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Breeding petrels of Dusky Sound, Fiordland – survivors from a century of stoat invasions

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Abstract A total of 49 breeding colonies of 3 petrel species was found on 44 of 56 islands surveyed in Dusky Sound, Fiordland National Park, New Zealand, in November 2016. Sooty shearwater (*Puffinus griseus*) was the most widespread and abundant species, with an estimated 21,400 burrows on 35 islands. Mottled petrels (*Pterodroma inexpectata*) were breeding on 12 islands (5500 burrows estimated), and broad-billed prions (*Pachyptila vittata*) on 2 islands (560 burrows estimated). Sooty shearwaters were found breeding among mottled petrels on 4 islands, and among broad-billed prions on 1 island. This is a 5-fold increase in the number of petrel colonies in Dusky Sound identified in published accounts, and the first estimate of the number of burrows on each island. Long-term survival of most or all of these colonies is dependent on ongoing control of stoats (*Mustela erminea*) in Dusky Sound. However, we suggest that islands too small to support a resident stoat population provided partial refugia for petrels, even if the islands are within stoat swimming range, allowing petrels to persist for multiple generations. In contrast, petrels were apparently rapidly extirpated from islands over 100 ha, where stoats maintained a resident population.

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INTRODUCTION

Fiordland has long been recognised as an area where data on breeding colonies of petrels (Procellariiformes) are almost entirely lacking (Oliver 1955; Marchant & Higgins 1990; Taylor 2000). Recent reviews of population sizes of shearwaters (*Puffinus* spp) and prions (*Pachyptila* spp) in New Zealand both identified this knowledge gap, and recommended that surveys be undertaken within Fiordland (Waugh *et al*. 2013; Jamieson *et al*. 2016), as did the *Tamatea/Dusky Sound conservation and restoration plan* (Wildland Consultants & Department of Conservation 2016).

There are numerous potential petrel breeding sites in Fiordland, including 572 islands within Dusky Sound (including Acheron Passage, Wet Jacket Arm and the outer coast of Resolution Island)

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(data from Department of Conservation [DOC] island database compiled by Wildland Consultants for the *Tamatea/Dusky Sound conservation and restoration plan*). Dusky Sound was the first New Zealand site where European naturalists recorded petrel breeding colonies, when James Cook and the naturalists on his second voyage reported vast numbers of broad-billed prions (*Pachyptila vittata*) in holes among tree roots and rocks on Anchor Island and the Seal Islands in April 1773 (Hoare 1982; Medway 2011). Subsequent reports of broad-billed prions breeding in Dusky Sound include a claim that they bred "in Breaksea Sd, Dusky Sd, and Chalky Inlet in 1986" (Kim Morrison *in* Gaze 1988), McEwen (1987) listed "outer islands in Dusky Sound" as a breeding site, possibly based on the same information, and Peat & Patrick (1996, p.82) stated that there was "a colony based at the islets off Five Fingers Peninsula...and burrows on several islets south of Anchor Island". Wildland Consultants & DOC (2016) also referred to "prions (unknown species)" on the small islands at the southern end of Five Fingers Peninsula, Resolution Island (i.e. at the northern entrance to Dusky Sound) (Wildland Consultants & DOC 2016).

Mottled petrels (*Pterodroma inexpectata*) were first reported breeding in Dusky Sound in February 1972, when J. Hilton found them nesting on 5 islands in the Shag Islands group (west of Cooper Island), with eggshells and old eggs found around the colonies (Dick Jackson *in* Edgar 1972). They were recorded subsequently on the largest Shag Island in April 1973: "many burrows, feathers at burrow entrances, one addled and one broken egg" (David Medway *in* Edgar 1973), and breeding on "Shag I" on 4 February 1983 (Morrison & Morrison 1983; Kim Morrison & Wynston Cooper *in* Booth 1984). Evidence of mottled petrels (3 corpses and 2 old eggs) was found on Front Island (at the southern entrance to Acheron Passage, 3.2 km west of the Shag Is) by Kim Morrison on 29 August 1978 (Fiordland National Park file, see Appendix 2), and they were found to be breeding there on 4 February 1983, in November-December 1986, and 11 November 1995 (Morrison & Morrison 1983; Morrison & Cooper *in* Booth 1984; Morrison *in* Gaze 1988; Cooper *in* O'Donnell & West 1998). Morrison also heard 2 mottled petrels in 'low density' burrows on the islet in Paget Passage (1.6 km south-east of the Shag Islands) on 12 May 1980 (Appendix 2).

Richard Henry (1902) mentioned "mutton-birds" (i.e. sooty shearwaters *Puffinus griseus*) having a regular breeding cycle in Dusky Sound, but did not describe where the birds were breeding. Kim Morrison found numerous sooty shearwater burrows on the largest of the Seal Islands (our 'East Seal Island') south-west of Anchor Island on 6 April 1977, and a few burrows and an egg on an islet in Acheron Passage (our 'Acheron Islet 1') on 19 March 1979 (Appendix 2). They were reported to be breeding on the Seal Islands and/or Petrel Islands (north of Anchor Island) in February 1984 (Morrison 1984), and on unspecified islands in Dusky Sound (McEwen 1987; Peat & Patrick 1996). More recently they have been reported as present on Indian Island (Willans 2010) and Resolution Island (Ledgard *et al.* 2011), with no details of numbers or whether they were breeding. The Resolution Island record was likely to have been based on birds seen offshore (George Ledgard, *pers. comm*. to C.M. Miskelly, 30 March 2017).

Rats (*Rattus* spp) are now absent from most islands in Dusky Sound, and stoats (*Mustela erminea*) have been eradicated or controlled to zero density on many islands there since 2001, to restore habitat for threatened land birds (Elliott *et al*. 2010; Clayton *et al.* 2011; Edge *et al.* 2011; Wildland Consultants & DOC 2016). Within Dusky Sound, weka (*Gallirallus australis*) are currently confined to the 2 largest Seal Islands plus 1 adjacent islet (our 'Seal Islet 1'), and Long Island (Robertson *et al*. 2007; Wildland Consultants & DOC 2016; authors *pers. obs*.), meaning that for the vast majority of the islands in the study area there are no land-based predators likely to be limiting petrel re-establishment or recovery.

We report on a rapid survey to identify petrel species breeding and estimate the number of burrows on selected islands in Dusky Sound. We also propose an explanation for the current distribution of petrel colonies in Dusky Sound in relation to stoat behaviour and ecology.

METHODS

A boat-based survey of islands in Dusky Sound, Fiordland National Park, south-west New Zealand, was undertaken by the first 5 authors between 15 and 24 November 2016, with a primary focus of locating petrel breeding colonies. The timing of the survey was selected to maximise the chance of locating the 3 petrel species previously reported breeding in Dusky Sound (broad-billed prion, mottled petrel and sooty shearwater). Priority was given to islands where breeding petrels had been reported previously (or were known or suspected by the Department of Conservation [DOC] boat crew), along with islands furthest from the shore or other islands, and islands nearest to the open sea.

Landings were made from a small inflatable dinghy, with 1-6 team members landing on each island for between 5 minutes and 4 hours (mean = 64 min; Appendix 1). Most landings were during daylight, with 3 islands landed on at night. Spot-lighting was undertaken from the deck of the main vessel (the 22 m *M.V. Southern Winds*) at 5 locations,

when sea conditions allowed close approach to islands after dark.

A total of 59 islands was landed on by 1 or more team member, with 56 of the islands surveyed for the presence of burrow-nesting petrels. Few of the islands had individual names on available maps and charts (where most are named as clusters of islands), and so we created names/numbers for them, usually numbering islands in each cluster from north to south and west to east. A central latitude and longitude reference point for each island is provided in Appendix 1, along with the reference number for each island used by DOC, from a GIS database of 713 islands in Dusky and Breaksea Sounds created by Wildlands Consultants (see Wildland Consultants & DOC 2016).

