Paleornithological Research 2013

Proceed. 8th Internat. Meeting Society of Avian Paleontology and Evolution

Ursula B. Göhlich & Andreas Kroh (Eds)

naturhistorisches museum wien

Holocene fossil bird remains from subantarctic Macquarie Island

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Abstract — Holocene fossil bird bones recovered from several sites on subantarctic Macquarie Island, southwest of New Zealand, provide a novel source of information about the island's history. There has been heavy modification through human activities, including the introduction of foreign mammals and a predatory flightless bird, the Weka (*Gallirallus australis*). The extinction of two endemic birds — the Macquarie Island Rail (*Gallirallus macquariensis*) and the Macquarie Island Parakeet (*Cyanoramphus novaezelandiae erythrotis*) — was documented in historic times. Fossils from the island include both these extinct species and provide evidence of a probable third global bird extinction — a teal (*Anas* sp.). Most fossil remains are from King Penguins (*Aptenodytes patagonicus*) and Royal Penguins (*Eudyptes schlegeli*) but several other species of seabird are represented, including one widespread species not previously reported from the island — the Subantarctic Little Shearwater (*Puffinus elegans*). The fossils provide evidence of population declines of some species.

Key words: Macquarie Island, Holocene, bird, fossils

Introduction

The subantarctic islands south of New Zealand are rich in wildlife but most have suffered much modification through human activities. The most southern of these, Macquarie Island, was discovered in 1810 and within 100 years several introduced pests became established, including Cats (*Felis silvestris catus* Linnaeus, 1758), Ship Rats (*Rattus rattus* Linnaeus, 1758), House Mice (*Mus musculus* Linnaeus, 1758), Rabbits (*Oryctolagus cuniculus* Linnaeus, 1758) and Weka (*Gallirallus australis* Sparrman, 1786) (Carrick 1957; Clark & Dingwall 1985; Cumpston 1968; Johnstone 1985; Selkirk *et al.* 1990). This isolated island is about 34 km long and 5.5 km wide, lying about 1,100 km southwest of New Zealand at 54°30′S 158°57′E. The direct exploitation of the penguin populations for oil from the 19th century until 1919 eventually caused an international outcry, with campaigners against the slaughter including the Antarctic explorer Douglas Mawson and the author H.G. Wells (Crowther 1933; Cumpston 1968; McEvey & Vestjens 1974; De La Mare 1990). Today the island is a wildlife sanctuary and boasts a rich fauna of seabirds but before the 20th century this was not well documented. Two endemic land birds, the Macquarie Island Rail (*Gallirallus macquariensis* (Hutton, 1879a)) and the Macquarie Island Parakeet (*Cyanoramphus novaezelandiae erythrotis* (Wagler, 1832)), are known to have become extinct on the island in the late 19th century owing to Cat and Weka predation (Taylor 1979) and numbers of many other species declined as a result of the introduced pests (Brothers 1984; Selkirk *et al.* 1990). Some species (e.g. Blue Petrels (*Halobaena caerulea* (Gmelin, 1789))

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published 10 Dec. 2013

FIGURE 1. Macquarie Island showing location of fossil sites

are now restricted to breeding on offshore stacks (Brothers 1984; Garnett *et al*. 2011).

Holocene fossil bones have been recovered from three of the six subantarctic island groups south of New Zealand: Auckland (Tennyson 2009), Campbell (Holdaway *et al*. 2010) and Macquarie Islands but the information from Macquarie Island has been scattered and not thoroughly reviewed. A. Hamilton found fossil bones in 1894 (Hamilton 1895), as did L.R. Blake and H. Hamilton in 1911–14 (McEvey & Vestjens 1974), but no fossils from these expeditions have been located. A.M. Gwynn's 1949 collections appear to be the earliest Macquarie Island fossil bone collections preserved (Vestjens 1963; McEvey & Vestjens 1974). In the 1950s–1960s several collections were made: K. Keith (1956), A.R. McEvey, W. Whitten and R.A. Falla (1957), W.J.M. Vestjens and I. Pederson (1962) (Vestjens 1963; McEvey & Vestjens 1974) and R. Carrick (?1960s) (this paper). Vestjens (1963) reviewed records of Macquarie Island Rail fossils. An analysis of penguin bones from sites at Finch Creek and Bauer Bay was published by McEvey and Vestjens following field studies carried out by them (McEvey & Vestjens 1974). "*A few bones of species other than penguins*" were collected by McEvey and Whitten but McEvey & Vestjens (1974) did not list them. Colhoun & Goede (1973) collected fragmentary penguin remains in 1972 and G.F. van Tets made further bone collections on the island in 1973 (unpublished and, in 2003, stored in the Australian National Wildlife Collection (ANWC), Canberra). Meredith (1985) examined fossil sites on the island during a three or four day visit and located and examined the previously collected non-penguin fossil collections from Finch Creek held (but unregistered) in the Museum Victoria, Melbourne (MV).

