Rurima I.	BOP	Before 1888	–	–	Large numbers	Unknown	Buller 1887–1888

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Moutohora I. (Whale I.)	BOP	Before 1934	<12	Burrows	Fewer than a dozen	Ground observation	Falla 1934
		1968–1970	625	Breeding pairs	–	Ground observation	Imber 1975
		1990s	–	Unknown	Breeding	Ground observation	Bay of Plenty Conservancy 1999
Whakaari I. (White I.)	BOP	Before 1934	<12	Burrows	Fewer than a dozen	Ground observation	B. Sladden <i>in</i> Falla 1934
East I. (Whangaokeno I.)	EHC	1979	–	Breeding pairs	Breeding	Ground observation	Moors 1980
		2001	50–150	Breeding pairs	–	Ground observation	H. Jonas & G. Taylor, pers. obs.
Bare I. (Motu-o-Kura I.)	EHC	1960	100	Burrows, occupied	–	Ground count	Merton 1961
		1988	20	Burrows, occupied	–	Ground count	Walls 1998
		1998	5	Burrows, occupied	–	Ground count	Walls 1998
Kapiti I.	WWL	Late 19th century	400+	Muttonbirds	400 taken one year	Unknown	Buller 1887–1888; Phillipps 1958
		1942	–	Breeding pairs	Breeding	Ground observation	Stidolph 1948
		1984–85	–	Burrows	Breeding	Ground observation	Howell 1985
		2006	15	Burrows	–	Ground observation	S. Waugh, pers. obs.
Mana I.	WWL	Before 1970s	–	Burrows	Breeding	Ground observation	Warham & Wilson 1982
		2012	100	Breeding pairs	–	Ground observation	C. Miskelly, pers. comm. 2012
Pipinui Point, Wellington	WWL	1960s	–	Burrows	Breeding	Ground observation	Bartle 1974; J.A. Bartle, pers. comm. 1995
		1995	–	Absent	–	Ground count	J.A. Bartle & A. Tennyson, pers. obs.
Stephens I. (Takapourewa I.)	MLS	Before 1980	–	Unknown	Breeding	Ground observation	Warham & Wilson 1982
		No date	100s	Breeding pairs	A few 100s	Unknown	Gaze 2000
		No date	200	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Puangiangi I.	MLS	1998	–	Individuals	Breeding	Ground observation	Nicoll 2012
		No date	20	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
		2012	0	–	Absent	Ground observation	Nicoll 2012
Trio Is (Kuru Pongi), Middle Trio I.	MLS	1964	100s	Adults and burrows	A few 100	Ground observation	Campbell 1967; Gaze 2000
		No date	200	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Long I.	MLS	No date	60	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
		1995	1	Burrow	–	Ground observation	A. Tennyson, pers. obs.
Fossil Point, Golden Bay	MLS	No date	16	Burrows	–	Unknown	Newman <i>et al.</i> 2009

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Tunnel I.	MLS	No date	50	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Nguroa I.	MLS	No date	100	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Kokomohua I.	MLS	No date	20	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Motuanauru I.	MLS	No date	100	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Motungarara I.	MLS	No date	100	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Otuhaereroa I.	MLS	No date	20	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Penguin I.	MLS	No date	20	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Pepin Stack	MLS	No date	10	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Stewart I.	MLS	No date	20	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Takawhero I.	MLS	No date	20	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Tonga I.	MLS	No date	50	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Victory I.	MLS	No date	100	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Titi I.	MLS	1987–98	–	Burrows	Moderately common	Ground observation	Gaze 2000
		No date	800	Burrows	–	Unknown	Newman <i>et al.</i> 2009
Cherwode Is, Nukuwaiata I.	MLS	2011	–	Chicks	10s breeding	Ground observation	C. Miskelly, pers. comm. 2012
Motuara I.	MLS	Before 1985	–	Burrows	Breeding	Ground observation	Wragg 1985
		1993	100s	Breeding pairs	100s of pairs	Ground observation	A. Tennyson, pers. obs.
		No date	60	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009
Motunau I.	CTC	1958	80	Burrows	–	Ground count (ACAP5)	Cox <i>et al.</i> 1967
		1983–84	20	Breeding pairs	Breeding	Ground observation	Wragg 1985
		1996	230	Burrows	–	Ground count (ACAP5)	Beach <i>et al.</i> 1997
Banks Peninsula, Le Bons Bay	CTC	1960s	–	Burrows	Breeding	Ground observation	Hamilton <i>et al.</i> 1997
Banks Peninsula, Tumbledown Bay	CTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1990s	0	Burrows	–	Ground count	K.-J. Wilson, pers. obs.
Banks Peninsula, Stony Bay	CTC	1995–2008	11	Burrows	–	Ground count (ACAP1)	Wilson 2000; K.-J. Wilson, pers. obs.
		No date	17	Breeding pairs	–	Unknown	Newman <i>et al.</i> 2009

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Banks Peninsula, Akaroa Heads, Island Bay Islet	CTC	1993	–	Burrows	Numerous burrows assumed to be this species	Ground observation	P. Langlands <i>in</i> O'Donnell 1995
Cape Foulwind, headland	WSC	2009	12	Burrows	–	Ground count	K.-J. Wilson, pers. obs.
Charleston, Joyce Bay	WSC	2009–10	2	Breeding pairs	–	Ground count	R. Lane, pers. comm. 2010
Seal I.	WSC	1988	2	Chicks	Several other burrows and 27 adults	Ground observation	K. Scollay <i>in</i> O'Donnell & West 1989
Perpendicular Point	WSC	1956	7	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
Twelve Mile Bluff, Motukiekie Rocks	WSC	1956	30	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		No date	50	Breeding pairs	–	Unknown	P. Scofield <i>in</i> Newman <i>et al.</i> 2009
Wanganui River Mouth, Mt Oneone (Doughboy Knoll)	WSC	1956	16	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1988	20	Burrows	–	Ground count	C. O'Donnell <i>in</i> O'Donnell & West 1989
		1995	11	Breeding pairs	–	Ground count	K.-J. Wilson, pers. obs.
		1994–97	50	Burrows	–	Ground count	Wilson 1999
		2008–09	17	Burrows	–	Ground count	K.-J. Wilson, pers. obs.
Okarito	WSC	Early 1940s	–	Burrows	Breeding	Ground observation	Hamilton <i>et al.</i> 1997
Makawhio Point	WSC	1950s	–	Burrows	Decreasing colony	Ground observation	R. Jackson <i>in</i> Sibson 1958
Arnott Point	WSC	2010	1	Egg	–	Unknown	Te Papa specimen NMNZ OR.29169
Open Bay Is, Taumaka I.	WSC	1973	75	Adults and burrows	–	Ground observation	K.-J. Wilson, pers. obs.
		1980	75	Adults and burrows	–	Ground observation	K.-J. Wilson, pers. obs.
Iota Bluff	WSC	No date	69	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
Oamaru, Oamaru Yacht Club	OTC	1997	15	Burrows	–	Ground count	Jones 2000
Oamaru, Boatmans Harbour	OTC	1997	28	Burrows	–	Ground count	Jones 2000
Oamaru, Bushy Beach	OTC	1992	56	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1997	143	Burrows	–	Ground count	Jones 2000
Cape Wanbrow	OTC	1984	50	Breeding pairs	Breeding	Ground observation	Wragg 1985

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Kakanui	OTC	1994–96	27	Burrows	–	Ground count	Lyver <i>et al.</i> 2000
		1997	18	Burrows	–	Ground count	Jones 2000
Moeraki Peninsula, Maukiekie I.	OTC	1980s	–	Individuals	Breeding	Ground observation	Hamilton <i>et al.</i> 1997
Moeraki Peninsula, Katiki Point	OTC	1997	17	Burrows	–	Ground count	Jones 2000
Shag Point (Matakaea)	OTC	1992	11	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1997	11	Burrows	–	Ground count	Jones 2000
Bobby's Head	OTC	1997	12	Burrows	–	Ground count	Jones 2000
Otago Harbour, Quarantine I.	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
Otago Harbour, Goat I.	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
Otago Harbour, Pudding I.	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
Otago Harbour, Wharekakahu I.	OTC	1985	1	Burrow	Active burrow	Unknown	Hamilton <i>et al.</i> 1997
Taiaroa Head, Pukekura Private	OTC	1970	400	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1984	500+	Breeding pairs	More than 500 breeding pairs	Ground observation	Wragg 1985
		1992	620	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1996	2164	Burrows	–	Ground count	Lyver <i>et al.</i> 2000
		1997	2100	Burrows	–	Ground count	Jones 2000
Taiaroa Head, Pukekura Reserve	OTC	1992–96	26	Burrows	–	Ground count	Lyver <i>et al.</i> 2000
		1997	70	Burrows	–	Ground count	Jones 2000
Cape Saunders	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Mt Charles	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
Grassy Point	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Highcliff	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Double Bay	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
The Chasm	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Cape Saunders	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Titikoraki	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Penguin Beach	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Ohinepuha	OTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Pipikaretu	OTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Victory Beach	OTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Sandymount	OTC	1992	49	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1997	62	Burrows	–	Ground count	Jones 2000
Dunedin, Tunnel Beach	OTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Dunedin, Lawyer's Head	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Dunedin, Maori Head	OTC	1940s–1950s	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
		1997–98	0	–	–	Ground observation	Jones 2000
Green I.	OTC	1983	150	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
Taieri I. (Moturata I.)	OTC	1943	100+	Burrows	100 burrows marked	Ground count	Hamilton <i>et al.</i> 1997
		1980s	100	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
Nugget Point (Tokata)	OTC	Early 1980s	370	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1992	287	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1997	316	Burrows	–	Ground count	Jones 2000
Nugget Point (Tokata), Roaring Bay, Colony A	OTC	1992–96	136	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997; Lyver <i>et al.</i> 2000
Nugget Point (Tokata), Colony B	OTC	1992–96	38	Burrows	–	Ground count	Lyver <i>et al.</i> 2000
Nugget Point (Tokata), Colony C (3 and 4)	OTC	1992–96	79	Burrows	–	Ground count	Lyver <i>et al.</i> 2000