Island areas were obtained from the DOC GIS database. Distance from the sea for each island was estimated from Google Earth, as a straight-line distance from the midpoint between Five Fingers Point and South Point (i.e. the entrance to Dusky Sound). The only exception was 'Acheron Islet 1', where the measurement was taken from the northern entrance to Breaksea Sound, with an angle made at the northern entrance to Acheron Passage.

Information on predator control history, effort and trapping results on islands in Dusky Sound was provided by P.G. McMurtie. There are currently more than 3300 'DOC150' stoat traps set in Dusky Sound (2351 on Resolution Island), which are checked 3 times per annum.

Petrel burrow entrances were searched for and counted on each island during walk-through surveys. The proportion of each island surveyed was estimated, with the estimated number of burrows on each island based on the actual count extrapolated to allow for areas not surveyed. On 2 islands where burrows were apparently confined to a portion of the island, we estimated the proportion of the colony (rather than the entire island) that we surveyed. On both these islands (Parrot Island and 'Main' Petrel Island) we searched only those parts of the islands where burrows had been reported, but did not see any further burrows while walking to our pick-up points 0.2-1.0 km away from the burrowed areas.

The petrel species present were identified by any of: adults or chicks extracted from burrows or seen on the colony surface or in collapsed burrows; vocalisations from birds inside burrows; corpses or failed eggs on the colony surface; burrow location and burrow entrance size. Any intact eggs were measured (length x maximum width) as a guide to species identification.

Previously unpublished data on petrel breeding sites from 1973-1986 island surveys held by the DOC Te Anau office are listed in Appendix 2, and summarised where relevant in the text.

RESULTS

Evidence of breeding petrels was found on 45 islands in November 2016, ranging in size from 0.1 to 40 ha, and up to 27 km from the open sea (Tables 1-3). We found mottled petrel burrows mainly on coastal slopes of islands, sometimes within a couple of metres of the shore, and usually among dense ground cover of moss and ferns. In contrast, sooty shearwater burrows (which had larger entrances) were mainly found in areas with less ground cover at the tops of coastal slopes and on the upper slopes and island summits.

Mottled petrel (*Pterodroma inexpectata*)

Mottled petrels, or their burrows, were found on 12 islands, 8 of which were in the middle section of Dusky Sound, 22-27 km from the open sea (Table 1, Fig. 1). These 8 islands were approximately equidistant from the sea via either Acheron Passage or Dusky Sound. Six of these 'inland' breeding sites had been mentioned in previous published accounts (e.g. Edgar 1972; Booth 1984), with new colonies found on 'Little Front Island' and on 'Shag Island 6', which is 600 m east of the main Shag Islands group. Note that our 'Shag Island 4' is identified as 2 islands in the DOC island database, but we were able to walk between the islands at low tide.

Four additional new colonies were found further west, near Anchor Island, on 2 adjacent islets in the eastern side of Anchor Island Harbour, 'East Seal Islet 2, (south-west of Anchor Island), and an islet north of the Useless Islands, east of Anchor Island (Fig. 1). A mottled petrel feather was also found on 'East Seal Islet 1'.

The 12 mottled petrel breeding islands were 0.1 to 1.1 ha in size (mean 0.4 ha), and were mainly covered in tall rata (*Metrosideros umbellata*)/rimu (*Dacrydium cupressinum*)/kamahi (*Weinmannia racemosa*) forest. A few sooty shearwater burrows were found on 4 of the islands. The timing of our survey was about a month before egg-laying for mottled petrels (Warham *et al.* 1977; Sagar *et al.* 2015), but old, damaged eggs were found on 4 islands (Table 1), with 3 of them intact enough to be measured: 57.2 x 41.6 mm ('Anchor Island Harbour Islet 1'), 54.4 x 40.4 mm ('Shag Island 3') and 55.2 x 43.9 mm ('Shag Island 6').

We estimated that each island had 90 to 1000 burrows, with the highest actual count of 594 burrows on 'Shag I 5' (Table 1). The total burrow estimate for the 12 islands was 5530.

The only mottled petrel islands that we landed on at night were 2 islets in Anchor Island Harbour on the night of 17-18 November 2016, when dozens of adult mottled petrels were seen in flight in the spotlight beam from the boat, and on land on the larger islet (Fig. 2). An adult and an egg were seen

Table 1. Evidence for mottled petrel presence on islands in Dusky Sound in November 2016, with the estimated number of burrows on each island. ID ISLAND is the Department of Conservation Dusky + Breaksea Sound island database reference no. for each island. See Appendix 1 for island locations and search effort.

Island name	ID ISLAND	Area (ha)	Distance from sea (km)	Evidence	Count	Estimate
'East Seal Islet 2'	295	0.2	3.6	burrows	33	400
'Anchor I Harbour Islet 1'	363	0.3	7.1	burrows, adults, corpses, egg	230	700
'Anchor I Harbour Islet 2'	360	0.1	7.1	burrows, adult, egg	12	100
'Useless Islet 1'	368	0.2	10.9	burrows	33	100
Front Island	106	1.0	22.1	burrows, corpses	297	1000
'Little Front Island'	105	0.1	22.3	burrows	156	200
'Shag Island 1'	32	0.2	25.5	burrows	114	140
'Shag Island 2'	36	0.2	25.6	burrows	74	90
'Shag Island 3'	37	1.1	25.9	burrows, adults, corpses, egg	581	1000
'Shag Island 4'	29 + 34	0.2	26.0	burrows	484	600
'Shag Island 5'	31	0.6	26.0	burrows, calls, skull	594	1000
'Shag Island 6'	458	0.3	26.6	burrows, egg	180	200
Total	-	4.5	-		2788	5530

Table 2. Evidence for broad-billed prion presence on islands in Dusky Sound in November 2016, with the estimated number of burrows on each island. ID ISLAND is the Department of Conservation Dusky + Breaksea Sound island database reference no. for each island. See Appendix 1 for island locations and search effort.

Island name	ID ISLAND	Area (ha)	Distance from sea (km)	Evidence	Burrows counted	Estimated burrows on island
'Northern Seal Islet'	56	1.7	2.5	burrows, 3 eggs, 5 chicks	80	400
'Southern Seal Islet'	41	0.3	2.8	burrows, chick	40	160
'Seal Islet 1'	53	1.8	2.5	contour feathers	0	-
'East Seal Islet 2'	295	0.2	3.6	2 tail feathers	0	-
'Main' Petrel I (west end)	64	21.1	6.7	down feathers	0	-
'Centre Island'	444	1.8	9.7	contour feathers	0	-
Total	-	26.7	-		120	560

during a brief landing on the smaller islet.

No mottled petrels were seen in the daytime at sea within the fiords during our survey. However, 2 were seen outside the fiords as we travelled south from Doubtful Sound on 15 November. About 10 mottled petrels were heard calling flying inland at night at The Basin (Resolution Island) on 16 November, with their flight direction being consistent with birds travelling to nesting colonies on the Front and Shags Islands. About 10 mottled petrels were also seen in flight in spotlights at night off the Many Islands (south of Anchor Island) on 20 November.

Table 3. Evidence for sooty shearwater presence on islands in Dusky Sound in November 2016, with the estimated number of burrows on each island. ID ISLAND is the Department of Conservation Dusky + Breaksea Sound island database reference no. for each island. See Appendix 1 for island locations and search effort.