In late 1995, one of us (RPS) found a Subantarctic Little Shearwater (*Puffinus elegans* Giglioli & Salvadori, 1869) bone in the Langdon Point caves, which AJDT later identified. RPS looked for further material during his second visit in 1996-97 in an attempt to better document the pre-human avifauna of the island. We identified the material collected by RPS and re-examined most of the pre-1995 collections of Holocene fossils (but excluded the penguin fossils that had previously been analysed).

Subsequently a few more bones have been collected including a parakeet beak in 2001 (K. Medlock pers. comm.) and more penguin bones, most recently by C. Oosthuizen and B. Arthur (Heupink *et al*. 2012).

Methods

The vast majority of fossil bones on Macquarie Island comprises penguins (Meredith 1985 gave a ratio of penguin to petrel bones in McEvey & Vestjens' collection, held in Melbourne, as 116: 1). As the penguin bones had already been thoroughly analysed, RPS concentrated on collecting non-penguin material; however, a few penguin bones were collected by RPS and these, along with some collected by van Tets, are listed here for completeness. Archaeological sites were not collected from by RPS. The bones collected by RPS were donated to the Museum Victoria and subsequently exchanged with the Museum of

New Zealand Te Papa Tongarewa (NMNZ), where AJDT was able to identify them using comparative material.

We reviewed the identity of most previous Holocene bird remains collected on Macquarie Island by visiting the MV, examining VAN TETS' collection in ANWC, and borrowing most of the non-penguin bones from MV. Without carbon-dates and knowing the exact stratigraphy of the sites, it was sometimes unclear whether a collected specimen was truly a Holocene fossil or was actually recent — no doubt some sites contain bones of both ages and from those in the grey area in between. This was particularly the case for VAN TETS' collection but even RPS's collections include species such as Grey Duck (*Anas superciliosa* GMELIN, 1789), which may have colonised Macquarie during the 20th century (CARRICK 1957; but see NORMAN 1987). Our list reflects our interpretation of the taphonomy of the bones. To increase the sample size of measurements of Chestnut Teal (*Anas castanea* (EYTON, 1838)) crania, extra specimens were measured in museums in Frankfurt (SMF) and Tring (NHM) in 2012. We have not examined fossils found by others since 1997. Anatomical terms follow BAUMEL & WITMER (1993). Bird taxonomy follows GILL *et al*. (2010), except for the Macquarie Island Rail which follows TENNYSON & MARTINSON (2007).

Abbreviations

alar phal = alar phalange, cf. = similar to and probably, cmc = carpometacarpus, coll = collected, cor = coracoid, fem = femur, fib = fibula, frag = fragment, hum = humerus, L = left, MNI = minimum number of individuals, ped phal = pedal phalanx, R = right, rad = radius, pel = pelvis, scap = scapula, tbt = tibiotarsus, tmt = tarsometatarsus, uln = ulna.

Results

Fossil remains of birds found at Macquarie Island listed by site and taxonomically, including only a summary of penguin finds.

Aurora Cave

Teal(?) (*Anas* sp.) — MNI = 1: 1 partial skull, coll: 5 Jan 1962, VESTJENS, Australian National Antarctic Research Expeditions (ANARE) Zoology Number M62/B/48, MV collection unnumbered. On 15 Nov 1978, H. KING identified this specimen as "*Anas* ?*giberifrons*[sic]" [= Grey Teal *A. gracilis* BULLER, 1869] and MEREDITH (1985) confirmed it as an *Anas*. We compared this cranial fragment with skulls of other ducks (Tab. 1).

The overall shape of the skull is similar to that of other *Anas* but it has a relatively larger prominentia cerebellaris and the interorbital width most closely matches the skulls of the Chestnut Teal and Brown Teal (*Anas chlorotis* GRAY, 1845) (Tab. 1). The interorbital width is greater than that of the flightless Auckland Island Teal (*Anas aucklandica* (GRAY, 1849)) and Campbell Island Teal (*Anas nesiotis* (FLEMING, 1935)), slightly broader than that of Grey Teal (*Anas gracilis*), and narrower than that of Mallard (*Anas platy-*

TABLE 1. Measurements (mm) of minimum dorsal interorbital bone width of *Anas* species. All recent specimens were from the NMNZ collection, apart from *Anas castanea* SMF 4578, SMF 10575, NHM S/1966.51.5, NHM S/1966.51.10 & NHM S/2002.35.2.

Species	Mean (range)	Sample size
Grey Teal *Anas gracilis*	7.0 (5.8–8.1)	10
Chestnut Teal *Anas castanea*	8.1 (7.2–9.0)	7
Brown Teal *Anas chlorotis*	8.8 (7.7–10.2)	10
Auckland Island Teal *Anas aucklandica*	5.9 (5.4–6.7)	12
Campbell Island Teal *Anas nesiotis*	5.5 (5.1–6.3)	6
Macquarie Island specimen	8.4	1
Mallard *Anas platyrhynchos*	9.8 (8.7–10.8)	13
Grey Duck *Anas superciliosa*	9.3 (6.9–10.7)	13

rhynchos Linnaeus, 1758). It is narrower than that of a Grey Duck (although within the width range of this species) but overall has a much smaller cranium.

