

Holocene bird bones found at the subantarctic Auckland Islands

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ABSTRACT: More than 3,500 Holocene bones, representing at least 853 individual birds, have been recovered on the uninhabited subantarctic Auckland Islands, south of New Zealand. Today this island group has a rich seabird and land-bird fauna, although there have been at least four bird extinctions (a duck, two petrels and a plover) due to predation by introduced mammals and hunting by humans. The Holocene bone fauna, overwhelmingly from sand dunes on Enderby Island, is dominated by seabirds still found at the island group (particularly diving petrels *Pelecanoides* spp., southern royal albatrosses *Diomedea epomophora*, and prions *Pachyptila* spp.). Remains of all endemic taxa (apart from the Auckland Island tomtit *Petroica macrocephala marrineri*) were recovered from the deposits. All the taxa known to have gone extinct at the island group have now been recovered in Holocene bone deposits, except for the shore plover (*Thinornis novaeseelandiae*). The deposits indicate also that the abundance of other species has changed. For example, both the eastern rockhopper penguin (*Eudyptes filholi*) and white-chinned petrel (*Procellaria aequinoctialis*) are common in the Enderby Island deposits but are rare on the island today, and the Auckland Island rail (*Lewinia muelleri*) is present as bones in these dunes but has no historical records from the island. This information on the prehistoric distributions of birds will assist the management of the avifauna of the Auckland Islands, which is currently the subject of a major ecological restoration programme.

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Introduction

The subantarctic Auckland Islands (Maukahuka/Motu Maha, 50°44'S, 166°05'E), south of New Zealand, have a rich and important bird fauna that has suffered many impacts from human modification. This rugged island group, predominantly formed by Miocene volcanic rocks, consists of many islands covering c. 56,750 ha that extend 51 km north to south (Miskelly *et al.* 2020 – Chapter 2 in this book). While the islands show extensive evidence of glaciation, the ice cap and glaciers apparently pre-dated the Last Glacial Maximum and subsequent Antarctic Cold Reversal 28,000–13,000 years ago, and so forest, shrublands, and grasslands are likely to have persisted through this period to the present day (Miskelly *et al.* 2020 – Chapter 2).

The avifauna consists of at least 46 breeding species, with a further 76 migrants, vagrants, and failed colonisers (Miskelly *et al.* 2020 – Chapter 2). Four species are thought to have become extinct historically at the Auckland Islands – Auckland Island merganser (*Mergus australis*) (in 1902); South Georgian diving petrel (*Pelecanoides georgicus*) (soon after 1943); white-faced storm petrel (*Pelagodroma marina*) (no records since 1989); and shore plover (*Thinornis novaeseelandiae*), which is represented by a single specimen (collected in 1840) (Miskelly *et al.* 2020 – Chapter 2). The New Zealand raven (*Corvus antipodum*) may also have become extinct, although it is currently regarded as a vagrant to the Auckland Islands as only a single bone has been found (Dawson 2020 – Chapter 8 in this book). [Note that Fischer *et al.* (2018) proposed the name Whenua Hou diving petrel *Pelecanoides whenuahouensis* for 'South Georgian diving petrels' from the New Zealand region, including the birds previously found on Enderby and Dundas Islands in the Auckland Islands. We have chosen to retain the name South Georgian diving petrel *P. georgicus* (based on Gill *et al.* 2010) throughout this collection of papers to emphasise that it is the same taxon as referred to in all previous publications cited – Eds.]

The western coast of the Auckland Islands, being exposed to the prevailing westerly ocean flows, is dominated by towering cliffs. Where beaches occur on the more sheltered eastern coasts, most are boulder beaches while sandy beaches are rare.

Sand and gravel sites have provided the only areas where prehistoric bird bones have been found on the Auckland Islands. These give an insight into the past fauna of the island group. By far the most productive of these sites is the 20 ha of dunes behind Sandy Bay (50°30'S, 166°17'E; Fig. 1), on the southern shore of Enderby Island (695 ha), which borders Port Ross. In pre-human times this dune-field may have been largely covered in tussock vegetation (McFadgen & Yaldwyn 1984; Yaldwyn 1986; Anderson 2005). Much smaller deposits have been found in sand deposits on Dundas Island (this study), in a shell bank on Friday Island (this study), and in a cave at Tagua Bay, Carnley Harbour, Auckland Island (Anderson 2005, 2009; all sites shown in Fig. 1). Anderson (2009) reported shell deposits around Lindley Point, on the main Auckland Island to the west of Friday Island, that appear to be similar to those on Friday Island, and he concluded that these were 'probably a mixture of sea-lion midden and storm debris'.

As Enderby Island is at the more temperate northern end of the island group and its eastern coast is within the relatively sheltered Port Ross, Sandy Bay has been a focus of human activity since humans first reached the island group (Anderson & O'Regan 2000; Anderson 2005, 2009). Sandy Bay allows relatively easy boat landings and has continued to be the primary base for modern scientific research on the Auckland Islands, with the most longstanding study, since 1975, being on the New Zealand sea lion (*Phocarctos hookeri*) colony there (Miskelly & Taylor 2020 – Chapter 1 in this book).

Enderby Island has been extensively modified by humans, since the brief Polynesian settlement in the thirteenth to fourteenth centuries AD, which involved hunting and probable forest clearance (Anderson & O'Regan 2000; Anderson 2005, 2009). European discovery of the Auckland Islands occurred in 1806, followed closely by extensive sealing and whaling, along with intermittent habitation, hunting, and the introduction of several mammal species. Mammals released on, or that colonised, Enderby Island were: mouse (*Mus musculus*) (present from before 1840 until 1993), rabbit (*Oryctolagus cuniculus*) (present 1840–c. 1846 and 1865–1993), goat (*Capra hircus*) (present 1850, 1865–89, and 1890), dog (*Canis familiaris*) (present 1842–56 and 1887–95), pig (*Sus scrofa*) (present 1807–56 and 1867–87), horse

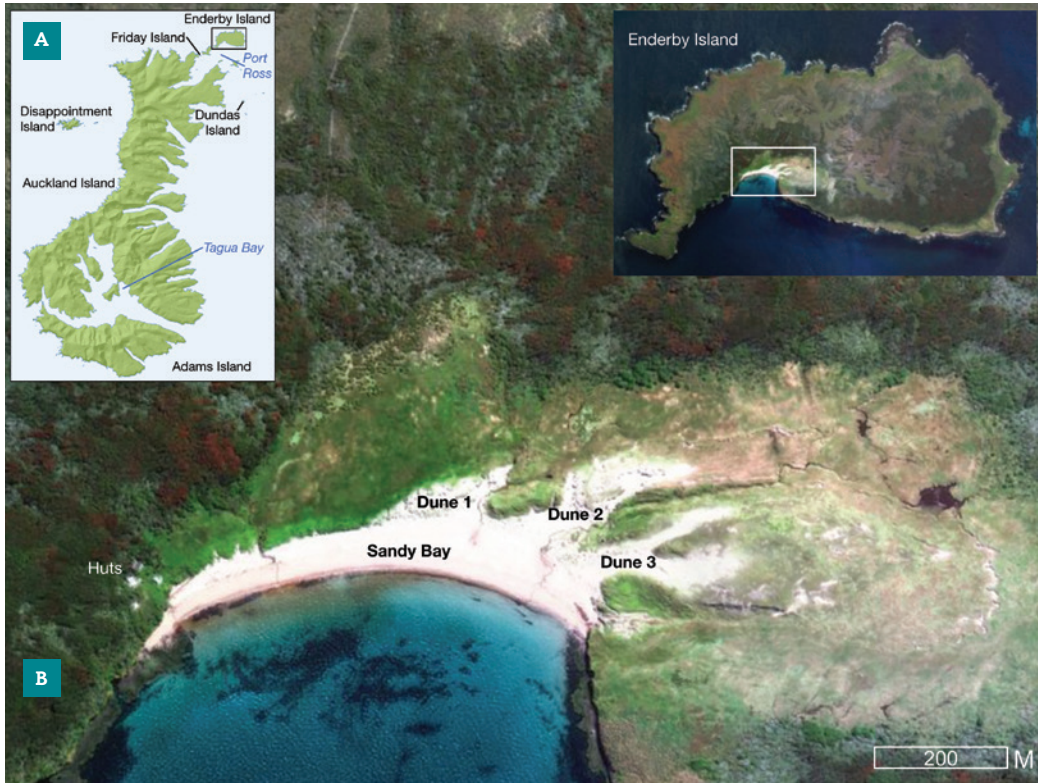


FIGURE 1. A. The Auckland Islands, showing the sites where Holocene bones have been collected. **B.** Sandy Bay, Enderby Island, showing the sites where Holocene bones have been collected. Inset box shows the location of Sandy Bay on Enderby Island.

(*Equus ferus*) (present 1849–52), sheep (*Ovis aries*) (present 1849–55 and 1890–1901), and cattle (*Bos taurus*) (present 1849–55 and 1894–1993) (Russell *et al.* 2020 – Chapter 6 in this book). There is some evidence of dogs being present during the prehistoric settlement (Anderson 2005, 2009); and a cat (*Felis catus*) mandible (Museum of New Zealand Te Papa Tongarewa collections (= NMNZ) S.42109) found in the Sandy Bay dunes on 18 Jan 1964 suggests that cats may have been present once also. However, other predators, such as rats (*Rattus* spp.), never became established. The last of the introduced mammals were eradicated in 1993 (Torr 2002; Russell *et al.* 2020 – Chapter 6), allowing the island to commence a natural recovery.