Island name	ID ISLAND	Area (ha)	Distance from sea (km)	Evidence	Burrows counted	Estimated number of burrows
'Goose Cove Islet 1'	511	1.3	11.7	burrows	20	100
Parrot Island[1]	4	40.2	10.0	burrows, 2 eggs	174	500
'Parrot Islet 1'	484	3.6	10.4	burrows	5	5
'Pigeon Islet 2'	491	2.4	10.8	burrows	30	100
'Centre Island'	444	1.8	9.7	burrows, egg	552	5000
'North' Petrel Island	66	5.5	7.5	burrows, egg	404	1500
'Petrel Islet'	65	0.5	7.4	burrows	50	200
'Main' Petrel I[1]	64	21.1	6.7	burrows	94	300
'Anchor I Harbour Islet 1'	363	0.3	7.1	burrow, calls	1	1
'Anchor I Harbour Islet 3'	337	0.1	6.7	burrow	1	1
'North-east Anchor Islet 1'	400	1.0	8.3	burrows	198	1500
'North-east Anchor Islet 2'	397	3.0	8.7	burrows, egg	116	400
'North-east Anchor Islet 3'	386	0.6	9.2	burrows	3	3
'North-east Anchor Islet 5'	388	4.6	9.7	burrow	1	1
'North-east Anchor Islet 6'	389	1.3	10.1	burrows	10	10
Useless Island	25	3.2	10.7	burrows, egg	35	200
'Useless Islet 2'	351	0.5	11.1	burrows	5	5
'Northern Seal Islet'	56	1.7	2.5	burrow, adult	1	1
'Seal Island west'	51	9.5	2.4	burrows	16	300
'Seal Islet 1'	53	1.8	2.5	burrows, adults	41	100
'Seal Island east'	54	13.7	2.9	burrows	71	2000
'East Seal Islet 1'	290	0.6	3.5	burrows	108	400
'East Seal Islet 2'	295	0.2	3.6	burrows, egg	12	100
'Many Island 1'	308	7.5	4.1	burrows, egg	82	1000
'Many Island 2'	286	1.1	3.9	burrows	240	2000
'Many Island 3'	292	2.1	4.2	burrows	30	150
'Many Island 4'	276	2.8	4.1	burrows	247	2500
'Many Islet 1'	280	0.3	4.1	burrows	7	10
'Many Islet 2'	282	0.2	4.3	burrow	1	1
'Many Islet 3'	294	0.2	4.4	burrows	11	15
Nomans Island (east end)	6	20.1	7.6	burrows, egg	224	2000
Thrum Cap	14	4.1	8.3	burrows, corpses, 2 eggs	122	1000
Front Island	106	1.0	22.1	burrow, calls	1	1
'Shag Island 3'	37	1.1	25.9	egg	1 egg	1
'Acheron Islet 1'	586	0.9	11.5	burrows	7	20
Total	-	159.9	-		2922	21425

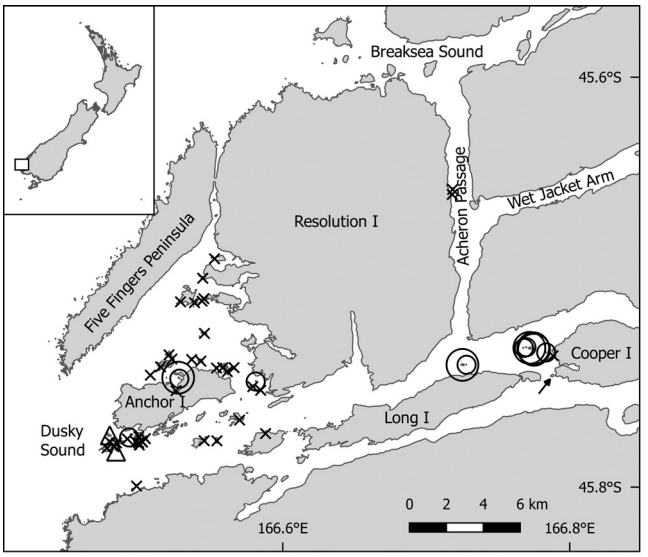

Fig. 1. Distribution of mottled petrel colonies (circles) and broad-billed prion colonies (triangles) surveyed in Dusky Sound in 2016. For mottled petrels, circle sizes denote colony size, with large circles showing colonies with 600-1000 burrows, and small circles 90-400 burrows estimated. Crosses show islands visited without either species being recorded. The arrow shows an islet that had mottled petrels in 1980, not included in the 2016 survey.

Broad-billed prion (*Pachyptila vittata*)

Broad-billed prions were found breeding on 2 small weka-free islets in the Seal Islands, south-west of Anchor Island and within 3 km of the open sea (Table 2, Fig. 1). Large downy chicks were found on both islets, with 5 extracted from burrows on 'Northern Seal Islet' (Fig. 3), and 1 on 'Southern Seal Islet'.

The prions were nesting under kokomuka (*Veronica elliptica*) and shore spleenwort (*Asplenium obtusatum*) in the tiny patches of soil on each islet, which were predominantly bare rock. Where the soil was of sufficient depth, there was c.1 burrow/m^2, with a total burrow estimate for the 2 islands of 560 (Table 2). Three failed eggs were found on 'Northern Seal Islet', 2 of which measured 48.7 x 36.7 mm and 51.5 x 37.2 mm.

About 30 broad-billed prions were seen in the spotlight beam from the lagoon at the western end of the Seal Islands on the night of 15 November 2016. Most flew over the top of 'Seal Islet 1' to the north of the vessel, heading in the direction of 'Northern Seal Islet', where breeding was confirmed 8 days later. Prion feathers were found on 4 other islands (Table 2) that may also have low densities of breeding broad-billed prions among the larger numbers of sooty shearwaters present. A sooty shearwater was found in a burrow among the broad-billed prions on 'Northern Seal Islet'.

An adult broad-billed prion landed on the deck of *M.V. Southern Winds* during a spot-lighting session in Luncheon Cove, Anchor Island, at midnight on 20 November 2016. No prions were seen at sea during our survey.

Fig. 2. Adult mottled petrel at night on 'Anchor Island Harbour Islet 1', Dusky Sound, 17 November 2016. Image: Jean-Claude Stahl, Te Papa.

Fig. 3. Broad-billed prion chick on 'Northern Seal islet', Dusky Sound, 23 November 2016. Image: Colin Miskelly, Te Papa.

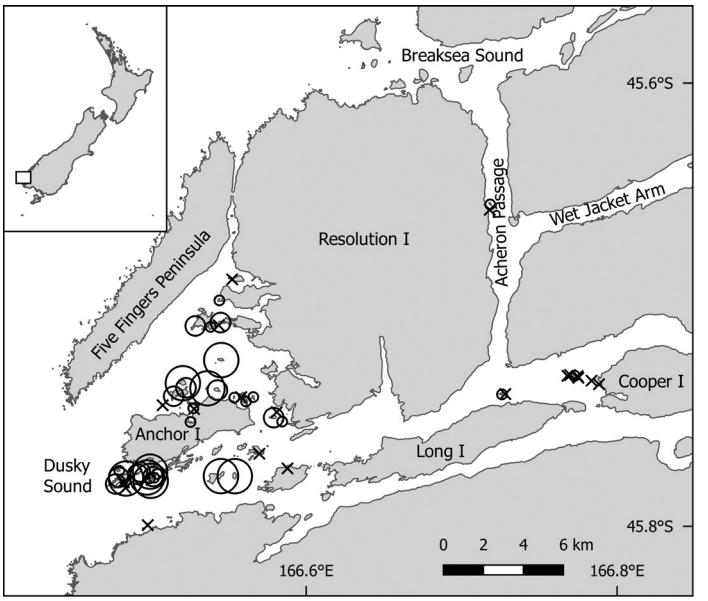

Fig. 4. Distribution of known sooty shearwater colonies within Dusky Sound. Circle sizes denote colony size, with large circles showing colonies with 1000-5000 burrows, medium circles 100-500 burrows, and small circles 1-20 burrows estimated. Crosses show islands visited without evidence of sooty shearwaters being recorded.

Sooty shearwater (*Puffinus griseus*)

The sooty shearwater was the most widespread and abundant petrel species found in Dusky Sound, with an estimated 21,400 burrows on 35 islands (Table 3, Fig. 4). Excluding islands where fewer than 30 burrows were seen or estimated, sooty shearwaters bred on 21 islands that were 0.2 to 40 ha in size (mean 6.8 ha), and 3-12 km from the open sea (mean 6.6 km).