"Wandering Albatross" (*Diomedea exulans* Linnaeus, 1758) — MNI = 8: pel, coll: 13 Apr 1962, Vestjens, ANARE M62/B/118, MV B12147; L hum, coll: 30 Jul 1962, Vestjens, ANARE M62/B/119, MV B12148; skull, 2L3R cor, coll: 5 Jan 1962, Vestjens, ANARE M62/B/41, MV B12149; sternum, coll: 13 Apr 1962, Vestjens, ANARE M62/B/120, MV B12150; 5 furcula, MV B31651; 3L5R hum, 3L uln, 1 R rad, coll: 12 Apr 1956, Keith, MV B31703; skull, 20 vertebrae, 4L4Rscap, 7L8Rtbt, 1L1R cmc, 2L2Rfem, 1Ltmt, coll: 14 Apr 1956, Keith, MV B31705. "Aurora Point" is the locality recorded for MV B11860 and "NT of Aurora Point" is the locality recorded for MV B31703 but we have assumed that both these specimens are from Aurora Cave. Although MV B31651 has little collection information, we have assumed that it is part of the Aurora Cave 1956 Keith collection. MNI is based on the 8 right tbt (MV B31705).

In 1949 Gwynn found a midden of bones ("*almost exclusively... young wandering albatrosses*", that he believed were of human origin, in a cave about half a mile north of Aurora Point (Gillham 1967: 101). In 1956 "*parts of at least seventy birds were collected from it, but it still appeared to be full in 1960, when part of it had disappeared under a recent rock fall*" (Gillham 1967: 101). In 1957, after recently returning from Macquarie, Carrick noted that the "Wandering Albatross" would have been "*an easy source of winter food*" for sealers and shipwrecked mariners and that a "*collection of skeletons*" had been recently found in a west coast cave (Carrick 1957). We presume that this "west coast" cave is Aurora Cave. A collection of 48 skulls and mandibles of albatrosses collected by R. Carrick from a "sealers' midden" in "196?" (ANWC reg. nos. 5438-5468, van Tets' nos. PROS1087-1117) was thrown out from the ANWC collection in the 1990s when van Tets' disordered collections were partly sorted and reorganised following his death (J. Wombey pers. comm. 2003). Carrick & Ingham (1970) reported a "recent discovery of over 100 ["Wandering Albatross"] skulls in caves inhabited by sealers or castaways", which presumably refers to Keith's and/or Carrick's collections. Although some 1956 collections made by Keith remain at MV, it is possible that the material thrown out from ANWC was actually much of the 1956 collection. We have not located an unpublished 1956 manuscript by Keith that contains further details about these collections (see De La Mare & Kerry 1994).

Lengths of the "Wandering Albatross" crania, humeri, tibiotarsi and tarsometatarsi in the MV collection were measured for comparison with modern skeletons of Antipodean Albatross in NMNZ (Tab. 2). The Macquarie skull measurements are larger than those of Antipodean Albatrosses but the post-cranial bones, although averaging larger, are all within the range of those of Antipodean Albatrosses. This suggests that some of the fossils represent the Wandering Albatross, which is a larger species (see Marchant & Higgins 1990), and that some may represent Antipodean Albatrosses, but we lacked

TABLE 2. Summary of measurements (mm) of maximum bone lengths of fossil Macquarie Island "Wandering Albatross" specimens and modern Antipodean Albatross specimens, showing mean ± 1 s.d., n = sample size, range. Macquarie Island specimens: Museum Victoria B12148, B12149, B31703, B31705; each element was assumed to be from a different individual, except in one case (right tibiotarsus B31705) which was excluded from the analysis because identical lengths were obtained for 2 left tibiotarsi. Antipodean Albatross specimens: Museum of New Zealand Te Papa Tongarewa NMNZ 606-S, 19352, 24673a, 24674a, 24973, 24979, 25130, 25131, 25132, 25210, 25211, 25212, 25213, 25214, 25215, 25628a, 25629a, 25630a, 25631, 26744, 26885, 27007, 27008, 27188, 28654a.

	Macquarie Island	***Diomedea antipodensis***
Crania	247, 261, n = 2	227.0 ± 8.86, n = 24, 213–2442
Humeri	408.6 ± 13.19, n = 9, 378–422	398.2 ± 14.32, n = 23, 376–427
Tibiotarsi	232.4 ± 7.83, n = 14, 220–242	225.3 ± 8.37, n = 21, 212–243

comparative measurements of modern Wandering Albatross skeletons.

Macquarie Island Rail (*Gallirallus macquariensis* (Hutton, 1879a)) — Vestjens (1963) noted that the remains of several Macquarie Island Rails had been found in this cave: a mandible (by Keith in 1956), a skull (by Falla in Dec 1957, but subsequently lost), 3 skulls (by Vestjens on 5 Jan 1962; MV B31658–31660).

