TE PAPA
OUR PLACE

27
2016

TUHINGA

RECORDS OF THE MUSEUM OF NEW ZEALAND TE PAPA TONGAREWA

Tuhinga: Records of the Museum of New Zealand Te Papa Tongarewa

The journal of scholarship and mātauranga

Number 27, 2016

Tuhinga: Records of the Museum of New Zealand Te Papa Tongarewa
is a peer-reviewed publication, published annually by
Te Papa Press
PO Box 467, Wellington, New Zealand

TE PAPA
PRESS

TE PAPA ® is the trademark of the Museum of New Zealand Te Papa Tongarewa
Te Papa Press is an imprint of the Museum of New Zealand Te Papa Tongarewa

Tuhinga is available online at www.tepapa.govt.nz/tuhinga

It supersedes the following publications:
Museum of New Zealand Records (1171-6908);
National Museum of New Zealand Records (0110-943X);
Dominion Museum Records; *Dominion Museum Records in Ethnology*.

Editorial board: Catherine Cradwick (editorial co-ordinator), Claudia Orange, Stephanie Gibson, Patrick Brownsey, Athol McCredie, Sean Mallon, Amber Aranui, Martin Lewis, Hannah Newport-Watson (Acting Manager, Te Papa Press)

ISSN 1173-4337

All papers © Museum of New Zealand Te Papa Tongarewa 2016
Published June 2016

For permission to reproduce any part of this issue, please contact the editorial co-ordinator, *Tuhinga*, PO Box 467, Wellington.

Cover design by Tim Hansen
Typesetting by Afineline
Digital imaging by Jeremy Glyde

Tuhinga: Records of the Museum of New Zealand Te Papa Tongarewa

Number 27, 2016

Contents

 Copyright © Museum of New Zealand Te Papa Tongarewa (2016)

A partnership approach to repatriation: building the bridge from both sides

Te Herekiekie Herewini* and June Jones**

* Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington, New Zealand (teherekiekieh@tepapa.govt.nz)

** University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom (j.jones.1@bham.ac.uk)

ABSTRACT: Māori and Moriori ancestral remains were traded throughout Europe, the Americas and Australia from the 1770s onwards. Repatriation requests have successfully secured the return of many ancestral remains, but the act of repatriation does not always lead to a lasting legacy of friendship and continued collaboration. The University of Birmingham and the Museum of New Zealand Te Papa Tongarewa worked together to build a bridge that allowed collaborative work to continue beyond the formal handover ceremony of Māori ancestors in 2013. The bridge was built by mutual respect, increased levels of understanding and willingness to cooperate for the good of both parties through the handover ceremony. From the university's perspective, the act of repatriation was a moral duty, providing an opportunity to address colonial attitudes that had led to the collection and retention of the ancestors. From Te Papa's perspective, the formal handover ceremony provided an opportunity to show respect to the ancestors in an appropriate and culturally sensitive way.

KEYWORDS: Māori, Toi moko, repatriation, ceremony, partnership, culture, belief, ancestral remains, reconciliation, iwi.

Introduction

During the nineteenth century, Britain experienced a growing fascination with exoticism. Visiting travelling shows, which displayed animals and people with rare conditions and unusual human anatomy, became a popular Victorian day out (Qureshi 2011). Medical museums also became fashionable attractions. Alberti (2011) sets the historical context to contemporary debates about collecting and displaying human remains for educational purposes. Anatomical displays of the 'partial person' promoted academic and public discourse about the nature of disease and death. On the one hand, medical museums valued the objects on display as teaching aids and promoters of knowledge, whereas on the other, opening the medical museum to general viewing provided a source of revenue and an opportunity for the public to indulge further in its morbid curiosity. As the public became more aware of these collections in the mid-twentieth century, questions were raised about how the objects were gathered. In the United States, Native American graves were disturbed to gather skulls for prestigious museums and medical schools to expand their comparative anatomy collections (Fabian 2010). The rights of indigenous people not to have grave items taken was finally addressed by the enacting of the Native American Graves Protection and Repatriation Act in 1990. In Britain in the early twentieth century, the use of paupers' bodies to teach anatomy to medical students was challenged as unethical and deeply dishonouring to the destitute, who could not protect their bodies in death any more than they had been able to in life (Hurren 2012). The context of morbid curiosity and ethical questions about collecting practices provide the background for Māori human remains to be considered.

The beginning of dealings between Māori and Europeans has been described as a time of 'mutual incomprehension', with both sides soon seeking to benefit from new relationships (O'Malley 2012: 14). One aspect of incomprehension on the part of the Europeans was the traditional Māori practice of preserving the heads of loved ones and enemies, each for different purposes. This practice soon became the ground for trade between Māori and Europeans, who seemed to overcome any reticence they may have had in order to make a profit when they traded heads back in Europe. Today, Māori view this part of their history very differently and have come to a position where they seek repatriation of preserved heads and other human remains back to Aotearoa New Zealand.

Museums and medical schools are commonly referred to as 'holding institutions' in debates about repatriation. Requests for repatriation of human remains place a holding institution and indigenous communities in a unique relationship. This relationship is most often one of an extreme power imbalance, with communities requesting the return of ancestors who hold positions of great importance to them and institutions facing the potential loss of valuable parts of their collections. Indigenous communities have no power beyond that of request, whereas institutions may be governed by a legal remit to ensure their collections remain intact. Therefore, the most common experience is one of indigenous communities requesting repatriation and holding institutions being unable or unwilling to comply.

This paper details the unique relationship that has been built between the Museum of New Zealand Te Papa Tongarewa (Te Papa) and the University of Birmingham, which began in 2011 when the university offered repatriation of a previously unknown collection of Māori ancestral remains. The relationship continues beyond this act of repatriation, building a long-lasting collaboration that is mutually beneficial to both sides. The two institutions are consequently ideally situated as partners working together to promote the understanding of repatriation of ancestral remains within the wider contexts of the values and beliefs held by both.

History of trade of indigenous remains in Britain and Europe, and from Aotearoa New Zealand

During the colonial period, several philosophies emerged to explain and justify treatment of indigenous communities. Among these was the fascination in Britain and Europe with the exotic 'other', and a morbid preoccupation with beliefs and rituals surrounding life and death. When explorers and traders brought back evidence of cultural diversity, a trade grew to supply museums and private collectors with, among many things, human heads. Tapsell (2005) explains that there were diverse motives for this trade. Profit was one motive, with museums and private collectors paying considerable sums for good specimens, while exchange of goods was another, whereby museums with large collections of indigenous objects were willing to exchange these for European museum objects (Tapsell 2005: 157–159). Some individuals sought to expand their personal collections, such as Horatio Robley (1840–1930), who amassed Toi moko (preserved tattooed Māori head/s) from curio shops in London (Robley 2001). Others, such as the American physician Samuel George Morton (1799–1851), sought skulls from around the world to advance physical anthropology, which gave way to scientific racism, where the shape of a skull was thought to indicate the intellectual and moral characteristics of the race to whom the person belonged (Gould 1978: 503–509). This bolstered colonial beliefs about 'superior' and 'primitive' cultures, creating a rationale for much of the treatment of indigenous people we now find abhorrent.

Europeans arriving in Aotearoa New Zealand

Europeans began arriving in Aotearoa New Zealand coastal waters from 1642, when Dutch explorer Abel Tasman visited the country but failed to land owing to a skirmish between his men and the local iwi (tribe) Ngāti Tumatakokiri at Golden Bay in northwest Te Waipounamu, or South Island. During Captain James Cook's visit to Aotearoa New Zealand in 1769, the first exchange of Māori human remains occurred between Māori and Pākehā (foreigners), with a mummified child 'accepted' by ship's surgeon William Monkhouse from an elder at a village near Anaura Bay, about 75 km north of the modern-day city of Gisborne (Salmond 2004: 124). On the same voyage, but this time at Queen Charlotte Sound in northeast Te Waipounamu, botanist Joseph Banks exchanged a pair of used linen underwear for a Toi moko after he cemented the exchange by producing a musket to provoke the male elder into releasing the head (Te Awekotuku & Nikora 2007: 48).

Some rangatira (chiefs), such as Hongi Hika (Ngāpuhi, 1772–1828) and Pōmare I (Ngāpuhi, ?–1826), became heavily involved in the trade of Toi moko between 1815 and the late 1820s, as they realised a mummified head could command a valuable exchange in items such as muskets, ammunition and metal goods (Te Awekotuku & Nikora 2007: 48; McLintock 2011). Many of these Toi moko are from warriors who were defeated and died in battle, and whose heads were quickly mummified by the victors and then traded at will to visiting ships from Europe, Australia and America (Lee 1983: 145; Ballara 2003: 133). This, however, is only part of the story of how Māori and Moriori remains found their way into collections abroad.

On 6 February 1840, Māori chiefs signed Te Tiriti o Waitangi (the Treaty of Waitangi), which provided for the British Crown to govern Aotearoa New Zealand, while Māori retained property rights to their land, fisheries and forests, and also became British subjects (Brookfield 1999: 98–99). Settlers from Britain began to enter the country at this point, and became interested in obtaining Māori tribal lands for farming. Many iwi resisted selling their lands, however, and under increasing pressure from the settlers, the Crown began to obtain the land actively through confiscations of iwi territories (Durie 1998: 35).

From the late 1860s, weighed down with the pressure of the New Zealand land wars, iwi became extremely despondent and vulnerable, and many were unable to protect their lands, including wāhi tapu (sacred repositories), from the prying eyes and hands of Pākehā (Durie 1998: 35; Smith & Aranui 2010: 190; Prebble 2012). With the establishment of colonial and regional museums from this period, the newly appointed directors and/or curators became part of an active trading network involving private collectors, traders, international museums, medical institutions and universities that extended from Europe and the Americas to Australia and Aotearoa New Zealand. Museum directors such as Julius von Haast of the Canterbury Museum and James Hector of the Colonial Museum (now Te Papa) either 'collected' kōiwi tangata (Māori skeletal remains) or received the tūpuna (ancestors) from other 'collectors' in Aotearoa New Zealand (Smith & Aranui 2010: 190; Solomon & Forbes 2011: 217). Te Papa's research of Māori and Moriori ancestral remains housed in institutions around the world indicates most were stolen after 1860 and traded within Aotearoa New Zealand or directly to collectors, auction houses, museums and/or institutions in Australia, Europe and America.