Our survey was about 1-2 weeks before peak egg-laying (Warham *et al.* 1982), and no fresh eggs were found. Old eggs were found on 10 islands (Table 3), with 7 sufficiently intact for full measurement: 74.9 x 46.2 mm (Parrot Island), 75.0 x 49.9 mm ('Centre Island'), 73.9 x 51.5 mm ('North-east Anchor Islet 2'), 72.0 x 49.0 mm (Useless Island), 72.1 x 45.7 mm ('Shag Island 3'), and 70.7 x 51.6 mm and 78.0 x 52.5 mm (Thrum Cap).

The largest colony was on 'Centre Island', north-east of Anchor Island (5000 burrows estimated in c.1.1 ha of soil), with colonies of 1000 to 2,500 burrows estimated on 8 other islands (Table 3, Fig. 4). Most burrows were under tall forest on island summits and spurs, but on small, densely burrowed islands (e.g. 'Many Island 2' and 'Many Island 4'), burrows were found within 10 m of the coastal vegetation fringe, and less than 5 m asl.

Sooty shearwaters were seen at night on 'Seal Islet 1', and were heard or seen in burrows during the day on 'Northern Seal Islet', 'Anchor Island Harbour Islet 1' and Front Island.

Sooty shearwaters were common outside the fiords as we travelled from and to Doubtful Sound on 15 and 24 November, but were not seen at sea within the fiords in the daytime. At night while spotlighting, 1 sooty shearwater was seen in flight off Oke Island, Wet Jacket Arm, on 19 November and c.50 were seen off the Many Islands on 20 November.

Stoat trapping effort and captures on petrel breeding islands in Dusky Sound

Stoat traps were present on 17 (38%) of the islands where we found evidence of petrels during the November 2016 survey (Fig. 5, Appendix 1), as a precautionary measure to reduce the risk of stoats using the islands as 'stepping stones' to reinvade Resolution and Anchor Islands (Wildland Consultants & DOC 2016). Within Dusky Sound, trapping for stoats began on Indian Island in 1999, Parrot, Cormorant, Useless, Nomans and Front Islands and Thrum Cap in 2000, Anchor, Seal, Many and Petrel Islands in 2001, Pigeon Island in 2005, Resolution Island in 2008, and Long Island in 2012 (Elliott *et al.* 2010; Clayton *et al.* 2011; Edge *et al.* 2011; Wildland Consultants & DOC 2016). Trapping on the Shag Islands has been intermittent, with traps set on islands 3 and 5 from 2003 to May 2007, and again on islands 3, 5 and 6 from June 2014.

Six stoats were caught on Parrot Island between 2001 and 2005, and single animals on 'Shag Island 3'

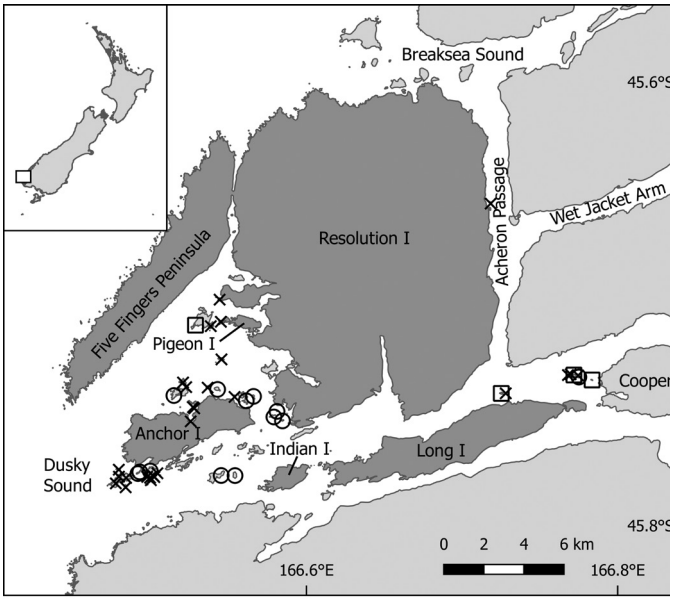

Fig. 5. Stoat trap locations and sites where stoats have been caught on petrel breeding islands in Dusky Sound. Crosses show islands with breeding petrels but no stoat traps. Circles denote petrel breeding islands with traps but where no stoats have been caught. Squares show four islands with breeding petrels where stoats have been trapped. At the time of the 2016 survey, there were extensive stoat trap networks on the five large shaded islands (Resolution, Long, Anchor, Indian and Pigeon Islands), plus on the eastern shoreline of Acheron Passage.

in May 2007, and on Front Island and 'Shag Island 6' in July 2014 (Fig. 5).

DISCUSSION

Regional and national significance of Dusky Sound petrel colonies

The main finding of this survey was that Dusky Sound has far more, and larger, petrel colonies than is evident in published accounts. Sooty shearwaters, in particular, are far more abundant there than indicated by a recent review (Waugh *et al.* 2013, based on Morrison 1984), which reported a single colony of unknown size on the Petrel Islands. Most of the 35 sooty shearwater colonies that we surveyed were known to DOC staff involved with animal pest control in Dusky Sound, although in many cases the petrel species responsible for the burrows had not been identified (Pete Young, *pers. comm*. to authors, November 2016).

The 21,400 sooty shearwater burrows estimated on these 35 islands is small compared to many colonies further south, where colonies on Snares Islands/Tini Heke, Taukihepa/Big South Cape Island, Putauhinu Island, Poutama Island and Whenua Hou/Codfish Island all exceed 170,000 pairs or burrows (Lyver 2000; Newman *et al.* 2009; Waugh *et al.* 2013). However, the Dusky Sound population is at least an order of magnitude larger than any other known site north of Foveaux Strait (Lyver *et al*. 2000; Newman *et al.* 2009; Waugh *et al.* 2013). Further to the sites where we found sooty shearwaters in 2016, Kim Morrison recorded them at 4 additional sites in Dusky Sound in 1983, including on 2 of the islands that we surveyed, but did not find them (Appendix 2; Morrison 1983, Report on a visit to Breaksea & Dusky Sounds, February 1983).

Elsewhere in Fiordland, sooty shearwaters have been recorded breeding on the islet at the northern entrance to Poison Bay (Appendix 2); Nee, Shelter and Seymour Islands in Doubtful Sound (Appendix 2; Elliott *et al*. 2010); Breaksea, Hawea, 'Inner Gilbert 1, 2, 5 & 7' and Entry Islands in Breaksea Sound, plus an islet north of Breaksea Sound entrance (Appendix 2; McEwen 1987; Hamilton *et al.* 1997); an unnamed islet near Woodhen Cove, Resolution Island (Appendix 2); Chalky and Garden Islands in Chalky Inlet (McLean *et al.* 1993; Newman *et al.* 2009; Waugh *et al.* 2013); and Spit and Round Islands in Preservation Inlet (Appendix 2). Other Fiordland breeding sites reported by Pete Young (*pers. comm*. to AJDT & CMM, 24 November 2016) included 'Post Office Rock', Anita Bay and around the Saint Anne Point lighthouse in Milford Sound, Styles Island in Caswell Sound, Utah Island in Doubtful Sound, Great, Passage, 'little' Passage, and Small Craft Harbour Islands in Chalky Inlet, and Single Tree and outer Cording Islands in Preservation Inlet.

In contrast to sooty shearwater, at least half the mottled petrel colonies that we surveyed were already known (e.g. Edgar 1972; Booth 1984). However, none of the previous published accounts

provided any estimates of the number of pairs or burrows present in Dusky Sound. Our estimate of 5500 burrows suggests that Dusky Sound may hold the fourth largest breeding concentration of mottled petrels after Whenua Hou/Codfish Island, Snares Islands/Tini Heke and Taukihepa/Big South Cape Island (Warham *et al.* 1977; Taylor 2000; Miskelly *et al.* 2001; Sagar 2013).