General observations — Meredith (1985) noted "*abundant remains of seabirds eaten by the past human occupants of this cave*" and "*more recent material, presumably collected by cats... in small amounts*". He specifically noted the presence of "Wandering Albatross", White-headed Petrel (*Pterodroma lessonii* (Garnot, 1826)), Blue Petrel, Grey Petrel (*Procellaria cinerea* (Gmelin, 1789)), Sooty Shearwater (*Puffinus griseus* (Gmelin, 1789)) and Subantarctic Skua (*Catharacta skua lonnbergi* (Mathews, 1912)). However, "*due to the historic nature of these deposits*" Meredith "*left them as little disturbed as possible*", but noted that "*they are so extensive*" that they warranted further investigation. Two complete Southern(?) Giant Petrel (*Macronectes* ?*giganteus* (Gmelin, 1789)) mandibles were sketched and measured (141 & 144 mm long) (but not collected) by RPS on 21 Jan 1997. RPS also noted about 50 partial skulls of "Wandering Albatrosses" but owing to its archaeological nature he left this site undisturbed also.

Bauer Bay Site F

coll: RPS on 10, 12, 15, 20 Nov, 2, 9, 10 Dec 1996, 15 Jan 1996, 23 Apr 1996

Grey Duck — MNI = 1: hum 1, 1 uln, 1 rad, 2 cmc, 1 fem, 2 tbt, 1 fib, NMNZ S.44619, S.44646.

Giant Petrel (*Macronectes* sp.) — MNI = 1: 1 tmt, 1? feather, NMNZ S.44630, S.44644.

White-headed Petrel — MNI = 1: 1 hum, 1 uln, 1 cmc, 1 fem, NMNZ S.44620, S.44633.

Blue Petrel — MNI = 5: 8 hum, 3 uln, 1 rad, 1 cmc, 1 fem, 2 tbt, 1 tmt, NMNZ S.44615, S.44626, S.44637, S.44641, S.44648.

Antarctic Prion (*Pachyptila desolata* (Gmelin, 1789)) — MNI = 4: 6 hum, 7 uln, 3 rad, 5 cmc, 1 tbt, NMNZ S.44614, S.44625, S.44636, S.44647.

Short-tailed Shearwater (*Puffinus tenuirostris* (Temminck, 1836)) — MNI = 1: 1 hum, 1 uln, 1 cmc, NMNZ S.44618, S.44623, S.44632.

Subantarctic Little Shearwater — MNI = 1: 1 tbt, 1 tmt, NMNZ S.44635.

Diving petrel (*Pelecanoides* spp.) — MNI = 4: 5 hum, 1 rad, 1 cmc, 1 tmt, NMNZ S.44616, S.44629, S.44640, S.44645.

Macquarie Island Rail — MNI = 2: 2 tbt, NMNZ S.44624.

Subantarctic Skua — MNI = 2: 1 hum, 2 uln, 2 rad, 1 alar phal, 2 tmt, NMNZ S.44617, S.44622, S.44634.

Macquarie Island Parakeet — MNI = 1: 1 rectrix, NMNZ S.44639.

General observations — Between Oct and Dec 1962, Vestjens made the first collections of bones at this site, which was described in detail by McEvey & Vestjens (1974). King Penguin (*Aptenodytes patagonicus* Miller, 1778) bones were more common than those of Royal Penguins (*Eudyptes schlegeli* Finsch, 1876), and bones from here were dated at 3,980 ± 140 years B.P. (McEvey & Vestjens 1974). In Nov 1972, Colhoun & Goede (1973) collected additional fragments of King Penguin bones at Bauer Bay. In 1996 RPS collected only fragmentary penguin remains here including: Eastern Rockhopper Penguin (*Eudyptes filholi* Hutton, 1879b) (MNI = 1: 1 quadrate, 1 scap, 1 fem; NMNZ S.44627, S.44638, S.44643) and Royal Penguin (MNI = 1: 1 mandible; NMNZ S.44628). Recent radiocarbon dating of eight King Penguin bones from this location (including bones collected by McEvey and more recently by Oosthuizen and Arthur) revealed them to average 7,927 (range 6,834-8,429) years old (Heupink *et al*. 2012). Meredith

(1985) located six of the seven sites (sites A-G) recorded by McEvey & Vestjens (1974) at Bauer Bay and found abundant King Penguin bones but he did not find site F where RPS collected bones.

Bauer Bay, Strata FS (DD are collector numbers)

Teal(?) (*Anas* sp.) — MN1=1: 1 pel, MV collection unnumbered. This fragmentary pelvis resembles that of a Brown Teal in that it appears to have a broad fused dorsal surface to the synsacrum. It is smaller than that of Mallards and Grey Ducks which suggests that it may be from a teal.

Grey-headed(?) Albatross (*Thalassarche* cf. *chrysostoma* (Forster, 1785)) — MNI=1: ped phal, DD16, MV collection unnumbered.

White-headed Petrel — MNI=1: 1 fem, DD16, MV collection unnumbered.

Blue Petrel — MNI=1: 1 hum, 1 rad, DD16, MV collection unnumbered.

Antarctic Prion — MNI=1: 1 cor, DD3, MV collection unnumbered.

Sooty Shearwater — MNI=1: 1 uln (possibly large *Pterodroma*),1 cmc, 1 alar phal, 1 ped phal, all DD16, MV collection unnumbered.

