

# **Observations of seabirds on the Auckland Islands and Campbell Island during the Australasian Antarctic Expedition 2013-14.**

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**Subantarctic skua on a nest Ewing Island.**

## ABSTRACT

The Australasian Antarctic Expedition 2013-14 presented an opportunity to add to existing knowledge on the distribution and abundance of seabirds on the Auckland Islands and Campbell Island. Here we report observations of cliff nesting species on Enderby Island (Auckland Islands). The distribution of burrow breeding petrels is poorly documented, especially so at the Auckland Islands where petrels were surveyed on Ewing, Masked and Figure of Eight Islands. Ewing Island is of particular interest as seabird abundance and diversity has apparently declined with the spread of an introduced tree daisy. As climate is projected to become more variable and sea conditions change, inshore foraging, sub-Antarctic birds such as penguins, shags and terns are likely to be affected. We review the data on shag and Antarctic tern numbers on the islands visited and recommend colonies for regular monitoring.

## INTRODUCTION

Two recent workshops, the first on research priorities for New Zealand breeding petrels and albatrosses (Wilson & Croxall 2012) and the second for seabirds in general (Wilson & Waugh 2013) have highlighted the urgent need for information on the breeding distributions and abundance of seabirds in the New Zealand region. Similarly, two recent papers (Waugh *et al.* 2013; Jamieson *et al.* 2016) noted the paucity of recent information on shearwaters (*Puffinus* spp) and prions (*Pachyptila* spp) respectively. These publications show that of all the island groups in the New Zealand region the least known are the Auckland Islands, and of all seabird groups the least known are the burrow-breeding petrels. Information on the distribution and abundance of sub-Antarctic seabirds is of particular interest given the impact of present and projected anthropogenic climate change and associated marine changes on food availability (Trathan *et al.* 2007; Weimerskirch *et al.* 2003; Boyd *et al.* 2015). The impact climate change may have on seabirds is poorly studied in New Zealand although eastern rockhopper penguin (*Eudyptes filholi*) declines at Campbell Island appear to be correlated with changes in sea surface temperature (Cunningham & Moors 1994; Morrison *et al.* 2014), presumably linked to climate change. Declines in eastern rockhopper penguins and erect crested penguins (*Eudyptes sclateri*), several species of albatrosses, sooty shearwaters (*Puffinus griseus*) and southern elephant seals (*Mirounga leonina*) on the New Zealand sub-Antarctic islands have occurred in parallel with increasingly variable air and ocean temperatures (Turney *et al.* 2017). Fisheries bycatch has doubtless contributed to declines in albatross and shearwater populations (Richard & Abraham 2015; Waugh *et al.* 2008) but it is unlikely to have caused the observed decline in penguin (Morrison *et al.* 2014) and elephant seal numbers (Taylor & Taylor 1989).

A major review of the predicted impact climate change will have on Australian birds showed seabirds to be particularly vulnerable; especially those which forage locally, breed on remote islands, or those near the southern or northern limits of their distributions (Garnett & Franklin 2014). This would suggest that penguins, terns, skuas and shags breeding on the New Zealand sub-Antarctic Islands are likely to be among those seabirds most affected by climate change.

The Australasian Antarctic Expedition (AAE) 2013-14 (<http://www.spiritofmawson.com>.) presented an opportunity to obtain further data on the distribution and abundance of seabirds on the Auckland Islands and Campbell Island. The research priorities for seabirds while at the islands were;

1. To survey burrow-breeding petrels on the various islands visited; and
2. To census New Zealand Antarctic terns (*Sterna vittata bethunei*), subantarctic skuas (*Catharacta antarctica lonnbergi*), Auckland Island shags (*Leucocarbo colensoi*) and Campbell Island shags (*L. campbelli*) at those locations visited; and
3. Make other observations on seabirds as opportunity allowed.

The AAE 2013-14 was a multi-disciplinary research expedition and each day at the islands up to nine science teams were deployed to various locations within a 15 km radius of the expedition ship. The small number of days at each island group, weather and logistical constraints limited the time ashore at each location. In this report we present colony censuses and other observations of seabirds at the Auckland Islands and Campbell Island. New breeding records of seabirds on Masked and Figure of Eight Islands (Auckland Islands), Cossack Rock (Campbell Island) and the south coast of The Snares have been published separately (Wilson *et al.* in review).