Elsewhere in the region, mottled petrels breed on Single Tree Island in Preservation Inlet (McLean *et al.* 1993), a nearby islet in Isthmus Sound (Morrison & Morrison 1982; McEwen 1987; Peat & Patrick 1996), and an islet south of Mary Island in Lake Hauroko (Booth 1983; skeleton OR.022127 in Te Papa collection, collected 19 April 1977). Further north, mottled petrels were reported from an islet between Cascade and Awarua Points, South Westland (McEwen 1987). The Lake Hauroko population is estimated at 120 pairs (Peat & Patrick 1996, p.95); there are no published population estimates for other sites in Fiordland and South Westland.

Apart from Morrison (*in* Gaze 1988) referring to broad-billed prions breeding in Dusky Sound in 1986 (with no further detail on location or evidence), and the Peat & Patrick (1996) reference to a colony at the tip of Five Fingers Peninsula, we were unaware of any previous published reports of broad-billed prion eggs or chicks within Dusky Sound before we found chicks in burrows on 2 islets in the Seal Islands in November 2016. However, Kim Morrison (*pers. comm*. to CMM, 14 July 2017) reported 10 'broad-billed prion sites' found in Dusky Sound in November-December 1986, at a time of year when they would have had large chicks (Appendix 2). Dusky Sound (specifically Anchor Island) is considered the type locality for *Pachyptila vittata* (see Gill *et al.* 2010), and James Cook and Rheinhold and Georg Forster believed prions to be nesting in "holes under huge stones & between the rocks" when they visited Dusky Sound on Cook's second voyage in March-May 1773 (Hoare 1982; Medway 2011). Cook and the Forsters were unable to extract any birds from burrows, and made no mention of seeing eggs or chicks. Broad-billed prions lay in August-September and their chicks fledge in December-January (Richdale 1965; Miskelly *et al.* 2001). The birds seen and heard in April 1773 were likely to have been mainly adults returning to breeding sites after completing their post-breeding moult (see Richdale 1965; Medway 2011; Miskelly 2013).

Elsewhere in Fiordland, broad-billed prions have been reported breeding at a headland near Nancy Sound (Peat & Patrick 1996), on an islet near Oliver Point at the northern entrance to Breaksea Sound (Appendix 2; Peat & Patrick 1996), on Wairaki, Hawea and 'Inner Gilbert Island 1' in Breaksea Sound (Appendix 2; Taylor 2000; Jamieson *et al.* 2016), on 3 islets off the west coast of Resolution Island (Appendix 2), and on Zero Nugget and Finger Rock in Chalky Inlet (Appendix 2; Kim Morrison *in* Cooper 1986).

The impact of stoats on Dusky Sound petrel populations

Burrow-nesting petrels are particularly vulnerable to stoat predation because they have few behavioural defences, low breeding output, and their colonial nesting and well-defined breeding seasons result in birds being concentrated in space and time (Moors & Atkinson 1984; Warham 1996). Stoats are the main predator of adult sooty shearwaters and their chicks at mainland colonies in Otago (Lyver *et al.* 2000), and the smaller and less aggressive mottled petrel and broad-billed prion are likely to be even more susceptible to stoat predation.

Whether petrels persisted on, or recolonised, any island in Dusky Sound after stoats established in the region in the early 20th century is likely to have been influenced by island size (i.e. whether the island was large enough to support a resident stoat population) and distance from the nearest established stoat population (influencing the frequency of stoat reinvasion). All the islands that we found petrels on were less than 41 ha, with the mottled petrels and broad-billed prions all on islands less than 1.2 ha. These small islands are likely to have provided partial refugia from stoat predation, as islands under 50 ha are considered too small to support a resident stoat population (Taylor & Tilley 1984; Elliott *et al.* 2010; Veale *et al*. 2012). The initial knock-down of stoats on Resolution Island revealed a minimum density of 1.4 stoats km^{-2} (Clayton *et al*. 2011), or 1 stoat per 70 ha, supporting the suggestion that small Fiordland islands are unlikely to have resident stoats.

Stoats are capable of swimming more than 3 km, and within Fiordland have been recorded from islands up to 1 km offshore in fiords, and 2 km in lakes (Elliott *et al*. 2010; Veale *et al*. 2012). While stoats are likely to have swum to almost all the islands in Dusky Sound occasionally, if their visits were infrequent, and each visit was no more than 1 breeding season in duration, petrel populations could persist for multiple generations. Once the adults and juveniles departed at the end of the breeding season – or all were killed – the stoat(s) would need to move on. Even on very small islands (where all breeding petrels and their young would potentially be killed by a single stoat invasion) there would be a reservoir of pre-breeding and non-breeding birds at sea that would avoid predation and be able to return to breed in subsequent seasons. The larger petrel colonies would be buffered against

predator impacts through predator swamping, as only a small proportion of the population could be killed by 1 or a few stoats during a single breeding season (Peck *et al*. 2008). Petrel immigration from nearby colonies could also offset high predation rates at those colonies more accessible to stoats (Bonnaud *et al*. 2009).

A scenario of sporadic stoat incursions separated by long time intervals would lead to a punctuated petrel population decline, with periodic rapid declines followed by slow population growth between incursions. This contrasts with land bird species vulnerable to stoat predation (and particularly those species with limited dispersal = recolonisation ability), where the entire local population can be extirpated by a single stoat invasion (Crouchley 1994; Hooson & Jamieson 2003; Veale *et al*. 2012).

Three of the islands that we found petrels on were included in an experimental study of stoat reinvasion rates of Fiordland islands (Elliott *et al*. 2010). Although no stoats were caught on Useless and Front Islands during 2001-05, Elliott *et al*. (2010) predicted a reinvasion rate of 0.31 and 0.34 stoats respectively over 4 years for these 2 islands, based on reinvasion rates of these and other small (<66 ha) islands within 1 km of stoat-inhabited shores. This equates to 1 stoat every 12-13 years (95% confidence intervals of 1 stoat every 5-33 and 5-29 years respectively, calculated from Table 1 of Elliott *et al*. 2010). A stoat was caught on Front Island 9 years after the study, but the reinvasion rate of this island will have declined further now that stoats are being controlled to low density on nearby Long Island. Note that Front Island is 1.3 km from the mainland, but only 500 m from Long Island.

Broad-billed prions have increased vulnerability to land-based predation compared to the highly migratory sooty shearwater and mottled petrel, which are absent from breeding islands for at least 4 months of the year (Warham *et al*. 1977 & 1982). Broad-billed prions can be found ashore almost year-round, although outside the breeding season visits are sporadic (Richdale 1965; Miskelly *et al.* 2001), meaning that prions would be most vulnerable on large islands with a resident stoat population (cf. small islands that stoats visit infrequently and where they would be unable to survive if seabirds were absent). However, stoat predation is unlikely to have been the cause of extirpation of broad-billed prions on 1380 ha Anchor Island, where the "vast flights" reported in 1773 had apparently gone before stoats reached Dusky Sound c.1900 (Hoare 1982; Hill & Hill 1987; Medway 2011). Norway rats *Rattus norvegicus* (presumed to have been present from the late 18th century, and possibly themselves extirpated by stoats) are a more plausible explanation of prion extirpation on Anchor Island (Medway 2011; Miskelly *et al*. accepted ms).

The *Tamatea/Dusky Sound conservation and restoration plan* (Wildland Consultants & DOC 2016) listed 5 islands or island groups in Dusky Sound that may never have been invaded by stoats, including Thrum Cap and Nomans and Passage Islands included in this survey. The relatively low densities of petrels on these islands (which are all within 800 m of 'stepping stone' islands that may have facilitated stoat access) indicate that they are all likely to have been reached by stoats occasionally. We suggest that the best candidate for a 'pristine' island within Dusky Sound is 1.8 ha 'Centre Island', north-east of Anchor Island. This is the most isolated island in the fiord, 1.6 km offshore from Resolution Island, and held the largest petrel colony (5,000 sooty shearwater burrows at ≈ 0.45 burrows m^{-2}). The only other colonies with similar burrow densities were the 2 tiny islets in the Seal Islands with breeding broad-billed prions.