Subantarctic Little Shearwater — MNI=3: 1 skull (DD1), 1 sternum (DD15), 3 cor (DD2, DD4, DD5), 1 hum (DD16), 1 uln (DD16), 2 pel (DD11, DD12 & DD13 are parts of the same pel), 1 tbt (DD16), MV collection unnumbered.

Diving petrel — MNI=1: 1 rad, 1 fem, both DD16, MV collection unnumbered.

General observations — Meredith (1985) identified bones of Blue Petrel and Antarctic Prion in site "F5#DD16" and those of White-headed Petrel, a "*Pterodroma sp. medium size, (mollis?)*", Antarctic Prion, juvenile Sooty Shearwater, ?Fluttering Shearwater (*Puffinus gavia* Forster, 1844) and Common(?) Diving petrel ("*Pelecanoides* prob. *urinatrix*") in site "F5#DD3" ("F5" appears to be a misreading of "FS"). Meredith's (1991) reference to the presence of bones of "*Pterodroma lessonii, juvenile Puffinus prob. griseus, and a small Puffinus similar to Puffinus gavia but too poorly represented to be confidently identified*" is based on his 1985 article. We believe that Meredith's "*Puffinis gavia*" bones are those of Subantarctic Little Shearwaters because they are too small for those of Fluttering Shearwaters. Also the preserved humerus has a flattened shaft characteristic of several *Puffinus* spp. but unlike the humeri of *Pterodroma* petrels. We did not identify any medium-sized *Pterodroma* bones among these specimens.

Brothers Point Caves

Antarctic Prion — MNI=1: 1 hum, coll: 1 Nov 1996, RPS, NMNZ S.44612.

General observations — Meredith (1985) first brought attention to the potential for bird bones to be found in a group of caves just south of Brothers Point, near Finch Creek. In one cave he found "*a variety of petrel, skua and penguin bones, but all appeared to be recent in origin, their presence due to the use of these caves by cats*". In another cave which he was not able to fully explore he found "*abundant material of the Dove [= Antarctic] Prion Pachyptila desolata... but...no evidence of cat activity*". A parakeet beak and some other bird bones were collected in these caves on 7 Dec 2001 by G. Hedley and deposited in the Tasmanian Museum & Art Gallery, Hobart (registration number of beak B4678) (K. Medlock pers. comm. 2012; G. Hedley pers. comm. 2013). Photos of other bones collected in 2001 (G. Hedley pers. comm. 2013) include a few post-cranial Macquarie Island Rail bones and possibly some duck bones. Clearly a full investigation of these caves and collections made in them is needed.

Eagle Cave

Meredith (1985) noted that this cave may be worth excavating for bones but did not visit it due to lack of time. Although he noted that it had

been "*well picked over in the past*", we have not located any collections of bones from this site. Vestjens (1963) reported that he found part of a cranium of the Macquarie Island Rail in this cave on 16 Jan 1962 (MV B31661).

Finch Creek

McEvey & Vestjens (1974) provided a detailed history and description of this site. Blake recorded probable penguin bones and may have collected some in 1911-14. Gwynn collected some bones in 1949, which were deposited in the MV. On 13, 17 and 18 Dec 1957, McEvey and Whitten studied this site and collected further bones, including "*a few bones of species other than penguins*". Vestjens spent all of 1962 on the island and, with Pederson, made further collections of the bones here. The majority of bones from this site are Royal Penguin, a sample of which were dated at 6,100 ± 120 years B.P. Meredith (1985) found all of McEvey & Vestjens' sites at Finch Creek and identified a few Royal Penguin bones. RPS did not investigate this site. We have not located the non-penguin bones that were apparently collected but they may be listed here under Bauer Bay as this collection is poorly labelled.

Green Gorge

In Nov 1972, Colhoun & Goede (1973) collected fragmentary King Penguin bones from an uplifted marine terrace at this site.

Isthmus at base of North Head

In 1894, A. Hamilton (1895) found bones representing a large former King Penguin rookery and two skulls "*of a very large species of albatross*" (presumably "Wandering") at this site. Along with some crew members, the skulls were subsequently swept overboard from the ship and lost on Hamilton's return journey to New Zealand. In 1911, H. Hamilton found "masses" of King Penguin bones here (McEvey & Vestjens 1974). This is now near the site of the main ANARE base station and the beach where the deposit is exposed on the eastern coast is named Fossil Beach. van Tets collected only penguin bones at "Base Camp" on 1 Dec 1973: King Penguin (4L1R cor, 5 fib, 1 partial pel, 1 distal R fem, 12 L16R tbt, 6 tmt, all were juvenile except one R tbt; all van Tets no. SPHS30, ANWC collection unnumbered). Recently at least 20 King Penguin bones were collected by Oosthuizen and Arthur from the Landing Beach on the Isthmus for DNA analysis; radiocarbon dating of seven of these bones revealed them to average 1,002 (range 816-1,134) years old (Heupink *et al*. 2012).

Langdon Point Caves

Subantarctic Little Shearwater — MNI = 1: 1 tmt, coll: late 1995, RPS, NMNZ S.44610.