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Nugget Point (Tokata), Colony D	OTC	1992–96	64	Burrows	–	Ground count	Lyver <i>et al.</i> 2000
Jacks Bay, Tuhawaiki I. (Jacks I.)	OTC	1985	1406	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1992	1050	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
		1992–96	1192	Burrows	–	Ground count (ACAP1)	Lyver <i>et al.</i> 2000
Jacks Bay, Tunnel Rocks, Jacks Blowhole	OTC	1992	105	Burrows	–	Ground count	Hamilton <i>et al.</i> 1997
Wilkie Falls	OTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
Cannibal Bay	OTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
Rainbow Isles	OTC	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997
Cosgrove I.	OTC	1984	–	Burrows	Breeding	Ground observation	Hamilton <i>et al.</i> 1997
Irihuka (Long Point)	OTC	1997	30	Burrows	–	Ground count	Jones 2000
Ruapuke I.	STC	1963	–	Individuals	Uncommon	Ground observation	Watters 1963
Ruapuke I., Hazelburgh Group	STC	1963	–	Individuals	Common	Ground observation	Watters 1963
Ruapuke I., Bird I.	STC	1965	–	Individuals	Moderately common	Ground observation	Blackburn 1965
Ruapuke I., South I.	STC	1999–2005	–	Muttonbirds	Breeding	Ground observation	Newman <i>et al.</i> 2009
Ruapuke I., Topi I.	STC	1999–2005	–	Muttonbirds	Breeding	Ground observation	Newman <i>et al.</i> 2009
Green I.	STC	1941	–	Unknown	Common	Ground observation	Wilson 1959
Omaui I.	STC	1991	30	Burrows	–	Ground count	Cooper & McClelland 1992
Raratoka I. (Centre I.)	STC	1975	147	Burrows	–	Ground observation	Cooper 1991
		1989	80	Burrows	–	Ground observation	Cooper 1991
Solander I. (Hautere I.)	STC	1947	–	Burrows	Breeding	Ground observation	Falla 1948
		1973	–	Individuals	Common	Ground observation	K.-J. Wilson, pers. obs.
		1996	–	Burrows and chicks	Common, but weka predation	Ground observation	G. Taylor & A. Tennyson, pers. obs.
Little Solander I.	STC	1976	–	Individuals	Breeding	Ground observation	Cooper <i>et al.</i> 1986
Te Kakahu	FLD	No date	500	Burrows	–	Unknown	D. Scott <i>in</i> Newman <i>et al.</i> 2009

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Breaksea I.	FLD	Before 1990s	–	Unknown	Breeding	Ground observation	Hamilton <i>et al.</i> 1997
Breaksea Sound, Hawea I.	FLD	1986	–	Burrows	Small colonies	Ground observation	Hamilton <i>et al.</i> 1997; G. Taylor, pers. obs.
Dusky Sound, Petrel Is	FLD	1884	–	Individuals	Breeding	Ground observation	Medway 2011
Chalky Inlet, Garden Is	FLD	1992	1	Egg	Old egg	Ground count	McLean <i>et al.</i> 1993
North I. (Pikomamakau-iti I.)	STW	2006	–	Muttonbirds	Breeding	Unknown	Bragg <i>et al.</i> 2008
Womens I. (Pikomamakau-nui I.)	STW	No date	–	Muttonbirds	Breeding	Ground observation	Kitson & Moller 2008
		2006	–	Muttonbirds	Breeding	Unknown	Bragg <i>et al.</i> 2008
Motunui I. (Edwards I.)	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
Jacky Lee I. (Pukeokaoka I.)	STW	1932	–	Muttonbirds	Breeding	Ground observation	Wilson 1959
Herekopare I. (Te Marama I.)	STW	1911	–	Muttonbirds	Breeding	Ground observation	Guthrie-Smith 1914
		2001	–	Muttonbirds	Breeding	Unknown	Bragg <i>et al.</i> 2008
Bunker Islets	STW	1971–73	–	Burrows	Common	Ground observation	K.-J. Wilson, pers. obs.
Bench I.	STW	1971	25	Adults and burrows	–	Ground count	K.-J. Wilson, pers. obs.
		1979	–	Burrows	Uncommon	Ground observation	K.-J. Wilson, pers. obs.
Whero Rock	STW	1941	400	Burrows	–	Ground count	Richdale 1942
		1938–57	625	Individuals	–	Ground observation	Richdale 1963
		2010	0	–	–	Ground observation	Peat 2011
Halfmoon Bay, Ackers Point	STW	1985–86	6	Adults and burrows	–	Ground count	K.-J. Wilson, pers. obs.
		No date	200	Burrows	–	Unknown	B. Bevan <i>in</i> Newman <i>et al.</i> 2009
Stewart I./Rakiura East Coast, Starling Head	STW	No date	–	Unknown	Breeding	Ground observation	Hamilton <i>et al.</i> 1997
Stewart I./Rakiura East Coast, Chew Tobacco	STW	No date	–	–	Colony	Unknown	Hamilton <i>et al.</i> 1997

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Pihore I.	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
Weka I.	STW	1971	1750	Burrows	–	Ground observation	K.-J. Wilson, pers. obs.
Tia I. (Entrance I.)	STW	1972–74	–	Adults and burrows	Abundant	Ground observation	K.-J. Wilson, pers. obs.
Breaksea Is, Joss's I. (Rukawahakura I.)	STW	2001–06	–	Muttonbirds	Breeding	Unknown	Bragg <i>et al.</i> 2008
Breaksea Is, Potuatua I. (Pohotuatua)	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
Breaksea Is, Takawiwini I.	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
Breaksea Is, Pomatakiarehua I. (Te Pohomatakiarehua)	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
Breaksea Is, Wharepuitaha I. (Te Wharepuitaha I.)	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
Breaksea Is, Kaihuka I.	STW	No date	–	Muttonbirds	Breeding	Unknown	Kitson & Moller 2008
Horomamae I. (Owen I.)	STW	No date	–	Muttonbirds	Breeding	Unknown	Kitson & Moller 2008
Kopeka I.	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
The Brothers	STW	1974	1750	Burrows	–	Ground observation	K.-J. Wilson, pers. obs.
Port Pegasus (Pikihaiti), Unnamed I.	STW	1974	30	Burrows	–	Ground observation	K.-J. Wilson, pers. obs.
Port Pegasus (Pikihaiti), Pearl I.	STW	1974	–	Adults and burrows	Uncommon	Ground observation	K.-J. Wilson, pers. obs.
Port Pegasus (Pikihaiti), Islet Cove	STW	1974	10	Adults and burrows	–	Ground count	K.-J. Wilson, pers. obs.
Port Pegasus (Pikihaiti), Hebe I.	STW	1974	–	Burrows	Moderately common	Ground observation	K.-J. Wilson, pers. obs.
Port Pegasus (Pikihaiti), Dryad I.	STW	1974	175	Adults and burrows	–	Ground observation	K.-J. Wilson, pers. obs.

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Ernest I.	STW	1974 and 1979	–	Adults and burrows	Abundant	Ground observation	K.-J. Wilson, pers. obs.
Broad Bay	STW	1974	–	Individuals	Rare	Ground observation	M. Scofield, pers. comm. 1974
Broad Bay, Kaninihi I.	STW	1974	–	Unknown	Common	From boat	K.-J. Wilson, pers. obs.
Poutama I.	STW	1994	387,508	Burrows	–	Ground count (ACAP3)	Lyver 2000
		1995	337,732	Burrows	–	Ground count (ACAP3)	Lyver 2000
Taukihepa (Big South Cape I.)	STW	1965	–	Individuals	Abundant	Ground observation	Blackburn 1965
		1999–2005	1,120,000	Burrows	–	Ground count (ACAP3)	Newman <i>et al.</i> 2008, 2009
Pukeweka I.	STW	2006	–	Adults	Abundant	Ground observation	M. Charteris, pers. comm. 2011
Pukuparara I.	STW	1999–2005	–	Muttonbirds	Breeding	Ground observation	Newman <i>et al.</i> 2009
Rerewhakaupoko I. (Solomon I.)	STW	1965	–	Individuals	Abundant	Ground observation	Blackburn 1965
		2006	–	Adults	Common	Ground observation	M. Charteris, pers. comm. 2011
Pohowaitai I.	STW	1965	–	Burrows	Common	Ground observation	Blackburn 1965
Tamaitemioka I.	STW	1965	–	Burrows	Common	Ground observation	Blackburn 1965
Kaimohu I.	STW	2006	–	Muttonbirds	Breeding	Unknown	Bragg <i>et al.</i> 2008
Tupari Bay	STW	1971	–	Adults	Breeding	From boat	K.-J. Wilson, pers. obs.
Mokinui I. (Big Moggy I.)	STW	No date	–	Muttonbirds	Common	Ground observation	Kitson & Moller 2008
Timore I. (Chimney I.)	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a
Big I. (Stage I.)	STW	1965	–	Individuals	Abundant	Ground observation	Blackburn 1965
Betsy I.	STW	No date	–	Muttonbirds	Breeding	Unknown	Bragg <i>et al.</i> 2008
Kundy I. (North I.)	STW	1929	–	Unknown	Common	Ground observation	Stead 1932; Wilson 1959
		2000s	–	Muttonbirds	Common	Unknown	Kitson & Moller 2008
Mokoiti I.	STW	1999–2005	–	Muttonbirds	Breeding	Ground observation	Newman <i>et al.</i> 2009
Rat I.	STW	No date	–	Muttonbirds	Breeding	Unknown	Department of Conservation 2011a