The benefits of stoat control to Dusky Sound petrel populations

Most of the islands where we found petrel colonies have received comprehensive protection from stoat predation by the intensive trap network installed and maintained by DOC in and around Dusky Sound during the past 10-15 years (Wildland Consultants & DOC 2016, plus GIS data held by PGM). Provided the current trapping effort is sustained, the only colonies that remain at high risk of stoat reinvasion are the mottled petrels on the Shag Islands, which lie 0.3 to 1.0 km across water from sites where stoats are uncontrolled, on Cooper Island and the north side of Bowen Channel. We note that 2 stoats have been trapped on the Shag Islands during only 6 years of trapping. If mottled petrels are still present on islet 420 in Paget Passage (Appendix 2), they will be even more vulnerable to stoat invasion, as the islet lies only 70 m from Cooper Island.

Stoat control in Dusky Sound has been primarily focused on their eradication from 1137 ha Anchor Island and 20,887 ha Resolution Island in order to provide safe habitat for kākāpō (*Strigops habroptilus*) and other threatened land bird species (Elliott *et al*. 2010; Clayton *et al.* 2011). Most of the petrel colonies described here have benefited from the trapping effort to date, through the elimination of source populations for stoat reinvasion, and trapping of 'stepping stone' islands (often holding petrel colonies), to minimise stoat reinvasion of the large islands. Additional protection of mottled petrels breeding east of Acheron Passage would be achieved by placement of at least 2 traps on each of the Front and Shag Islands and islet 420, and lines of traps at the western end of Cooper Island and

along 4 km of mainland coast east of the southern entrance to Acheron Passage. If the decision is ever made to cease trapping on Resolution Island, we further recommend that trapping continue on the headlands of Resolution Island closest to Anchor Islands, 'Centre Island' and Parrot Island in order to protect the numerous petrel colonies around and between Anchor and Parrot Islands.

Recommendations for further survey and monitoring

All our petrel colony size estimates obtained in 2016 were based on rapid walk-through surveys without repeated measurements or counts within measured transects or plots, with no attempts made to estimate burrow occupancy. We are therefore unable to estimate survey error, or translate our burrow counts into precise estimates of population size. We recommend more detailed surveys on islands where ≥90 burrows were estimated, following accepted guidelines for monitoring burrow-nesting petrels (e.g. Wolfaardt & Phillips 2011; Parker & Rexer-Huber 2016).

Numerous potential petrel breeding islands within Dusky Sound remain to be surveyed or resurveyed. Based on information in the *Tamatea/ Dusky Sound conservation and restoration plan* and DOC Te Anau files (Appendix 2; Wildland Consultants & DOC 2016), plus the sizes of the islands that we found different petrel species on, and their locations, we identify 3 priorities for further survey: (i) sites where broad-billed prions were found in 1986 (Appendix 2); (ii) islet 420 (west of Cooper Island) for mottled petrels; and (iii) Prove Island and Stop Island for sooty shearwaters.

Monitoring of selected petrel colonies within Dusky Sound at regular intervals could provide information on the effectiveness and outcomes of sustained predator control, as well as contributing to assessment of the national status of these petrel species within New Zealand (Taylor 2000; Waugh *et al*. 2013; Jamieson *et al*. 2016).

For mottled petrels, we recommend monitoring 3 of the 4 largest colonies, namely 'Anchor Island Harbour Islet 1', Front Island, and either 'Shag Island 3' or 'Shag Island 5'. These accessible, sheltered islands are a subset of colonies that each contain 700+ burrows, and are spread over 19 km. An additional factor to consider with sooty shearwaters (which mainly nest nearer the open sea) is avoiding islands that have large numbers of New Zealand fur seals (*Arctocephalus forsteri*) around the shoreline and under the forest, because seals in high density prevent surveyors' access to parts of the islands. Large sooty shearwaters colonies with relatively safe landing sites and low (or zero) fur seal populations include 'North-east Anchor Islet 1', 'Many Island 1' and Thrum Cap.

The 2 broad-billed prion breeding sites reported here are impractical to regularly monitor as they are very exposed to the open sea, difficult to land on, and have small fragile areas of soil. 'Northern Seal Islet' is the easier of the 2 to access, and should be checked at least every 5 years to confirm that prions are still present.

While Dusky Sound is a remote area to undertake further petrel survey and monitoring, DOC staff are regularly present there undertaking kākāpō management and pest control, and the fiord is a popular destination for eco-tourism. More rigorous surveys of known colonies, and ongoing monitoring of a few accessible large colonies, would be well suited to community conservation initiatives involving DOC, ecotourism operators and conservation trusts. Surveys of Fiordland islands beyond Dusky Sound are also required to assess the full distribution of petrels and estimate their numbers in the region.

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APPENDIX 1. Island locations and search effort. ID ISLAND is the Department of Conservation (DOC) Dusky + Breaksea Sound island database reference no. for each island. 'Petrels' refers to whether evidence of petrels breeding was recorded in November 2016 (see Tables 1-3). 'Trap' refers to whether at least 1 stoat trap was maintained on the island by DOC at the time of our visit. Note that many islands receive protection by being adjacent to islands that are trapped. 'Time' is the approximate length of time (in minutes or hours:minutes) that observers were ashore.

Island name	ID ISLAND	Latitude S	Longitude E	Petrels	Trap	Date	Observers	Day/Night	Time
'Cormorant Cove Islet' (west end)	530	45.6885°	166.5524°	No	Yes	18-Nov	AT & CM	Day	50
'Goose Cove Islet 1'	511	45.6982°	166.5442°	Yes	No	18-Nov	AS & J-CS	Day	30
Parrot Island (west end)	4	45.7075°	166.5344°	Yes	Yes	18-Nov	AT & CM	Day	2:25
'Parrot Islet 1'	484	45.7100°	166.5387°	Yes	No	18-Nov	AS & J-CS	Day	20
'Pigeon Islet 1'	485	45.7094°	166.5437°	No	No	18-Nov	AS	Day	15
'Pigeon Islet 2'	491	45.7083°	166.5451°	Yes	No	18-Nov	AS & J-CS	Day	30
'Centre Island'	444	45.7250°	166.5454°	Yes	No	18-Nov	AT, CM, J-CS & AS	Day	1:50
'North' Petrel Island	66	45.7353°	166.5206°	Yes	No	22-Nov	AT & CM	Day	40
'Petrel Islet'	65	45.7376°	166.5227°	Yes	No	23-Nov	AT & CM	Day	25
'Main' Petrel Island (west end)	64	45.7413°	166.5148°	Yes	Yes	22-Nov	AT & CM	Day	2:05
Entry I	26	45.7455°	166.5078°	No	No	23-Nov	AT & CM	Day	30
'Anchor Island Harbour Islet 1'	363	45.7467°	166.5272°	Yes	No	17-Nov	AT, CM & J-CS	Day + night	1:50
'Anchor Island Harbour Islet 2'	360	45.7471°	166.5279°	Yes	No	18-Nov	AT & CM	Night	5
'Anchor Island Harbour Islet 3'	337	45.7530°	166.5256°	Yes	No	17-Nov	AS	Day	20
Anchor I (northern headland)	21	45.7449°	166.5273°	No	Yes	24-Nov	AT & CM	Day	30
'North-east Anchor Islet 1'	400	45.7378°	166.5365°	Yes	No	17-Nov	AT, CM & J-CS	Day	1:30
'North-east Anchor Islet 2'	397	45.7384°	166.5428°	Yes	Yes	17-Nov	AT, CM & J-CS	Day	1:30
'North-east Anchor Islet 3'	386	45.7419°	166.5538°	Yes	No	17-Nov	AT & J-CS	Day	50
'North-east Anchor Islet 4'	391	45.7415°	166.5584°	No	Yes	17-Nov	AT & J-CS	Day	25
'North-east Anchor Islet 5'	388	45.7437°	166.5613°	Yes	Yes	17-Nov	CM & AS	Day	40
'North-east Anchor Islet 6'	389	45.7417°	166.5661°	Yes	Yes	17-Nov	CM & AS	Day	30