Bone deposits at Sandy Bay were first reported in Jan 1875, when Hermann Krone recorded the site as ‘covered abundantly with bleached bones, most particularly from the albatross and the birds of the coast’, and ‘skeletons lie about in large numbers, in as many different kinds as the animals of the island provide them . . . cormorants and albatross and seagulls and penguin; petrel too, the black variety,

is frequently represented among them’ (translated from the original German in Miskelly & Taylor 2020 – Chapter 1). The Senckenberg Natural History Collections of Dresden retain bones of probable southern royal albatrosses (*Diomedea epomophora*) collected by Krone (Miskelly & Taylor 2020 – Chapter 1). The deposits were also recorded by Ethel Richardson as she and her sisters, visiting from New Zealand, crossed the Sandy Bay sand hills on 25 Oct 1890: ‘we got some albatross bones on the sand so clean and white’ but later that day she tripped and ‘smashed all my albatross [sic] bones except one wishing bone’ (Cass 2014: 88–89). Ethel’s sister Fannie tripped later that day and ‘fell on an albatross beak she

was carrying and broke it against her eyebrow' (Cass 2014: 89). English explorer Edward Wilson, returning from Antarctica on the *Discovery* in 1904, also reported the deposits: 'On the beach just here are the remains of a lot of albatross, bleached bones, for which I couldn't account' (Wilson 1966: 350). Rowley Taylor noted bones (probably albatrosses) in the dunes at Sandy Bay in 1954 (R. Taylor, *pers. comm.*, 1 Jul 2019). He suggested that these albatross bones were midden remains from 'feasts' (R.H. Taylor 1971), but those that have been collected from surface exposures since the 1960s show no sign of having been eaten by humans (Yaldwyn 1986; Tennyson 2009; this study).

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More recently (since 1963), researchers have made sporadic collections from the Sandy Bay deposits (Yaldwyn 1986; Tennyson 2009; this study). John Yaldwyn in 1963, and Elliot Dawson in 1963 and 1964, were the first researchers to investigate the bone deposits in detail (Dawson 1964; Yaldwyn 1986). Yaldwyn (1986) described the royal albatross skeletons that he collected in 1963. Dawson (1964) reported bones of large albatrosses, and the Auckland Island rail (*Lewinia muelleri*) (no longer present on any islands in Port Ross), and the tarsometatarsus of an extinct raven (*Corvus antipodum*; the only record of this extinct taxon at the Auckland Islands; Dawson 2020 – Chapter 8). Bones representing at least one giant petrel (*Macronectes* sp.), prion (*Pachyptila* sp.), and sooty shearwater (*Ardenna grisea*) were collected from the Sandy Bay dunes on 29 Dec 1972 (Kerry-Jayne Wilson; Canterbury Museum AV.27274–27276), but these may be of recent origin. A further collection (now stored at the CSIRO, Canberra, within the registration series 21058–25858) of hundreds of bones of a similar range of species was made by van Tets in 1972–73, but this is a mixed collection of prehistoric and recent bones (author, *pers. obs.* Dec 2003). Yaldwyn made further collections of seabird bones in 1975, making further comments on the albatrosses and other seabirds in the dunes (Yaldwyn 1986). McFadgen & Yaldwyn (1984) and Yaldwyn (1986) described the structure and formation of the Sandy Bay dunes in detail.

In 1998 and 2003, Atholl Anderson and colleagues investigated and proved early Polynesian presence at Sandy Bay (Anderson & O'Regan 2000; Anderson 2005, 2009); however, it is believed that the most extensive bone deposits in Sandy Bay are

mainly natural in origin (Yaldwyn 1986; Tennyson 2009). In 1998, I collected bones from the surface of the natural deposits in Sandy Bay, while the archaeological team excavated the archaeological sites. Some of the 1998 and all of the 2003 collections were analysed shortly afterwards, and included at least 20 bird species, dominated by bones of yellow-eyed penguins (*Megadyptes antipodes*), southern royal albatrosses, white-headed petrels (*Pterodroma lessonii*), prions, white-chinned petrels (*Procellaria aequinoctialis*), sooty shearwaters, diving petrels (*Pelecanoides* spp.), and Auckland Island shags (*Leucocarbo colensoi*) (Tennyson 2009). A notable find included bones of a South Georgian diving petrel (no longer present in the Auckland Islands) (Tennyson 2009). I compared the prehistoric archaeological and naturally deposited bird bone collections from the Auckland Islands and concluded that the largest species were preferentially targeted for food, with very few small species taken (Tennyson 2009). Nearly all archaeological bones recovered were fully ossified, indicating that adult birds were hunted. However, the 1998 collections were not fully identified and analysed at that time.

The exposures of bones in eroding dunes at Sandy Bay were more accessible in the past. In 1903 the dunes were 'moving inland' and 'invad[ing] the forest zone' due to erosion by 'cattle, and perhaps rabbits' (Cockayne 1904). By 1981, McFadgen & Yaldwyn (1984) reported that about half of the 20 ha dune area was stable and covered with vegetation. Comparing photos of Sandy Bay from Jul 1903 (Cockayne 1904: plate XII), 1954 (R. Taylor, *unpubl.*), Dec 1972 (McFadgen & Yaldwyn (1984: fig. 2; photo taken early-Dec 1972, R. Taylor, *pers. comm.*, 1 Jul 2019), and Jan 1978 (R. Taylor, *unpubl.*), it appears that there was more sand exposure in 1903 but little change between 1954 and 1978. A 1964 photo in Sandy Bay (Fig. 2) shows shorter vegetation and fresher erosion surfaces than was apparent in 1998, and the amount of freshly exposed erosional surfaces was reduced even further by 2018 (author, *pers. obs.*). The reduction of erosion and increase in vegetation on these dunes is presumably related to the recovery of vegetation following burning, and since the eradication of cattle and rabbits in 1993.

Here I summarise the completion of the identification of existing Holocene (natural and



FIGURE 2. Sandy Bay, Enderby Island, 1964, showing close-cropped vegetation and active sand erosion; Dr Keith Lewis (geologist at New Zealand Oceanographic Institute) in foreground. Image: Elliot Dawson.

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archaeological) bird bone collections, and include new material collected in 2018. However, the 1875 Krone material in Dresden, the 1972 Wilson collection in Christchurch, and the mixed (prehistoric and recent) 1972–73 van Tets collection in Canberra are excluded. Although mammal bones (sea lion, rabbit, cattle, sheep, cat, and mouse) are also common in the Sandy Bay deposits (Tennyson 2009, *unpubl.*), these remains are not detailed here.

Methods

Collections analysed in this study from natural sites at Sandy Bay, Enderby Island, were made during 1962 to 2018. Collections up to 1985 were made during 26 Dec 1962 to 20 Jan 1963 (J.C. Yaldwyn, *pers. comm.* to author, 6 May 1998), 11 May 1963 (E.W. Dawson), 18 Jan 1964 (E.W. Dawson), 1965 (R.J. Singleton), Jan 1966 (R.A. Falla), 15–20 Jan 1975 (J.C. Yaldwyn), 31 Jan–1 Feb 1981 (J.C. Yaldwyn), and 18–20 Feb 1985 (J.C. Yaldwyn & C.J.R. Robertson). The locations of some of these collections were at more specific dune sites, e.g. McFadgen & Yaldwyn (1984) and Yaldwyn (1986) described ‘dune ridges’ that they numbered 1–3; this numbering system was followed in 1998 and 2018.

I made collections in 1998 in the Sandy Bay dunes (Figs 1, 3–5) as follows: 22 Jun at Dune 3 Sites 98/1, 98/2, and 98/3; 23 Jun at Dune 1 Site 98/7, Dune 2 Site 98/6, Dune 3 Sites 98/3, 98/4, and 98/5, and Pan Site 98/8. Dune 1 was exposures on ‘dune ridge 1’, Dune 2 was exposures on ‘dune ridge 2’, etc. Site 98/8 was small sand blowouts between Dune 1 and the western end of Sandy Bay. Sites 98/1, 98/2, etc. were localised areas within each larger dune site. This study completes the identification of this 1998 collection.

In 2018, I made further collections in the Sandy Bay dunes 18–30 Jan with Aditi Sriram, Margaret McFarlane, and Colin Miskelly: Dunes 1–3 (= 2018 Sites 1–3); 2018 Site 4 = small blowouts to the north-east of Dune 3. GPS locations of these sites are: Dune 1/Site 1 (50.4996°S, 166.2837°E), Dune 2/Site 2 (50.4997°S, 166.2848°E), Dune 3/Site 3 (50.5001°S,



FIGURE 3. Dunes, Sandy Bay, Enderby Island, from the west. Dune 1 on the left, Dune 2 centre left, and Dune 3 centre right. Image: Alan Tennyson, 28 January 2018.

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FIGURE 4. Dunes 1–3 from the east, with Dune 3 in the foreground and Dune 1 the most distant exposure, showing deflation surfaces where bones were found, Sandy Bay, Enderby Island. Image: Alan Tennyson, 28 January 2018.



FIGURE 5. Dunes 2 and 3 from the west, with Dune 2 in the foreground and Dune 3 to the right, showing deflation surfaces where bones were found, Sandy Bay, Enderby Island. *Image: Alan Tennyson, 27 January 2018.*

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FIGURE 6. South-east end of Dundas Island, where bones were found in the foreground sand in 1998. *Image: Alan Tennyson, 18 January 2018.*



FIGURE 7. Shell bank on the south-east corner of Friday Island. The site where bones were found is below the vegetation on the lower left. Image: Alan Tennyson, 25 January 2018.

276 166.2857°E), north-east of Dune 3/Site 4 (50.4997 S, 166.2867 E).

In addition, small numbers of bones were collected at three other natural sites: Dundas Island dunes (50.5774°S, 166.3224°E; Fig. 6) on 24 Jun 1998 (by me; I found no bones there on 18 Jan 2018); Tagua Bay cave (50.81°S, 166.07°E), Auckland Island, on 7 Feb 2003 (by A.J. Anderson); and from a shell bank on Friday Island (50.5189°S, 166.2342°E; Figs 7–8) on 25 Jan 2018 (by me).

The archaeological collections in Sandy Bay were made by A.J. Anderson, G. O'Regan, K. Gillies, D. Austin, and R. Egerton on 22–23 Jun 1998; and by A.J. Anderson and K. Jones 14–19 Feb 2003. The 1998 archaeological collection is reanalysed in this paper. Maps of these excavation sites are provided by Anderson (2009); they lie primarily to the west of the natural sites of Dunes 1–3, but overlap in the area of Dune 1.

Minimum numbers of individuals (MNIs) are calculated based on collections made in one year at each naturally deposited site, because ongoing dune erosion is likely to have destroyed any bones on or near the surface between collecting years. A small number of bones of some individuals may be present in more than one collection.

All bones analysed in this study are stored in the Museum of New Zealand Te Papa Tongarewa (NMNZ) collections, Wellington, apart from the archaeological collection made at Sandy Bay in Jun 1998, which is held by the Ngāi Tahu Development Corporation, Dunedin. I identified each bone using comparative skeletal specimens; the primary comparative specimens used are listed in Appendix 1.