How the indigenous ancestors arrived at Birmingham University

While many museums and universities have excellent provenance for the indigenous ancestors housed in their collections, in others provenance is either lacking or completely absent. However, in institutions like the University of Birmingham, where collections exist without provenance, some pointers do still remain. The university's medical school building was established in 1825, when surgeon William Sands Cox began a course of anatomical demonstrations in his father's house. The first dedicated medical school was constructed in 1828 and the Queen's Hospital opened as a teaching hospital in 1841. The school was officially opened on its current site at the University of Birmingham in 1938.

Birmingham was an affluent city in the nineteenth century and home to numerous famous physicians, many of whom may have had personal collections of skulls for teaching and research. One tantalising glimpse of this comes from an all-too-brief single line in the minutes of a Medical Faculty meeting held on 30 January 1911: 'Dr McMunn donated mummy heads and skulls to school' (University of Birmingham 1911). This was most likely Charles Alexander McMunn (1852–1911), a life governor of University of Birmingham, who practised as a physician in Wolverhampton (26 km from Birmingham) throughout his career. We have not been able to identify further records of skulls being donated to the university, but it is undoubtedly the case that the physicians themselves, or their families, donated the skulls from their personal collections as public opinion increasingly viewed skull collecting in a morally problematic light.

Māori requesting the return of their ancestors

As indicated earlier, from 1769 Māori became aware that the remains of their kith and kin were departing their villages and coastal regions for locations beyond their iwi territories. Through the activities of men like naturalist and collector Andreas Reischek and Julius von Haast, who plundered wāhi tapu and took tūpuna, iwi became increasingly aware that their ancestors were being stolen for collections in institutions overseas (Smith & Aranui 2010: 190; Prebble 2012). For those tūpuna that remained in museums in Aotearoa New Zealand, some were placed on display and would remain there until the 1960s (as was the case for the National Museum, now Te Papa) and into the 1970s (in the case of the Whanganui Regional Museum).

Museum practice in Aotearoa New Zealand gradually began to change under the influence of people such as Māui Pōmare of Ngāti Toa Rangatira and Ngāti Mutunga, who in the 1970s was chair of the National Museum. Through his work, the National Museum established an informal wāhi tapu for Māori and Moriori remains in the 1980s. At the same time, some iwi responded by making their own arrangements to bring their ancestors home, such as the Whanganui people, who in 1988 repatriated their rangatira Hohepa Te Umuroa from Maria Island in Tasmania, and the Tainui people, who in 1985 repatriated their rangatira Tūpāhau from the Imperial Natural History Museum in Vienna, later burying him on Maunga Taupiri. Also in 1988, Sir Graham Latimer, on behalf of the Māori Council, sought an injunction in England to prevent the auction of a Toi moko. This tupuna was eventually returned home and buried in the Taitokerau (Northland). In the late 1990s, entertainer Dalvanius Prime of Ngā Rauru Kītahi and Ngāti Ruanui was another campaigner who was active in arranging a number of repatriations.

With the growing support for the repatriation movement in Aotearoa New Zealand in the late 1990s, iwi gathered at national hui (meetings) to seek resourcing and establishment of a programme supported by the New Zealand government. It would, however, take a number of years before a fully realised and resourced initiative would eventuate.

The British response to indigenous repatriation requests

Through the work of Māui Pōmare with museums in the United Kingdom and Ireland in the 1980s, Māori ancestral remains discreetly began their journey home. However, the first formal requests for repatriation from the United Kingdom came from Australia on behalf of the Aboriginal community. The prime ministers of the United Kingdom and Australia issued a joint statement in 2000, declaring that increased efforts would be made to repatriate human remains to Australian indigenous communities 'where possible and appropriate' (Law Library of Congress Australia 2009). A working group was commissioned in May 2001 to examine the status of human remains within publically funded museums and galleries in the United Kingdom, and to consider the possibility and desirability of legislative change to allow repatriation to take place (Department of Culture, Media and Sport 2005). The recommendations of the working group were incorporated into the United Kingdom Human Tissue Act 2004, which in subsection 2 of section 47 states that institutions previously prohibited by law from de-accession of human remains would now be able to 'transfer human remains from their collections if it appears to them appropriate to do so for any reason whether or not it relates to their other functions. The power only applies to human remains which are reasonably believed to be of a person who died less than 1,000 years before this section comes into force'.

The instigation for the Human Tissue Act 2004 was public outrage at the retention without parental consent of around 850 children's organs in more than 2000 pots at Alder Hey Children's Hospital, Liverpool, from 1988 to 1995. The vast majority of the Act consequently deals with appropriate handling of current human tissue, with only section 47 dealing with the possibility of repatriation. In the absence of clear and specific legislation, museums and other institutions need to make moral decisions about how to respond to repatriation requests.

The creation of the Karanga Aotearoa Repatriation Programme

In 2003, the Karanga Aotearoa Repatriation Programme (KARP) was established by Te Papa, which was mandated by the New Zealand government to seek the repatriation of Māori and Moriori ancestral remains housed overseas (Ministry for Culture and Heritage Te Manatū Taonga 2004). To offer clarity about Te Papa's role to iwi and also within the international sector, the work of KARP is governed by six overarching principles and policy guidelines:

- the government's role is one of facilitation – it does not claim ownership of kōiwi tangata;
- repatriation from overseas institutions and individuals is by mutual agreement only;
- no payment for kōiwi tangata will be made to overseas institutions;
- kōiwi tangata must be identified as originating from New Zealand;

- Māori are to be involved in the repatriation of kōiwi tangata, including determining final resting places, where possible; and
- the repatriation of kōiwi tangata will be carried out in a culturally appropriate manner. (Department of Internal Affairs 2003)

From its establishment in 2003 to March 2015, KARP has negotiated the return of 355 Māori and Moriori remains from more than 50 international institutions (Herewini 2015). Five of these, including a Toi moko and four kōiwi tangata, were returned from the University of Birmingham in October 2013.

The beginning of a partnership

Following the introduction of the Human Tissue Act 2004 in the United Kingdom, the University of Birmingham's School of Medicine formally separated human tissue used for teaching and research from its collection of ancient human remains. In January 2011, a thorough inventory of the ancient collection began. By reviewing the collection and examining anatomy and physiology ledgers, it became clear that there was little available provenance for much of the collection. Although the collection had been preserved, no accompanying documentation has been found to date and is presumed lost during extensive renovations and relocations of the medical school. One part of the collection that had provenance by virtue of its uniqueness was the Toi moko. A series of meetings began between the dean of the School of Medicine, the university's head of religious and cultural beliefs and the director of its Human Biomaterials Resource Centre. These meetings focused around the desire to proactively initiate contact with Te Papa to offer the Māori ancestral remains for repatriation. The decision centred on the moral duty of the university to return Māori ancestral remains, because they were an identifiable part of the collection, they had never been used for teaching or research, and an established Māori repatriation programme was in place that made clear the desire for repatriation. The meetings also highlighted the nefarious historical collecting practices of Toi moko, which strengthened the university's resolve about the moral need to undertake repatriation. In February 2011, the Te Papa repatriation manager was contacted via email by June Jones, the university's head of religious and cultural beliefs, to initiate dialogue and offer repatriation.

Repatriation claim, negotiation and agreement

Email dialogue and the exchange of information established the remains as being Māori. This was then followed by a repatriation claim, issued in writing by Te Herekiekie Herewini, repatriation manager at Te Papa, to the University of Birmingham. It detailed the mandate Te Papa had on behalf of the New Zealand government to make such a claim, along with a request for a written response from the university, inviting formal agreement. The university agreed to the claim after consultation with its legal department ensured that it had the lawful right to de-accession the ancestral remains from its collection. The university acknowledged that the repatriation process could go ahead at a point agreeable to Te Papa, taking into account their schedule for wider repatriation throughout the United Kingdom and Europe. The timeframe for repatriation was negotiated, allowing flexibility for both sides to set a mutually convenient date.

The formal handover ceremony

Once the repatriation date had been agreed, work began on organising the formal handover ceremony. The university was honoured that Te Papa offered the possibility of a two-day visit, with a repatriation seminar and a Māori music demonstration for staff, students and members of the public to be held the day before the formal handover ceremony. This provided the university with the opportunity to understand and fully engage with the significance of repatriation of Māori ancestral remains. An outline of both seminars was provided, which the university gratefully accepted. The repatriation seminar was held in the School of Medicine lecture theatre, while the music seminar was held in the newly opened Bramall Music Building. Both events were advertised throughout the university and wider community, and drew significant interest and appreciation.

Te Papa delegation

Chosen for their knowledge in tikanga (Māori philosophical and customary practice), and of the repatriation process, the delegation from Te Papa included Taki Turner (kaumātua, or senior male elder), Ratau Turner (rūruhi, or senior female elder), Arapata Hakiwai (Te Papa's kaihautū, or Māori co-leader), Te Herekiekie Herewini (Te Papa's repatriation manager) and Te Arikirangi Mamaku (Te Papa's repatriation coordinator) (Fig. 1).

Fig. 1 Delegation from Te Papa with June Jones at the University of Birmingham on 18 October 2013. Left to right: Arapata Hakiwai (kaihautū, or Māori co-leader, Te Papa), June Jones (head of religious and cultural beliefs, University of Birmingham), Te Herekiekie Herewini (repatriation manager, Te Papa), Taki Turner (kaumātua, or senior male elder), Te Arikirangi Mamaku (repatriation coordinator, Te Papa) and Ratau Turner (rūruhi, or senior female elder) (photo: courtesy of University of Birmingham).

The delegation was charged with four main kaupapa (themes) to uphold: to pay their respects to the tūpuna according to Māori cultural practice; to physically prepare and place the tūpuna into their travelling cases according to Māori cultural and conservation practice; to provide an understanding of why it is important for Māori to repatriate their ancestors; and to emphasise and convey the wairua (spirit) of whakaaro pai (dignity, respect and goodwill). This last kaupapa became a shared theme for the two institutions at the formal handover ceremony and continues as the relationship is forged further.

Components of the formal handover ceremony and their significance

Te Papa supplied the university with very useful documentation about hosting a ceremony in accordance with respecting Māori traditional beliefs and practices. The room layout requirements and the order of ceremony were clearly described, allowing the university to select the most appropriate room. Photographs and a video tour of the room chosen, the university's Senate Chambers, were sent to Te Papa to ensure that it provided the optimum opportunity for the ceremony to be conducted in accordance with Māori beliefs and practices. In October 2013, the Te Papa delegation visited the university for the formal handover ceremony of five Māori ancestors.