## STUDY SITES AND ITINERARY

### Auckland Islands

The expedition arrived in Port Ross, Auckland Islands on 28 November 2013 aboard the MV *Akademik Shokalskiy*. As the ship passed Shoe Island that afternoon we noted large burrow entrances on the island's steep southern slopes; in places the ground was bare perhaps due to trampling by birds. The soil on this island was honeycombed with burrows and the ground was covered by prion bones in 1903 (Waite 1909), probably the result of skua kills.

On 29 November we spent the entire day on Enderby Island where we surveyed light mantled sooty albatross (*Phoebastria palpebrata*), Auckland Island shag and Antarctic tern colonies starting from at the point at -50.4952, 166.2648 on the north coast working clockwise back to Sandy Bay. We did not have time to visit Derry Castle Reef where another research team made observations for us.

On 30 November we visited Ewing Island landing on the stony spit at the south-western point of the island. We planned to walk around the perimeter of the island to survey Auckland Island shags, northern giant petrels (*Macronectes halli*) and Antarctic terns then cut across the island making a series of petrel burrow density plots. However, the incredibly dense *Olearia lyallii* forest proved too tangled to push through, too rotten to climb over and too low to crawl beneath; thus, we could survey only the western and southern coasts, and undertake burrow density plots in the south-western part of the island. Petrel burrows were counted in each of six 3 m radius burrow-density plots in *Olearia* forest in the south-western part of Ewing Island. The mean burrow density was 0.14/m<sup>2</sup> (0 - 0.3/m<sup>2</sup>) and of the 25 burrows inspected a sooty shearwater was seen in one and a Subantarctic diving petrel (*Pelecanoides urinatrix exsul*) in another. Other burrows were empty.

The ship moved south to Carnley Harbour overnight; on 1 December 2013 we visited Masked Island and Figure of Eight Island the following day. Seabird surveys were undertaken on both islands, the findings reported in a separate paper (Wilson *et al.* in review). Despite the close proximity of Masked island to the feral pig (*Sus scrofa*) infested mainland the luxuriant understory with palatable ferns including *Asplenium sp*, and large leafed megaherbs such as *Stilbocarpa polaris* indicates that pigs are absent from that Island. Mice (*Mus musculus*) were recorded on Masked Island in 1907 (Waite 1909) and both mice and feral cats (*Felis catus*) in 1973 (Taylor 1975).

Our visit to Figure of Eight Island on 2 December 2013 involved a 12 km journey by zodiac boat along almost the entire length of North Arm from our ship moored in Tagua Bay. Weather and sea conditions were vigorous allowing only an hour and 20 minutes ashore. The vegetation is low, open rata forest on hummocky ground over a sparse, youthful *Dracophyllum*, *Coprosma* and *Stilbocarpa* understory with a luxuriant ground cover of moss. The forest extends down to the coastal rocks with very little non-forested ground. No introduced mammals were recorded on Figure of Eight Island in 1973 (Taylor 1975) and we assume it remains free of introduced mammals. New Zealand sea lions (*Phocarctos hookeri*) breed on Figure of Eight Island; however, we encountered only six non-territorial male sea lions ashore with no sign of breeding activity. The luxuriant moss cover suggested sea lions had not bred on this island for at least a year.

Our surveys of seabirds on Masked and Figure of Eight Islands has been reported in a separate paper (Wilson *et al.* in review), in this report we present other observations of seabirds in Carnley Harbour.

## **Campbell Island**

We arrived at Campbell Island on 3 December 2013. For the remainder of that day and part of 4 December we were ship based in Perseverance Harbour. In the evening of 4 December, the ship stood off Northeast Harbour. That evening we circumnavigated Cossack Rock then cruised along the length of Northeast Harbour in a zodiac searching for wildlife. Cossack Rock is a small, completely cliff-bound island; it is flat-topped with a carpet of tussock grassland.

## **METHODS**

At each location visited we endeavoured to make the best use of the time available to add to the existing data on seabird status. Our primary objective was to determine the seabird species breeding at each location and where possible estimate their numbers. Our approach varied location to location taking into account prior knowledge of the species present, any previous quantitative surveys with which we could compare our counts and time available. For example, on Enderby Island where the island is too large to obtain meaningful data on the density of burrow-breeding petrels or yellow-eyed penguins (*Megadyptes antipodes*) our priority was a census of Auckland Island shags to compare with counts undertaken in 1988, 1989 and 2011/12 (Taylor 1988, Moore & McClelland 1990, Chilvers *et al.* 2015). Whereas on Masked and Figure of Eight Islands (Auckland Islands)

where there was no prior data on seabirds present, our priority was to determine which species were breeding there.