Age of deposits

Most of the naturally deposited bones were recovered from the Sandy Bay dune deflation surfaces, and so their ages are unclear. This natural accumulation process could lead to a series of bones of mixed ages in the same horizon. The bone-bearing layers in the dunes are thought to be younger than c. 2,800 years before present (McFadgen & Yaldwyn 1984), while the youngest may be only a few years old. The presence in the Sandy Bay bone deposits of several species that were introduced by humans to New Zealand (Eurasian blackbird *Turdus merula*, common starling *Sturnus vulgaris*, rabbit, cattle, sheep, cat, mouse; Tennyson 2009; this study) are evidence that these deposits include some bones from very recent times. Rabbit bones were still common in the Enderby Island dunes in 2018 (author *unpubl.*), despite the species having been eradicated from the island 25 years earlier (Torr 2002). The bones of two starlings and two blackbirds are the only remains of any exotic bird species known from the Holocene bone deposits on the Auckland Islands. Subantarctic skuas (*Catharacta antarctica lonnbergi*) are common in Sandy Bay today and commonly regurgitate bird prey remains in the area; however, prey remains that had clearly been regurgitated recently were not included in this study. The Tagua Bay site was dated to c. 2,550 years before present (Anderson 2005, 2009). The age of bones found at the Dundas and Friday Island sites is unknown; however, they are both in modern-day coastal deposits, therefore Holocene.

The prehistoric archaeological sites at Sandy Bay, Enderby Island, were dated to the thirteenth to fourteenth centuries AD (Anderson 2005, 2009), although there was some 'contamination' from probable natural material (e.g. diving petrels NMNZ S.41962, S.42057) and more recent material that must date from the post-European era, e.g. a few rabbit bones (NMNZ S.42014, S.42064).

Results

Summary of numbers

Collections of Holocene bones, made 1963–2018, at sites on the Auckland Islands include 3,456 identified bird bones (plus partial skeletons of another 50 birds), representing at least 853 individual birds.

These collections are primarily from the dune deposits at Sandy Bay, Enderby Island. From the 1963–2018 collections from natural sites at Sandy Bay, 2,403 bones were identified (plus 49 partial skeletons). These represent at least 692 individual birds (Table 1). The 1998 collections totalled more than 1,521 bird bones, plus partial skeletons of another 14 birds, while the Sandy Bay collections in 2018 totalled more than 413 bird bones.

Archaeological excavations at Sandy Bay in 1998 and 2003 were detailed by Tennyson (2009), and these results are updated here based on reanalysis of some of the material. The 1998 excavations recovered about 70 bird bones, which included

56 bones identifiable to taxon (plus one piece of eggshell) and represented at least 28 individual birds (Appendix 2). The 2003 excavations recovered 967 bird bones, plus one partial skeleton, representing at least 125 individual birds (Table 1).

Small numbers of bones were found at three other natural sites: Dundas Island (8 bones, MNI = 3), Tagua Bay, Auckland Island (19 bones, MNI = 3), and Friday Island (3 bones, MNI = 2).

Species accounts of Holocene bones from deposits on the Auckland Islands

Numbers listed are by site: SBN = Sandy Bay natural deposits, SBA = Sandy Bay archaeological deposits, DIN = Dundas Island natural deposit, TBN = Tagua Bay natural deposit; FIN = Friday Island natural deposit, '(x/y)' = '(number of individual bones/minimum number of individual birds represented)'. Museum registration details are provided in Appendices 3–7).



FIGURE 8. Close-up of site where bird bones were found on the south-east corner of Friday Island, showing shells, stones, and otariid bones. Image: Alan Tennyson, 25 January 2018.

TABLE 1. Bird bones by taxon found in natural sites (this paper) and middens in 2003 (from Tennyson 2009, table E.1; updated this study) in Sandy Bay, Enderby Island, given as minimum number of individuals (MNI) and percentages of total MNIs, and ratio of midden MNIs to natural MNIs. Scientific names for all taxa are provided within individual species accounts in the text.

Species	MNI in natural sites	% of natural sites	MNI in middens	% of midden sites	% midden/ % natural sites*
Auckland Island merganser	2	0.3	0	0	–
Auckland Island teal	13	1.9	3	2.4	1.3
King penguin	1	0.1	0	0	–
Eastern rockhopper penguin	29	4.2	1	0.8	0.2
Snares crested penguin	2	0.3	0	0	–
Erect-crested penguin	5	0.7	0	0	–
Yellow-eyed penguin	35	5.1	10	8.0	1.6
Penguin spp.	2	0.3	0	0	–
Southern royal albatross	91	13.2	12	9.6	0.7
White-capped mollymawk	3	0.4	0	0	–
Light-mantled sooty albatross	1	0.1	0	0	–
Giant petrel spp.	12	1.7	2	1.6	0.9
Cape petrel	1	0.1	0	0	–
Kerguelen petrel	1	0.1	0	0	–
White-headed petrel	21	3.0	8	6.4	2.1
Chatham Island taiko	1	0.1	0	0	–
Blue petrel	2	0.3	0	0	–
Broad-billed prion	3	0.4	0	0	–
Antarctic prion	3	0.4	0	0	–
Lesser fulmar prion	4	0.6	0	0	–
Prion spp.	82	11.8	4	3.2	0.3
White-chinned petrel	8	1.2	28	22.4	18.7
Grey petrel	4	0.6	0	0	–
Sooty shearwater	53	7.7	26	20.8	2.7
Subantarctic little shearwater	10	1.4	0	0	0
Grey-backed storm petrel	2	0.3	0	0	–
White-faced storm petrel	1	0.1	0	0	–
Black-bellied storm petrel	4	0.6	0	0	–
Subantarctic diving petrel	1	0.1	0	0	–
South Georgian diving petrel	5	0.7	0	0	–
Diving petrel spp.	158	22.8	4	3.2	0.1

Species	MNI in natural sites	% of natural sites	MNI in middens	% of midden sites	% midden/ % natural sites*
Auckland Island shag	60	8.7	19	15.2	1.7
Auckland Island rail	11	1.6	0	0	0
Auckland Island snipe	6	0.9	3	2.4	2.7
Bar-tailed godwit	1	0.1	0	0	–
Auckland Island banded dotterel	1	0.1	0	0	–
Subantarctic skua	6	0.9	1	0.8	–
Skua sp.	1	0.1	0	0	–
Southern black-backed gull	25	3.6	1	0.8	0.2
Red-billed gull	8	1.2	2	1.6	1.3
Tern sp.	1	0.1	0	0	–
Antipodes Island parakeet	1	0.1	0	0	–
Parakeet sp.	1	0.1	0	0	–
Bellbird	1	0.1	1	0.8	–
Tui	1	0.1	0	0	–
New Zealand raven	1	0.1	0	0	–
Eurasian blackbird	2	0.3	0	0	–
Common starling	2	0.3	0	0	–
Auckland Island pipit	3	0.4	0	0	–
Total	692		125	100	

* Only taxa with at least 1% of natural or midden sites are listed.

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Auckland Island merganser *Mergus australis* (SBN 4/2)

This paper reports the first prehistoric remains of this extinct species from the Auckland Islands (Fig. 9). While the species was reported from the Port Ross region in historical times (Miskelly *et al.* 2020 – Chapter 2), the bones in the natural deposits of the Sandy Bay dunes are the first specific record of it having been present on Enderby Island. The rarity of bones of this relatively large species at Enderby Island (representing probably single individuals found in both 1998 and 2018) suggests that it was never common ashore there in pre-human times.

Auckland Island teal *Anas aucklandica* (SBN 23/13, SBA 5/3)

Bones of this species were found in the natural deposits of the Sandy Bay dunes in 1975, 1985, 1998, and 2018, and remains of at least three birds were found in archaeological sites in 2003; it is a common bird on Enderby Island today (French *et al.* 2020 – Chapter 4 in this book).

King penguin *Aptenodytes patagonicus* (SBN 1/1)

A single mandible was found in the natural deposits of the Sandy Bay dunes in 1998. King penguins do not breed at the Auckland Islands, but were reported alive on Enderby Island four