The university chose to host the handover in its Senate Chambers for a number of reasons. First, it is the most prestigious room in the institution, a place where senate members meet to govern the university. Second, it is a circular room with movable furniture and two private entrances, providing easy access. And third, it is situated above the main entrance to the Aston Webb building, where staff who died whilst serving in the two world wars are honoured in two large marble memorials. This room

Fig. 2 Repatriation handover ceremony in the Senate Chambers at the University of Birmingham on 18 October 2013 (photo: courtesy of University of Birmingham).

represents the importance of governance, decision-making and honouring those no longer with us – concepts all relevant to repatriation.

The ceremony itself lasted 35 minutes, beginning with the sounding of the pūtātara (conch-shell trumpet) to acknowledge the arrival of the tūpuna, and followed by te hikoi (the procession of the ancestral remains), karanga (the female spiritual acknowledgement to the ancestors), mau kākahu (placement of contemporary Māori cloaks on the ancestors), karakia me te mihi (traditional male-led prayers and greeting to the ancestors), whaikōrero (speeches by members of the university and Te Papa), hainatanga o te whakaaetanga (signing the legal transfer agreement between the university and Te Papa), koha (exchanges of gifts between the university and Te Papa) and hongi (Māori greeting in which noses and foreheads are pressed together to share the breath of life). To complete the ceremony, rūruhi Ratau Turner farewelled the tūpuna with a karanga as they were carried from the room to their waiting transportation. As the participants left the ceremonial room, they had the opportunity of wai whakanoa (cleansing oneself with water), and sharing something to eat.

An important element of the formal ceremony was the customary giving of a gift to members of the university taking part. Te Papa provided a number of gifts, including a range of books about Māori culture and neck pendants made of pounamu (New Zealand greenstone). The university reciprocated by giving a fine print of the architect's drawing of the Aston Webb building, where the repatriation ceremony was being held. For both institutions, the presentation of gifts is seen as a lasting memento of their partner organisation, namely the place where the ceremony was held, and the homeland to where the tūpuna returned for their final rest.

Discussion

This paper concludes with personal perspectives on the handover process from the authors, who represent both parties involved. The first two paragraphs are by June Jones from the University of Birmingham, while the remainder of the section is by Te Herekiekie Herewini of Te Papa's KARP.

From an ethical perspective, repatriation of indigenous remains is an important endeavour. Working in partnership with the Te Papa delegation allowed University of Birmingham staff to explore how this ethical endeavour could best be undertaken. Having guests present to take part in the ceremony was important. In partnership, we took the decision to invite the New Zealand High Commissioner and 50 other guests, including senior members of the university, members of the chaplaincy and student representatives, as well as members of partner institutions in the local community. We created a ceremony booklet for each guest, in the form similar to an order of service common at funerals in the UK. This served as a sign of respect to the Māori delegation and as an indication of what would happen during this unique ceremony, enabling guests to feel more comfortable as they encountered the unknown. As the ceremony finished at lunchtime, we chose to invite all of our guests to stay for a buffet lunch in a room close to the handover ceremony. This created a relaxed atmosphere where guests stayed to meet the Māori delegation and network with colleagues. It also served as an informal opportunity for colleagues to debrief after the ceremony. Several guests found the ceremony very emotional and lingered to reflect rather than returning immediately to work. We chose to provide an elaborate buffet because we wanted to honour our Māori guests and demonstrate our intention of a good legacy, with a lasting friendship that would endure beyond the process of repatriation. The final act of repatriation created the opportunity for a legacy of which both the university and Te Papa is proud.

Photographs of the ceremony served a number of important ethical purposes. They demonstrated to those members of the Māori community who could not be present that due respect was paid to the ancestors through upholding Māori beliefs and practices. They also served as a point of reference for the university in recording the acts that took place. Photographs of the repatriation delegation and hosts served as a legacy of important relationships. In partnership with Te Papa, we decided that we would use the university's press department to liaise with media outlets. We collaborated to invite selected media to the ceremony, including BBC News, BBC History, Māori TV and TV New Zealand. Each media organisation was provided with a strict protocol by the press department about ways in which the ceremony could be recorded and the recordings used. Te Papa provided the media format for recording the ceremony, where media are not permitted to enter the sacred space created as part of the ceremony. The Māori delegation and university host were interviewed live for local BBC news. In collaboration with Te Papa, the university made a recording of the ceremony for YouTube (University of Birmingham 2013), so that as many people as wished could have access to it. Our intention was to create a resource that other institutions could consult when considering how to host their own repatriation ceremonies. The recordings also mark the significant collaboration between the University of Birmingham and Te Papa.

The focus of the repatriation team at Te Papa is bringing our tūpuna home with their mana intact. It is important for us to convey the strong connection that remains between us, as their living descendants, and these ancestors, male and female, who lived and fought on our behalf so many generations ago. From 1769 Māori and Moriori ancestral remains have been viewed by Europeans as exotic curiosities, for trade and exchange, and placed in private collections, museums and medical institutions, where they were examined, probed and displayed. Most likely the hundreds and possibly thousands of people who came across the tūpuna gave little thought as to their past lives, the dark trade in indigenous remains, or how these deceased people came to be exhibited and displayed as part of collections so far from their indigenous homelands. We have little power to change the past and the deeds or misdeeds of our ancestors, but as the present generation we do have the opportunity to offer mana and whakaaro pai in how we bring the misdeeds to a conclusion.

The process of offering whakaaro pai is not to forget how the tūpuna arrived overseas, because that is an important element of the story. For the Te Papa repatriation team, the elements tono (request), whakawhitiwhiti kōrero (negotiation), and tuku tūpuna (releasing the ancestors) and hiki tūpuna (uplifting the ancestors) are equally important, as they allow both institutions involved to achieve tatau pounamu (enduring peace) and to make the exchange with whakaaro rangatira (honour). The process also allows both groups to walk away as rangatira, with dignity, respect, power and prestige.

The collaboration with the University of Birmingham allowed the Te Papa delegation to bring closure to the events of the past in a way that our tūpuna would be familiar with, and where both groups offered each other resolution in the process and created a new chapter to the story that started in 1769. The experience will remain in the memories of those who participated.

E kore e warewaretia. Never to be forgotten.

References

Alberti, S. (2011). *Morbid curiosities: medical museums in nineteenth-century Britain.* Oxford: Oxford University Press. 256 pp.

Ballara, A. (2003). *Taua: musket wars, land wars or tikanga? Warfare in Māori society in the early nineteenth century.* Auckland: Penguin. 543 pp.

Brookfield, F.M. (1999). *Waitangi and indigenous rights: revolution, law and legitimation.* Auckland: Publishing Press Ltd. 253 pp.

Department of Culture, Media and Sport. (2005). *Guidance for the care of human remains in museums.* London: Department of Culture, Media and Sport. 36 pp. Retrieved in April 2015 from www.britishmuseum.org/pdf/DCMS%20Guide.pdf.

Durie, M. (1998). *Whaiora Maori health development.* Auckland: Oxford University Press. i–viii + 244 pp.

Fabian, A. (2010) *The skull collectors: race, science and America's unburied dead.* Chicago, IL: University of Chicago Press. 288 pp.

Gould, S.J. (1978). Morton's ranking of races by cranial capacity. *Science* 200: 503–509.

Hurren, E. (2012). *Dying for Victorian medicine: English anatomy and its trade in the dead poor* c. *1834–1929.* London: Palgrave Macmillan. 400 pp.

Law Library of Congress Australia (2009). Repatriation of historic human remains. Executive summary. *In*: *The Law Library of Congress* [website]. Retrieved on 16 September 2015 from www.loc.gov/law/help/repatriation_%20final_%20rpt.pdf. 22 pp.

Lee, J. (1983). '*I have named it the Bay of Islands …*'. Auckland: Hodder & Stoughton. 328 pp.

McLintock, A.H. (*ed.*) (2011). Pomare I, Whetoi or Whiria. *In*: *An encyclopaedia of New Zealand* (originally published in 1966) [website]. Retrieved on 3 February 2016 from www.TeAra.govt.nz/en/1966/pomare-i-whetoi-or-whiria/1.

O'Malley, V. (2012). *The meeting place: Māori and Pākehā encounters, 1642–1840.* Auckland: Auckland University Press. 320 pp.

Prebble, R.G. (2012). Reischek, Andreas. *In*: *Te ara – the encyclopedia of New Zealand* [website]. Retrieved on 3 February 2016 from www.TeAra.govt.nz/en/biographies/2r14/reischek-andreas.

Qureshi, S. (2011). *Peoples on parade: exhibitions, empire and anthropology in nineteenth-century Britain.* Chicago, IL: University of Chicago Press. 392 pp.

Robley, J. (2001). Major General Horatio Gordon Robley (1840–1930). *In*: *Robley Genealogy* [website]. Retrieved on 10 February 2015 from www.robley.org.uk.

Salmond, A. (2004). *The trial of the cannibal dog: the remarkable story of Captain Cook's encounters in the South Seas.* Auckland: Penguin. i–xiv + 506 pp.

Smith, N. and Aranui, A. (2010). For evolution's sake: the collection and exchange of kōiwi tangata from Te Waipounamu. *Archaeology in New Zealand* 53(3): 185–194.

Solomon, M. and Forbes, S. (2011). Indigenous archaeology: a Moriori case study. Pp. 213–232. *In*: Phillips, C. and Allen, H. (*eds*). *Bridging the divide: indigenous communities and archaeology into the 21st century.* Walnut Creek, CA: Leftcoast Press Inc. 290 pp.

Tapsell, P. (2005). Out of sight, out of mind: human remains at the Auckland Museum – Te Papa Whakahiku. Pp.157–159. *In*: Janes, R.R. and Conaty, G.T. (*eds*). *Looking reality in the eye: museums and social responsibility.* Calgary: University of Calgary Press. 208 pp.

Te Awekotuku, N. and Nikora, L.W. (2007). *Mau moko. The world of Māori tattoo.* Auckland: Penguin Viking. 259 pp.

University of Birmingham (2013). Maori remains repatriation ceremony at the University of Birmingham (full ceremony). *In*: *YouTube* [website]. Retrieved on 2 February 2016 from www.youtube.com/watch?v=7UobfYENpS8.

Unpublished sources

Department of Internal Affairs (2003). Cabinet Policy Paper POL Min (03) 11/5, 14 May. Department of Internal Affairs, Wellington.