General observations — Meredith (1985) was correct in predicting that a bone deposit may have occurred in caves here, although he did not find it himself. RPS found a significant natural deposit of bones here in late 1995 but as most appeared to be recent, he collected only one.

North Head (presumed to be north of the ANARE base station)

Macquarie Island Shag (*Leucocarbo purpurascens* (Brandt, 1837)) — MNI = 1: alar phal, 3 ped phal, coll: 30 Nov to 3 Dec 1973 by van Tets, ANWC collection unnumbered.

General observations — van Tets also collected a small number of penguin bones at this time: Eastern Rockhopper Penguin (1 ped phal, ANWC collection unnumbered), Royal Penguin (1 L cor, van Tets no. SPHS30, ANWC collection unnumbered; 1 ped phal, van Tets no. SPHS36, ANWC collection unnumbered).

Plateau between Bauer Bay and Finch Creeks

White-headed Petrel — MNI = 1: hum 1, uln 1, coll: 20 Nov 1996, RPS, NMNZ S.44613.

Discussion

The human impacts on the bird fauna of Macquarie Island have been both colourful and devastating; however, with the exception of up to four extinct taxa, most species found in fossil sites on the island still breed there. Fossils provide evidence of reduced distributions of some species. McEvey & Vestjens (1974) noted that fossil bones suggested that "*colonies of King Penguins at Macquarie were either more numerous than, or differently situated from those mentioned in the recorded history of this species*" and that the "*fossil remains of [King and Royal Penguins] provide evidence of former colonies that do not now exist, in certain localities*". Colhoun & Goede (1973) suggested that King Penguins "*were formerly distributed on most beaches*" on the island.

Almost all species known to currently or formerly breed on the island are now known from fossil sites, with our study reporting the first fossils of Grey Duck, Eastern Rockhopper Penguin, Grey-headed(?) Albatross, Southern(?) Giant Petrel, Short-tailed Shearwater, Subantarctic Little Shearwater, Macquarie Island Shag and Macquarie Island Parakeet (Tab. 3). Breeding species that should be present with larger samples of fossils but not yet identified are: Gentoo Penguin (*Pygoscelis papua* (Forster, 1781)), Light-mantled Sooty Albatross (*Phoebetria palpebrata* (Forster, 1785)), Northern Giant Petrel (*Macronectes halli* Mathews, 1912), Southern Black-backed Gull (*Larus dominicanus* Lichtenstein, 1823) and Antarctic Tern (*Sterna vittata* Gmelin, 1789) (Selkirk *et al*. 1990; Copson & Brothers 2008). The Soft-plumaged Petrel (*Pterodroma mollis* (Gould, 1844)), which has only just colonised Macquarie (Fullagar *et al*. 1986; Holdaway *et al*. 2001; Copson & Brothers 2008; Garnett *et al*. 2011), was not identified from fossil material, despite Meredith's listing of "*Pterodroma* sp. medium size, (*mollis*?)". He did not detail to which specimens he was referring, however, we suspect that these bones were of the Subantarctic Little Shearwater, as some bones of this species are similar in size to those of Soft-Plumaged Petrel but differ in shape. Similarly, Black-browed Albatrosses (*Thalassarche melanophris* (Temminck, 1828)) and Cape Petrels (*Daption capense* (Linnaeus, 1758)) are probably also recent colonists of Macquarie Island (Carrick 1957; MacKenzie 1968; Tennyson *et al*. 1998; Copson & Brothers 2008), and so these species would not be expected in fossil deposits.

A significant find of this study is the probable presence of an extinct teal on Macquarie Island. This small duck is represented by a fragmentary skull and pelvis — unfortunately the bones are too damaged to identify the species represented with certainty using morphological criteria. Some 19th century authors suggested that there was a teal resident on Macquarie Island (e.g. see Scott 1883; Falla 1937: 19). On the basis of morphology and measurements, we favour the idea that the bones represent an extinct endemic species. Endemic flightless teals are found on the two nearest subantarctic islands — Auckland and Campbell — so an endemic teal on Macquarie might be expected. Norman (1987) concluded

TABLE 3. List of species recorded in fossil sites on Macquarie Island. *no specimens preserved in museum collections, **new fossil records for Macquarie Island.

Teal(?) (*Anas* sp.)
Grey Duck (*Anas superciliosa*)**
King Penguin (*Aptenodytes patagonicus*)
Eastern Rockhopper Penguin (*Eudyptes filholi*)**
Royal Penguin (*Eudyptes schlegeli*)
"Wandering Albatross" (*Diomedea exulans/antipodensis*)
Grey-headed(?) Albatross (*Thalassarche* cf. *chrysostoma*)**
Southern(?) Giant Petrel (*Macronectes* ?*giganteus*)**
White-headed Petrel (*Pterodroma lessonii*)
Blue Petrel (*Halobaena caerulea*)
Antarctic Prion (*Pachyptila desolata*)
Grey Petrel (*Procellaria cinerea*)*
Sooty Shearwater (*Puffinus griseus*)
Short-tailed Shearwater (*Puffinus tenuirostris*)**
Subantarctic Little Shearwater (*Puffinus elegans*)**
Diving petrel (*Pelecanoides urinatrix exsul/georgicus*)
Macquarie Island Shag (*Leucocarbo purpurascens*)**
Macquarie Island Rail (*Gallirallus macquariensis*)
Subantarctic Skua (*Catharacta skua lonnbergi*)
Macquarie Island Parakeet (*Cyanoramphus novaezelandiae erythrotis*)**