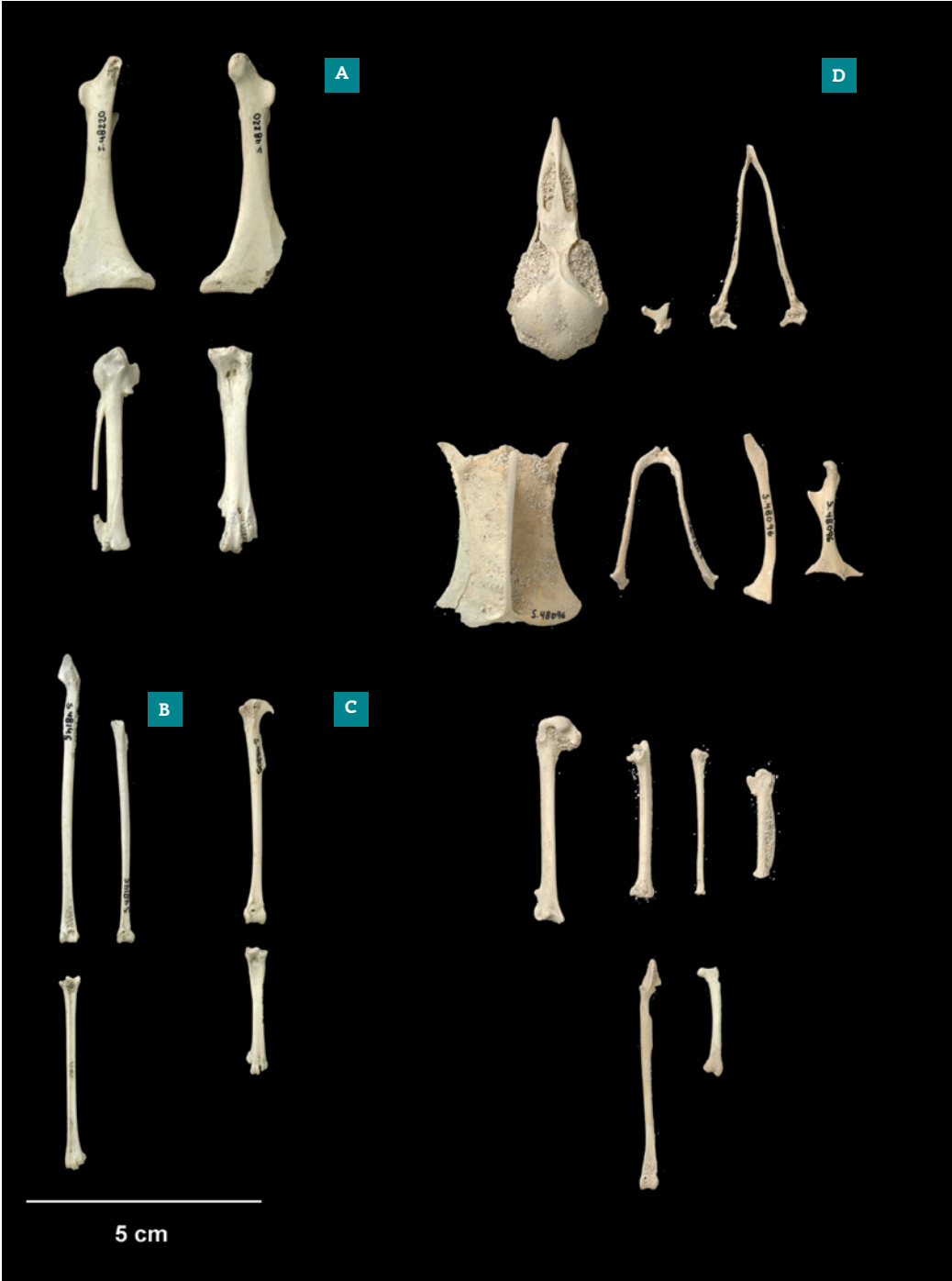


FIGURE 9. Holocene bones of bird species extinct at Enderby Island, from the Sandy Bay dunes. **A.** Auckland Island merganser, left and right coracoids, left tarsometatarsus, NMNZ S.48220; right carpometacarpus, NMNZ S.47956. **B.** White-faced storm petrel, left and right tibiotarsus, right tarsometatarsus, NMNZ S.48145. **C.** Auckland Island rail, left tibiotarsus and left tarsometatarsus, NMNZ S.48205. **D.** South Georgian diving petrel, partial skeleton, NMNZ S.48096. Image: Jean-Claude Stahl, Te Papa.

times between 1972 and 2006 (Miskelly *et al.* 2020 – Chapter 2).

Eastern rockhopper penguin

Eudyptes filholi (SBN 80/29, SBA 2/1)

Bones were found in the natural deposits of the Sandy Bay dunes in 1963, 1966, 1975, 1981, 1985, 1998, and 2018, and remains of at least one further bird were found in an archaeological site in 2003. This species breeds in large numbers at the Auckland Islands, but has never been recorded breeding in the Port Ross area (Miskelly *et al.* 2020 – Chapter 2). It has been reported as a visitor to Enderby Island on 19 occasions (French *et al.* 2020 – Chapter 4). The high frequency of rockhopper penguin bones in dunes on Enderby Island (being only slightly fewer than bones of yellow-eyed penguins) suggests that the species has declined substantially in numbers at the Auckland Islands, as was concluded by W. Cooper (1992) and Tennyson (2009).

Snares crested penguin

Eudyptes robustus (SBN 2/2)

A carpometacarpus (found in 1998) and a femur (found in 2018) matching those of a Snares crested penguin were found 20 years apart in the natural deposits of the Sandy Bay dunes, indicating that they originated from different individuals. These identifications are tentative because many bones of crested penguins are notoriously difficult to tell apart. Snares crested penguins breed only at the Snares Islands, but were reported alive on Enderby Island on four occasions between 2000 and 2017 (Miskelly *et al.* 2020 – Chapter 2).

Erect-crested penguin

Eudyptes sclateri (SBN 10/5)

Remains of a least five birds in the natural deposits of the Sandy Bay dunes were tentatively assigned to this species (one found in 1966, one in 1975, two in 1998, and one in 2018). Erect-crested penguins are rarely reported at the Auckland Islands, but there have been several sightings on Enderby Island (Miskelly *et al.* 2020 – Chapter 2).

Yellow-eyed penguin

Megadyptes antipodes (SBN 114 + 2 part individuals/35, SBA 72/13)

Bones were found in 1963, 1964, 1966, 1975, 1981, 1985, 1998, and 2018 in the natural deposits of the Sandy Bay dunes, and remains of at least 13 further birds were found in archaeological sites there in 1998 and 2003. This species is a common breeder on Enderby Island today (Muller *et al.* 2020 – Chapter 9 in this book).

Penguin spp.

(SBN 3/2, SBA 2/1)

Poorly preserved and juvenile bones found in 1998 in the archaeological deposits and in 2018 in the natural deposits of the Sandy Bay dunes could be assigned only to either *Eudyptes* or *Megadyptes*.

Southern royal albatross

Diomedea epomophora (SBN 309 + 29 part individuals/91, SBA 77/12)

Bones were found in 1963, 1964, 1965, 1975, 1981, 1985, 1998, and 2018 in the natural deposits of the Sandy Bay dunes. The remains of at least a further 12 individuals were found in the archaeological sites there in 2003. This species has been the most discussed of those found in the Enderby Island deposits, with comments noting that it evidently used to breed in the dune area (e.g. Yaldwyn 1986). A breeding population of more than 100 nests on the island in 1840 was wiped out by 1868 (due to human hunting; French *et al.* 2020 – Chapter 4) but the species had recolonised by 1942 (McEwen 2006: 114), with 43 nests in 2018 (French *et al.* 2020 – Chapter 4). The high frequency at which the species occurs in the Sandy Bay dune deposits (including many juvenile remains) provides strong evidence that it formerly nested there. Also, several eggshell remains collected from these dunes match the thickness of royal albatross eggs (i.e. NMNZ S.41993, S.42018, S.48196, S.48216, S.48219, S.48339, and S.36414, which is associated with a juvenile royal albatross bone).

White-capped mollymawk
Thalassarche cauta steadi
(SBN 3/3, DIN 1/1)

Remains of four birds were found: single bones in 1964, 1998, and 2018 in the natural deposits of the Sandy Bay dunes, and a right femur in the dunes of Dundas Island in 1998. Although this species does not breed on Enderby or Dundas Islands, it breeds elsewhere at the Auckland Islands and is often reported in the waters around Enderby and Dundas Islands (Tennyson 2009; Miskelly *et al.* 2020 – Chapter 2).

Light-mantled sooty albatross
Phoebastria palpebrata
(SBN 1/1)

A single partial humerus of this species was found in the natural deposits of the Sandy Bay dunes in 1998. Small numbers of this species nest on Enderby Island (French *et al.* 2020 – Chapter 4).

Giant petrel spp. *Macronectes* spp.
(SBN 74 + 2 part individuals/12,
SBA 6/3)

282 Bones were found in the natural deposits of the Sandy Bay dunes in 1963, 1964, 1966, 1998, and 2018, and remains of at least three further birds were found in archaeological sites there in 1998 and 2003. Northern giant petrels are a common breeding species on Enderby Island, and southern giant petrels (*Macronectes giganteus*) are vagrants there (Miskelly *et al.* 2020 – Chapter 2; French *et al.* 2020 – Chapter 4).

Cape petrel
Daption capense
(SBN 1/1)

A single tarsometatarsus was found in the natural deposits of the Sandy Bay dunes in 2018. This species breeds in small numbers at the Auckland Islands but is not known to nest at Enderby Island; however, it is common in the adjacent waters of Port Ross (Miskelly *et al.* 2020 – Chapter 2).

Kerguelen petrel
Lugensa brevirostris
(SBN 1/1)

A single tarsometatarsus of this species was found in the natural deposits of the Sandy Bay dunes in 2018 (Fig. 10). This species has not been

reported from the Auckland Islands previously, but it is widespread in the southern oceans and so would sometimes be expected to occur close to the Auckland Islands (Marchant & Higgins 1990).

White-headed petrel
Pterodroma lessonii
(SBN 64/21, SBA 52/10, FIN 2/1)

Bones were found in the natural deposits of the Sandy Bay dunes in 1963, 1964, 1966, 1975, 1985, 1998, and 2018, and the remains of at least another ten individuals were found in the archaeological sites there in 1998 and 2003. Remains of at least one individual were found in a shell bank on Friday Island in 2018. The species is a common breeder at the Auckland Islands, including on Enderby and Friday Islands (Miskelly *et al.* 2020 – Chapter 2).

Chatham Island taiko
Pterodroma magentae
(SBN 5/1)

Five leg bones, possibly from a single bird, were found together in the natural deposits of the Sandy Bay dunes in 1998 (Fig. 10). These bones match a *Pterodroma* petrel the size of a Chatham Island taiko, i.e. smaller than those of a white-headed petrel. In prehistoric times, Chatham Island taiko were much more abundant than they are today (J.H. Cooper & Tennyson 2008), and recent tracking of their at-sea range has shown that some individuals range many thousands of kilometres from their colonies, often southwards (G.A. Taylor 2013). It is therefore plausible that the species regularly ranged to the region of Auckland Islands in the past.

Blue petrel
Halobaena caerulea
(SBN 3/2)

Remains of probably two individuals were found in the Sandy Bay natural dune deposits in 1998. Six recently killed individuals were found dead in skua middens on Enderby Island in 2018 (Miskelly *et al.* 2020 – Chapter 2). It is likely that skuas were also the source of the prehistoric specimens.