Burrow density plots were carried out using a rope knotted at 1 m intervals tied to a central point to count the number of burrows in a 3 m radius (28.3 m<sup>2</sup>) plot. To avoid double counting and to minimize the chance of missing burrows two people searched together. The outer person held the rope taut, the inner searcher checking each burrow as it was found, the pair slowly moving the rope around the circle back to the marked start point. Burrows were inspected using a burrowscope (Sextant Technology, <http://www.s-t.co.nz/burrowscope>) and species present recorded. On each Island visited (except Enderby Island) we inspected as many burrows as time allowed to establish which burrow-breeding species were present.

During land-based coastal surveys we counted birds using binoculars from observation points that gave the best view of areas likely to support seabird colonies. During boat based surveys the distance from the cliffs varied in order to safely obtain the optimal view of likely seabird breeding sites.

## **RESULTS**

### **Port Ross, Auckland Islands**

#### *Yellow-eyed penguin*

The Yellow-eyed penguin populations on Enderby Island have been surveyed on several occasions (Moore 1992; Chilvers 2014). It was not possible to get meaningful data given our time constraints, so we did not search for penguin nests. However, during our visit to Enderby Island on 29 November 2013 we came across two yellow-eyed penguins near the cliff edge at the western end of Ihupuku Bay, two near the cliff edge on the eastern side of Whakahao Bay and two others between North East Cape and Pebble Point. Yellow-eyed penguins were also seen near Sandy Bay where these penguins have regularly been counted (Chilvers 2014).

One yellow-eyed penguin was seen on the southern side of Shoe Island as the ship steamed past on 28 November. Three yellow-eyed penguins and five sites where this species had moulted were encountered in the dense *Olearia* forest on the south-western promontory of Ewing Island on 30 November 2013.

#### *Light mantled sooty albatross*

On 29 November 2013, 55 mound-type nests were counted on a headland west of Ihupuku Bay, Enderby Island (-50.4889, 166.2861). Four nests were occupied by a single light mantled sooty albatross in incubating pose, all other nests were vacant. Taylor (1988) found one nest, a chick and three adult albatrosses there in February 1988 and one pair had been seen in December 1972 (K-JW unpublished). Auckland Island shags have been recorded nesting in this area (Chilvers *et al.* 2015) and some nests may have been constructed by shags.

### *Northern Giant petrel*

On 30 November 2013, 12 half-grown northern giant petrel chicks were counted at the edge of the coastal *Olearia* forest near the south-western tip of Ewing Island, where 25 chicks had been seen in November 1989 (Moore & McClelland 1990). Moore & McClelland also found at least five chicks on the south-eastern point of this island. Only eight chicks were counted on Ewing Island on 3 December 2015 (Parker *et al.* 2016), indicative of a declining population. This species was not found nesting on Ewing Island in 1972/73 (Moore & McClelland 1990).

### *Sooty shearwater*

Of the 25 burrows found in the burrow density plots on Ewing Island only one contained a sooty shearwater. One other sooty shearwater was found in another burrow on that island. At The Snares most sooty shearwater eggs are laid between 20 and 24 November with just a few in the first few days of December (Warham *et al.* 1982) thus, by 30 November we would expect most burrows used by breeding pairs of these shearwaters to be occupied, suggesting that sooty shearwaters are now uncommon on Ewing Island where they were common in 1988 and 1989 (Moore & McClelland 1990, Taylor 1988).

### *Subantarctic diving petrel*

Of the 25 burrows found in burrow density plots on Ewing Island one contained a pair of Subantarctic diving petrels which were captured and standard measurements taken (Table 1). Other small burrows in the coastal *Olearia* forest on Ewing Island were probably also used by this species. This was the most abundant small petrel breeding on Ewing Island in 1989 (Moore & McClelland 1990).