Herewini, T. (2015). Ten-year review of the Karanga Aotearoa Repatriation Programme. Museum of New Zealand Te Papa Tongarewa, Wellington. 10 pp.

Ministry for Culture and Heritage Te Manatū Taonga. (2004). Repatriation of kōiwi tāngata Māori (Māori ancestral human remains). Letter. Ministry for Culture and Heritage Te Manatū Taonga, Wellington. 2 pp.

University of Birmingham (1911). Minutes of the Medical Faculty meeting held on 30 January. University of Birmingham Archives.

Tuhinga 27: 10–20 Copyright © Museum of New Zealand Te Papa Tongarewa (2016)

Māori fishhooks at the Pitt Rivers Museum: comments and corrections

Jeremy Coote

Pitt Rivers Museum, University of Oxford, South Parks Road, Oxford, OX1 3PP, United Kingdom
(jeremy.coote@prm.ox.ac.uk)

ABSTRACT: Chris D. Paulin's account in the pages of this journal (*Tuhinga* 21; https://www.tepapa.govt.nz/Tuhinga21) of the Māori fishhooks at the University of Oxford's Pitt Rivers Museum provides an inaccurate picture of the collection and its history. In particular, he misattributes to Hawai'i an important Māori fishhook acquired on Cook's first voyage (1768–71). An accurate account of the museum's collection is provided here, some of the errors in Paulin's report are corrected, and the evidence for the Māori provenance of the first-voyage hook is presented.

KEYWORDS: Māori fishhooks, Cook-voyage collections, collections history, Pitt Rivers Museum, University of Oxford.

Introduction

In an earlier issue of this journal, Chris D. Paulin published a report on Māori fishhooks in European museums (Paulin 2010), based on research he had carried out in 2009 while the holder of a Winston Churchill Memorial Trust Fellowship (Paulin [2009]). Unfortunately, the section devoted to the fishhooks in the University of Oxford's Pitt Rivers Museum (PRM) provides a confusing account of the collection and its history.[1] Moreover, Paulin misattributes to Hawai'i an important Māori fishhook collected on James Cook's first voyage to the Pacific on the *Endeavour* in 1768–71. I am not an expert on fishhooks, Māori or otherwise. I am, however, able to present a brief account of the history of the PRM collection, to comment on some of the errors in Paulin's report, and to provide an authoritative account of the provenance of the first-voyage Māori fishhook.

The PRM collection

The PRM is the University of Oxford's museum of anthropology and world archaeology (see O'Hanlon 2014). It was founded by the university in 1884 to house a collection of more than 26,000 objects given to it by Augustus Henry Lane Fox Pitt-Rivers. Of the 26,000 objects in the founding collection, some 1750 are provenanced to the Pacific (including Australia), of which 32 are fishhooks, 9 of them recorded as Māori. The founding collection was quickly added to. The 'ethnographic' collections already in the Ashmolean Museum (founded in 1683) and University Museum (founded in 1860; later 'of Natural History') were transferred to the newly arrived Pitt Rivers Collection in 1886–87; these transfers included seven Māori fishhooks, four from the Ashmolean and three from the University Museum.

The transfer from the Ashmolean included the well-known collection of objects acquired by Johann Reinhold Forster and his son George on HMS *Resolution* on Cook's second famous voyage to the Pacific (1772–75) and given by them to the university in 1776, along with a manuscript, 'Catalogue of curiosities sent to Oxford' (Forster & Forster 1776).[2] Thanks to the survival of this manuscript catalogue we know that the Forsters included in their donation an unspecified number of 'Fishhooks of Mother of pearl' from 'OTaheitee and the Society Isles' and 'a parcel of Fishhooks of various Sizes' from 'The Friendly Isles' (entries 34 and 64, respectively), but none from New Zealand; that is, there is no evidence that the Forsters included a Māori fishhook in the collection they sent to Oxford.

As was discovered in 2002, the transfer from the University Museum in 1886-87 included the larger part of a collection that had been given by January 1773 to Christ Church, his old Oxford college, by Joseph Banks after sailing on HMS *Endeavour* with Cook on his first Pacific voyage in 1768–71 (Coote 2004a,b; see also Coote 2015, 2016). In 1860 these objects had been transferred on loan from Christ Church to the University Museum, though the fact that they had been given to Christ Church by Banks after Cook's first voyage had been forgotten. Among these objects is the Māori fishhook claimed by Paulin to be Hawaiian, discussed in detail below. (The other part of the collection Banks had given to Christ Church was transferred directly from the college to the PRM at around the same time.)

The PRM's collections have been added to ever since, of course. Today, they number more than 315,000 objects, plus extensive holdings of photographs, along with sound recordings, films and manuscripts. The Pacific collections number some 22,000 objects, of which some 4800 are provenanced to Polynesia, including 1700 to New Zealand. There are some 760 Pacific fishhooks in the collection, of which 350 are provenanced to Polynesia, including 225 to New Zealand (not '450', as Paulin states (2010: 27)).

The PRM's records for all its collections are available in the online version of the museum's fully searchable, partially illustrated and regularly updated working database.[3] Moreover, everything in the collection is available for examination by bona fide researchers by appointment, including those on display; *pace* Paulin (2010: 28) – indeed, some of the 129 objects that were made available for Paulin to examine during his three-day visit were removed from display for that purpose. Although the PRM does not yet have photographs of all the items in its collections, those it does have are made available online, and researchers are welcome to order photographs of any item through the museum's photographic services.

Quotations and corrections

Paulin opens the section of his article devoted to the PRM as follows: 'The Pitt Rivers Museum (PRM) collection at Oxford is regarded by specialists as the most important of the Forster collections and one of the most important of all the collections made on any of Cook's three voyages, with a total of 186 objects identified as being from those voyages' (Paulin 2010: 27).

Here Paulin takes some words from a paper by Peter Gathercole, Nicolette Meister and myself, published in 2000 (though giving only me as author), topping and tailing them in such a way as to vitiate their meaning. The original text (Coote *et al.* 2000: 180) reads: 'The collection at Oxford is regarded by specialists as the most important of the Forster collections and as one of the most important of all the collections made of any of Cook's three voyages'. By changing the original '[Forster] collection at Oxford' to 'the Pitt Rivers Museum collection at Oxford', Paulin has altered the sense. And by adding 'with a total of 186 objects identified as being from those voyages', he implies that the Forster collection includes objects from all three of Cook's voyages, when it is well known to be an exclusively second-voyage collection (given to Oxford in January 1776, long before the third voyage returned).

Paulin begins the second paragraph with 'the Oxford collection has not yet been satisfactorily published, although some individual items have been widely illustrated, and other non-fishhook items have been studied in great detail' (Paulin 2010: 27). Although ostensibly referring to the PRM collection as a whole, Paulin is in fact again quoting (without acknowledgement) Coote, Gathercole and Meister (2000: 180), who write of the Forster collection: 'The Oxford collection has not yet been satisfactorily published. Individual items have been widely illustrated and some have been studied in great detail.' The failure to distinguish between the PRM collection as a whole and the Forster collection in particular is again misleading.

Paulin continues: 'This collection includes approximately 450 Māori fishhooks collected during the nineteenth or early twentieth centuries. Of these, less than a dozen were collected prior to the mid-1800s, but many of the hooks do not appear to be of Māori origin' (Paulin 2010: 27). There are not 450 Māori fishhooks in the PRM's collection. There are some 225, along with another 125 provenanced to elsewhere in Polynesia (and other 410 provenanced to elsewhere in Oceania). Paulin is probably accurate in his estimation that 'less than a dozen were collected prior to the mid-1800s', but it is unclear what he means by 'many of the hooks do not appear to be of Māori origin'. If he means many of the imaginary 450, then he is certainly right, as there are only 225 provenanced to New Zealand. If he means many of the dozen collected before 1850, then it would have been helpful for him to have specified which ones.

Paulin continues: 'There is circumstantial evidence (PRM catalogue notes) that Māori and Polynesian fishhooks were included among anthropological objects transferred from the Ashmolean Museum, Christ Church College, Oxford University, to the PRM in 1886' (Paulin 2010: 27). The Ashmolean Museum is not part of Christ Church; they are completely separate institutions. As explained above, two years after the PRM was founded by the university in 1884, the 'ethnographic' collections at the university's Ashmolean Museum were transferred to it. This transferred collection amounted to some 2351 objects, of which some 450 are provenanced to Polynesia, including 80 to New Zealand. Of the Polynesian objects, some 32 are fishhooks, of which 4 are provenanced to New Zealand. This is not 'circumstantial evidence' – there was a transfer and there were Māori and other Polynesian fishhooks included in it.

Paulin continues:

> Furthermore, they probably originated either from Captain Cook on the second voyage and were donated by Reinhold or Georg Forster, or from two other collections obtained by Captain Frederick William Beechey in 1825–28 and Charles A. Pope in 1868–71. Beechey had presented a significant group of material to the Ashmolean Museum (PRM catalogue notes), collected in 1825–28 when he commanded the *Blossom* during a northern Pacific surveying voyage (Beechey 1831). The Pope collection (mostly originating in North America), from St Louis, Missouri, was probably donated by John O'Fallon Pope (son of Charles A. Pope), who was at Christ Church from 1868 to 1871 (PRM catalogue notes; Coote 2004[b]). (Paulin 2010: 27)

It is not clear what Paulin means by 'originated from Captain Cook', but I can state categorically that there is no evidence that any object in the PRM's collections is traceable to Cook's personal ownership. Nor are any Māori fishhooks traceable to the Forsters; as explained above, they included none in the collection they sent to Oxford in January 1776.

Beechey certainly donated a collection – acquired on his 1825–28 voyage on HMS *Blossom* – to the Ashmolean Museum some time before 1836, and this included some Polynesian material. Unfortunately, no list has ever been found. As a result, as well as being known to be the source of a number of specific objects, Beechey is also one of a number of possible sources of otherwise undocumented Pacific objects in the collections (see Coote 2014: 413).

As I have shown elsewhere (Coote 2004a,b), references to 'the Pope collection' in discussions of the Pacific collection at the PRM are irrelevant. Charles A. Pope gave a collection of North American material to Christ Church (not the Ashmolean), which later came to the PRM. Before the collection was transferred to the PRM, some of the Tahitian and Māori objects given by Joseph Banks to Christ Church after Cook's first voyage had been thought, mistakenly, to be part of the Pope collection. These were all 'textiles' – that is, Māori belts and cloaks and Tahitian barkcloth. There has never been a suggestion (except by Paulin) that any fishhook is traceable to the Pope collection. (The dates Paulin gives for Pope acquiring his collection, 1868–71, are – as he notes later – the dates his son, John O'Fallon, was at Christ Church, not the dates of his collecting activities.)