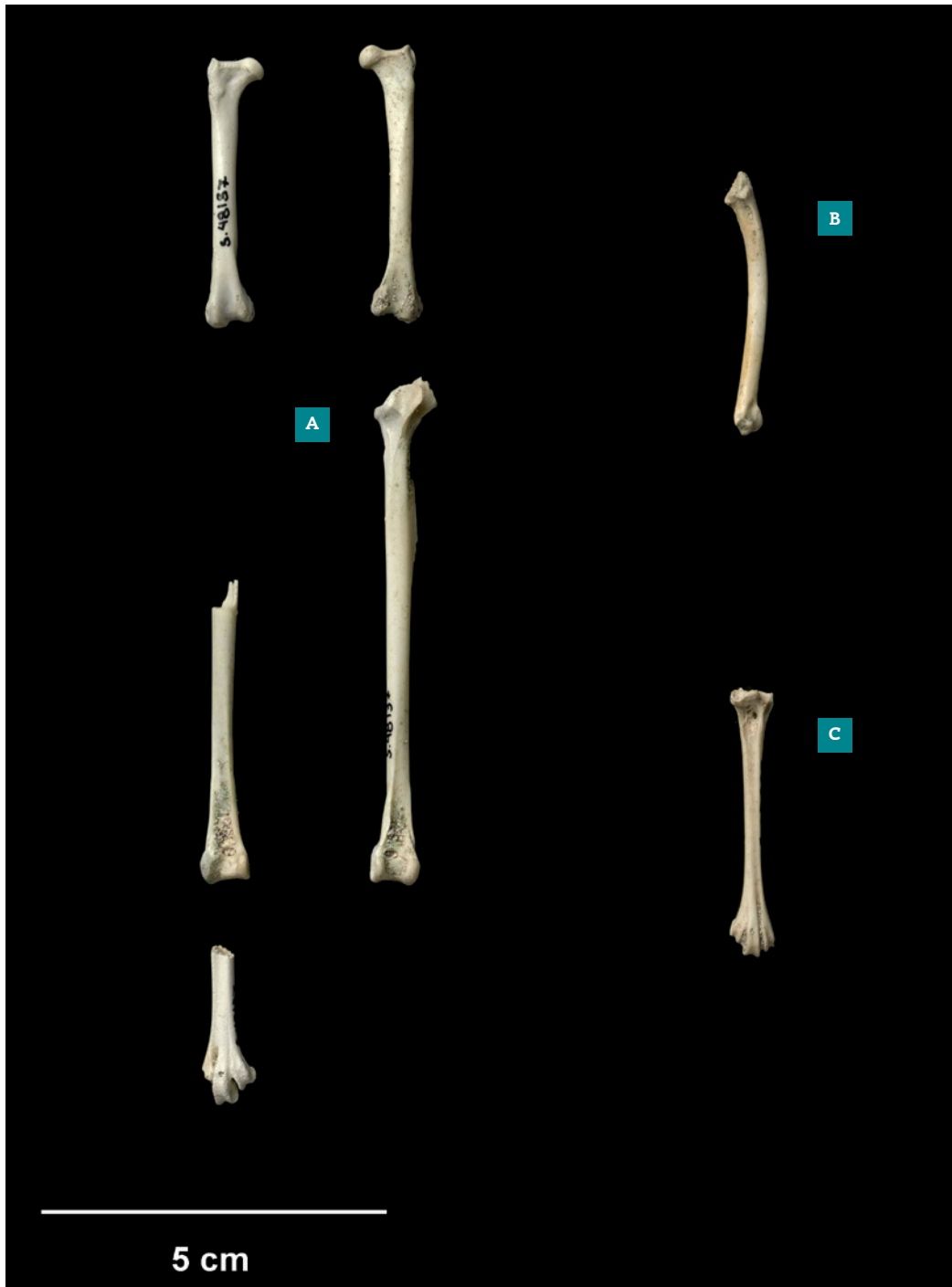


FIGURE 10. Unique records of bird species from the Auckland Islands based on Holocene bones from Sandy Bay dunes, Enderby Island. **A.** Chatham Island taiko, left and right femora, left and right tibiotarsi, distal right tarsometatarsus, NMNZ S.48137. **B.** Antipodes Island parakeet, right ulna, NMNZ S.48157. **C.** Kerguelen petrel, left tarsometatarsus, NMNZ S.47985. *Image: Jean-Claude Stahl, Te Papa.*

Broad-billed prion
Pachyptila vittata
(SBN 5/3)

Five bones representing at least three individuals were found in the natural deposits of the Sandy Bay dunes in 1998. The species is simpler to identify from isolated bones than the two prion taxa that breed at the Auckland Islands because it is notably larger. Broad-billed prions are a rare component of skua middens on the Auckland Islands, with three records from Enderby Island (Miskelly *et al.* 2020 – Chapter 2).

Antarctic prion
Pachyptila desolata
(SBN 3/3, DIN 1/1)

While prion remains are common in the Sandy Bay dune deposits, few can be identified to species because the two prion taxa breeding at the Auckland Islands are similar in size. Three beak remains, found in 1998 (two) and 2018 (one) in the natural deposits of the Sandy Bay dunes, and one found in the Dundas Island dunes in 1998, could be confidently identified as being from Antarctic prions. Antarctic prions are an abundant species at the Auckland Islands, including at sea adjacent to both Enderby and Dundas Islands (Miskelly *et al.* 2020 – Chapter 2). The species has been reported ashore at Enderby Island on many occasions and is presumed to breed there (French *et al.* 2020 – Chapter 4). The partial beak found on Dundas Island is the only record of the species ashore there and it is not thought to breed on the island (Miskelly *et al.* 2020 – Chapter 2).

Lesser fulmar prion
Pachyptila crassirostris flemingi
(SBN 4/4)

Four of the very smallest prion bones found in the natural deposits of the Sandy Bay dunes were tentatively assigned to this taxon, which is marginally smaller than the Antarctic prion: one humerus and one ulna in 1998, and two humeri in 2018. Fulmar prions are known at Enderby Island only as ‘visitors’, but they breed on other nearby islands in Port Ross (Miskelly *et al.* 2020 – Chapter 2; French *et al.* 2020 – Chapter 4).

Prion spp.
Pachyptila spp.
(SBN 355/82, SBA 12/8, DIN 5/1, TBN 19/3)

Prion bones were found in the natural deposits of the Sandy Bay dunes in 1964, 1965, 1966, 1975, 1985, 1998, and 2018; remains of at least another eight individuals were found in the archaeological deposits there in 1998 and 2003. Additionally, the remains of at least one bird were found in the Dundas Island dunes in 1998 and the remains of at least three individuals were found at Tagua Bay in 2003. Prions are abundant at the Auckland Islands, including in skua middens and at sea adjacent to the Auckland Island group (Miskelly *et al.* 2020 – Chapter 2).

White-chinned petrel
Procellaria aequinoctialis
(SBN 17/8, SBA 260/28)

Several bones of this species were found in the natural deposits of the Sandy Bay dunes in 1975, 1998, and 2018, and a surprising number (at least 28 individuals) were recovered from archaeological sites in 2003. The petrel is an abundant breeder at the Auckland Islands but not on Enderby Island, where only two burrows were found in 2018 (Miskelly *et al.* 2020 – Chapter 2). The high frequency of bones suggests that the species bred on Enderby Island in larger numbers in the past (Tennyson 2009; this study).

Grey petrel
Procellaria cinerea
(SBN 7/4)

Seven bones found in the natural deposits of the Sandy Bay dunes were tentatively referred to this species: one in 1985, two in 1998, and four in 2018. The species has been reported alive only three times at the Auckland Islands – multiple birds at sea in May on three occasions (Miskelly *et al.* 2020 – Chapter 2).

Sooty shearwater
Ardenna grisea
(SBN 166/53, SBA 247/31, TBN 4/1, FIN 1/1)

Bones of at least 53 individuals were found in the natural deposits of the Sandy Bay dunes in 1964, 1966, 1975, 1981, 1985, 1998, and 2018; the

remains of at least a further 31 birds were found in the archaeological sites there in 1998 and 2003. Remains of at least one individual were found at Tagua Bay in 2003, and a humerus was found in a shell bank on Friday Island in 2018. The species is a common breeder at the Auckland Islands, including on Enderby Island, but the bone reported in this study is the only record of the species ashore on Friday Island. The sooty shearwater has apparently become extinct on the main Auckland Island due to predation by mammals (Miskelly *et al.* 2020 – Chapter 2).

Subantarctic little shearwater
Puffinus elegans
 (SBN 18/10)

Remains of at least ten birds were found in the natural deposits of the Sandy Bay dunes: one in 1964, one in 1966, one in 1975, one in 1985, five in 1998, and one in 2018. The species is frequently seen at sea around the Auckland Islands but there are no records of live birds ashore (Miskelly *et al.* 2020 – Chapter 2). It is taken as prey by subantarctic skuas, presumably offshore from the Auckland Islands, and regurgitated ashore in small numbers (Miskelly *et al.* 2020 – Chapter 2), and so this may be the source of the Holocene bones also. However, one of the dune bones (a tarsometatarsus NMNZ S.48144) is from a nestling, based on its lack of ossification, which suggests that it was eaten by a skua at the shearwater's breeding site. Given the absence of any live records of subantarctic little shearwaters ashore at the Auckland Islands, one explanation could be that a skua swallowed the shearwater chick in its nesting colony, such as at the Antipodes Islands (Tennyson *et al.* 2002), and regurgitated the bird's remains on Enderby Island.

Grey-backed storm petrel
Garrodia nereis
 (SBN 2/2)

Two bones, representing two individuals, were found in the natural deposits of the Sandy Bay dunes in 1998. The status of this species on Enderby Island is unclear, but it probably breeds there (French *et al.* 2020 – Chapter 4).

White-faced storm petrel
Pelagodroma marina
 (SBN 3/1)

Bones, representing probably one individual, were found in the natural deposits of the Sandy Bay dunes in 1998 (Fig. 9). The species used to breed at the Auckland Islands but there is only a single record from Enderby Island (in 1840) (Miskelly *et al.* 2020 – Chapter 2). There have been no records of the species from the entire Auckland Island group since 1989, suggesting that this population has been extirpated (Miskelly *et al.* 2020 – Chapter 2).

Black-bellied storm petrel
Fregetta tropica
 (SBN 9/4)

Remains of at least two individuals were found in the natural deposits of the Sandy Bay dunes in both 1998 and 2018. This species is widespread at the Auckland Islands and breeds on Enderby Island (Miskelly *et al.* 2020 – Chapter 2).

Subantarctic diving petrel
Pelecanoides urinatrix exsul
 (SBN 1/1)

A single cranium of this species, found in 1998, was identified from the natural deposits of the Sandy Bay dunes. Although the remains of diving petrels were abundant in these dune deposits, only those with cranial remains could be identified to species, based on skull features described by Worthy (1998).