that all early "teal" records related to the Grey Teal. However, the only confirmed records of Grey Teal on the island relate to vagrants (Copson & Brothers 2008). An 1822 reference reporting "*Widgeons (called Tussock fowl by the sealers as they lived among the tussock and did not fly)*" as well as "*teal (from the lagoons on top of the island)*" (Cumpston 1968: 51) may well refer to a locally breeding teal (Tennyson & Martinson 2007: 80). Finds of more complete bones of this duck should quickly resolve the question.

Another important finding of this study is the presence of 13 Subantarctic Little Shearwater bones in fossil sites. These bones come from three sites and suggest that this species may have formerly bred. The Subantarctic Little Shearwater currently breeds in the New Zealand region at the Chatham and Antipodes Islands and, further afield, on islands in the Tristan and Gough groups in the South Atlantic (Marchant & Higgins 1990), so a former breeding colony on Macquarie would not be surprising. Falla (1937) correctly commented that the island "*compares unfavourably with many other subantarctic islands in regard to the number of petrel species found breeding there*" and that the "*possibility of some of the smaller ones having been previously exterminated by dogs, cats, rats, or wekas must...be considered*". If Subantarctic Little Shearwaters did breed on Macquarie, it is likely that the species was exterminated in the late 19th century by Cats and Weka, at the same time that the rail and parakeet were wiped out. Holocene Subantarctic Little Shearwater bones are also found in dune deposits on Enderby Island, Auckland Islands, but breeding has also never been detected on that island group (Tennyson 2009), so another possibility is that the seas around Auckland and Macquarie Islands are (or were) part of the normal at-sea range of Subantarctic Little Shearwaters and predatory skuas caught them and regurgitated their remains onshore. The Subantarctic Little Shearwater is considered a "*very rare vagrant*" at Macquarie Island today (Selkirk *et al*. 1990). The previous tentative identification of small shearwater bones as being from Fluttering Shearwaters is most unlikely because the Macquarie bones are too small and the island is well outside the normal range of this species. There is only one record of a Fluttering Shearwater on Macquarie Island (a mummy found by K.G. Simpson in 1965, ANWC 10602, pers. obs.). Otherwise the most southerly records of a Fluttering Shearwater, and the similar Hutton's Shearwater (*Puffinus huttoni* Mathews, 1912), are nearly 1,000 km to the northeast at The Snares in the 19th century and even these records are doubtful (Miskelly *et al*. 2001; Tennyson *et al*. submitted manuscript).

The bones of a Short-tailed Shearwater from Bauer Bay site F appear to be from one individual, which was presumably a vagrant. This species has never been found breeding on Macquarie Island but it has been found as a vagrant on the island several times since 1960 (Jones 1980; Brothers 1984; Copson & Brothers 2008; RPS found the remains of five individuals in 1996), and it regularly ranges south to Antarctic waters (Kerry *et al*. 1983).

Both birds previously known to have become extinct on Macquarie Island (the endemic rail and parakeet) have now been found in fossil sites. The Macquarie Island Parakeet previously occurred "*in great numbers round the shore*" (Scott 1883) and was recorded alive between 1810 and 1890, with 21 specimens being collected for museums (Taylor 1979; Scofield 2005; RPS unpublished data). The tail feather found in 1996 and the beak found in 2001 are the first fossil records of this species.

We are aware of the following fossil Macquarie Island Rail bones having been found: one mandible in Aurora Cave in 1956, one complete skull in Aurora Cave in 1957, three skulls in Aurora Cave in 1962, one skull in Eagle Cave in 1962 (Vestjens 1963), two tibiotarsi in Bauer Bay in 1996 and some post-cranial bones in Brothers Point Cave in 2001 (reported here). This rail became extinct about 1890 and is represented by only three surviving skin specimens (Tennyson & Martinson 2007) — one in Otago Museum (AV740, AJDT pers. obs.) and two in the Natural History Museum, England (NHM 1881.12.27.1 & NHM 1881.12.27.2) (Buller 1905; Oliver 1955; Vestjens 1963; AJDT pers. obs.). When Joseph Burton left Macquarie Island in 1900, he apparently left behind a collection of prepared bird skins, including "*four or five landrails of a kind of which no Museum in Europe possesses a specimen, except Rothschild, and he*