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Putauhinu I.	STW	2005	520,000	Breeding pairs	–	Ground count	Bragg <i>et al.</i> 2009; Newman <i>et al.</i> 2009
Putauhinu I., Nuggets	STW	1999–2005	–	Muttonbirds	Breeding	Ground observation	Newman <i>et al.</i> 2009
Codfish I. (Whenuahou I.)	STW	1934	–	Individuals	Common	Ground observation	Wilson 1959
		1966	–	Burrows	Common	Ground observation	Blackburn 1968
		2001–06	173,000	Breeding pairs	–	Ground count (ACAP3)	Scott <i>et al.</i> 2009
		2001–06	170,000	Breeding pairs	–	Re-estimated	Newman <i>et al.</i> 2009
Codfish I. (Whenuahou), Sealer's Bay Nugget	STW	1991	100	Burrows	–	Ground observation	G. Taylor & A. Tennyson, <i>in</i> O'Donnell & West 1998
Codfish I. (Whenuahou), Trig I.	STW	2011	<10	Burrows	Fewer than 10	Ground observation	C. Miskelly, pers. comm. 2012
Chatham I.	CIS	1981–85	190	Burrows	Many burrows deserted, evidence of predation by cats	Ground observation	Imber 1994
Chatham Is, Houruakopara I.	CIS	1981	–	Individuals	Breeding	Ground observation	Imber 1994
Pitt I. (Rangiauria I.)	CIS	c. 1990	–	Burrows	Uncommon	Ground observation	Imber 1994
Pitt I. (Rangiauria I.), Kokope	CIS	c. 1990	–	Individuals	Breeding	Ground observation	Imber 1994
		1997	Up to 50	Breeding pairs	–	Ground observation	A. Tennyson, pers. obs.
Rangatira I. (South East I.)	CIS	1989	17,000	Burrows	–	Ground count	West & Nilsson 1994
Mangere I.	CIS	1987–88	5000	Breeding pairs	–	Ground count	Tennyson 1989
Little Mangere I. (Tapuaenuku)	CIS	1868	–	–	Extraordinarily numerous	Unknown	H. Travers <i>in</i> Tennyson & Millener 1994
		c. 1976	5000	Breeding pairs	–	Unknown	J. Flack <i>in</i> Newman <i>et al.</i> 2009
Murumurus, Western Nugget	CIS	1987	6	Breeding pairs	Six located	Ground observation	Tennyson <i>et al.</i> 1993
Rabbit I.	CIS	1980–81	100s	Breeding pairs	Many 100s of pairs	Ground observation	Imber & Lovegrove 1982
The Sisters (Rangitatahi Is), Big I.	CIS	c. 1990	–	Individuals	Breeding	Ground observation	Imber 1994
The Sisters (Rangitatahi Is), Middle I.	CIS	c. 1990	–	Individuals	Breeding	Ground observation	Imber 1994

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Table 4 Population data for sooty shearwater, *Puffinus griseus*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Star Keys (Motuhope)	CIS	1977	–	Individuals	Breeding	Ground observation	Imber 1978, 1994
The Snares Is (Tini Heke Is)	SNI	1969–71	3,287,000	Burrows	–	Ground count (ACAP5)	Warham & Wilson 1982
		1969–71	2,750,000	Breeding pairs	–	Ground count (ACAP5)	Warham & Wilson 1982
		1996–2001	2,061,000	Burrows	Burrow entrances	Ground count (ACAP5)	Scott <i>et al.</i> 2008
		1996–2001	1,100,000	Breeding pairs	–	Re-estimated	Newman <i>et al.</i> 2009
Western Chain, Tahī I	SNI	1990s	–	Adults	Breeding	Ground observation	Miskelly <i>et al.</i> 2001
Antipodes Is	ANT	1969	–	Adults	Uncommon	Ground observation	Warham & Bell 1979
		1978	–	Adults	Uncommon	Ground observation	Imber 1979
		1995	1000	Breeding pairs	–	Ground observation	Tennyson <i>et al.</i> 2002
Adams I.	AKI	1972	–	Adults	Breeding	Ground observation	K.-J. Wilson, pers. obs.
Enderby I.	AKI	1976	–	Burrows	Common	Ground observation	Bartle & Paulin 1986
		1988	–	Burrows	Locally common	Ground observation	G. Taylor pers. obs.
Ewing I.	AKI	1973	–	Adults	Breeding	Ground observation	K.-J. Wilson, pers. obs.
Ocean I.	AKI	1943	1	Egg	–	Unknown	Te Papa specimen NMNZ OR.191118
		1972	4	Adults	–	Ground observation	K.-J. Wilson, pers. obs.
Disappointment I.	AKI	1976	–	Burrows	Abundant	Ground observation	Bartle & Paulin 1986
		1988	–	Chicks	Common	Ground observation	G. Taylor, pers. obs.
Campbell I. (Motu Ihupuku)	CBL	1940s	–	Burrows	Common	Ground observation	Bailey & Sorensen 1962
		1984–87	1000–10,000	Burrows	–	Ground observation	G. Taylor, pers. obs.
		1997	–	Burrows	Common	Ground observation	S. Waugh, pers. obs.
Jacquemart I.	CBL	1980	–	Adult in burrow	Burrows common	Ground observation	Foggo & Meurk 1981
Dent I.	CBL	1975	–	Burrows	Breeding	Ground observation	Robertson 1980
		1984–87	–	Individuals	Abundant	Observed from a distance	G. Taylor, pers. obs.
		Unknown	5000	Breeding pairs	–	Unknown	J. Timms <i>in</i> Newman <i>et al.</i> 2009
Monowai I.	CBL	1985	<2000	Burrows	Fewer than 2000 breeding	Ground observation	G. Taylor, pers. obs.

Table 5 Population data for fluttering shearwater, *Puffinus gavia*. Sites are listed in roughly north–south order (TKI = Manawatawhi Is (Three Kings Is); NLW = Northland West; NLE = Northland East; AKE = Auckland East; CDL = Coromandel; BOP = Bay of Plenty; EHC = East Coast, Hawke’s Bay; WTT = West Coast North I. Waikato–Taranaki–Whanganui; WWL = Wellington–Wairarapa; MLS = Marlborough Sounds; NLS = Nelson; – = no data or comments; for sampling protocol, see ‘Methods and conventions’).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Manawatawhi Is (Three Kings Is)	TKI	Before 1934	–	Burrows	Breeding	Ground observation	Falla 1934
		1959	–	Burrows	Abundant	Ground observation	Wilson 1959
Manawatawhi Is (Three Kings Is), Great I./Ohau I.	TKI	1945–46	–	Chicks	Common	Ground observation	Turbott & Buddle 1948
		1970	–	Burrows	Abundant	Ground observation	Ramsay & Watt 1971
		1985	–	Breeding pairs	Widespread, low density	Ground observation	McCallum <i>et al.</i> 1985
Manawatawhi Is (Three Kings Is), West I.	TKI	1951	1	Egg	–	Ground observation	Johnson 1952
		1985	500+	Burrows and chicks	Largest colony in island group, more than 500	Ground observation	McCallum <i>et al.</i> 1985
Manawatawhi Is (Three Kings Is), North East I.	TKI	1947	–	Chicks	–	Ground observation	Turbott & Buddle 1948
		1985	20–50	Chicks	10s breeding		McCallum <i>et al.</i> 1985
Manawatawhi Is (Three Kings Is), Hinemoa I.	TKI	1985	1	Chick	Breeding	Ground observation	McCallum <i>et al.</i> 1985
Manawatawhi Is (Three Kings Is), South West I.	TKI	1947	–	Chicks	Many	Ground observation	Turbott & Buddle 1948
		1985	<1000	Breeding pairs	Fewer than 1000 breeding	Ground observation	McCallum <i>et al.</i> 1985

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### Fluttering shearwater

Ninety discrete islands or localities have been reported as current breeding sites, however less than half have quantitative data (Table 5). Ongoing monitoring is recommended at two sites, Maud I. (Te Hoiere) and Mana I., where the populations were established from translocations. Thirty-seven other current breeding sites had some numerical information, but only *c.* 24 of these have more than 10 pairs nesting, of which some would be suitable candidates for ongoing monitoring (see Table 5), and others less promising owing to their remoteness or fragility. Potential sites for monitoring identified here include: Terakautuhaka I. (Kowhai Islet), Simmonds Is; Tawhiti Rahi I., Poor Knights Is; Muriwhenua I., Chicken Is, Northland; Wooded I., Hauraki Gulf; Saddle I., off Great Barrier I.