South Georgian diving petrel
Pelecanoides georgicus
 (SBN 2 + 3 part individuals/5)

Five individuals from the natural deposits of the Sandy Bay dunes were identified based on their skull shape. Three of these were partial skeletons of individuals (one found in 1985, two found in 1998; Fig. 9 illustrates one of these birds), one was a complete skull (found in 1985), and one was a cranium (found in 1998). There are only two records of this species ashore at the Auckland Islands (three specimens from Enderby Island in 1840 and one from Dundas Island in 1943, but breeding was confirmed on both islands; Miskelly *et al.* 2020 – Chapter 2). With the species being considered extinct on

the Auckland Islands now, these five Holocene records (based solely on cranial material and considering the number of other diving petrel bones unidentified to taxon) provide firmer evidence of a formerly significant breeding population on Enderby Island. The ratio of skulls identified here suggests that South Georgian diving petrels were formerly more common at Sandy Bay than subantarctic diving petrels, which is the only diving petrel taxon breeding there now (Fischer *et al.* 2017).

Diving petrel spp.

Pelecanoides spp.

(SBN 747 + 6 part individuals/158, SBA 29 + 1 part individual/12, DIN 1/1)

Bones were found in the natural deposits of the Sandy Bay dunes in 1964, 1965, 1966, 1975, 1985, 1998, and 2018; the remains of at least 12 more individuals were found in the archaeological sites there in 1998 and 2003. This was the most abundant taxon recorded in these dune deposits, indicating that diving petrels were formerly abundant on Enderby Island. Specimens confirm former breeding in these dunes, such as NMNZ S48099, which is a partial skeleton of a nestling mixed with eggshell matching the thickness of a diving petrel egg. Two species of diving petrel historically used to breed on Enderby Island: the subantarctic diving petrel still breeds there but the South Georgian diving petrel is extinct (Fischer *et al.* 2017; Miskelly *et al.* 2020 – Chapter 2). One bone was found in the Dundas Island dunes in 1998. There is only one previous record of a diving petrel ashore on Dundas Island – a South Georgian diving petrel incubating an egg in 1943. However, subantarctic diving petrels are common offshore there today, and diving petrels are commonly consumed and regurgitated by subantarctic skuas at the Auckland Islands (Miskelly *et al.* 2020 – Chapter 2).

Auckland Island shag

Leucocarbo colensoi

(SBN 245/60, SBA 241/22)

In the Sandy Bay dunes, bones of at least 60 individuals were found in the natural deposits in 1963, 1964, 1966, 1975, 1981, 1985, 1998, and 2018, with remains of at least another 22 birds found in the archaeological sites there in 1998 and 2003.

Enderby Island is an important breeding site for this species (French *et al.* 2020 – Chapter 4).

Auckland Island rail

Lewinia muelleri

(SBN 15 + 1 part individual/11)

Remains of at least 11 individuals were recovered from the natural deposits of the Sandy Bay dunes: one in 1963, one in 1981, and nine in 1998 (Fig. 9 illustrates one of these specimens). Dawson found another rail pelvis there on 18 Jan 1964 but lost it before returning to the ship (Dawson 1964; E. Dawson, *pers. comm.* to C. Miskelly, 2019), and Falla found another pelvis there in 1966 but its current location is unknown (Falla, in Supplementary material, <http://notornis.osnz.org.nz/node/4445>). These are the only confirmed records of this species from Enderby Island, and indicate that these small, secretive rails were probably common on the island prehistorically. The species is now confined to Adams and Disappointment Islands (Miskelly *et al.* 2020 – Chapter 2).

Auckland Island snipe

Coenocorypha aucklandica aucklandica

(SBN 15/6, SBA 4/3)

Remains of at least six snipe were found in the natural deposits of the Sandy Bay dunes: one in 1975 and five in 1998. Remains of at least three further birds were found in the archaeological sites in 2003. Snipe are widespread at the Auckland Islands, but their numbers and distribution are strongly affected by introduced mammals; numbers on Enderby Island have increased greatly since the last mammal pests were eradicated there in 1993 (Miskelly *et al.* 2020 – Chapter 2; Shepherd *et al.* 2020 – Chapter 16 in this book).

Bar-tailed godwit

Limosa lapponica

(SBN 1/1)

A right ulna found in the natural deposits of the Sandy Bay dunes in 1998 is the first Holocene record of this species found at the Auckland Islands. Bar-tailed godwits are rare but regular migrants to Enderby Island (Miskelly *et al.* 2020 – Chapter 2).

Auckland Island banded dotterel
Charadrius bicinctus exilis
 (SBN 1/1)

A left ulna found in the natural deposits of the Sandy Bay dunes in 1998 is the first Holocene record of this taxon. The Auckland Island banded dotterel is a common bird on Enderby Island (French *et al.* 2020 – Chapter 4).

Subantarctic skua
Catharacta antarctica lonnbergi
 (SBN 5 + 1 part individual/6, SBA 3/2)

The remains of at least six birds were found in the natural deposits of the Sandy Bay dunes: five in 1998 and one in 2018. Remains of at least two further birds were found in archaeological sites in 1998 and 2003. This species is widespread at the Auckland Islands and is common on Enderby Island, particularly in the sea lion colony at Sandy Bay (Miskelly *et al.* 2020 – Chapter 2; French *et al.* 2020 – Chapter 4).

Skua sp.
 (SBN 1/1)

A partial left coracoid of a pomarine skua (*Coprotheres pomarinus*) or an Arctic skua (*Stercorarius parasiticus*) was found in the natural deposits of the Sandy Bay dunes in 2018. These skuas have been reported at sea off the Auckland Islands but the specific identity of the remains is unverified (Miskelly *et al.* 2020 – Chapter 2).

Southern black-backed gull
Larus dominicanus
 (SBN 57 + 5 part individuals/25, SBA 2/1)

Bones were found in the natural deposits of the Sandy Bay dunes in 1963, 1964, 1966, 1975, 1981, 1985, 1998, and 2018, and remains of at least one further bird were found in an archaeological site there in 2003. This species is common on Enderby Island (French *et al.* 2020 – Chapter 4).

Red-billed gull
Chroicocephalus novaehollandiae scopulinus
 (SBN 12/8, SBA 6/2)

Bones of this species were found in the natural deposits of the Sandy Bay dunes in 1966, 1975, 1985,

1998, and 2018, and remains of at least two further birds were found in archaeological sites there in 2003. It is a common species on Enderby Island today (French *et al.* 2020 – Chapter 4).

Tern sp.
Sterna sp.
 (SBN 1/1)

A single juvenile humerus of a tern was found in the natural deposits of the Sandy Bay dunes in 1998. Its size indicates that it is from either a white-fronted tern (*Sterna striata*) or an Antarctic tern (*Sterna vittata*). Both species are common on Enderby Island (French *et al.* 2020 – Chapter 4).

Antipodes Island parakeet
Cyanoramphus unicolor
 (SBN 1/1)

A right ulna of a large parakeet, found in the natural deposits of the Sandy Bay dunes in 1998, matches that of an Antipodes Island parakeet (Fig. 10), and is larger than the ulnae of both yellow-crowned parakeet (*Cyanoramphus auriceps*) and the larger red-crowned parakeet (*C. novaehollandiae*). At 36.4 mm long, it is longer than the ulnae of every skeleton of red-crowned parakeet in the NMNZ collection, which includes 37 specimens of both sexes from throughout New Zealand and examples of the following subspecies (in addition to the nominate form): Kermadec parakeet *C. n. cyanurus* and Chatham Island red-crowned parakeet *C. n. chathamensis*, as well as Reischek's parakeet *C. hochstetteri*. Finding the remains of an Antipodes Island parakeet at the Auckland Islands was surprising because this species is endemic to the Antipodes Islands, c. 900 km to the east of Enderby Island (Tennyson *et al.* 2002). It is possible that a stray bird flew from the Antipodes Islands to Enderby Island. Another possibility is that a subantarctic skua ate a parakeet on the Antipodes Islands and flew to Enderby Island, where it regurgitated parts of the parakeet. A third possibility is that the Antipodes Island parakeet, or a similar-sized parakeet, used to have a resident population on the Auckland Islands but has now become extinct.

Parakeet sp.
***Cyanoramphus* sp.**
(SBN 1/1)

A single tibiotarsus was found in the natural deposits of the Sandy Bay dunes in 1998; it fell within the size range of both red-crowned and yellow-crowned parakeets. These parakeet taxa, or hybrids between them, are common on Enderby Island (French *et al.* 2020 – Chapter 4).

Bellbird
Anthornis melanura
(SBN 2/1, SBA 1/1)

A bellbird humerus and partial tarsometatarsus were found at the same site in the natural deposits of the Sandy Bay dunes in 1998, and therefore the bones may be from the same individual. Additionally, a left ulna was found in an archaeological site in 2003. Bellbirds are common on Enderby Island (French *et al.* 2020 – Chapter 4).

Tui
Prosthemadera novaeseelandiae
(SBN 1/1)

A right coracoid found in the natural deposits of the Sandy Bay dunes in 1998 is the only tui bone identified from any of the Auckland Islands' Holocene sites. Tui are a regular part of the avifauna of Enderby Island (French *et al.* 2020 – Chapter 4).

New Zealand raven
Corvus antipodum
(SBN 1/1)

The single tarsometatarsus found in the natural deposits of the Sandy Bay dunes in 1964, discussed by Dawson (2020 – Chapter 8 in this book), remains the only record of this species ever reported from the Auckland Islands. This bone is considered to be from a vagrant bird that flew south from either the South Island or Stewart Island (Dawson 2020 – Chapter 8).

Eurasian blackbird
Turdus merula
(SBN 2/2)

Two blackbird left femora were found in the natural deposits of the Sandy Bay dunes in 1998. Eurasian blackbirds were first reported from

Enderby Island in 1901 and have been seen there regularly ever since (French *et al.* 2020 – Chapter 4).

Common starling
Sturnus vulgaris
(SBN 2/2)

The two bones found in the natural deposits of the Sandy Bay dunes in 1998 and 2018 are presumed to represent two individual birds. Common starlings were present on Enderby Island in the 1940s and have been seen there regularly ever since (French *et al.* 2020 – Chapter 4).

Auckland Island pipit
Anthus novaeseelandiae
aucklandicus
(SBN 3/3)

Three bones of this species, representing three individuals, were found in the natural deposits of the Sandy Bay dunes (two in 1998 and one in 2018). This species is common on Enderby Island (French *et al.* 2020 – Chapter 4).