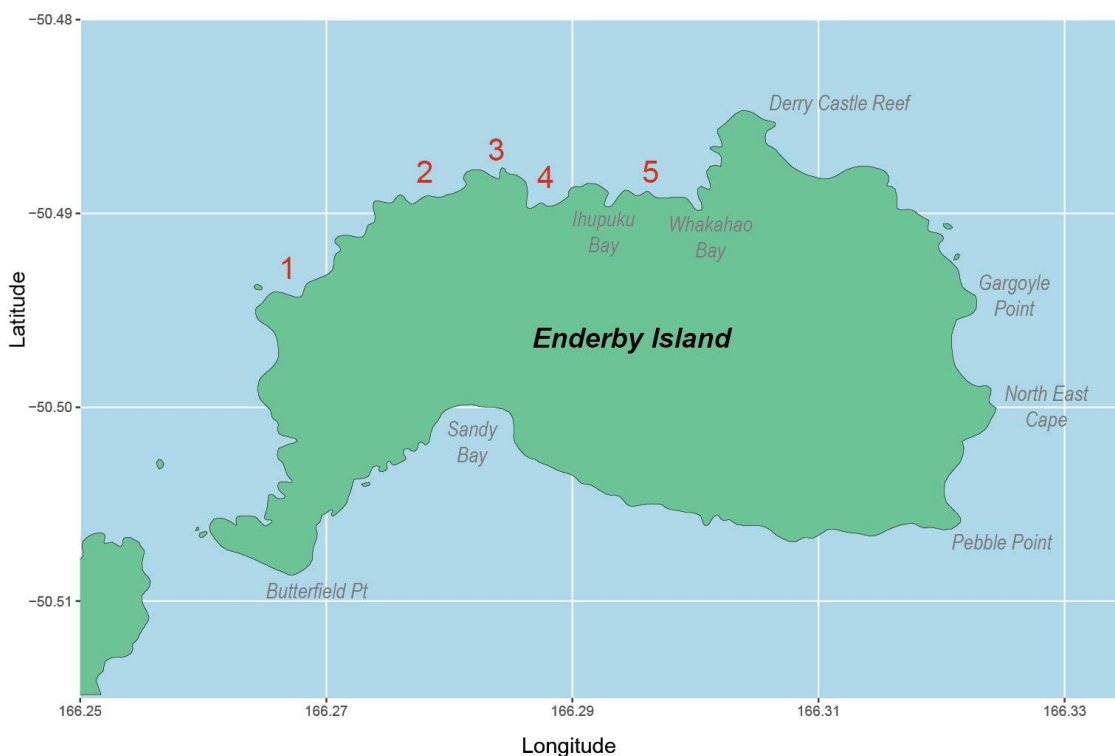
**Table 1.** Standard measurements of a pair of Subantarctic diving petrels found together in a burrow on Ewing Island.

	Weight gm	Bill length mm	Bill width mm	Bill depth mm	Wing mm	Tarsus mm
Bird 1	145	17.2	8.5	10.2	122	23.5
Bird 2	150	17.4	9.6	11.1	124	24.4

## Auckland Island shag

Auckland Island shag colonies along the northern and eastern coasts of Enderby Island were surveyed on 29 November 2013. The numbers of birds and occupied nests counted at each location is given in Table 2 together with counts made at those locations in 1988 (Taylor 1988), 1989 (Moore & McClelland 1990) and 2011/12 (Chilvers *et al.* 2015). Of all the previous counts only the North East Cape colony had been counted in November; their count of 90 nests on 19 November 1989 is close to our >80 nests (not all nests were visible from our observation point) on 29 November 2013.

Moore & McClelland (1990) counted 306 shag nests on the south-eastern cliffs of Ewing Island on 30 November 1989 where Taylor (1988) noted a very large colony in February 1988. Shags were breeding there in 2013 but we were unable to visit that colony.



**Figure 1.** Enderby Island showing locations of Auckland Island shag colonies where counts were made on 29 November 2013.

**Table 2.** Counts of Auckland Island shag nests on the northern and eastern coasts of Enderby Island in February 1988 (Taylor 1988), November 1989 (Moore & McClelland 1990), December 2011 and 24 January- 1 February 2012 (Chilvers *et al.* 2015) plus our nest and bird counts on 29 November 2013.