Paulin continues:

> Catalogue notes (attributed to Peter Gathercole, Department of Anthropology, Otago University, 26 February 1997) state that there is not enough distinctive stylistic evidence or concrete documentation to determine whether any of the fishhooks included in the Cook's catalogue were collected by the Forsters, or if they could even be associated with Cook's voyages. (Paulin 2010: 27)

There is indeed a note in 24 entries in the PRM's database that reads 'there is not enough distinctive stylistic evidence or concrete documentation to determine whether any of the fish hooks included in the Cook catalogue were collected by the Forsters or if they could even be associated with Cook voyages'. This is not 'attributed' to Gathercole, but recorded as a statement made by him on 26 February 1997 on a visit to the PRM to assist with the recataloguing of the Forster collection. (Moreover, Gathercole left Otago in 1968, so it is unclear why Paulin gives this as his affiliation in 1997.) By 'the Cook catalogue' (not 'the Cook's catalogue'), Gathercole was referring to the set of index cards first compiled by PRM staff member Beatrice Blackwood in 1955–56 in an attempt to provide a working list of the objects in the PRM's collections that might be traceable to Cook's voyages (see Coote 2014: 411). Gathercole had drawn on this card index when researching the Forster collection for the special exhibition *'From the Islands of the South Seas 1773–4': An exhibition of a collection made on Capn. Cook's second voyage of discovery by J.R. Forster*, held at the PRM in 1970–71 (see Gathercole [1970]; see also Coote 2005). In carrying out his research, Gathercole added to and amended the card index, as other members of the PRM's staff continued to do until 1997–99, when all the information it contained was incorporated into the PRM's computerised working database (Coote *et al.* 1999: 56–62).

Gathercole included two Tahitian and five Tongan hooks in the 1970 exhibition (Gathercole [1970]), and his attribution of these seven hooks to the Forster collection was followed by Adrienne Kaeppler in her 'Artificial curiosities' catalogue (Kaeppler 1978: 157, 235). In 1997, Gathercole was less sanguine about the certainty of these attributions, hence the note added to the relevant entries in the database. Eighteen years later, the situation is little clearer. It seems reasonable to assume that at least some of the otherwise undocumented Tahitian and Tongan fishhooks in the collection transferred from the Ashmolean in 1886 might be identified as the Tahitian and Tongan fishhooks given to the university by the Forsters in 1776, but it has not yet been possible to establish with any certainty which they may be.[4]

Interesting as all this is, it is of course irrelevant to a discussion of Māori fishhooks as the Forsters did not include any in their donation to Oxford. Knowing this, Gathercole did not search for examples to include in the Forster exhibition, nor did Kaeppler list any in 'Artificial curiosities'. Paulin's discussion of these matters is thus not only confused, it is irrelevant to the subject of his research.

Paulin continues:

> A number of fishhooks have been assigned Forster numbers (1282, 1292, and 1301–1305) but these attributions are tenuous. Catalogue notes (attributed to Assistant Keeper Evans of the Ashmolean Museum, 1884–1908) state that 'it is very plain that all these fish-hooks (No. 1281 to 1305) belong to more than one collection and that at some previous time they had been carelessly mixed together. There is not one of Captain Cook's original number labels on any of them, and therefore none may belong to his collection but probably that will never be known now'. (Paulin 2010: 27)

The first sentence here (an unacknowledged quotation, from the same 24 entries in the PRM database) refers to the fact that Gathercole included seven fishhooks (from Tahiti and Tonga) in his 1970–71 exhibition (see above), with the PRM accession numbers 1886.1.1282, 1886.1.1292, 1886.1.1301–1886.1.1305. The second sentence quotes an assertion by Edward Evans (assistant keeper at the Ashmolean from 1879) in the manuscript catalogue of the Ashmolean's anthropological collection prepared before its transfer to join the newly arrived Pitt Rivers Collection (Evans 1884–86).[5] Charged by his employers with drawing up a catalogue, Evans set about doing so by building on the work of his predecessor, George Rowell, trawling the available literature, and paying close attention to the objects themselves. His work was exemplary for its time and circumstances, but so far as the Cook-voyage/Forster collection was concerned, his efforts were hampered by the fact that he did not have access to the Forsters' manuscript catalogue. He made a good job of identifying which fishhooks should be provenanced to Polynesia, but was not able to go further as they were not labelled and, as he tells us, none bore one of the numbered labels that Evans had realised identified objects belonging to the Forster ('Captain Cook') collection (though he did not know that the numbered labels referred to a manuscript catalogue). Again, this is all very interesting, but as the Forsters did not include any Māori fishhooks in their donation, it is beside the point.

A first-voyage Māori hook

The errors and misunderstandings discussed above are compounded by Paulin in relation to one particular hook (Fig. 1). Given its importance, I quote Paulin at length:

> One composite wooden hook with a bone point (1887.1.379) was figured and described by Coote (2004[b]: fig. 26) as a Māori fishhook from New Zealand. The hook was probably part of the collection transferred to the PRM from Christ Church College, via the University Museum, in 1886. This collection comprised artefacts originally thought to be from North America, but some of which were later recognised as early Polynesian, and were incorrectly assumed to be from the Charles A. Pope collection (Coote 2004[b]). It is unclear how Pope acquired the early Polynesian artefacts mixed among his North American material. Coote (2004[b]) provided tenuous and circumstantial evidence to show that rather than being from the Pope collection, the wooden hook was acquired by Joseph Banks during the first Cook's voyage, and was part of a 'forgotten collection' of Banks material held in the PRM that had been among the objects donated in 1773.
>
> However, the hook is not from New Zealand – the point lashing is typically Polynesian, not Māori, it is lashed with sennit, not New Zealand flax, and it has old ink writing directly on the wooden shank (partially obscured by the registration number): 'Sandwich Ids, Dr. Lee'S Trustees. Ch.Ch., Transf. fm. Unty. Mus.'. This hook could not have been included in the collection donated to Christ Church College by Banks in or prior to 1773 (Coote 2004[b]), as the 'Sandwich' Islands (= Hawaiian Islands) were not visited by Europeans until Cook's third voyage in 1778. Hence, it remains a puzzle how Banks could have acquired a hook that could only have been collected on or after the third voyage. It is more likely that this hook is not part of the Banks collection, but rather came from the Beechey collection, which was transferred to the PRM at the same time as the Pope collection, and was acquired in Hawai'i during the period between 1825 and 1828. (Paulin 2010: 27–28)

Fig. 1 Māori fishhook, by March 1770, wood, harakeke, kiekie, bone, 180 mm long (excluding cord). Maker unknown. Acquired on the first of James Cook's famous voyages to the Pacific, in HMS *Endeavour* (1768–71); given by Joseph Banks to Christ Church, Oxford, by 16 January 1773; transferred on loan from Christ Church to the University Museum, Oxford, in 1860; 'incorporated' into the Pitt Rivers Collection in 1887 (Christ Church collection, Pitt Rivers Museum, University of Oxford: 1887.1.379) (photo: taken for the museum by Malcolm Osman, image no. PRM000012479; courtesy and copyright Pitt Rivers Museum, University of Oxford).

This fishhook has nothing to do with the Pope collection, of which Paulin provides a contradictory and confusing account. The collection transferred from Christ Church had two components, only one of which was once, falsely, associated with Pope (see Coote 2004a,b), and the fishhook in question is not of that component. Nor does the hook have anything to do with Frederick William Beechey of HMS *Blossom*, who donated material to the Ashmolean by 1836 (Coote 2014: 413), but did not give anything to Christ Church. As for what Paulin refers to as the 'tenuous and circumstantial evidence' showing that the collection – including the hook – was acquired during Cook's first voyage, I have set this out in detail elsewhere (Coote 2004a,b; see also Coote 2015, 2016) and there is little point in setting it out again here. While Paulin is entitled to his view, it may be worth pointing out here that my arguments