Changes in Sandy Bay deposits over time

There are changes evident between the earliest collections made in the 1960s at Sandy Bay and those made in 2018. Notable is the relative decrease in southern royal albatross skeletons over this time. Earlier collectors often found partial skeletons of this albatross in the dunes (Yaldwyn 1986) but this is no longer the case, with albatross remains now being rarer and found generally as scattered individual bones. Skeletons of individual albatrosses were collected as follows: 10 in 1963, 1 in 1964, 0 in 1965, 0 in 1966, 9 in 1975, 0 in 1981, 6 in 1985, and 3 in 1998. No individual skeletons of any bird species were found in 2018. Presumably this is due to ongoing natural revegetation of the area, leading to more stable dunes, less erosion, and fewer bones being exposed, as well as ongoing erosion of the remaining bones that had been exposed.

Comparison of species in archaeological and natural sites

Comparing abundancies of species in middens with their abundance in natural sites (Table 1), many species (Auckland Island teal, southern

royal albatross, giant petrel, red-billed gull) were found in fairly similar proportions. Some species were over-represented in middens, white-chinned petrel being 18.7 times more common, sooty shearwater and Auckland Island snipe nearly three times more common (although the sample size of snipe was small), and yellow-eyed penguin, white-headed petrel, and Auckland Island shag about twice as abundant. This suggests that these species were preferentially targeted as human food. Species under-represented were prions, at less than a third of the number; eastern rockhopper penguins and southern black-backed gulls, being found at only a fifth of the rate; diving petrels, found at merely 10% of the rate; and subantarctic little shearwaters and Auckland Island rails, which were not found in middens at all (although the sample sizes of the latter two species were small). This suggests that the two small seabirds found most abundantly at the Auckland Islands (prions and diving petrels) were not preferentially targeted for food by humans.

Discussion

The main finding of this study is that the bird fauna identified using the Holocene bone collections is generally similar to the current avifauna of the Auckland Islands (Miskelly *et al.* 2020 – Chapter 2 in this book). However, a few species represented by bones are known to be part of the former fauna of the island group, and a few are the only evidence of the species occurring at the Auckland Islands. Additionally, the frequency of some bones found on Enderby Island indicates that there has been change in the population status of some species.

Forty-six bird taxa were found in natural Holocene dune deposits on Enderby Island. Nearly all the species known to breed on the island were found in the deposits. While earlier accounts of these deposits made primary reference to royal albatross remains (e.g. Yaldwyn 1986), smaller seabird taxa, particularly prions and diving petrels, are more common than earlier observers reported (as noted by Tennyson 2009). The most common finds were: diving petrel spp. (22.8%), southern royal albatross (13.2%), prion spp. (11.8%), Auckland Island shag (8.7%), sooty

shearwater (7.7%), yellow-eyed penguin (5.1%), and eastern rockhopper penguin (4.2%). Generally these species are common birds on Enderby Island today, with the exception of the rockhopper penguin, which is no more than a visitor today but was probably more abundant in the past.

Auckland Island rail (1.6% of remains) has never been reported alive on Enderby Island, and so must have been extirpated there early in the human period. Subantarctic little shearwater (1.4%) has never been reported alive onshore on any of the Auckland Islands, and probably entered the dune deposits as regurgitated prey remains of subantarctic skuas. White-chinned petrel (1.2%) is today a very rare breeder on Enderby Island, but was perhaps more common in the past.

The high numbers of small seabirds (prions and diving petrels) found probably reflects a former natural abundance of these species on Enderby Island, as both are common breeders at the Auckland Islands group today (Miskelly *et al.* 2020 – Chapter 2). Large birds (eastern rockhopper penguin, yellow-eyed penguin, southern royal albatross, white-headed petrel, sooty shearwater, Auckland Island shag, and southern black-backed gull) may be over-represented in the deposits due to their large bones being more robust, and so more easily preserved and seen.

This study presents the first Auckland Islands Holocene bone records (all from Sandy Bay) of several species already known as breeding (or former breeding) taxa on the island group: the Auckland Island merganser, light-mantled sooty albatross, Cape petrel, Antarctic prion, lesser fulmar prion, grey-backed storm petrel, white-faced storm petrel, black-bellied storm petrel, subantarctic diving petrel, Auckland Island banded dotterel, tui, Eurasian blackbird, common starling, and Auckland Island pipit. Only one endemic taxon now lacks a Holocene bone record – the Auckland Island tomtit (*Petroica macrocephala marrineri*). Other new bone records are of species that visit the island group only occasionally (Miskelly *et al.* 2020 – Chapter 2): king penguin, Snares crested penguin, erect-crested penguin, blue petrel, broad-billed prion, grey petrel, bar-tailed godwit, and pomarine or Arctic skua. This study also provides unique records of a few species at the Auckland Islands: Kerguelen petrel, Chatham Island taiko, and Antipodes Island parakeet (Fig. 10) – alongside

the previously reported extinct New Zealand raven (Dawson 2020 – Chapter 8).

The Sandy Bay deposits have now revealed bones of all but one of the bird taxa known to have become extinct at the Auckland Islands (Fig. 9). Bones of the merganser were found in 1998 and 2018, those of the South Georgian diving petrel in 1985 and 1998, and those of a white-faced storm petrel in 1998. The shore plover is known from the Auckland Islands by only a single specimen (Miskelly *et al.* 2020 – Chapter 2), and the bone record has so far been unable to verify the prehistoric presence of this species at the group.

About nine species that are considered to breed on Enderby Island currently (French *et al.* 2020 – Chapter 4) have not been recovered in the Enderby Island dune deposits: grey duck (*Anas superciliosa*)/mallard (*A. platyrhynchos*), New Zealand falcon (*Falco novaeseelandiae*), white-fronted tern or Antarctic tern, red-crowned parakeet or yellow-crowned parakeet, Auckland Island tomtit, silvereye (*Zosterops lateralis*), song thrush (*Turdus philomelos*), dunnock (*Prunella modularis*), and common redpoll (*Carduelis flammea*). The small size of many of these species (e.g. the five passerines) is probably the main reason for their absence, because small size means that their bones are more quickly eroded and destroyed, and also less easily seen/found. Grey ducks and/or mallards have limited habitat on Enderby Island, and so, while regularly seen, have never been common (French *et al.* 2020 – Chapter 4). Similarly, falcons are a prominent species that is regularly seen but occurs in very low numbers (French *et al.* 2020 – Chapter 4). Single bones of a small tern and a small parakeet were found in the dune deposits, but neither could be confidently identified to species. Given that these taxa are seen alive fairly commonly on Enderby Island, the lack of Holocene bone records is puzzling. However, these terns and parakeets are also relatively small species, and so may not have been preserved as commonly as large taxa.

The absence of Gibson's wandering albatross (*Diomedea antipodensis gibsoni*) in the Sandy Bay deposits is not surprising as the taxon has never been recorded breeding as far north in the Auckland Island group as Enderby Island, and at-sea records around the Auckland Islands are mainly in the south of the group around

Adams Island (Miskelly *et al.* 2020 – Chapter 2).

With DOC currently investigating the feasibility of eradicating the last of the feral mammals from the Auckland Island group (Russell *et al.* 2020 – Chapter 6), the information on the prehistoric distributions of birds presented in this study can be used to assist the ongoing ecological restoration of these important islands. Specifically, this study provides evidence of a formerly significant colony of South Georgian diving petrels on Enderby Island and indicates that Auckland Island rails were also formerly common; both taxa could potentially be restored to the Port Ross area. Additionally, apparently much larger numbers of rockhopper penguins, white-chinned petrels, and probably several other small petrel species used to occur on Enderby Island, and so investigating ways to encourage such seabirds back could also be investigated.

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Appendices

292 APPENDIX 1. Primary comparative skeletons (all part of the NMNZ collection)

Auckland Island merganser *Mergus australis* OR.23515; Chatham Island merganser *M. milleneri* S.45519; Auckland Island teal *Anas aucklandica* OR.17620, OR.24052a; Australasian shoveler *A. rhynchotis* OR.27401; king penguin *Aptenodytes patagonicus* OR.26965; eastern rockhopper penguin *Eudyptes filholi* OR.19291, OR.19303, OR.19306; Snares crested penguin *E. robustus* OR.23736, OR.23737, OR.23755; erect-crested penguin *E. sclateri* OR.25558, OR.25560; yellow-eyed penguin *Megadyptes antipodes* OR.18335, OR.23135, OR.30195; Gibson's wandering albatross *Diomedea antipodensis gibsoni* OR.24973; southern royal albatross *D. epomophora* OR.24961 & 27589; white-capped mollymawk *Thalassarche cauta stadi* OR.15880, OR.23932, OR.30459; light-mantled sooty albatross *Phoebastria palpebrata* OR.19325; northern giant petrel *Macronectes halli* OR.29173; Cape petrel *Daption capense* OR.21549; Kerguelen petrel *Lugensa brevirostris* OR.29066; white-headed petrel *Pterodroma lessonii* OR.14625; Chatham Island taiko *Pt. magentae* OR.25209a; soft-plumaged petrel *Pt. mollis* OR.26288a;

mottled petrel *Pt. inexpectata* OR.23451; blue petrel *Halobaena caerulea* OR.17591, OR.24529; broad-billed prion *Pachyptila vittata* OR.29859; Antarctic prion *P. desolata* OR.19794, OR.29596; fulmar prion *P. crassirostris* OR.22944, OR.23581; white-chinned petrel *Procellaria aequinoctialis* OR.19809, OR.25170; grey petrel *P. cinerea* OR.12474, OR.24659; sooty shearwater *Ardenna grisea* OR.25635, OR.29007; subantarctic little shearwater *Puffinus elegans* OR.22083, OR.26446; grey-backed storm petrel *Garrodia nereis* OR.29504; white-faced storm petrel *Pelagodroma marina maoriana* OR.29737; black-bellied storm petrel *Fregetta tropica* OR.18963, OR.23798; subantarctic diving petrel *Pelecanoides urinatrix exsul* S.893, OR.17623, OR.17625; South Georgian diving petrel *P. georgicus* OR.27549a; Auckland Island shag *Leucocarbo colensoi* OR.18275, OR.18896; Auckland Island rail *Lewinia muelleri* OR.25556; Auckland Island snipe *Coenocorypha aucklandica aucklandica* OR.18340, OR.26380a; bar-tailed godwit *Limosa lapponica* OR.16514; turnstone *Arenaria interpres* OR.28595; banded dotterel *Charadrius bicinctus bicinctus* OR.24688; Auckland Island banded dotterel *C. b. exilis* OR.25787; shore plover *Thinornis novaeseelandiae* OR.28594, OR.28955; subantarctic skua *Catharacta antarctica lonnbergi* OR.29940a; pomarine skua *Coprotheres pomarinus* OR.22783; Arctic skua *Stercorarius parasiticus* OR.29153a; southern black-backed gull *Larus dominicanus* OR.11412, OR.24270, OR.30359; red-billed gull *Chroicocephalus novaehollandiae scopulinus* OR.16505; white-fronted tern *Sterna striata* OR.29458; Antarctic tern *S. vittata* OR.24692; red-crowned parakeet *Cyanoramphus novaeseelandiae novaeseelandiae* OR.27183, OR.27941a; OR.29739; OR.29869; yellow-crowned parakeet *C. auriceps* OR.29522; Antipodes Island parakeet *C. unicolor* OR.28621, OR.28622; bellbird *Anthornis melanura melanura* OR.29984; tui *Prothemadera novaeseelandiae novaeseelandiae* OR.29067, OR.30269; New Zealand raven *Corvus antipodum* S.27925; Auckland Island tomtit *Petroica macrocephala marrineri* OR.18318; silvereye *Zosterops lateralis* OR.16231; Eurasian blackbird *Turdus merula* OR.18962, OR.29130; song thrush *T. philomelos* OR.30056; common starling *Sturnus vulgaris* OR.16226; Auckland Island pipit *Anthus novaeseelandiae aucklandicus* OR.17617; New Zealand sea lion *Phocarctos hookeri* MM.2877; rabbit