Place name	Latitude	Longitude	No. nests Feb 1988	No. nests 19 Nov 1989, from land	No. nests 24 Dec 2011 from boat	No. nests Jan - Feb 2012 from land	No nests 12 Jan 2012 from helicopter	No. nests 29 Nov 2013	No. birds 29 Nov 2013
1	- 50.4940	166.2685			0	-		0	>3
2	- 50.4913	166.2729	present		23	0	16	8	8
3	- 50.4880	188.28250			82	38	112	0	0
4	- 50.4895	166.2877	246		81	138	232	9	9
5	- 50.4894	166.2933			93	46	71	14	17
Whakahao Bay	- 50.4895	166.2979			88	70	70	>30	>85
Gargoyle Pt.	- 50.4945	166.3224	136	120	407	394	479	-	-
North East Cape	- 50.5005	166.3239	83	90	104	115	301	>80	>120

*Subantarctic skua*

We saw about 25 skuas along the north coast and about 15 on the east coast of Enderby Island on 29 November 2013. None of those seen by us were aggressive, many were in flight, moving to and fro along the coast preventing more accurate counts. We did not find any nests however, that day Greg Mortimer found one nest near Derry Castle Reef. In February 1988 there were 11 pairs of skuas nesting on Enderby Island plus about 25 non-breeders (Taylor 1988).

On 30 November 2013 a subantarctic skua was incubating eggs in a nest on the stony spit at the western extremity of Ewing Island.



*Red-billed gulls (Larus novaehollandiae scopulinus)* and *southern black-backed gulls (L. dominicanus dominicanus)*

We did not record either red-billed or black-backed gulls nesting at those Port Ross localities visited by us. There was a small red-billed gull colony at Boat Bay, Ewing Island in 1989 (Moore & McClelland 1990) and both species bred in small numbers on Enderby Island in 1988 (Taylor 1988).

*Antarctic tern*

On 29 November 2013 we encountered two pairs of Antarctic terns, neither yet on nests, on headlands west of the board walk on Enderby Island, where a few were nesting in December 1972 (K-JW unpublished). On 29 November 2013, Brent Bevan counted about 80 Antarctic terns with about 20 nests on Derry Castle Reef where they were breeding in December 1972 (K-JW unpublished).

### **Carnley Harbour, Auckland Islands**

*Sooty shearwater*

Sooty shearwaters were numerous in Carney Harbour and going to and from Figure of Eight Islands we passed through a raft of several hundred off Musgrove Peninsula. We found them breeding on both Masked and Figure of Eight Islands (Wilson *et al.* in review). There were no previous records of any petrels breeding on these islands.

*White-headed petrel (Pterodroma lessonii)*

On 1 December 2013, four white-headed petrels were found in burrows on Masked Island and next day they were seen incubating in three of the burrows we burrowscoped on Figure of Eight Island (Wilson *et al.* in review).

*Antarctic prion (Pachyptila desolata)*

Prions, presumably Antarctic prions, were found in two burrows on Masked Island on 1 December 2013 (Wilson *et al.* in review). A dead prion, probably an Antarctic prion, was found in a skua midden on Figure of Eight Island but none were found in those burrows we inspected on that island.

*Northern giant petrel*

On 2 December 2013 two Northern giant petrels were seen in flight near Figure of Eight Island but there is no evidence of them ever breeding there (Parker *et al.* 2016).

### *Auckland Island shag*

On 2 December 2013, seventeen Auckland Island shags were seen roosting, but not breeding on the eastern end of Figure of Eight Island. On the boat journey to that island we counted about 40 shags roosting on Flagstaff Point, Musgrave Peninsula with about 70 seen there on the return journey (accurate counts proving impossible from a moving zodiac in rough seas). In addition, there was a raft of about 50 Auckland Island shags just west of Musgrave Peninsula and 6 on nearby Haskell Pt. Auckland Island shags were seen on coastal rocks on Masked Island but they did not appear to breed on that island. These counts suggest that there must have been about 200 Auckland Island shags in the North Arm of Carnley Harbour on 2 December 2013. Auckland Island shags were numerous in North Arm, Carnley Harbour in 1907 and 1912 (Waite 1909; Falla 1937). These shags were present on Figure of Eight Island in June 1912 and the description of that visit implies they were breeding there (Falla 1937).

### *Subantarctic skua*

A pair of Subantarctic skuas were nesting at each end of Figure of Eight Island (Wilson *et al.* in review). Skuas were seen at Masked Island but they did not appear to breed on that island.

### *Red-billed gull*

Red-billed gulls were seen on Figure of Eight Island but they did not appear to be breeding there.

### *Southern black-backed gull*

Black-backed gulls were seen on both Masked and Figure of Eight Islands but they did not appear to breed on either island. Black-backed gulls bred on Masked Island in 1907 (Waite 1909).