(Aotea Is); Ruamahuanui I. and Ngahoro I., The Aldermen Is; Motuheka I., East Coast; Middle Trio I., Trio Is (Kuru Pongi); and Long I., Marlborough Sounds. The total population size is unknown but is clearly at least some tens of thousands. Robertson & Bell (1984) estimated 100,000 to 1,000,000 breeding pairs, but the lower end of this estimate seems more reasonable. Most breeding sites have never been surveyed but the species is known to be common on many islands, some of which may also be suitable candidates for long-term monitoring. There is no substantial information on population size trends, however historical accounts document extinctions, presumably due to predation, on Te Hauturu-o-Toi/Little Barrier I., Middle Chain I. and Moutohora I. (Whale I.) At Carr’s Road, Taranaki, the entire islet collapsed, destroying the colony.



Table 5 Population data for fluttering shearwater, *Puffinus gavia*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Motuopao I.	NLW	1988–92	–	Burrows	Breeding	Ground observation	Pierce & Parrish 1993
Simmonds Is, Terakautuhaka I. (Kowhai Islet)	NLE	1965	15	Burrows	–	Ground count	Wagener 1966
Simmonds Is, Motu Purihi I.	NLE	1990	1	Individual	1 ashore, 2 flying	Unknown	R. Parrish & B. Waddell <i>in</i> Taylor & Parrish 1991
Moturoa Is, Moturoa I.	NLE	1968	–	Burrows	Extremely abundant	Ground observation	Adams 1971
		1985	–	Adults and burrows	Large numbers	Ground observation	Miller 1986
Moturoa Is, Motutapu I. (Green I.)	NLE	1968	–	Burrows	Extremely abundant	Ground observation	Adams 1971
		1985	–	Adults and burrows	Large numbers	Ground observation	Miller 1986
Moturoa Is, Sugarloaf I.	NLE	1968	–	Burrows	Extremely abundant	Ground observation	Adams 1971
		1985	–	Adults and burrows	Large numbers	Ground observation	Miller 1986
Moturoa Is, Tuputupungahau I. (Whale I.)	NLE	1968	–	Burrows	Low numbers	Ground observation	Adams 1971
		1985	–	Adults and burrows	Large numbers	Ground observation	Miller 1986
Wekaruia I.	NLE	1991	100+	Breeding pairs	More than 100	Ground observation	R. Parrish & P. Miller <i>in</i> Taylor & Parrish 1992
Stephenson I. (Mahinepau I.)	NLE	No date	–	Unknown	Breeding	Unknown	Checklist Committee 1990
Cavalli Is, Motuharakeke I.	NLE	1951	–	Chicks	A considerable breeding colony	Ground observation	Sibson 1953
		1988	–	Burrows, empty	Numerous, probably this species as medium-sized burrows	Ground observation	G. Taylor, pers. obs.
Cavalli Is, Motutakapu I.	NLE	c. 1969	–	Unknown	Breeding	Unknown	G. Adams <i>in</i> Millener 1980
		1988	–	Burrows, empty	A few, probably this species as medium-sized burrows	Ground observation	G. Taylor, pers. obs.
Cavalli Is, Te Anaputa I.	NLE	c. 1969	–	Unknown	Breeding	Unknown	G. Adams <i>in</i> Millener 1980
		1988	–	Burrows, empty	Occasional, probably this species as medium-sized burrows	Ground observation	G. Taylor, pers. obs.

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Table 5 Population data for fluttering shearwater, *Puffinus gavia*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Cavalli Is, Motukawanui I.	NLE	c. 1975	–	Unknown	Breeding	Unknown	D. Crockett <i>in</i> Millener 1980
Poor Knights Is	NLE	Before 1934	–	Burrows	Breeding	Ground observation	Falla 1934
Poor Knights Is, Tawhiti Rahi I.	NLE	1980	1000s	Breeding pairs	Many 1000s	Ground observation	McCallum 1981
Poor Knights Is, Aorangi I.	NLE	1940	–	Individuals	Common	Ground observation	Wilson 1959
Bream Is (2 islets)	NLE	No date 1968	–	Unknown Adults and eggs	Breeding Numbers of burrows on both islands	Unknown Ground observation	Falla 1934 Cheyne 1968
Marotere Is (Chicken Is), Whatapuke I.	NLE	1982	1	Burrow	–	Ground observation 1984	McCallum <i>et al.</i>
Marotere Is (Chicken Is), Middle Rock	NLE	1939	4	Burrows	Occupied burrows	Ground observation	Skegg 1964
		1982	25	Burrows	Chicks present	Ground observation	McCallum <i>et al.</i> 1984
		1994	–	–	Chicks present	Ground observation	G. Taylor, pers. obs.
Marotere Is (Chicken Is), Pupuha I.	NLE	1992	4	Adults and burrows	Uncommon	Ground observation	M. Imber <i>in</i> Taylor & Parrish 1994b
Marotere Is (Chicken Is), Muriwhenua I.	NLE	1982	1000s	Breeding pairs	Several 1000	Ground observation	McCallum <i>et al.</i> 1984
		1992	1000s	Breeding pairs	A few 1000 burrows	Ground observation	A. Tennyson, R. Pierce & R. Parrish <i>in</i> Taylor & Parrish 1994b; A. Tennyson, pers. obs.
Marotere Is (Chicken Is), West Chicken I. (Mautaha I.)	NLE	1994	2	Burrows	–	Ground count	Tennyson & Pierce 1995
Marotere Is (Chicken Is), Lady Alice I. (Maumua I.)	NLE	1880	–	Breeding pairs	–	Ground observation	A. Reischek <i>in</i> Skegg 1964
		1962	10+	Individuals	–	Ground observation	Skegg 1964
		1992	1	Incubating adult	Rare	Ground observation	M. Imber <i>in</i> Taylor & Parrish 1994b
Marotere Is (Chicken Is), Coppermine I.	NLE	1965	1	Individual	Moderate numbers heard, 1 seen	Ground observation	Merton & Atkinson 1968
Taranga I. (Hen I.)	NLE	Before 1934	–	Burrows	Breeding	Ground observation	Falla 1934
		1960–64	–	Individuals	Large numbers	Ground observation	Skegg 1964
		1991	–	Adults and burrows	Small numbers	Ground observation	G. Taylor, pers. obs.

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Table 5 Population data for fluttering shearwater, *Puffinus gavia*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Mokohinau Is	NLE	Before 1889	–	Burrows	'Breeds on one island' only, and not in great numbers	Ground observation	Sandager 1889
Mokohinau Is, Burgess I. (Pokohinau I.)	NLE	2011–12	10+	Breeding pairs	Uncommon, at least 10 pairs	Ground observation	G. Taylor, pers. obs.
Mokohinau Is, Lizard I.	NLE	1944	2	Burrows	Breeding	Ground observation	C. Fleming <i>in</i> Marples & Falla 1946
Mokohinau Is, Trig I.	NLE	c. 1973	–	–	Low numbers breeding	Unknown	D. Veitch <i>in</i> McCallum 1980
Mokohinau Is, Maori Bay I.	NLE	c. 1973	–	–	Low numbers breeding	Unknown	D. Veitch <i>in</i> McCallum 1980
Mokohinau Is, Stack H	NLE	c. 1973	–	–	Low numbers breeding	Unknown	D. Veitch <i>in</i> McCallum 1980
Te Hauturu-o-Toi/ Little Barrier I.	AKE	1882	–	Chicks	–	Unknown	Wragg 1985; Reichek Collection Vienna Museum, A. Tennyson, pers. obs.
		Before 1934	–	Burrows	Breeding	Ground observation	Falla 1934
		1988–90	0	–	–	Ground observation	A. Tennyson, pers. obs.
Te Hauturu-o-Toi/ Little Barrier I., Lots Wife I.	AKE	1989	1	Breeding pair	Incubating adult	Ground observation	A. Tennyson & T. Lovegrove <i>in</i> Taylor & Parrish 1991
Great Barrier I. (Aotea I.), stack southwest of Opakau I.	AKE	1990	–	Burrows	Abundant	Ground observation	T. Lovegrove, G. Taylor & A. Tennyson <i>in</i> Taylor & Parrish 1991
		1994	–	Chicks	Breeding	Ground observation	A. Tennyson & K. McConkey, pers. obs.
Great Barrier I. (Aotea I.), Saddle I.	AKE	Before 1934	–	Unknown	Breeding	Unknown	Falla 1934
		1960	–	Burrows	Breeding	Ground observation	Bell & Braithwaite 1964
		1990	3	Individuals	Many disused burrows, ship rats on site	Ground observation	T. Lovegrove, G. Taylor & A. Tennyson, <i>in</i> Taylor & Parrish 1991
		1994	100s	Individuals	Rats present	Ground observation	A. Tennyson & K. McConkey, pers. obs.
Great Barrier I. (Aotea I.), Close I.	AKE	1980–81	1	Chick	Other burrows probably this species also	Ground observation	Bellingham <i>et al.</i> 1982