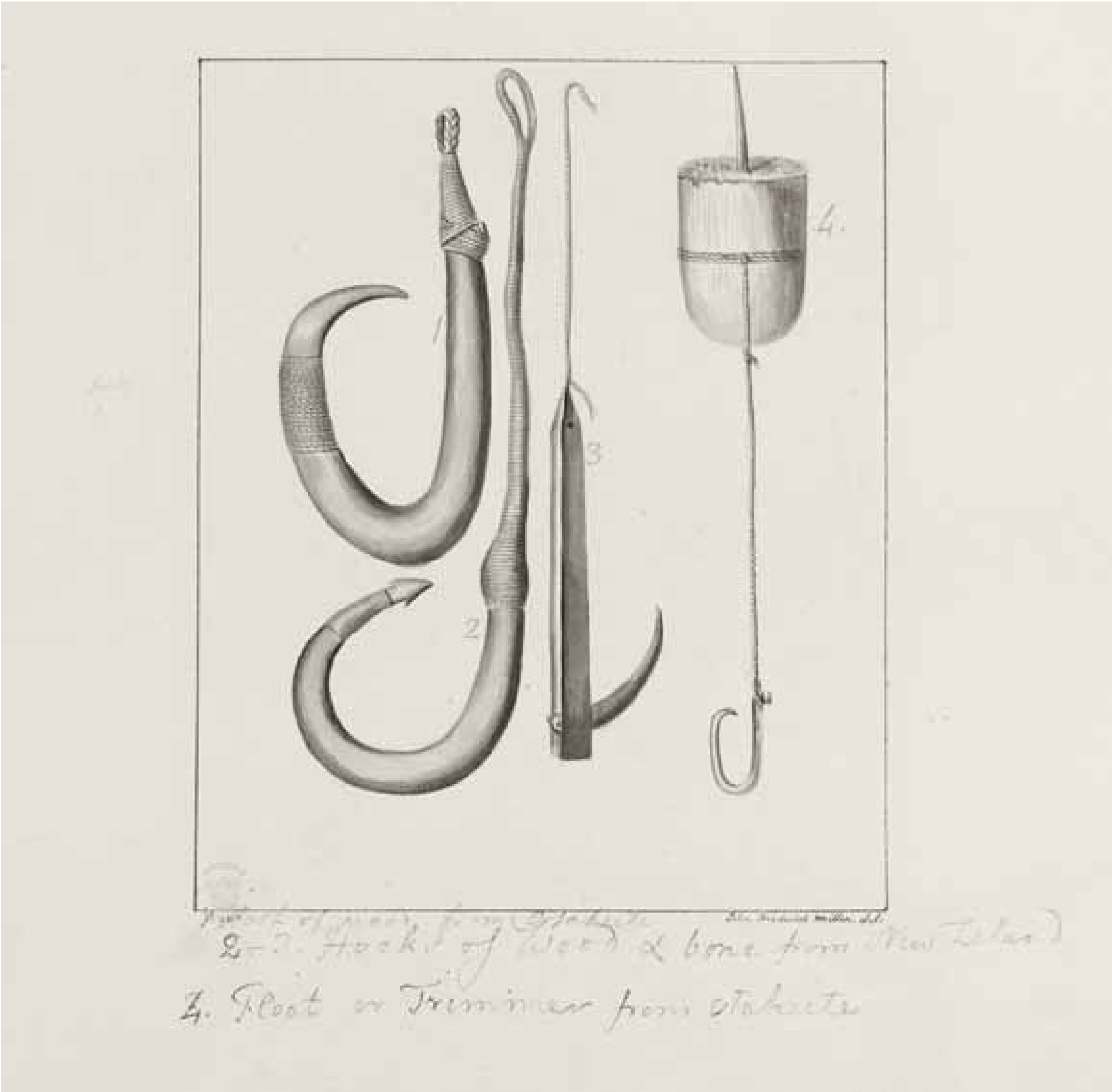

Fig. 2 Untitled [‘Fishing Tackle from Tahiti and New Zealand’], by John Frederick Miller, probably 1772, pen and wash on watermarked paper, mounted sideways on folio paper; 203 × 165 mm. The pencil inscription below the drawing is in Banks’s hand and serves as a key to the four objects depicted, from left: ‘1. Hook of wood from Otaheite; 2–3. Hooks of wood & bone from New Zeland [*sic*]; 4. Float or Trimmer from Otaheite’ (collections of the British Library, London: Add. MS 15508, f. 27 (no. 29); photo courtesy and copyright British Library, London).

have been accepted by other scholars working in the field (see, for example, Henare 2005: 46, n. 4; Tamarapa 2007: 98; Wallace 2007: 18; Kaeppler 2009: 56; Tapsell 2009).

Paulin is not, however, entitled to his opinion that the hook in question is not Māori but Hawaiian. I am not an expert on Pacific fishhooks so do not attempt to provide here a technical refutation of Paulin’s claim about the lashing, instead limiting myself to a discussion of the materials. My initial provenancing of the hook to New Zealand was based on my inexpert observation that the snood was made of harakeke (New Zealand flax, *Phormium tenax*). This was confirmed by a number of scholars on general stylistic grounds (that is, they agreed that the hook *looked* Māori), but also by the marked similarity between the present hook and another illustrated for Banks by John Frederick Miller in or around 1772 (see number 2 in Fig. 2). This is annotated by Banks in pencil as one of two ‘Hooks of Wood & bone from New Zeland [*sic*]’ (see also Joppien & Smith 1985: 218, no. 1.168). The two hooks do not appear to be identical – that is, I am not arguing that the hook illustrated by Miller is the hook now at the PRM – but the similarities are marked.

Fig. 3 Detailed view of the inscription, added by the Pitt Rivers Museum's first curator, Henry Balfour, in 1887 at the earliest, on the Māori fishhook illustrated in Fig. 1 (Christ Church collection, Pitt Rivers Museum, University of Oxford: 1887.1.379) (photo: taken for the museum by Malcolm Osman, image no. PRM000012478; courtesy and copyright Pitt Rivers Museum, University of Oxford).

What is now indisputable is the fact that the bone point is not lashed to the hook with 'sennit' (that is, coconut-husk fibre), but with kiekie (*Freycinetia banksii*), which is, of course, native to New Zealand and not to Hawai'i. This has been established by microscopic analysis by my PRM colleague Jeremy Uden (deputy head of conservation) and confirmed by electronic microscopic analysis by Caroline Cartwright of the Department of Conservation and Scientific Research at the British Museum.[6] Moreover, Uden and Cartwright confirm that the snood is made of muka, the fibre prepared from harakeke, which is also, of course, native to New Zealand and not to Hawai'i.[7] As it is difficult to make definitive identifications of worked plant fibre, it is thus of some importance that it has been possible to carry out microscopic analyses of the plant fibres used in the manufacture of the fishhook, and thus prove the Māori origin of this important object from Cook's first voyage.

As for 'the old ink writing' Paulin refers to, I have discussed briefly elsewhere (Coote 2012: 12–13) both Paulin's error and the power of inscriptions to mislead even the most careful of researchers. Suffice it to say here that it behoves museum curators and researchers in general to treat with care, if not downright suspicion, every inscription, label and document – indeed, every written text. Certainly, the 'evidence' provided by an inscription should never be given precedence over careful material, technical and historiographical analysis.

To be precise, the inscription – which is not (*pace* Paulin 2010: 28) 'partially obscured' – in fact reads 'SANDWICH I^{DS} | Dr Lee's Trustees, Ch. Ch. | Transf. fr. Univ. Mus.' (Fig. 3). It was added to the hook in 1887 at the earliest by Henry Balfour, the PRM's first curator, to record the fact that the hook had been transferred to the PRM from the University Museum, and that it was part of the collection loaned to the University Museum in 1860 by the dean and chapter ('Dr Lee's Trustees') of Christ Church (see Coote 2004a,b). By this time, the fact that Banks had given a collection to Christ Church had been forgotten and there was no extant list. Balfour was at the very beginning of his career and would not have had the skills then to identify the presence of kiekie and muka, or the knowledge of the significance of this to provenancing the hook. I expect that his (mis)provenancing of the hook to Hawai'i may have been influenced by the fact that there was no similar Māori hook in the collections at the time, and that what appeared to be a broadly similar hook in the Andrew Bloxam collection – from the voyage of HMS *Blonde* (1824–26), transferred to the PRM from the Ashmolean in 1886 – certainly is from Hawai'i (Fig. 5). A comparison of the inscriptions on the two hooks (Figs 3 and 4) shows that Balfour catalogued them both, the example from the *Blonde* voyage probably a year or so before the example from the *Endeavour* voyage. It is certainly not at all surprising that, without the information we have now about its history and the materials from which it is made, Balfour came to the conclusion that the Māori hook we now know was given by Banks to Christ Church after Cook's first voyage was Hawaiian.

Fig. 4 Detailed view of the inscription, added by the Pitt Rivers Museum's first curator, Henry Balfour, in February 1886 at the earliest, on the Hawaiian fishhook illustrated in Fig. 5 (Pitt Rivers Museum, University of Oxford: 1886.1.1311) (photo: taken for the museum by Malcolm Osman, image no. PRM0001509835165; courtesy and copyright Pitt Rivers Museum, University of Oxford).

Fig. 5 Hawaiian fishhook, by 1825, wood, coconut-husk fibre, bone, 250 mm long. Maker unknown. Acquired on the voyage of HMS *Blonde* to Hawai'i in 1825; given by Andrew Bloxam to the Ashmolean Museum, Oxford, in 1826; transferred to the Pitt Rivers Collection on 13 February 1886 (Pitt Rivers Museum, University of Oxford: 1886.1.1311) (photo: taken for the museum by Malcolm Osman, image no. PRM000011966; courtesy and copyright Pitt Rivers Museum, University of Oxford).

Conclusion

Given Paulin's awareness that 'In order to determine traditional fishhook design used by Māori, it was necessary to examine hooks with known provenance, and particularly those that were collected by eighteenth-century explorers prior to the cultural changes that followed colonisation of New Zealand' (Paulin 2010: 14), it is ironic that he misattributes to Hawai'i one of the very few Māori hooks that can be traced to Cook's first voyage.

I regret that I was not able to spend more time with Paulin when he visited the PRM in 2009 and that I did not make my concerns known to him when I received the copy of his unpublished report (Paulin [2009]) that he kindly supplied to the PRM, on which his 2010 article is based. Moreover, it is with some reluctance that I have prepared this critical response. Scholarly understanding of Māori material culture in general and fishing technology in particular, however, depends upon careful and painstaking technical analysis of objects in the context of the historical collections of which they are parts. Such work requires both technical expertise and historiographical skills. Having added a Māori fishhook to the small corpus that can be traced to Cook's voyages, and the even smaller corpus that can be traced to the first voyage, I was disappointed to find it dismissed by Paulin on the basis of inaccurate information and analysis.

I was also disappointed that an inaccurate account of the PRM's collection had been published. My hope is that the information I have been able to provide here will be useful to other researchers; to those interested in the history of early-voyage collections; and to those interested in the technical history of Māori fishing technology.

Acknowledgements

My work on the Cook-voyage collections at the Pitt Rivers Museum has been made possible by a series of grants from: the Hulme University Fund (1995), the South Eastern Museums Service (1996), the Jerwood/MGC Cataloguing Grants Scheme 1997–98 (supported by the Museums and Galleries Commission, the Jerwood Foundation, and the Department for Culture, Media and Sport), and the Innovation Awards Scheme of the Arts and Humanities Research Board (2001; award number B/IA/AN4817/APN13726). I have drawn here on this work, as well as on the help and advice I have received over the years from numerous colleagues both in and beyond the museum. I acknowledge in particular the work carried out by my colleague Jeremy Uden (deputy head of conservation at the Pitt Rivers Museum) during his Clothworkers Foundation Conservation Fellowship (2012–13).

Notes

1 Paulin discusses the collections of some dozen European museums. For obvious reasons, my comments are limited to what Paulin has to say about the PRM and its collections. It may, however, be useful to take this opportunity to note that Paulin is also in error in referring (2010: 14, 20, 34) to the drawings reproduced as plate XXVI in the published version of Sydney Parkinson's journal (Parkinson 1784) as being by Parkinson himself. As is well known, Parkinson died at sea in 1771 on the *Endeavour*'s voyage home. His journal was published posthumously, and while most of the plates are based on Parkinson's drawings and paintings, plate XXVI comprises a set of drawings by Samuel Hieronymous Grimm (1733–94) of Tahitian and Māori objects that *may* have been in Parkinson's collection, though some or all of them may have been provided for the purpose by his shipmates (for a useful, recent account, see Heringman 2013: 49–55; for more on Grimm, see Hauptman 2014).