### *Antarctic tern*

Antarctic terns appeared to be uncommon in North Arm, Carnley Harbour. During five ten-minute observation periods undertaken from the ships bridge 1-2 December 2013, a total of eight Antarctic terns were seen, plus an additional six seen outside those observation periods. Stormy weather prevented close inspection of the shore line where these terns may possibly breed.

## Campbell Island

### *Yellow-eyed penguin*

Seventeen yellow-eyed penguins were seen during the two and a half hours of systematic ship based observations in Perseverance Harbour (Table 3). Of these 10 were seen ashore, one in the bay east of Davis Point, one on the southern shore southwest of Davis Point and seven on a steep slope on the southern coast of the Harbour southeast of De la Vire Point. These are all locations where yellow-eyed penguins have been recorded breeding in previous surveys (Moore 1992; Moore *et al.* 2001).

During 30 minutes of systematic shipboard observation between East Cape and Northeast Harbour, five yellow-eyed penguins were seen off Smoothwater Bay. Additionally, two were seen at sea near Cossack Rock and five in the outer third of Northeast Harbour where this species is known to be common (Moore 1992; Moore *et al.* 2001).

### *Northern giant petrel*

One northern giant petrel chick was found near the whalers' try pots at Northeast Harbour.

### *Snares Cape petrel (Daption capense australe)*

Snares Cape petrels were seen patrolling the cliffs on both sides of the Cossack Rock and one was seen landing on a ledge, suggesting a few Cape petrels breed on this island (Wilson *et al.* in review).

### *Campbell Island shag*

Campbell Island shags were common in both Perseverance and Northeast Harbours. During 2.5 hours of ship-board observations in Perseverance Harbour, 129 Campbell Island shags were recorded (Table 3) but we found no sign of them nesting within the Harbour. They were evenly distributed along the length of Perseverance Harbour with feeding flocks of 38 off Beeman Point at the inner end of the Harbour, 13 near Davis Point at the Harbour entrance and 20 midway between these locations.

Six Campbell Island shags were seen near the entrance to Northeast Harbour and three others in the seaward third of the Harbour. On 4 December only one was seen during 30 minutes of systematic observation between East Cape and Northeast Harbour. On 3 December 2015 when approaching Campbell Island these shags were first seen when about 5 km north of the island.

A survey of Campbell Island shag breeding colonies in 1975-76 found them nesting only on the outer coast of Campbell Island and on some of the satellite islands; the total population was estimated to be about 2000 pairs (van Tets 1980).

**Table 3.** Birds recorded during 15 ten-minute observation periods of shipboard observations in Perseverance Harbour, Campbell Island.

	Total seen	No./hour
Southern royal albatross ( <i>Diomedea epomophora</i> )	23	9.2
Campbell blackbrow albatross ( <i>Thalassarche impavida</i> )	1	0.4
Light mantled sooty albatross	9	3.6
Snares cape petrel	9	3.6
Northern giant petrel	5	2
Sooty shearwater	14	5.6
Yellow-eyed penguin	17	6.8
Campbell Island shag	129	51.6
Subantarctic skua	7	2.8
Black-backed gull	76	30.4
Red-billed gull	46	18.4
Antarctic tern	59	23.6

#### *Subantarctic skua*

One skua was seen flying over Cossack Rock suggesting that a pair nested there.

#### *Antarctic tern*

During the two and a half hours of systematic shipboard observations in Perseverance Harbour, 59 Antarctic terns were seen (Table 3). They were recorded in all but one 10 minute observation period and were evenly distributed along the length of the Harbour. Six were recorded in 30 minutes of shipboard observations between East Cape and Northeast Harbour. Five Antarctic terns were seen on the northern coast of Northeast Harbour less than 1 km from the entrance. These were territorial suggesting two or three pairs bred there. Three Antarctic terns were observed at the inner end of Northeast Harbour.

#### *Campbell Island teal (Anas nesiotis)*

A pair of Campbell Island teal were seen foraging along the shore line near the trytops at the inner end of Northeast Harbour.

## *New Zealand sea lion*

We discovered a group of New Zealand sea lions on a rocky ledge on the southern shore (-52 31.017'S 169 12.588'E) of Northeast Harbour. We counted five mature males, 14 females, five young males ashore, plus five additional males in the water.