APPENDIX 1. continued

Island name	ID ISLAND	Latitude S	Longitude E	Petrels	Trap	Date	Observers	Day/Night	Time
Useless Island	25	45.7509°	166.5791°	Yes	Yes	22-Nov	AT, CM & J-CS	Day	1:45
'Useless Islet 1'	368	45.7485°	166.5812°	Yes	Yes	22-Nov	CM	Day	35
'Useless Islet 2'	351	45.7528°	166.5846°	Yes	Yes	22-Nov	AT	Day	30
'Northern Seal Islet'	56	45.7749°	166.4796°	Yes	No	23-Nov	AT & CM	Day	3:00
'Seal Island west'	51	45.7809°	166.4776°	Yes	No	23-Nov	J-CS, HE, RW & DA	Day	2:40
'Seal Islet 1'	53	45.7780°	166.4796°	Yes	No	15-Nov	AT & CM	Night	1:00
'Seal Island east'	54	45.7784°	166.4836°	Yes	No	21-Nov	AT, CM, J-CS & HE	Day	4:00
'Seal Islet 2'	47	45.7803°	166.4822°	No	No	23-Nov	AT	Day	35
'Seal Islet 3'	49	45.7801°	166.4828°	No	No	21-Nov	AT	Day	10
'East Seal Islet 1'	290	45.7765°	166.4918°	Yes	Yes	23-Nov	AT & CM	Day	30
'East Seal Islet 2'	295	45.7757°	166.4931°	Yes	Yes	23-Nov	J-CS & HE	Day	50
'Southern Seal Islet'	41	45.7819°	166.4839°	Yes	No	23-Nov	CM	Day	35
'Many Island 1'	308	45.7753°	166.4998°	Yes	Yes	21-Nov	AT & CM	Day	1:25
'Many Island 2'	286	45.7780°	166.4978°	Yes	No	20-Nov	AT	Day	45
'Many Island 3'	292	45.7775°	166.5016°	Yes	No	20-Nov	CM	Day	1:00
'Many Island 4'	276	45.7794°	166.5000°	Yes	No	20-Nov	AT & CM	Day	35
'Many Islet 1'	280	45.7785°	166.4994°	Yes	No	21-Nov	J-CS & DA	Day	30
'Many Islet 2'	282	45.7781°	166.5022°	Yes	No	21-Nov	J-CS & DA	Day	20
'Many Islet 3'	294	45.7763°	166.5042°	Yes	No	21-Nov	J-CS & DA	Day	20
'South Dusky Islet 1'	257	45.7994°	166.4981°	No	No	23-Nov	AT & CM	Day	15
Nomans Island (east end)	6	45.7776°	166.5441°	Yes	Yes	16-Nov	AT, CM & AS	Day	2:00
Thrum Cap	14	45.7774°	166.5541°	Yes	Yes	16-Nov	AT, CM & AS	Day	1:00

APPENDIX 1. continued

Island name	ID ISLAND	Latitude S	Longitude E	Petrels	Trap	Date	Observers	Day/Night	Time
Passage Island (south coast)	71	45.7660°	166.5688°	No	Yes	16-Nov	J-CS	Day	1:20
Indian Island (north coast)	2	45.7780°	166.5897°	No	Yes	20-Nov	AT, CM, HE & RW	Day	3:10
Front Island	106	45.7404°	166.7256°	Yes	Yes	19-Nov	AT, CM, J-CS & AS	Day	1:25
'Little Front Island'	105	45.7403°	166.7281°	Yes	No	19-Nov	AT, CM, J-CS, AS, DA	Day	25
'Shag Island 1'	32	45.7321°	166.7680°	Yes	No	19-Nov	AS	Day	20
'Shag Island 2'	36	45.7318°	166.7697°	Yes	No	19-Nov	CM	Day	20
'Shag Island 3'	37	45.7322°	166.7725°	Yes	Yes	19-Nov	AT, CM, J-CS, AS, DA	Day	1:10
'Shag Island 4'	29+34	45.7324°	166.7746°	Yes	No	19-Nov	AT & J-CS	Day	1:15
'Shag Island 5'	31	45.7330°	166.7751°	Yes	Yes	19-Nov	CM & AS	Day	1:15
'Shag Island 6'	458	45.7343°	166.7836°	Yes	Yes	19-Nov	AT	Day	20
'Cooper Islet'	454	45.7359°	166.7884°	No	No	19-Nov	CM & AS	Day	15
'Acheron Islet 1'	586	45.6547°	166.7183°	Yes	No	20-Nov	AT, CM, HE & RW	Day	1:00
'Acheron Islet 2'	583	45.6573°	166.7180°	No	No	20-Nov	AT, CM & HE	Day	55

APPENDIX 2. Petrels reported during 1973-1986 surveys of Fiordland islands, extracted from Fiordland National Park (FNP) island survey data sheets and reports held by the Te Anau DOC office (provided as pdf scans by Jeanette Charteris, May 2017, and from Kim Morrison *pers. comm.* to CMM, 14 July 2017). Sites are listed approximately from north to south, then west to east within island cluster, for each species.

Mottled petrel (*Pterodroma inexpectata*)

Dusky Sound

Resolution Island, 13 January 1974, calling in flight over The Basin at night (Charles Fleming, Visit to southwest Fiordland, January 1974). Front Island [45.7404°S 166.7256°E], 29 August 1978, low density burrows, 3 corpses + 2 old eggs (Kim Morrison, FNP Island Survey Form); 4 February 1983, a few occupied burrows, old corpses + eggs (Kim Morrison 1983, Report on a visit to Breaksea & Dusky Sounds, February 1983). Shag Island [no. 3; ID ISLAND 37, 45.7322°S 166.7725°E], 29 August 1978, few burrows, corpse + old egg (Kim Morrison, FNP Island Survey Form); 4 February 1983, a few burrows (Kim Morrison 1983, *ibid*.). Shag Island [no. 4; ID ISLAND 29+34, 45.7324°S 166.7746°E], 12 & 14 May 1980, burrows common, 2 birds seen (Kim Morrison, FNP Island Survey Form). Shag Island [no. 5; ID ISLAND 31, 45.7330°S 166.7751°E], 4 February 1983, several burrows in use, 1 adult seen inside burrow (Kim Morrison 1983, *ibid*.). Unnamed islet in Paget Passage [ID ISLAND 420, 45.7456°S 166.7881°E], 12 May 1980, low density, 2 heard in burrows (Kim Morrison, FNP Island Survey Form).

Broad-billed prion (*Pachyptila vittata*)

Breaksea Sound

Unnamed islet north of Oliver Point [ID ISLAND 683, 45.5738°S 166.6707°E], 8 December 1986, 'broad-billed prion site' (Kim Morrison 2017, *pers. comm*. to CMM, 14 July 2017). Hump at south-west side of Hawea Island [45.5926°S 166.6426°E], 8 December 1986, 'broad-billed prion site' (Kim Morrison 2017, *ibid*.). Inner Gilbert 1 [ID ISLAND 666, 45.6026°S 166.6513°E], 14 December 1974, 1 downy chick found among fern (Kim Morrison 1975, Report on visit to Breaksea Sound, December, 1974; Bruce Thomas, Report on visit to Breaksea Island, the 'Seal Islands' and the Gilbert Islands, Fiordland, December, 1974).

Outer Resolution Island

Unnamed islet near Woodhen Cove [ID ISLAND 594, 45.6346°S 166.5588°E], 8 December 1986. Unnamed islet north of Five Fingers Peninsula [ID ISLAND 619, 45.6234°S 166.5437°E], 7 December 1986. Unnamed islet north-west of Five Fingers Peninsula [ID ISLAND 601, 45.6309°S 166. 5329°E], 7 December 1986. All listed as 'broad-billed prion sites' by Kim Morrison (*pers. comm*. to CMM, 14 July 2017).