only one" (Cumpston 1968: 206–210). Although some specimens from this collection were salvaged for the British Museum (now the Natural History Museum) in 1902 (Cumpston 1968: 209-210), apparently the rails were not among them. The holotype is the Otago Museum specimen. It was described in October 1879, being collected "*last March by a sealing expedition, and... presented to the Otago Museum by Messers. Elder and Co.*" when the species was "*common on the south part of the island*" (Hutton 1879a). The two Natural History Museum specimens were sent by George Grey to P.L. Slater "*some twenty years ago or more*" before 1902 (Buller 1905). Oliver (1955) speculated that these were collected by the same collector who obtained the Otago bird. Additionally, the Otago Museum specimen includes a sternum, ribs and pectoral elements (Hutton 1879a; AJDT pers. obs.) and there is a Macquarie Island Rail pelvis labelled "prior to 1894" in the NMNZ collection (reg. no. 15139). The pelvis is well preserved and appears to have been extracted from a whole bird. In the late 1800s, body bones from skinned or mounted specimens were often preserved in the Colonial Museum (now NMNZ) (AJDT pers. obs.). The pelvis has a label "*Rallus macquariensis*" in what appears to be Hutton's handwriting (AJDT pers. obs.). As Hutton described this species based on the Otago specimen which lacks a pelvis, Tennyson & Bartle (2008) concluded that the NMNZ pelvis is part of the holotype specimen.

Given the wealth of fossil bone sites on Macquarie Island, much more research on deposits should be done to elucidate the past bird fauna of the island. Further collecting should reveal whether other species have become extinct in historic times. More bones of the small duck are required to firmly establish its status. Bones of other species, *e.g.*, a *Coenocorypha* snipe and pipit *Anthus* sp., might be expected.

The past status of "Wandering Albatrosses" on the island needs clarification. The current population has built up from just one or two nests in 1911 and results from "considerable immigration" but the source population(s) are unknown (De La Mare & Kerry 1994). There have been suggestions that the smaller darker Antipodean Albatross (*Diomedea antipodensis* Robertson & Warham, 1992) used to occur on Macquarie Island (Smith 1997). Measurements of the Aurora Cave fossil bones indicate that Wandering Albatrosses are represented and Antipodean Albatrosses may be represented. It is unfortunate that the majority of fossil albatross skulls from Macquarie Island were thrown out after about 40 years in a museum collection and, subsequent to our 2003 visit, apparently further van Tets material has been disposed of from ANWC (T. H. Worthy pers. comm. 2012). Wandering Albatrosses breed on Macquarie Island currently and the fossil evidence suggests that they used to historically also. However, the past and current status of Antipodean Albatrosses on the island is less clear as the identity of most fossil albatross bones is uncertain and records of darker-plumaged "Wandering Albatrosses" recorded ashore by Gillham (1967: 104) and Terauds & Stewart (2005) suggest that Antipodean Albatrosses may be more regular than previously documented. It would be valuable to carry out molecular analyses on the fossil bones to expand on a previous study which examined the relationships of the living Macquarie Island Wandering Albatross population (Alderman *et al.* 2005).

Subantarctic Diving Petrels (*P. urinatrix exsul* Salvin, 1896) and South Georgian Diving Petrels (*Pelecanoides georgicus* Murphy & Harper, 1916) have been recorded at Macquarie Island (Bourne 1981; Brothers 1984; Copson & Brothers 2008) but we were unable to assign a species to the fossil material. Seven Subantarctic and eight South Georgian Diving Petrel skeletons (in the NMNZ collection) were measured for comparison with Macquarie Island bones. Some fossil Macquarie diving petrel bones fell within the size range of the larger Subantarctic Diving Petrel, others were within the range of the South Georgian species and others fell between the ranges of both. Therefore, we could not determine whether both species were represented or whether all bones belonged to one species that has a larger size range than is represented in the NMNZ collection. If cranial material was found, this should allow specific identity (Worthy 1998). Similarly, further work on prion (*Pachyptila* spp.) fossils would be valuable as the past breeding status of several prion taxa is unclear (Brothers 1984; Copson & Brothers 2008). Investigating the identity of fossils of these taxa

using molecular analyses would be helpful also.

A great deal more systematic excavation and analysis of fossils is required to help illuminate the pre-human bird fauna of Macquarie Island — the identity of large albatrosses and the teal are a priority.

Acknowledgements

Thanks to: Bob Gould (Tasmania Parks and Wildlife Service) for allowing his permit to be used by RPS to collect the Macquarie Island bones; Rory O'Brien (Museum Victoria) for the loan and exchange of bones from Melbourne; Kerri-Anne Edge (Otago Museum) for providing information on the Macquarie Island Rail type specimen in 1998; John Wombey for information on collections in ANWC (Canberra), and to him, Robert Palmer and Terry Chesser for hosting us there in Dec 2003; Wayne Longmore for assisting AJDT at the Museum Victoria in Apr 2007; Gerald Mayr (SMF) for helping AJDT at the Forschungsinstitut Senckenberg Museum, Frankfurt in Jun 2012; Joanne Cooper for assisting AJDT at the Natural History Museum, Tring, in Jul 2012; Karen Roberts (Museum Victoria) for providing registration details of Macquarie Island Rail specimens; Kathryn Medlock (Tasmanian Museum and Art Gallery) and Georgie Hedley (New Zealand) for information on the bones found in Brothers Point Caves; and Martin Lewis and Christine Kiddey (NMNZ library) for obtaining some of the references. Walter Boles (Sydney) and Colin Miskelly (NMNZ) provided helpful comments on the manuscript.

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