## **DISCUSSION**

Wise management of the sub-Antarctic Islands and their bird faunas requires knowledge of which species nest on each island, within each island archipelagos plus accurate counts of representative colonies for each species, repeated at predetermined intervals to assess population trends. On the Auckland and Campbell Islands even the distribution of seabird breeding sites is inadequately recorded and population trend data is available only for some species of albatross (ACAP 2009a,b, 2010, Sagar 2013; Elliott & Walker 2005), rockhopper penguins on Campbell Island (Morrison *et al.* 2014) and for yellow-eyed penguins on Enderby Island (Chilvers 2014) with some older counts on Campbell Island (Moore *et al.* 2001). Globally seabirds are one of the most threatened groups of birds (Croxall *et al.* 2012), and this will only worsen with increased climate variability and long-term ocean warming (Armour *et al.* 2016; Morrison *et al.* 2014; Garnett & Franklin 2014; Turney *et al.* 2017), plus the insidious and rapidly growing threat from plastic ingestion (Wilcox *et al.* 2015).

The Auckland Island and Campbell Island shags have restricted distributions and, as inshore foragers are presumably sensitive to changes in local marine conditions. Determining population trends should be a priority but it is difficult to compare the various counts carried out on Enderby Island the only place where repeated counts have been made. Shags tend to have extended and asynchronous breeding seasons not always returning to the same colony. In December 1972 some hundreds of Auckland Island shags nested on the eastern cliffs, others along the northern coast with smaller numbers between Sandy Bay and Butterfield Point (K-JW unpublished); distributions similar to those mapped by Taylor (1988), Chilvers *et al.* (2015) and us (Fig 1). While shag distributions have remained broadly similar, each of these surveys showed colonies not recorded in the others, suggesting movement between sites. There were 90 nests at North East Cape in November 1989 (Table 3), similar to our count of >80 on 29 November 2013. Other counts vary greatly but whether this is a result of population trends, methodology or time of year is inconclusive.

The only full island counts were made during the 2011/2012 summer and the three different methods used showed that land based, and boat based counts were 27% and 26% respectively lower than the count of 1889 nests made from a helicopter (Chilvers *et al.* 2015). The only other estimate of the Enderby Island shag population was made in February 1988; based on a count of >475 nests from cliff-top vantage points, Taylor (1988) estimated there to be at least 500 pairs.

Egg laying for the Auckland Island shag extends from November to February (Marchant & Higgins 1990) but there is no information on when peak laying may be. The counts made in December 2011 and January 2012 are higher than any November or February count (Table 3),

suggesting that December or January may be the optimal months for monitoring Auckland Island shag populations. Alternatively, there may have been more shags present in 2011/12 than in the other seasons, or that there has been a redistribution of shags within the Auckland Island Archipelago. There has only ever been one census of Campbell Island shags (van Tets 1980) although the population is assumed to be stable.

There have been several opportunistic counts of Antarctic terns on Enderby Island. In February and March 1982 there were estimated to be more than 150 Antarctic terns on Enderby Island including 36 at Derry Castle Reef (Thomson 1986) and over 30 north-west of Sandy Bay (Penniket 1986). In February 1988 Taylor (1988) counted at least 54 pairs of Antarctic terns on Enderby Island; all counts in line with the 80 birds and about 20 nests reported by Brent Bevan on 29 November 2013.

Enderby Island is the most frequently visited of the Auckland Islands; it probably hosts the largest population of Auckland Island shags and is a major breeding ground for Antarctic terns. We recommend island wide surveys of both species at three to five yearly intervals.

Although neither Figure of Eight nor Masked Island support large populations of seabirds we have recommended full surveys be undertaken on each (Wilson *et al.* in review). Both islands are small, the habitat easy to work in and a full survey of breeding seabirds could be undertaken in under one day for each island.

The low burrow occupancy found by us on Ewing Island (this study) and on Masked and Figure of Eight Islands (Wilson *et al.* in review) does not necessarily indicate that so few burrows remain in use. On Ewing Island four medium diameter burrows in the burrow density plots had white feathers near their entrances and these are likely to belong to white-headed petrels. These birds lay between 19 November and late December and are absent from their breeding colonies immediately before egg laying (Marchant & Higgins 1990) thus, many burrows used by this species would be cleaned out but not occupied on 30 November. Sixteen of the 25 burrows in the Ewing Island plots were small, no bird was present, but the burrows had been cleaned out with nesting material in place. Of the three species most likely to use small burrows on that island, Antarctic prions lay late November to December, black-bellied storm petrels (*Fregetta tropica*) December to January, and only Subantarctic diving petrels are likely to have virtually completed egg-laying by the end of November (Marchant & Higgins 1990).