2 For transcriptions of, and further information about, the Forsters' 'Catalogue of curiosities sent to Oxford', see Coote *et al.* 2000 and MacGregor 2000: 249–52; see also Coote 2015.

3 www.prm.ox.ac.uk/databases.html.

4 For the most up-to-date information about the Tahitian and Tongan hooks that are currently, tentatively, identified as among those donated by the Forsters, see the relevant entries in the PRM's database (http://www.prm.ox.ac.uk/databases.html). See also the relevant pages on the *Cook-voyage collections at the Pitt Rivers Museum* website at http://web.prm.ox.ac.uk/cookvoyages.

5 For a transcription of Evans' 1884–86 catalogue, see MacGregor 2000: 255–413. For the most recent discussion of Evans and his work, see Coote 2014: 399–408; see also Coote 2015.

6 For microscope and electron-microscope images of fibres from both the cord and the binding, see the page devoted to the fishhook on the *Cook-voyage collections at the Pitt Rivers Museum* website at http://web.prm.ox.ac.uk/cookvoyages/index.php/en/the-objects/102-objects/new-zealand/335-1887-1-379.html. See also Caroline Cartwright's report ([2013]).

7 Paulin also claims that at least two of the Māori 'composite wooden hooks with bone points' in the PRM's collection appear to be fakes. One of these is the hook with the number 1884.11.47 that he illustrates in his fig. 12, and from his list of 'hooks examined' (Paulin 2010: 29) it is clear that the other hook he thinks may be a fake is that with the accession number 1919.52.2. It appears that Paulin's grounds for suggesting that 1884.11.47 and 1919.52.2 are fakes is that they have 'ornately carved bone points'. However, he also claims that 1884.11.47 has 'a plaited snood of sennit rather than New Zealand flax' (Paulin 2010: 28). For the record, the plaited snood on 1884.11.47 is not made of coconut-husk fibre (i.e. sennit) but of muka.

References

Beechey, F.W. (1831). *Narrative of a voyage to the Pacific and Beering's Strait to co-operate with the polar expeditions: performed in His Majesty's Ship* Blossom*, under the command of Captain F. W. Beechey … in the Years 1825, 26, 27, 28. Vols 1 and 2.* London: Henry Colburn and Richard Bentley. 742 pp.

Cartwright, C. [2013]. Scanning electron microscope identification of fibres and hairs from the Cook voyage collection at the Pitt Rivers Museum. *In*: *Cook-voyage collections at the Pitt Rivers Museum* [website]. Available online at http://web.prm.ox.ac.uk/cookvoyages/index.php/en/the-objects/102-objects/new-zealand/335-1887-1-379.html.

Coote, J. (2004a). An interim report on a previously unknown collection from Cook's first voyage: the Christ Church collection at the Pitt Rivers Museum, University of Oxford. *Journal of Museum Ethnography* 16: 111–121.

Coote, J. (2004b). *Curiosities from the* Endeavour*: a forgotten collection – Pacific artefacts given by Joseph Banks to Christ Church, Oxford after the first voyage.* Whitby: Captain Cook Memorial Museum. 28 pp.

Coote, J. (2005). *'From the islands of the South Seas, 1773–4'*: Peter Gathercole's special exhibition at the Pitt Rivers Museum. *Journal of Museum Ethnography*, 17: 8–31.

Coote, J. (2012). Objects and words: writing on, around, and about things – an introduction. *Journal of Museum Ethnography* 5: 3–18.

Coote, J. (2014). A Tongan *tapua* in the Pitt Rivers Museum: historiographical notes and curatorial reflections. *Journal of the Polynesian Society* 123(4): 399–420.

Coote, J. (2015). The Cook-voyage collections at Oxford, 1772–2015. Pp. 74–122. *In*: Coote, J. (*ed.*). Cook-voyage collections of 'artificial curiosities' in Britain and Ireland, 1771–2015. *MEG Occasional Paper* 5. Oxford: Museum Ethnographers Group. 300 pp.

Coote, J. (2016). Dressing up, taking over, and passing on: Joseph Banks and artificial curiosities from the *Endeavour* voyage. Pp. 80–85. *In*: Chambers, N. (ed.) *Endeavouring Banks: exploring the collections from the* Endeavour *voyage, 1768–1771*. London: Paul Holberton. 304 pp.

Coote, J., Gathercole, P. and Meister, N. (2000). 'Curiosities sent to Oxford': the original documentation of the Forster collection at the Pitt Rivers Museum. *Journal of the History of Collections* 12(2): 177–192.

Coote, J., Knowles, C., Meister, N. and Petch, A. (1999). Computerizing the Forster ('Cook'), Arawe, and founding collections at the Pitt Rivers Museum. *Pacific Arts* 19/20: 48–80.

Gathercole, P. [1970]. *'From the Islands of the South Seas, 1773–4': an exhibition of a collection made on Capn. Cook's second voyage of discovery by J.R. Forster – a short guide*. Oxford: Pitt Rivers Museum. 24 pp.

Hauptman, W. (2014). *Samuel Hieronymous Grimm (1733–1794): a very English Swiss*. Milan: 5 Continents Editions. 224 pp.

Henare, A.J.M. (2005). *Museums, anthropology and imperial exchange*. Cambridge: Cambridge University Press. 323 pp.

Heringman, N. (2013). *Sciences of antiquity: romantic antiquarianism, natural history, and knowledge work*. Classical Presences Series. Oxford: Oxford University Press. 345 pp.

Joppien, R. and Smith, B. (1985). *The art of Captain Cook's voyages. Vol. 1: The voyage of the* Endeavour*, 1768–1771, with a descriptive catalogue of all the known original drawings of peoples, places, artefacts and events and the original engravings associated with them*. New Haven and London: Yale University Press (for the Paul Mellon Centre for Studies in British Art, in association with the Australian Academy of the Humanities). 247 pp.

Kaeppler, A.L. (1978). 'Artificial curiosities': being an exposition of native manufactures collected on the three Pacific voyages of Captain James Cook, R.N. at the Bernice Pauahi Bishop Museum, January 18, 1978–August 31, 1978 on the occasion of the bicentennial of the European discovery of the Hawaiian Islands by Captain Cook – January 18, 1778. *Bernice P. Bishop Museum Special Publication* 65. Honolulu: Bishop Museum Press. 293 pp.

Kaeppler, A.L. (2009). Enlightened ethnographic collections. Pp. 55–60. *In*: Kaeppler, A.L. *et al.* (*eds*). *James Cook and the exploration of the Pacific*. London: Thames & Hudson. 276 pp.

MacGregor, A. (2000). Manuscript catalogues of the early museum collections, 1683–1886. Part I. *British Archaeological Reports, International Series* 907. Oxford: Archaeopress, in association with the Ashmolean Museum, Oxford. 451 pp.

O'Hanlon, M. (2014). *The Pitt Rivers Museum: a world within*. London: Scala Arts & Heritage. 168 pp.

Parkinson, S. (1784 [1773]). *A journal of a voyage to the South Seas, in His Majesty's Ship the* Endeavour*: faithfully transcribed from the papers of the late Sydney Parkinson, draughtsman to Sir Joseph Banks, Bart. in his expedition with Dr. Solander round the world; and embellished with twenty-nine views and designs, engraved by capital artists*. London. 212 pp.

Paulin, C.D. (2010). Māori fishhooks in European museums. *Tuhinga: Records of the Museum of New Zealand Te Papa Tongarewa* 21: 13–41.

Tamarapa, A. (2007). Weaving a journey: the story of a unique cloak. Pp. 94–111. *In*: Labrum, B., McKergow, F. and Gibson, S. (*eds*). *Looking flash: clothing in Aotearoa New Zealand*. Auckland: Auckland University Press. 279 pp.

Tapsell, P. (2009). Footprints in the sand: Banks's Maori collection, Cook's first voyage, 1768–71. Pp. 92–111. *In*: Hetherington, M. and Morphy, H. (*eds*). *Discovering Cook's collections*. Canberra: National Museum of Australia. 130 pp.

Wallace, P. (2007). He whatu ariki, he kura, ke waero: chiefly threads, red and white. Pp. 12–27. *In*: Labrum, B., McKergow, F. and Gibson, S. (*eds*). *Looking flash: clothing in Aotearoa New Zealand*. Auckland: Auckland University Press. 279 pp.

Unpublished sources

Evans, E. (*comp.*) (1884–86). List of anthropological objects transferred from the Ashmolean to the Pitt Rivers' Museum. Vols 1 and 2. Unpublished catalogue. Catalogues, Pitt Rivers Museum, University of Oxford.

Forster, J.R. and Forster, J.G. (1776). Catalogue of curiosities sent to Oxford. Unpublished manuscript. Box 3/1, Pitt Rivers Museum Papers, Pitt Rivers Museum, University of Oxford. 16 pp.

Paulin, C.D. [2009]. Research report: Māori fishhooks in European museums – Winston Churchill Fellowship 2009. Unpublished typescript. Copy held at the Pitt Rivers Museum, University of Oxford (Related Document Files / Researchers / Paulin). 36 pp.

Response to 'Māori fishhooks at the Pitt Rivers Museum: comments and corrections'

Chris D. Paulin

5 Rosetta Road, Raumati South, Paraparaumu, New Zealand

I would like to thank the *Tuhinga* Editorial Board for the opportunity to comment on the paper by Jeremy Coote in this issue on the Māori fishhooks in the University of Oxford's Pitt Rivers Museum.

Coote provides an interesting and informative paper on the origins and documentation of various objects now in the Pitt Rivers collection that originated from several expeditions to the Pacific in the late eighteenth and early nineteenth centuries. However, there is no evidence, documentary or otherwise, that links the composite wooden hook with a bone point in question (1887.1.379) to the Banks collection and therefore New Zealand.

Coote claims that this hook was part of an unknown collection donated by Joseph Banks to Christ Church College, and subsequently transferred to the Pitt Rivers collection in 1887. However, as Coote himself comments, 'By this time, the fact that Banks had given a collection to Christ Church had been forgotten and there was no extant list.'