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Table 5 Population data for fluttering shearwater, *Puffinus gavia*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Wooded I.	AKE	1989	200	Breeding pairs	–	Ground count	Taylor & Tennyson 1999
The Noises, Maria I.	AKE	1989	1	Individual	1 caught, other heard	Ground observation	G. Taylor & R. Pierce <i>in</i> Taylor & Parrish 1991
Horuhoru Rock/ Gannet Rock	AKE	1988	10	Breeding pairs	<i>c.</i> 10 breeding pairs	Ground count	A. Tennyson & G. Taylor, pers. obs.
Channel I.	CDL	Before 1934	–	Unknown	Breeding	Ground observation	Falla 1934
Cuvier I. (Repanga I.)	CDL	2005	–	Individuals	Small colony	Ground observation	G. Taylor, pers. obs.
Cuvier I., Scotts Monument	CDL	2005–08	10	Individuals	Small colony	Observed from a distance	G. Taylor, pers. obs.
Mercury Is, Green I.	CDL	1966	–	Burrows	Uncommon	Ground observation	Thoresen 1967
Mercury Is, Korapuki I.	CDL	1961 1974	– –	Burrows, empty Burrows	Breeding Common	Ground observation Ground observation	Edgar 1962 Hicks <i>et al.</i> 1976
Mercury Is, Kawhitihu I. (Stanley I.)	CDL	1966	–	Burrows	Uncommon	Ground observation	Thoresen 1967
Mercury Is, Kawhitihu I. (Stanley I.), stack to the north	CDL	1988	–	Eggs and chicks	Common	Ground observation	A. Tennyson, G. Taylor & P. Scofield, pers. obs.
Mercury Is, Double I. (Moturehu I.)	CDL	1988	10–100	Burrows	–	Ground observation	A. Tennyson & G. Taylor, pers. obs.
Mercury Is, Red Mercury I. (Whakau I.)	CDL	1961 1971 1990 2001–03	>24 – 10–100 <20	Individuals Individuals Burrows Individuals	More than 24 Uncommon – Fewer than 20	Ground observation Ground observation Ground observation Ground observation	Edgar 1962 Fogarty & Douglas 1972 G. Taylor, pers. obs. G. Taylor, pers. obs.
Ohinauiti I.	CDL	1970	–	Individuals	Uncommon	Ground observation	Blackburn 1970
Centre I. (Motukorure)	CDL	1989	100+	Burrows	100 or more	Ground observation	A. Tennyson, G. Taylor & P. Scofield, pers. obs.
Moturoa (Tower I.)	CDL	1989	1	Burrow	–	Ground observation	A. Tennyson & P. Scofield, pers. obs.

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Table 5 Population data for fluttering shearwater, *Puffinus gavia*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Needle Rock	CDL	1989	–	Burrows	Many, probably breeding, medium-sized burrows	Ground observation	Taylor 1989
The Aldermen Is, Ruamahuanui I.	CDL	1994	3000–5000	Breeding pairs	Eggs and chick	Ground observation	G. Taylor & A. Tennyson, pers. obs.
The Aldermen Is, Ruamahuaitei I.	CDL	1920s	–	Burrows	–	Ground observation	Sladden & Falla 1927, 1928
		c. 1973	8+	Individuals	–	Ground observation	Fogarty & Douglas 1973
The Aldermen Is, Middle Chain I.	CDL	1920s	–	Burrows	–	Ground observation	Sladden & Falla 1927, 1928
		1994	0	–	–	Ground observation	G. Taylor & A. Tennyson, pers. obs.
The Aldermen Is, stack north of Middle Chain I.	CDL	1994	100–200	Burrows	About 100–200 burrows	Ground observation	G. Taylor & A. Tennyson, pers. obs.
The Aldermen Is, Ngahoro I.	CDL	1994	100–200	Breeding pairs	Egg and chick	Ground observation	G. Taylor & A. Tennyson, pers. obs.
Slipper I.	CDL	Before 1934	–	Unknown	Breeding	Unknown	Falla 1934
Penguin I.	CDL	1973	–	Burrows	Breeding	Ground observation	Douglas & Grubb 1974
Karewa I.	BOP	Late 19th century	–	Unknown	Breeding ground	Unknown	Buller 1887–1888
Motunau I. (Plate I.)	BOP	Before 1934	–	Burrows	Breeding	Ground observation	Falla 1934
		1988	–	Adults and empty burrows	Locally common	Ground observation	Taylor 1991
Moutohora I. (Whale I.)	BOP	Late 19th century	–	Unknown	Breeding ground	Ground observation	Buller 1887–1888
		No date	–	Burrows	Breeding	Ground observation	Falla 1934
		1968–70	–	Unknown	Absent	Ground observation	Imber 1975
Motoki I.	BOP	Late 19th century	–	–	Nesting ground	Unknown	Buller 1887–1888
Taumaihi I.	BOP	1992	–	Burrows	Breeding	Unknown	K. Owen <i>in</i> Taylor & Parrish 1994a
Rurima I.	BOP	No date	–	Unknown	Breeding	Unknown	Wragg 1985; Checklist Committee 1990

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Table 5 Population data for fluttering shearwater, *Puffinus gavia*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Motuhina I. or Moturipa I.	EHC	1959	–	Burrows	Large numbers	Ground observation	Bell & Blackburn 1960
		1983	500+	Breeding pairs	More than 500	Unknown	Wragg 1985
Motuheka I.	EHC	1959	100	Burrows	1 chick found	Ground observation	Bell & Blackburn 1960
Motuahiauru I.	EHC	1959	–	Individuals	Considerable numbers	Ground observation	Bell & Blackburn 1960
East I. (Whangaokeno I.)	EHC	1979	–	Chicks	Breeding	Ground observation	Moors 1980
		2001	500–1000	Breeding pairs	–	Ground observation	Taylor 2008; G. Taylor, pers. obs.
Stack off Carr's Road, Urenui	WTT	1988–89	>20	Burrows	More than 20, prospecting	Observed from a distance	OSNZ <i>in</i> Taylor 1990
		1990	>5	Burrows	–	Observed from a distance	D. Medway <i>in</i> Taylor & Parrish 1992
		1992	1	Burrow	–	Observed from a distance	D. Medway <i>in</i> Taylor & Parrish 1994b
		1991–95	0	–	Stack collapsed, colony gone	Ground observation	B. Williams & G. Taylor, pers. obs.
Mana I.	WWL	2012	18	Breeding pairs	Translocation	Ground count	Department of Conservation 2010; Friends of Mana I., H. Gummer pers. comm. 2013
Stephens I. (Takapourewa)	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985; Checklist Committee 1990
Rahuinui I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Nelson's Monument	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Anatakupu I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Stewart I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Trio Is (Kuru Pongi), Middle Trio I.	MLS	1964	625	Burrows	–	Ground observation	Campbell 1967
Chetwode Is, Te Kakaho I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985

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Table 5 Population data for fluttering shearwater, *Puffinus gavia*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Chetwode Is, Nukuwaiata I.	MLS	1936	–	Unknown	Breeding	Ground observation	Wilson 1959
		1976	–	Burrows	Uncommon	Ground observation	Meads 1977
Chetwode Is, 'The Haystack'	MLS	1958	–	Eggs	–	Ground observation	P. Harper <i>in</i> Wragg 1985
Duffers Reef	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Bird I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Maud I. (Te Hoiere)	MLS	1996	2	Breeding pairs	Translocation	Ground count	Bell <i>et al.</i> 2005
		2004	15	Breeding pairs	Translocation	Ground count	Bell <i>et al.</i> 2005
Titi I.	MLS	1987–88	–	Individuals	Breeding	Ground observation	Glaze 1985
Motuara I.	MLS	No date	–	Burrows	–	Unknown	B. Bell <i>in</i> Wragg 1985
		1993	100s	Breeding pairs	100s of pairs	Ground observation	A. Tennyson, pers. obs.
Kokomohua I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Long I.	MLS	1983	5000	Pairs	Extensive colony	Ground observation	Wragg 1985
		1995	1000s	Burrows	–	Ground observation	A. Tennyson, pers. obs.
		1990s–2000s	–	Fledglings	Common	Ground observation	Bell <i>et al.</i> 2005
The Twins	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Motungarara I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Amerikiwhati I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
South Brother I.	MLS	No date	–	Unknown	Breeding	Unknown	B. Bell <i>in</i> Wragg 1985
Glasgow I.	MLS	No date	–	Burrows	–	Unknown	Wragg 1985
		1990	–	Unknown	Small colony	Unknown	D. Brown <i>in</i> O'Donnell & West 1991
Archway I.	NLS	2000s	–	Individuals	Breeding	Observed from a distance	Department of Conservation 2011b

Table 6 Population data for Hutton's shearwater, *Puffinus huttoni* (MLK = Marlborough–Kaikoura; – = no data or comments; for sampling protocol, see 'Methods and conventions').