Oryctolagus cuniculus LM.2867; cow *Bos taurus* LM.679, house mouse *Mus musculus* LM.2652.

APPENDIX 2. Archaeological bird bones from Enderby Island, 1998, listed by taxon (number of individual bones/minimum number of individual birds represented), identified by AT in 1999

Yellow-eyed penguin (4/3), penguin spp. (2/1), giant petrel (1/1), white-headed petrel (3/2), prion spp. (5/4), sooty shearwater (11/5), diving petrel spp. (25/8), Auckland Island shag (4/3), subantarctic skua (1/1), eggshell (1/1).

APPENDIX 3. Archaeological bird bones from Enderby Island, 2003, listed by taxon and registration number

Auckland Island teal (NMNZ S.41939, S.41965, S.42001, S.42031), eastern rockhopper penguin (NMNZ S.42011, S.42105), yellow-eyed penguin (NMNZ S.41937, S.41947, S.41954, S.41963, S.41975, S.41984, S.41999, S.42022, S.42029, S.42039, S.42154), southern royal albatross (NMNZ S.41943, S.41950, S.41958, S.41968, S.41972, S.41979, S.41992, S.41993 (eggshell), S.42006, S.42017, S.42018 (eggshell), S.42026, S.42036, S.42043, S.42050, S.42059, S.42153, S.42155), giant petrel (NMNZ S.41951, S.41981, S.41996, S.42021), white-headed petrel (NMNZ S.41946, S.41983, S.41998, S.42009, S.42046, S.42053, S.42061), prion spp. (NMNZ S.41936, S.41961, S.42056, S.42062), white-chinned petrel (NMNZ S.41945, S.41953, S.41960, S.41974, S.41982, S.41995, S.42008, S.42020, S.42028, S.42038, S.42045, S.42052), sooty shearwater (NMNZ S.41935, S.41944, S.41952, S.41959, S.41969, S.41973, S.41980, S.41994, S.42007, S.42019, S.42027, S.42037, S.42044, S.42051, S.42060), diving petrel spp. (NMNZ S.41997, S.42010, S.42057, S.41962), Auckland Island shag (NMNZ S.41938, S.41948, S.41955, S.41964, S.41970, S.41976, S.41985, S.42000, S.42012, S.42023, S.42030, S.42040, S.42047, S.42054, S.42063), Auckland Island snipe (NMNZ S.41988, S.42013, S.42032), subantarctic skua (NMNZ S.42024), southern black-backed gull (NMNZ S.41986), red-billed gull (NMNZ S.41987, S.42002), bellbird (NMNZ S.42033).

APPENDIX 4. Holocene bird bones from Enderby Island, 1963–2018, listed by taxon and registration number

Auckland Island merganser (NMNZ S.47956, S.48220), Auckland Island teal (NMNZ S.36434, S.36443, S.36470, S.47752, S.47783, S.47957, S.48023, S.48082, S.48130, S.48221), king penguin (NMNZ S.48083), eastern rockhopper penguin (NMNZ S.36421, S.36432, S.36441, S.36451, S.36455, S.36468, S.47766, S.47786, S.47906, S.47959, S.48004, S.48025, S.48084, S.48131, S.48179, S.48197, S.48222), Snares crested penguin (NMNZ S.47758, S.48026), erect-crested penguin (NMNZ S.47787, S.48005, S.48132, S.48223, S.48312), yellow-eyed penguin (NMNZ S.36420, S.36431, S.36440, S.36447, S.36454, S.36467, S.42104, S.47767, S.47788, S.47958, S.47977, S.47983, S.48003, S.48024, S.48085, S.48133, S.48176, S.48180, S.48198, S.48224, S.48246, S.48258), penguin spp. (NMNZ S.47768, S.47789), southern royal albatross (NMNZ S.36389–417, S.42094–95, S.47753, S.47759, S.47762, S.47769, S.47790, S.47907, S.47960, S.47978, S.47984, S.47998, S.48006, S.48020–22, S.48086, S.48134, S.48165, S.48181, S.48199, S.48214–15, S.48243–44), white-capped mollymawk (NMNZ S.42096, S.47754, S.48087), light-mantled sooty albatross (NMNZ S.48225), giant petrel (NMNZ S.36418, S.42093, S.42100–101, S.47770, S.47791, S.47908, S.48007, S.48135), Cape petrel (NMNZ S.47792), Kerguelen petrel (NMNZ S.47985), white-headed petrel (NMNZ S.36419, S.36430, S.36439, S.36466, S.42103, S.47909, S.47793, S.47962, S.47979, S.47986, S.48011, S.48088, S.48136, S.48182, S.48200, S.48226, S.48259), Chatham Island taiko (NMNZ S.48137), blue petrel (NMNZ S.48089, S.48138), broad-billed prion (NMNZ S.48140, S.48228), Antarctic prion (S.47794, S.48139, S.48183), lesser fulmar prion (NMNZ S.47763, S.47795, S.48227, S.48247), prion spp. (NMNZ S.36429, S.36438, S.36465, S.42102, S.47760, S.47775, S.47796, S.47910, S.47961, S.47987, S.47999, S.48008, S.48027, S.48090, S.48141, S.48166, S.48184, S.48201, S.48229, S.48245, S.48248, S.48260), white-chinned petrel (NMNZ S.36428, S.47776, S.47964, S.48091, S.48142, S.48261), grey petrel (NMNZ S.36464, S.47963, S.47989, S.48230), sooty shearwater (NMNZ S.36425, S.36437, S.36453, S.36460, S.42097, S.47777, S.47797, S.47911, S.47965, S.47988, S.48009, S.48028, S.48092, S.48143, S.48185, S.48202, S.48231, S.48249, S.48262, S.48313), subantarctic little shearwater (NMNZ S.36426, S.36461, S.42098, S.47966, S.48010,

S.48029, S.48144, S.48167, S.48232), grey-backed storm petrel (NMNZ S.48094, S.48146), white-faced storm petrel (NMNZ S.48145), black-bellied storm petrel (NMNZ S. S.47967, S.48093, S.48147), subantarctic diving petrel (NMNZ S.48186), South Georgian diving petrel (NMNZ S.36463, S.48095–96, S.48148, S.48311), diving petrel spp. (NMNZ S.36427, S.36449–50, S.36462, S.42099, S.47764, S.47778, S.47798, S.47912, S.47968, S.47980, S.47990, S.48000, S.48012, S.48030, S.48097–101, S.48149, S.48168, S.48187, S.48203, S.48218, S.48233, S.48250, S.48263), Auckland Island shag (NMNZ S.36422, S.36433, S.36442, S.36456, S.36469, S.42106, S.47756, S.47779, S.47799, S.47969, S.47991, S.48013, S.48031, S.48102, S.48150, S.48188, S.48204, S.48234, S.48251, S.48264), Auckland Island rail (NMNZ S.36423, S.36457, S.48032, S.48103–04, S.48151, S.48189, S.48205, S.48235, S.48252), Auckland Island snipe (NMNZ S.36435, S.48105, S.48152, S.48190, S.48236), bar-tailed godwit (NMNZ S.48253), Auckland Island banded dotterel (NMNZ S.48265), subantarctic skua (NMNZ S.47970, S.48033, S.48106, S.48153, S.48178, S.48254), skua sp. (NMNZ S.47757), southern black-backed gull (NMNZ S.36424, S.36436, S.36444–45, S.36448, S.36452, S.36458, S.36471–72, S.42107, S.47761, S.48014, S.48034, S.48107, S.48154, S.48191, S.48206, S.48217, S.48237), red-billed gull (NMNZ S.36446, S.36473, S.47971, S.48015, S.48108, S.48155, S.48238, S.48255), tern sp.

(NMNZ S.48156), Antipodes Island parakeet (NMNZ S.48157), parakeet sp. (NMNZ S.48158), bellbird (NMNZ S.48160, S.48169), tui (NMNZ S.48170), New Zealand raven (NMNZ S.47719), Eurasian black-bird (NMNZ S.48171), common starling (NMNZ S.47973, S.48161), Auckland Island pipit (NMNZ S.47972, S.48035, S.48159), bird eggshell (NMNZ S.48196, S.48216, S.48196, S.48339).

APPENDIX 5. Holocene bird bones from Dundas Island, 1998, listed by taxon and registration number

White-capped mollymawk (NMNZ S.48270), Antarctic prion (NMNZ S.48267), prion spp. (NMNZ S.48268), diving petrel sp. (NMNZ S.48269).

APPENDIX 6. Holocene bird bones from Tagua Bay, Auckland Island, 2003, listed by taxon and registration number

Prion spp. (NMNZ S.42067, 42070, 42073, 42075), sooty shearwater (NMNZ S.42066, 42069, 42072, 42074).

APPENDIX 7. Holocene bird bones from Friday Island, 2018, listed by taxon and registration number

White-headed petrel (NMNZ S.47994), sooty shearwater (NMNZ S.47995).