Of the Auckland Islands, Ewing Island is of particular interest. In the 1970s and 1980's Ewing Island probably supported a greater diversity of burrow breeding petrels than other islands in the Port Ross area (Moore & McClelland 1990, Taylor 1988) including probably the largest colony in the New Zealand region of the rare Auckland Island fulmar prion (*Pachyptila crassirostris flemingi*) (Tennyson & Bartle 2005). In the 1980's white-chinned petrels (*Procellaria aequinoctialis*), sooty shearwaters (common), white-headed petrels, Subantarctic diving petrels, Antarctic prions and three species of storm-petrels (Moore & McClelland 1990, Taylor 1988) were recorded breeding on Ewing Island. In December 1972 we found sooty shearwaters, white-chinned petrels, white-headed

petrels, diving petrels, black-bellied storm petrels, yellow-eyed penguins and Subantarctic skuas breeding on Ewing Island (K-JW unpublished). Just 33 breeding pairs of white-chinned petrels were counted on this island in December 2015 (Rexer-Huber *et al.* 2016). Although confined to just one part of the island, the low burrow density measured by us (mean 0.14 burrow/m<sup>2</sup>), with large areas away from the coastal fringe devoid of burrows, suggests that relatively few burrowing petrels still nest on this island.

Ewing Island was the first site in the Auckland Islands where the tree daisy *Olearia lyallii* became established and since its arrival in the early 19<sup>th</sup> century it has spread to form a near monotypic forest over most of that island (Wilmshurst *et al.* 2015). In the past there was a coastal fringe of open habitat suited to nesting by giant petrels, skuas and Auckland Island shags, however, the *Olearia* forest now extends down to the cliff edge or coastal rocks along almost the entire Ewing Island coast. Other than the open habitat on the stony spit at the western end of the island, there was just one other small patch of non-forest vegetation on west facing coasts. We were unable to survey the eastern parts of the island. The *Olearia* forest is now denser and less penetrable than it was in 1972/73 when in a few hours K-JW walked around the perimeter and across the centre of the island. The *Olearia lyallii* forest is now so thick and tangled that it is impossible to walk more than a few metres and almost impossible to push through or scramble beneath the fallen trunks and tangled branches. In November 1989, Moore & McClelland (1990) made bird transects across the island in 40-45 minutes suggesting that the forest was then considerably easier to walk through than it was in 2013.

Seabird abundance and possibly diversity appears to have declined since the 1970's and 1980's coincident with the spread of *Olearia*. No introduced mammals were recorded on Ewing Island in 1973 (Taylor 1975) thus, predation is unlikely to have caused any such decline. With both birds and vegetation described at several occasions over the last 50 years Ewing Island presents an opportunity to better understand the relationship between seabirds and vegetation. It is curious that burrow density was so low in *Olearia* forest on Ewing Island yet, the same monotypic forest on The Snares supports huge numbers of burrow-breeding petrels (Miskelly *et al.* 2001; Warham *et al.* 1982).

As seas and climate warm, those seabirds which forage locally, breed on remote islands, or those near the southern or northern limits of their distributions are most likely to be affected (Garnett & Franklin 2014). This would suggest that penguins, terns, skuas and shags breeding on the New Zealand sub-Antarctic Islands are likely to be among those seabirds most affected by climate change. Colonial breeding penguins, Antarctic terns and some shags are relatively easily monitored and, with good baseline data, could serve as a proxy for changes in the marine environment. Accurate counts of these species are urgently required. The least known of the seabirds are the burrow breeding petrels, despite New Zealand having a number of endemic and/or threatened species and globally important populations of others. Two recent papers on distribution and abundance of shearwaters and prions in the New Zealand region (Waugh *et al.* 2013, Jamieson *et al.* 2016) stress the paucity of information on distribution, abundance and population trends for most petrel species.

Based on our own observations, any previous estimates and considering access issues we recommend the following populations are suitable for future monitoring; Auckland Island shags, Antarctic terns and yellow-eyed penguins on Enderby Island; northern giant petrels on Ewing Island and all species on Figure of Eight and Masked Islands. Ewing Island has previously been identified as a priority site for monitoring fulmar prion (Jamieson *et al.* 2016) and northern giant petrel (Parker *et al.* 2016) population trends. On Campbell Island we recommend regular monitoring of Campbell Island shags, yellow-eyed penguins and rockhopper penguins.

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