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Wharikiri Stream (Shearwater Stream)	MLK	1967–70	–	Breeding pairs	Common	Ground observation	Harrow 1976
		2006–08	8000	Breeding pairs	–	Ground count	Sommer <i>et al.</i> 2009
Upper Kowhai River	MLK	1964	675	Burrows	–	Ground count	Harrow 1965
		1960s	75,000	Burrows	–	Ground observation	Harrow 1976
		1986–89	133,400	Burrows	–	Ground count	Sherley 1992
		1989	94,000	Breeding pairs	–	Ground count	Taylor 2000a
		2006–08	106,000	Breeding pairs	–	Ground count	Sommer <i>et al.</i> 2009
Snowflake Stream	MLK	1960s	–	Burrows	Uncommon	Ground observation	Harrow 1976

### Hutton's shearwater

Two active colonies for this species at Wharikiri Stream (Shearwater Stream) and at the Upper Kowhai River remain in the Kaikoura Ranges of the South Island, and have had their population sizes assessed (Table 6). We have not listed historical breeding sites such as at Mt Tapuaenuku (Harrow 1976; Wragg 1985) because they are now extinct, presumably due to predation, and no counts were made (Sherley 1992), and we found only a single count from Snowflake Stream. At Wharikiri Stream (Shearwater Stream), only one published estimate of breeding pairs is recorded, with 8000 pairs in 2008 (Sommer *et al.* 2009). However, there are two population estimates for the Upper Kowhai River colony, with 133,400 burrows in the 1986–89 period (Sherley 1992) and 94,000 pairs in 1989 (Taylor 2000a), and 106,000 pairs in 2008 (Sommer *et al.* 2009), all having a high level of accuracy. Ongoing monitoring of the populations at Wharikiri Stream (Shearwater Stream) and the Upper Kowhai River would be beneficial. Monitoring of the population growth at the newly established (using translocations) shearwater colony on Kaikoura Peninsula will add further useful information (Ombler 2010). The most recent figures indicate a total population of around 114,000 breeding pairs, and Cuthbert found the overall population size to be stable

from 1989 to 1999 (Taylor 2000a). However, Sommer *et al.* (2009) and Cuthbert & Sommer (2009) concluded that the population increased from 1989 to 2008 at a rate of 1.7 % per year. It appears that Robertson & Bell's (1984) estimate of 10,000–50,000 breeding pairs was an underestimate.

### Kermadec little shearwater

For this subspecies, 10 breeding islands are recorded and there are population estimates for four significant colonies, but none is of high quality. The main breeding site is Curtis I., with about 100,000 breeding pairs. An estimate of 100+ pairs was recorded at the Herald Islets, 500 pairs were estimated to nest on Macauley I. and up to 1000 pairs were estimated at Cheeseman I. (Table 7). The large population on Curtis I. requires monitoring. Monitoring at North Meyer I. may be an option, although a sea-based index count method could be considered, given that this site is fragile and relatively inaccessible. Raoul I. and Macauley I. should be monitored to assess potential population recoveries after the recent eradications of mammals from both. The total population may be about 100,000 breeding pairs or slightly larger, and is clearly much greater than the 1000–5000 breeding pairs estimated by Robertson & Bell (1984). There is no information on population trends.



Table 7 Population data for Kermadec little shearwater, *Puffinus assimilis kermadecensis* (KMI = Kermadec Islands; – = no data or comments; for sampling protocol, see ‘Methods and conventions’).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Napier I.	KMI	1966–67	–	Breeding pairs	Small number	Ground observation	Merton 1970
Meyer Is, North Meyer I. and South Meyer I.	KMI	1907–08	–	Burrows	Breeding	Ground observation	Iredale 1910
		1929	–	Adults and burrows	Breeding	Ground observation	Guthrie-Smith 1936
		1944	–	Burrows	Breeding	Ground observation	Sorensen 1964
Meyer Is, North Meyer I.	KMI	1966	–	Chicks	Several	Ground observation	Merton 1970
		1977	2	Burrows	–	Ground count	Morrison 1979
Meyer Is, South Meyer I.	KMI	1966–67	–	Burrows	Several	Ground observation	Merton 1970
Herald Islets	KMI	1966	100+	Breeding pairs	100 or more	Ground observation	Veitch <i>et al.</i> 2004
Herald Islets, Dayrell I.	KMI	1966	–	Breeding pairs	Small number	Ground observation	Merton 1970
Herald Islets, northern Chanter I.	KMI	1967	–	Breeding pairs	Small number	Ground observation	Merton 1970
Herald Islets, southern Chanter I.	KMI	1967	–	Breeding pairs	Small number	Ground observation	Merton 1970
Macaulay I.	KMI	1988	500	Breeding pairs	–	Ground observation	Veitch <i>et al.</i> 2004
Haszard I.	KMI	1988	–	–	Breeding	Ground observation	Gaskin 2011
Cheeseman I.	KMI	1989	<1000	Breeding pairs	–	Ground observation	Gaskin 2011
Curtis I.	KMI	1989	100,000	Breeding pairs	–	Ground count	Veitch <i>et al.</i> 2004

### North Island little shearwater

Population estimates for the North Island little shearwater are patchy (Table 8). Although the subspecies currently nests at 30 sites, numerical data exist for only 13 sites. Among them, seven have more than 10 pairs reported. Hundreds of breeding pairs occur on Tawhiti Rahi I. (Poor Knights Is) and Taranga I. (Hen I.). At two islands in the Mercury group, the records are: Red Mercury I. (Whakau I.), c. 1000 pairs in 1990; and Kawhitihu I. (Stanley I.), hundreds of pairs in the 1990s. At The Aldermen Is in 1994, 1000–3000 pairs were estimated at Hongiora I. and 1000–2000 pairs were estimated at Ruamahuanui I. At Burgess I (Pokohinu I.). (Mokohinau Is) at least 50 pairs nest. Tawhiti Rahi I. and Hongiora I. may be too fragile to monitor routinely.

Therefore, Taranga I. (Hen I.), Ruamahuanui I., Red Mercury I. (Whakau I.), Kawhitihu I. (Stanley I.) and Burgess I. (Pokohinu I.) appear to provide the best monitoring potential for this subspecies, owing to the relatively large size of the populations and availability of basic numerical information. The subspecies is uncommon at most breeding sites, so the majority of these contribute little to the overall population size, which appears to number only in the low thousands of pairs, primarily at The Aldermen Is. Robertson & Bell (1984) estimated 5000–10,000 breeding pairs, and our calculations support this estimate. There is no information on population trends but the colony on Te Hauturu-o-Toi/Little Barrier I. is known to have become extinct in historic times, presumably due to predation.

Table 8 Population data for North Island little shearwater, *Puffinus assimilis haurakiensis*. Sites are listed in roughly north–south order (TKI = Manawatawhi Is (Three Kings Is); NLE = Northland East; AKE = Auckland East; CDL = Coromandel; – = no data or comments; for sampling protocol, see ‘Methods and conventions’).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Manawatawhi Is (Three Kings Is), Great I./Ohau I.	TKI	1945	–	Burrows	Empty burrows	Ground observation	Turbott & Buddle 1948
		1995	2	Chicks	–	Unknown	R. Parrish <i>in</i> Parrish & Lock 1997
Manawatawhi Is (Three Kings Is), North East I.	TKI	1999	–	Individuals	A few ashore	Unknown	R. Parrish <i>in</i> Parrish 2000
Moturoa Is, Moturoa I.	NLE	1968	–	Burrows	Scarce	Ground observation	Adams 1971
Moturoa Is, Motutapu I. (Green I.)	NLE	1968	–	Burrows	Scarce	Ground observation	Adams 1971
Moturoa Is, Sugarloaf I.	NLE	1968	–	Burrows	Scarce	Ground observation	Adams 1971
Moturoa Is, Tuputupungahau I. (Whale I.)	NLE	1968	–	Burrows	Scarce	Ground observation	Adams 1971
		1985	1	Individual		Ground observation	Miller 1986
Stephenson I. (Mahinepua I.)	NLE	1959		Burrows	Incubating adults	Ground observation	Bell 1960
Cavalli Is, Motuharakeke I.	NLE	c. 1969	–	Unknown	A few breeding	Unknown	G. Adams <i>in</i> Millener 1980
		1988	2	Individuals	Small colony	Ground observation	G. Taylor, pers. obs.
Poor Knights Is, Tawhiti Rahi I.	NLE	1980	100s	Breeding pairs	Several 100	Ground observation	McCallum 1981
Poor Knights Is, Aorangi I.	NLE	1958	–	Individuals	Heard, not seen	Ground observation	Kinsky & Sibson 1959
		1981	–	Chicks	Breeding	Ground observation	Harper 1983
		2011	–	Chicks	Uncommon	Ground observation	G. Taylor & A. Tennyson, pers. obs.
Mokohinau Is	NLE	Late 19th century	–	Burrows	Not very numerous but breeding on ‘all’ the islands	Ground observation	Sandager 1889
Mokohinau Is, Burgess I. (Pokohinau I.)	NLE	2012	50+	Burrows	50 or more breeding	Ground observation	G. Taylor, pers. obs.