Dusky Sound

Two unnamed islets off Five Fingers Point [ID ISLAND 366, 45.7422°S 166.4488°E and ID ISLAND 356, 45.7433°S 166.4456°E], 3 December 1986. 'Anchor Island Harbour Islet 2' [ID ISLAND 360, 45.7471°S 166.5279°E], 3 December 1986. Unnamed islet south-west of main Passage Island [ID ISLAND 70, 45.7676°S 166.5628°E], 13 November 1986. Unnamed islet south-west of Prove Island [ID ISLAND 323, 45.7683°S 166.5539°E], 13 November 1986. 'Northern Seal Islet' [ID ISLAND 56, 45.7749°S 166.4796°E], 6 November 1986. 'Seal Island east' [ID ISLAND 54, 45.7784°S 166.4836°E], 2 December 1986. 'Seal Islet 3' [ID ISLAND 49, 45.7801°S 166.4828°E], 6 November 1986. 'Southern Seal Islet' [ID ISLAND 41, 45.7819°S 166.4839°E], 6 November 1986. All listed as 'broad-billed prion sites' by Kim Morrison (*pers. comm*. to CMM, 14 July 2017). Unnamed islet on south side of Dusky Sound [ID ISLAND 253, 45.8011°S 166.4953°E], 7 February 1983, several smaller burrows on east slope, prion heard (Kim Morrison 1983, Report on a visit to Breaksea & Dusky Sounds, February 1983); 2 December 1986, 'broad-billed prion site' (Kim Morrison 2017, *ibid*.).

Chalky Inlet

Zero Nugget [46.0351°S 166.5132°E], 24 August 1986. Finger Rock [46.0356°S 166.5186°E], 24 August 1986. Both listed as 'broad-billed prion sites' by Kim Morrison (*pers. comm*. to CMM, 14 July 2017).

Sooty shearwater (*Puffinus griseus*)

Poison Bay

Unnamed islet [44.6451°S 167.6318°E], 13 June 1978, burrows (Kim Morrison, FNP Island Survey Form).

Doubtful Sound

Nee Island [45.2467°S 166.8711°E], 3 October 1975, burrows numerous on top (Kim Morrison, FNP Island Survey Form). Shelter Islands [45.2703°S 166.8934°E], 10 & 13 October 1974, burrows numerous on top of smaller [western] island (Kim Morrison, FNP Island Survey Form). Seymour Island [45.3074°S 167.0067°E], 30 January 1975, few burrows, 1 egg (Kim Morrison, FNP Island Survey Form).

Breaksea Sound

Unnamed islet north of entrance [ID ISLAND 699, 45.5567°S 166.6666°E], 18 October 1981, burrows (Kim Morrison 1982, Report on a visit to islands in Breaksea and Dusky Sounds, October, 1981). Breaksea Island [45.5780°S 166.6389°E], 6-11 December 1974, 62 counted, common breeding (Kim Morrison 1975, Report on visit to Breaksea Sound, December, 1974; Bruce Thomas, Report on visit to Breaksea Island, the 'Seal Islands' and the Gilbert Islands, Fiordland, December, 1974); 13 & 16 February 1983, many burrows on south-east ridge (Kim Morrison 1983, Report on a visit to Breaksea & Dusky Sounds, February 1983). Hawea Island [45.5910°S 166.6437°E], 12 & 17 December 1974, heavy concentration of burrows (Thomas, *ibid*.).

Inner Gilbert 1 [ID ISLAND 666, 45.6026°S 166.6513°E], 14 December 1974, 34 adults, breeding (Morrison 1975, *ibid*.); 3 February 1983, burrows in use (Kim Morrison 1983, *ibid*.). Inner Gilbert 2 [ID ISLAND 110, 45.6007°S 166.6597°E], 14 December 1974 & 19 October 1981, burrows (Thomas, *ibid*.; Morrison 1975, *ibid*.). Inner Gilbert 5 [ID ISLAND 111, 45.5994°S 166.6711°E], 14 December 1974, few burrows, 1 egg (Thomas, *ibid*.). Inner Gilbert 7 [ID ISLAND 112, 45.5986°S 166.6820°E], 16 December 1974, burrows present, 1 corpse (Morrison 1975, *ibid*.; Thomas, *ibid*.); 20 October 1981, burrows (Morrison 1982, *ibid*.). Entry Island [45.5953°S 166.7023°E), 19 March 1979, few burrows (Kim Morrison, FNP Island Survey Form).

Outer Resolution Island

Unnamed islet near Woodhen Cove [ID ISLAND 619, 45.6234°S 166.5438°E], 17 October 1981, heard in burrows (Morrison 1982, *ibid*.).

Acheron Passage

Unnamed islet [ID ISLAND 586, 45.6548°S 166.7184°E], 19 March 1979, few burrows, 1 egg (Kim Morrison, FNP Island Survey Form).

Dusky Sound

'North' Petrel Island [ID ISLAND 66, 45.7353°S 166.5206°E], 14 February 1984, burrows common from 50 m a.s.l. to summit (Kim Morrison 1984, Report on a visit to Doubtful, Breaksea & Dusky Sounds, February 1984). 'Petrel Islet' [ID ISLAND 65, 45.7376°S 166.5227°E], 14 February 1984, burrows common at southern end (Kim Morrison 1984, *ibid*.). 'Main' Petrel Island [ID ISLAND 64, 45.7413°S 166.5148°E], 14 February 1984, a few old burrows at western end (Kim Morrison 1984, *ibid*.). Unnamed islet south-west of Prove Island [ID ISLAND 323, 45.7683°S 166.5539°E], 8 February 1983, moderately burrowed, many droppings (Kim Morrison 1983, Report on a visit to Breaksea & Dusky Sounds, February 1983). 'Northern Seal Islet' [ID ISLAND 56, 45.7749°S 166.4796°E], 14 February 1984, burrows common under 30 m long *Hebe* clump (Kim Morrison 1984, *ibid*.). 'Seal Island west' [ID ISLAND 51, 45.7809°S 166.4776°E], 15 February 1984, burrows common (Kim Morrison 1984, *ibid*.). 'Seal Islet 1' [ID ISLAND 53, 45.7780°S 166.4796°E], 15 February 1984, burrows common on crests and points (Kim Morrison 1984, *ibid*.). Seal Islands [probably 'Seal Island east', ID ISLAND 54, 45.7784°S 166.4836°E], 6 April 1977, numerous burrows (Kim Morrison, FNP Island Survey Form). 'Seal Island east', 15 February 1984, burrows common on upper slopes (Kim Morrison 1984, *ibid*.). 'Seal Islet 2' [ID ISLAND 47, 45.7803°S 166.4822°E], 8 February 1983, a few old burrows (Kim Morrison 1983, *ibid*.) [this islet was overrun by fur seals in 2016]. 'Southern Seal Islet' [ID ISLAND 41, 45.7819°S 166.4839°E], 7 February 1983, summit moderately burrowed, fresh sign (Kim Morrison 1983, *ibid*.). 'Many Island 1' [ID ISLAND 308, 45.7753°S 166.4998°E], 15 February 1984, a few disused burrows (Kim Morrison 1984, *ibid*.). 'Many Island 4' [ID ISLAND 276, 45.7794°S 166.5000°E], 15 February 1984, burrows abundant (Kim Morrison 1984, *ibid*.). Unnamed islet on south side of Dusky Sound [ID ISLAND 253, 45.8011°S 166.4953°E], 7 February 1983, burrowed on summit and east slope, burrows in use (Kim Morrison 1983, *ibid*.).

Chalky Inlet

Chalky Island [46.0490°S 166.5236°E], 24-28 March 1973, moderate numbers, breeding (C.R. Veitch, C.W. Brown, D.J. Murphy & A. Cragg, FNP Island Survey Form); 31 October 1976, burrows (Ron Nilsson *in* Report on Preservation Inlet/Solander Islands).

Preservation Inlet

Spit Island [46.0723°S 166.6315°E], 19 July 1978, a few burrows on seaward side (Kim Morrison, FNP Island Survey Form). Round Island [46.0871°S 166.6825°E], 15 July 1978, a few burrows on higher slope (Kim Morrison, FNP Island Survey Form).