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Table 8 Population data for North Island little shearwater, *Puffinus assimilis haurakiensis*. Continued from previous page

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Mokohinau Is, Motuharakeke I. (Flax I.)	NLE	No date	–	Breeding pairs	Breeding	Ground observation	Taylor 2000b
Mokohinau Is, Stack D	NLE	c. 1973	–	Unknown	Breeding	Unknown	D. Veitch <i>in</i> McCallum 1980
Mokohinau Is, Stack H	NLE	1979	–	Unknown	Breeding, but rare	Ground observation	McCallum 1980
Mokohinau Is, Lizard Isle	NLE	1979	–	Unknown	Breeding, but rare	Ground observation	McCallum 1980
		1990	–	Individuals	Breeding	Ground observation	Taylor 2000b
		2011	–	Burrows	Uncommon	Ground observation	G. Taylor, pers. obs.
Taranga I. (Hen I.)	NLE	Before 1934	–	Burrows	Breeding	Ground observation	Falla 1934; Skegg 1964
		1930s–1950s	–	–	Small number breeding	Ground observation	Skegg 1964
		1960–64	100s	Burrows	Hundreds breeding	Ground observation	Skegg 1964
Marotere Is (Chicken Is), West Chicken I. (Mauitaha)	NLE	1994	<10	Burrows	–	Ground count	Tennyson & Pierce 1995; A. Tennyson, pers. obs.
Marotere Is (Chicken Is), Lady Alice I. (Mauimua)	NLE	1880	–	–	Ashore	Ground observation	A. Reischek <i>in</i> Skegg 1964
		1962	1	Individual	Ashore	Ground observation	Skegg 1964
		1992	–	Chicks	Common	Ground observation	R. Pierce, G. Taylor, M. Imber & R. Parrish <i>in</i> Taylor & Parrish 1994b
Marotere Is (Chicken Is), Coppermine I.	NLE	1965	2	Individuals	Moderate numbers heard, 2 seen	Ground observation	Merton & Atkinson 1968
Te Hauturu-o-Toi/ Little Barrier I.	AKE	1883	–	Chicks	–	Unknown	Buller 1887–1888; Reischek Collection Vienna Museum, A. Tennyson, pers. obs.
		1980s	0	–	–	Ground observation	A. Tennyson, pers. obs.
Mercury Is, Atiu I. (Middle I.)	CDL	1987	–	Breeding pairs	–	Ground observation	Taylor 2000a
		2003	–	Chicks	–	Ground observation	G. Taylor, pers. obs.
Mercury Is, Green I.	CDL	1966	–	Individuals	Uncommon	Ground observation	Thoresen 1967

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Table 8 Population data for North Island little shearwater, *Puffinus assimilis haurakiensis*. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Mercury Is, Korapuki I.	CDL	1961	1	Breeding pair	–	Ground observation	Edgar 1962
		1974	–	Burrows	Uncommon	Ground observation	Hicks <i>et al.</i> 1976
		2003	<10	Burrows and chicks	Fewer than 10 pairs	Ground observation	G. Taylor, pers. obs.
Mercury Is, Kawhitihu I. (Stanley I.)	CDL	1966	–	Individuals	Uncommon	Ground observation	Thoresen 1967
		1980s	100s	Burrows	–	Ground observation	G. Taylor & A. Tennyson, pers. obs.
		1993	100–500	Burrows and chicks	–	Ground observation	G. Taylor, pers. obs.
		2003	–	Burrows and chicks	Common	Ground observation	G. Taylor, pers. obs.
Mercury Is, Double I. (Moturehu I.)	CDL	1980s	–	Burrows	–	Ground observation	G. Taylor & A. Tennyson, pers. obs.
Mercury Is, Red Mercury I. (Whakau I.)	CDL	1961	42	Individuals	Breeding, 42 banded	Ground observation	Edgar 1962
		1963	–	Burrows	Breeding	Ground observation	Skegg 1963 <i>in</i> Fogarty & Douglas 1972
		1971	–	Individuals	Uncommon	Ground observation	Fogarty & Douglas 1972
		1974	20–30	Breeding pairs	–	Ground count	Hicks <i>et al.</i> 1976
		1990	1000	Breeding pairs	c. 1000 breeding pairs	Ground observation	Taylor 2000a; Taylor & Parrish 1992; G. Taylor, pers. obs.
Ohinauiti I.	CDL	1970	–	Individuals	Common	Ground observation	Blackburn 1970
The Aldermen Is, Hongiora I.	CDL	1994	1000–3000	Breeding pairs	Chicks	Ground observation	G. Taylor & A. Tennyson <i>in</i> Taylor 2000b
The Aldermen Is, Ruamahuanui I.	CDL	1994	1000–2000	Breeding pairs	–	Ground observation	G. Taylor & A. Tennyson, pers. obs.
The Aldermen Is, Ruamahuaitei I.	CDL	c. 1973	–	Probably breeding	–	Ground observation	Fogarty & Douglas 1973
Penguin I.	CDL	No date	–	Unknown	Breeding	Unknown	Taylor 2000a
Rabbit I.	CDL	No date	–	Unknown	Breeding	Unknown	Taylor 2000a

Table 9 Population data for subantarctic little shearwater, *Puffinus elegans* (CIS = Chatham Is; ANT = Antipodes Is; – = no data or comments; for sampling protocol, see 'Methods and conventions').

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Star Keys (Motuhope)	CIS	1975	100	Burrows	–	Ground count	Imber 1978, 1994
Antipodes Is	ANT	1969	–	Adults	Present	Ground observation	Warham & Bell 1979
Antipodes Is, Bollons I., Archway I., Inner Windward I.	ANT	1978	10,000–100,000	Breeding pairs	–	Ground observation	Tennyson <i>et al.</i> 2002
		1995	10,000–100,000	Breeding pairs	–	Ground observation	Tennyson <i>et al.</i> 2002
Antipodes Is, Archway I.	ANT	1978	–	Breeding pairs	Common	Ground observation	Imber 1979
Antipodes Is, Windward Is, Inner Windward I.	ANT	1978	–	Burrows	Common	Ground observation	Imber 1983

### Subantarctic little shearwater

This species has been recorded breeding at five sites but none of the population estimates has a high level of accuracy (Table 9). Imber's (1978) estimate of 100,000s of pairs at the Antipodes Is was an error, and was corrected by Tennyson *et al.* (2002) to 10,000–100,000 pairs – which was also the population estimate made in 1995. No individual island population estimates are available for the Antipodes Is group, although most of the birds nest on Bollons I. (A. Tennyson, pers. obs.). Breeding is suspected but has never been proven on Little Mangere I. (Tapuaenuku I.) in the Chatham Is (Imber 1994), and only one other breeding site is known in the New Zealand region: the Star Keys (Motuhope) in the Chatham Is (with 100 burrows in 1975). The Star Keys population should be monitored as it is relatively accessible. A long-term commitment to follow density plots on Bollons I. (as the most accessible breeding site in the Antipodes Is group) should be a high priority for this species. Clearly, almost the entire New Zealand breeding population occurs at the Antipodes Is, so the total population for the region is 10,000–100,000 pairs, in line with Robertson & Bell's (1984) estimate of 50,000–100,000 breeding pairs. There is no population trend information.

### Species population status summary

A summary of quantitative data on populations across the nine taxa of shearwaters breeding in New Zealand is given in Table 10. This shows that the overall quality of data is poor for all but two taxa, flesh-footed shearwater and Hutton's shearwater, and we have only an idea of population trends for these two species and the sooty shearwater. Current research will provide better information for flesh-footed and Buller's shearwaters. Overall population sizes are poorly estimated, and remain 'ball-park' figures for the majority of species.

#### Dates of counts

We examined the age of the data we collated and graphed these by decade of observation for all species (Fig. 1). This showed that since the 1960s some effort has been made to estimate the size of shearwater colonies; that the median age of data, both numerical and qualitative, was 1985; and that most data were collected before 2000.

Table 10 Summary of population size, trend and data quality for nine taxa of shearwaters breeding in New Zealand in 2012.

Species	Total population size (breeding pairs)	Current trend	Quality of overall data
Wedge-tailed shearwater	50,000	Unknown	Poor
Buller's shearwater	300,000–400,000	Unknown	Poor
Flesh-footed shearwater	10,000–15,000	Decreasing	Good
Sooty shearwater	5,000,000	?Decreasing	Medium
Fluttering shearwater	100,000	Unknown	Poor
Hutton's shearwater	114,000	?Increasing	Good
Kermadec little shearwater	100,000	Unknown	Poor
North Island little shearwater	5000–10,000	Unknown	Poor
Subantarctic little shearwater	10,000–100,000	Unknown	Poor

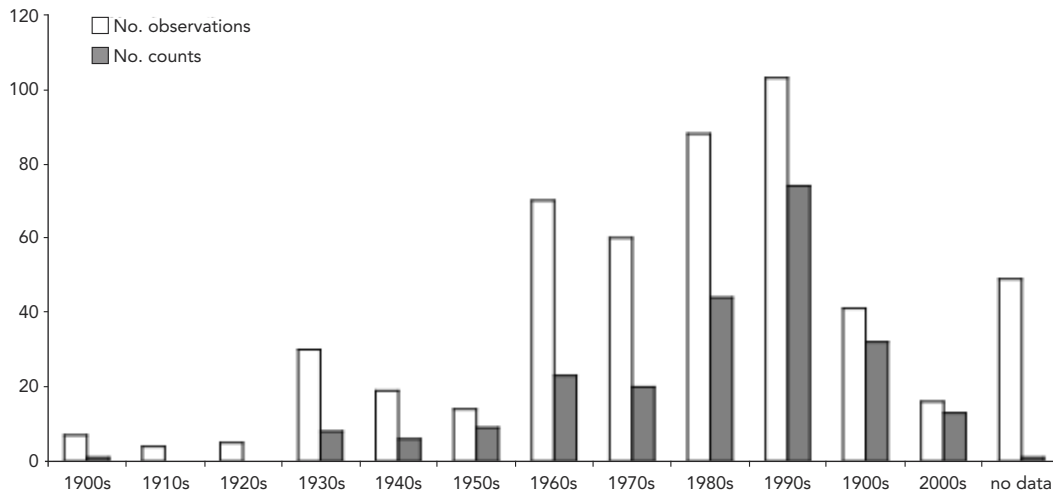


Fig 1 Dates of population information recorded for shearwater species at New Zealand breeding sites. Records with count data ( $n = 230$ ) are presented as grey columns; data for all records ( $n = 456$ ) are presented as white columns. Counts for the 2010s are incomplete because they include data taken only up to 2012.

## Discussion

### Information on species distributions and abundance

The data relating to the nine taxa of *Puffinus* shearwaters breeding in New Zealand provide a reasonable summary of breeding distributions and probably identify most key breeding sites for each species, but they give only a rough indication of the population sizes of most taxa. Most species are poorly studied and most data are more than 20 years old. Only for flesh-footed and Hutton's shearwaters is the information about most primary breeding sites less than 10 years old and quantitative. Total numbers of the other species are little better than educated guesses and there is almost no useful information on their overall population trends. The populations of one of the subtropical shearwaters – the wedge-tailed shearwater – are moderately well known, to the extent that there are population estimates for nearly all breeding sites, which allowed us to estimate the relative proportions of breeding birds at each colony. However, these counts date mainly from the late 1980s, so are nearly 25 years old in most cases. Population sizes of Kermadec little shearwater colonies are poorly documented. The current status of both of these species and their trends are poorly known, and repeat surveys at key sites are a high priority.

Data for Buller's shearwater, which is known to nest at only one island group, are very poor, with conflicting estimates of population size and with much data more than 30 years old. The large populations at Aorangi I. and Tawhiti Rahi I. urgently require quantitative surveys.

Regarding the other temperate breeding species, fluttering shearwater and North Island little shearwater, data are very poor, with 'ball-park' figures only for some of the key breeding populations. There are no reliable population estimates at the main breeding sites, hence it is impossible to detect trends in these populations. Data for flesh-footed shearwaters are improving rapidly at present, with research programmes underway to enumerate the main populations in Northland, Coromandel and Marlborough (Baker *et al.* 2010; Waugh & Taylor 2012).

For the cool-temperate breeding subantarctic little shearwater, there are no quantitative estimates of numbers at their main breeding sites.

The widely distributed sooty shearwater has been the subject of detailed studies at some key localities, with quantitative surveys conducted across several regions. This species is likely to have greater biomass than any other top predator

in the New Zealand marine ecosystem and to be a key agent of nutrient transfer in marine systems. For this reason alone there is a need for more detailed study of population size and trends. The two estimates for The Snares Is (Tine Heke Is) show a significant decline, provisionally attributed to pelagic net fisheries in the North Pacific (Scofield & Christie 2002; Scott *et al.* 2008). Veit *et al.* (1996) noted that sooty shearwater numbers in the California Current had fallen by 90% in 20 years. Aside from The Snares Is (Tini Heke Is) and Poutama I., where quantitative research has been done, little is known of the status and trends of large populations in the Southland area (many on beneficiary-owned muttonbirding islands), so the relative importance of different sites to the total New Zealand population is not well understood. The species is significant for southern Māori as a cultural, food and economic resource, warranting greater detailed study to help manage threats to the populations. Given the long periods between estimates, and the difficulty of estimating population sizes for such a numerous and widely distributed species, further efforts are required to quantify changes for this species at key sites. Consistent efforts are required to focus quantitative surveys at sites at which there have been at least one, or preferably several, higher-quality counts.

### Status of populations

Based on the data reviewed here, it is not possible to provide broad assessments of the status of shearwater populations in New Zealand. For most species, neither total population sizes nor trends are possible to determine with any degree of accuracy. The number of sites with two or more counts is low for all species. For sooty shearwater, some data may allow a reasonable time-series to be obtained. We consider that further counts at key sites indicated in the Results section are warranted in order to draw conclusions about population changes. It is important to note that a number of recent counts are of small colonies, which have been shown to be more vulnerable to fluctuations than larger colonies (Hamilton *et al.* 1997; Jones 2000).

One New Zealand breeding shearwater (Scarlett's shearwater, *Puffinus spelaeus* Holdaway & Worthy, 1994) that once nested at sites in the northwest of the South I. became extinct in prehistoric times, but information on the prehistoric distribution of other shearwater taxa is very poorly known (Holdaway *et al.* 2001; Worthy & Holdaway 2002). Fossil remains of shearwaters are found commonly in Holocene coastal deposits but it is usually not known if

these represent nearby breeding populations or if they were just strays cast ashore. It is assumed that many New Zealand shearwater populations became extinct following the introduction of mammalian predators, but there is not a great deal of direct evidence for this other than the absence of shearwaters from sites with predators where the birds might otherwise have been expected to occur (Worthy & Holdaway 2002). In a few instances, fossils reveal that species used to breed more widely, e.g. sooty shearwater fossils from a cave at Napenape, North Canterbury (Worthy & Holdaway 1996); fluttering shearwater remains from presumed breeding sites on both the mainland of the North I. and South I. (Holdaway *et al.* 2001; Worthy & Holdaway 2002); and a single North I. cave record of a little shearwater (presumably a North Island little shearwater) (Holdaway *et al.* 2001).

These few records, combined with the historical declines (described under the individual species accounts), document where predation is presumed to have caused extinctions, e.g. sooty shearwaters at Pipinui Point, along the Otago coast, and on Puangiangi I. and Chatham I.; fluttering and North Island little shearwaters on Te Hauturu-o-Toi/Little Barrier I.; fluttering shearwaters on Middle Chain I. and Moutohora (Whale I.); and Hutton's shearwaters on Mt Tapuaenuku. An expanding colony of shags destroyed the sooty shearwater colony at Whero Rock. In contrast, the loss of shearwater colonies from sites with no introduced mammalian predators or where only *Rattus exulans* was present, suggests a possible at-sea cause. The sites where species have disappeared include flesh-footed shearwater from Hen I. (Taranga I.), Red Mercury I. (Whakau I.), Hongiora I. and Whakaari I. (White I.); and sooty shearwater from the Cavalli Is, Taranga I. (Hen I.), Cuvier I. (Repanga I.) and Red Mercury I. (Whakau I.). These local population losses add weight to the idea that the overall populations of both flesh-footed and sooty shearwaters have declined in the last few decades.

### Survey methodologies

In various forums, there are concerted efforts to standardise and promote suitable methods of population estimation for burrowing seabirds. For example, the ACAP Population and Conservation Status Working Group is encouraging researchers to standardise their research methodologies and reporting (Wolfaardt & Phillips 2011). They recommend five methods of direct counts for albatrosses and petrels, and strongly encourage researchers to estimate errors as well as to be mindful of the influence of survey timing on the outputs

of their research. We encourage researchers to study the methods reported in Wolfaardt & Phillips (2011) and to select one suitable for the species and site they are working on. Further analyses on optimising survey efforts for burrowing seabirds by Schumann *et al.* (2013) showed that transect surveys could yield robust results, and even multiple-species survey information if the variability of species density and habitat stratification was taken into account.

### Conclusions on information relevancy

While reviewing the collated data, it has become clear that the information on which we are basing current-day assessments of the occurrence, range and population size of shearwaters in New Zealand is mostly out of date. The median date for the numerical estimates of all species combined was 1990. Half of the counts available (including qualitative information) are 30 or more years old, and there are relatively few data from the period since 2000. Even for Hutton's shearwater, where detailed counts from the late 1980s were reported, comparative data are now more than 20 years old. Only about 40 population estimates were recorded since 2000, or less than 20% of the total species-locality numerical estimates recorded in this paper. Considering the importance of marine birds, and shearwaters in particular, as predators in marine ecosystems, as well as the high endemism of shearwater taxa in New Zealand, the very poor status of information on this group of species undermines our ability to manage threats and other issues relating to them.

It is clear that there has been increasing focus on quantitative estimation of populations with time, and more recent estimates appear to provide more robust population size estimates than was attempted previously. Since the mid-1990s, the ability to obtain reliable population estimates has been greatly enhanced by the advent of burrowscopes to examine nest contents, accurate hand-held GPS units to locate sample plots, and new GIS software tools to stratify and map habitat types. Before this modern era most seabird workers concentrated on establishing the presence/absence of breeding species and estimated population sizes from a limited number of sample plots to determine 'typical' burrow densities. In the 1980s, many shearwater population estimates were made by staff of the New Zealand Wildlife Service and the Department of Conservation (DOC), as well as students from Auckland University. Since 1990, ongoing research programmes coordinated by DOC, the



Ministry of Fisheries and the Titi Project (Otago University) have obtained robust population estimates for several shearwater species. However, there is still an urgent need to develop agreed appropriate methodologies, especially for large colonies, in order to provide more robust and comparable estimates of the status and trends of these important populations of birds.

Finally, our aim was to document accessible information to make it easier for researchers to target their ongoing efforts with best effect. We hope that others will make available their findings, and assist with information-sharing to enable a better picture to be developed of the status of these *Puffinus* species. We are aware that our study is likely to have notable gaps, particularly for sooty shearwaters, and we hope that these are seen as challenges to fill, rather than inadequacies.

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