Coote states that his initial provenancing of the hook to New Zealand was based on his inexpert observation that the snood was made of harakeke (New Zealand flax, *Phormium tenax*). This was confirmed by a number of scholars on general stylistic grounds (that is, they agreed that the hook *looked* Māori), but also by the marked similarity between the present hook and another illustrated for Banks by John Frederick Miller in or around 1772. Having examined a large number of hooks made of traditional materials from both New Zealand and the wider Pacific, I am of the opinion that it is often virtually impossible to distinguish prepared New Zealand flax fibre (muka) from prepared hibiscus or mulberry fibre (fau) visually.

Furthermore, Coote states that the bone point of the hook has been lashed with kiekie (*Freycinetia banksii*) and is therefore from New Zealand. It is simply not credible that anybody, no matter how experienced, can visually distinguish dried prepared fibres of New Zealand kiekie from similar fibres from the congeneric *Freycinetia arborea*, a native Hawaiian species known as 'ie 'ie that was also used in traditional lashings.

It is ironic that Coote refers to the power of inscriptions to mislead even the most careful of researchers as a reason to question the label 'Sandwich Ids' as evidence for the hook's origin, then to claim that an annotation, reputably in Banks's handwriting, on an illustration of a hook that may be from New Zealand or Tahiti is proof that the style of hook is Māori.

Despite Coote's statement to the contrary, I believe I am entitled to my opinion that the hook in question is not Māori but Hawaiian, and furthermore, that it has no connection with the Banks collection or with James Cook's first voyage.

Ultimately, the debate on the origins of this hook will probably only be resolved through DNA analysis of the fibres and wood used in making the hook.

 Copyright © Museum of New Zealand Te Papa Tongarewa (2016)

Obsidian floater washed up on a beach in the Chatham Islands: geochemical composition and comparison with other volcanic glasses

Foss Leach,[*] Hamish Campbell,[**] Nelson Eby,[***] Katherine Holt,[‡] Marcel Regelous,[§] Rhys Richards[#] and Steve Weaver[¶]

[*] Research Associate, Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington, New Zealand
[**] GNS Science, PO Box 30368 Lower Hutt, New Zealand
[***] Department of Environmental, Earth and Atmospheric Sciences, University of Massachusetts Lowell, USA
[‡] Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand
[§] Naturwissenschaftliche Fakultät, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany
[#] 73 Seaview Road, Paremata, Porirua, New Zealand
[¶] Geochemistry Laboratory, Department of Geological Sciences, University of Canterbury, Christchurch, New Zealand

ABSTRACT: A large block of pumice with a thick layer of volcanic glass attached to one side was found on a beach in the Chatham Islands. The geochemical signature of the specimen was most unusual: it proved to be a peralkaline phonolite with a negative europium anomaly. Since there was no obvious eruptive event that might have been the source of the floating object, identification of its geographic source involved a series of steps that progressively narrowed in on fewer and fewer potential sources. This process eventually pointed most strongly to McDonald Island in the Antarctic region southwest of Australia. This was confirmed only after unpublished geochemical data for the island were found. The process of identification described could have wider application when trying to find the volcanic source of obsidian artefacts with greater certainty.

KEYWORDS: obsidian, pumice, Chatham Islands, McDonald Island, geochemistry, Pacific archaeology, sourcing model.

Introduction

This paper is about the identification of the geographic source of a piece of rock, embedded in pumice, which had floated to the location where it was found.

During the course of the research it became apparent that the process by which the conclusion was reached was of wider scientific interest than the identification itself. Normally, all that is needed to reach a conclusion with certainty in a case like this is a search among rocks with characteristics similar to those of the specimen in question, until an identical match is found. In this case, however, it was clear that there were a number of places with rocks very similar to that being studied. The process by which an exact match could be made was therefore not at all straightforward, and is described in full.

Some years ago, a block of obsidian attached to a large band of pumice was found on a beach at Waitangi West in the Chatham Islands. It was collected by Pat Tuanui or his son Patrick and placed in their garden at Waihi in about 2008 or 2009. Since the piece was found on a beach, it was assumed that it had floated in sea water from its volcanic source, but where that source might be was an open question. It seemed possible that the piece had come from the unconfirmed submarine source of obsidian on Chatham Island itself, recorded by geologist Julius von Haast (1885: 26): 'The Morioris also used flint "mataa", which they split

Fig. 1 Several views of the obsidian floater from the Chatham Islands. Maximum dimension *c.* 200 mm.

into thin, irregular, wedge-like shapes, as knives, there being no volcanic glass ("tuhua") obtainable in any quantity, although a reef of it is thought to exist under water at the south-east corner of the island at Manukau.'

Quite a few obsidian artefacts have previously been found in the Chatham Islands, although none has been excavated in a controlled archaeological context, so their ages and cultural associations are unknown. Analysis of these surface finds by PIXE-PIGME has shown that most derive from the volcanic source on Mayor Island (Tuhua) in New Zealand's Bay of Plenty, but some artefacts could not easily be matched to known sources (Leach *et al.* 1986). It was possible that some of these artefacts might derive from the supposed submarine source off Manukau Point. Clearly, it would be useful to have this block of floating pumice and obsidian examined for its chemical properties in an effort to locate its original volcanic source.

Rhys Richards became aware of the Chatham Island block and gave it to Hamish Campbell for analysis. He confirmed that it did indeed float in sea water. He gave a piece of the pumice to Katherine Holt for analysis; Foss Leach was subsequently given permission to carry out further analyses of a small sample of the obsidian. The GNS Science Petrology Collection number P81381 was allocated to the block (the catalogue numbers of all samples analysed are given in Appendix 1). The entire block weighed 1271.93 g, and the piece of obsidian removed for analysis weighed 71.38 g.

Fig. 2 The obsidian is olive-green in transmitted sunlight. Length 12 mm.

Physical description of the obsidian floater

The block is illustrated in Fig. 1, from which it can be seen that the bulk is pumice with only a small band of obsidian along one side. The maximum dimension is about 200 mm. A small, thin flake of obsidian was removed for analysis and photographed under transmitted sunlight (Fig. 2). This is clearly olive-green, similar in hand specimen to many obsidian artefacts that have been found in the past in the Chatham Islands, and also in New Zealand and further afield in the South Pacific. Such olive-green obsidian artefacts are frequently declared to be of Mayor Island (Tuhua) origin

Table 1 Electron microprobe analysis of pumice from the Chatham Islands obsidian floater, carried out and presented by Katherine Holt of Massey University, New Zealand.

Sample	**SiO_2**	**TiO_2**	**Al_2O_3**	**FeO**	**MnO**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**P_2O_5**	**SO_3**	**Cl**	**Cr_2O_3**	**NiO**	**TOTAL**
Ch098	55.67	0.42	19.98	3.80	0.14	0.30	1.29	11.34	5.99	0.07	0.00	0.86	0.00	0.14	100.00
Ch098	55.92	0.36	20.14	3.67	0.08	0.22	1.33	11.25	5.84	0.21	0.04	0.79	0.00	0.13	100.00
Ch098	55.84	0.40	19.99	3.73	0.15	0.31	1.32	11.18	5.90	0.25	0.00	0.92	0.00	0.00	100.00
Ch098	56.01	0.43	20.12	3.58	0.11	0.30	1.38	11.07	5.92	0.02	0.00	0.93	0.09	0.04	100.00
Ch098	55.67	0.47	20.12	3.80	0.13	0.28	1.35	11.12	5.92	0.16	0.00	0.86	0.11	0.00	100.00
Ch098	55.47	0.46	19.98	3.64	0.12	0.41	1.40	11.29	6.01	0.15	0.00	0.95	0.00	0.11	100.00
Ch098	55.83	0.61	20.02	3.90	0.00	0.30	1.29	11.06	5.84	0.25	0.00	0.85	0.05	0.00	100.00
Ch098	55.58	0.42	19.93	3.95	0.18	0.41	1.23	11.23	5.91	0.23	0.00	0.82	0.00	0.11	100.00
Ch098	55.88	0.36	20.12	3.88	0.09	0.28	1.31	11.19	5.97	0.04	0.02	0.84	0.01	0.00	100.00
Ch098	55.83	0.45	20.16	3.84	0.08	0.32	1.31	11.05	5.91	0.09	0.00	0.75	0.00	0.20	100.00
Ch098	55.89	0.43	20.15	3.75	0.20	0.32	1.26	11.14	5.97	0.09	0.00	0.80	0.00	0.00	100.00
Ch098	56.14	0.37	20.00	3.40	0.00	0.29	1.32	10.97	6.02	0.43	0.00	0.85	0.04	0.16	100.00
Ch098	55.98	0.35	19.88	3.90	0.08	0.36	1.25	11.07	5.82	0.41	0.00	0.91	0.00	0.00	100.00
Ch098	55.81	0.31	20.04	3.80	0.11	0.23	1.35	11.36	5.89	0.23	0.00	0.83	0.04	0.00	100.00
Ch098	55.87	0.49	19.95	3.82	0.11	0.36	1.27	11.36	5.77	0.14	0.00	0.80	0.05	0.00	100.00
Ch098	55.42	0.53	20.12	3.75	0.19	0.41	1.28	11.07	6.08	0.16	0.00	0.92	0.00	0.06	100.00
Ch098	55.64	0.39	20.15	3.86	0.13	0.41	1.38	11.07	5.78	0.16	0.00	0.88	0.05	0.09	100.00
Ch098	56.00	0.48	20.07	3.70	0.14	0.32	1.31	11.05	5.90	0.16	0.00	0.87	0.00	0.00	100.00
Mean	**55.803**	**0.429**	**20.051**	**3.765**	**0.113**	**0.324**	**1.313**	**11.159**	**5.913**	**0.181**	**0.003**	**0.857**	**0.024**	**0.058**	
SD	**0.193**	**0.072**	**0.088**	**0.134**	**0.055**	**0.059**	**0.047**	**0.121**	**0.084**	**0.111**	**0.010**	**0.054**	**0.035**	**0.068**	

by archaeologists without any definitive test being carried out. Some sources of obsidian in Northland have similar coloration in transmitted light. This present piece does not come from either Northland or Mayor Island (Tuhua), as will be shown below.

Electron microprobe analyses of the pumice fraction

Eighteen spots on the sample were analysed on an EDS Jeol JXA-840A electron microprobe (EMP) at the University of Auckland. The assays were collected using a Princeton GammaTech Prism 2000 Si (Li) EDS X-ray detector using a 20 µm defocused beam, an accelerating voltage of 12.5 kV, a beam current of 600 pA and a live count time of 100 seconds. The EMP results are presented in Table 1.

The analyses were made on a small sample (~1 g) of the pumice, that is, of the vesiculated portion of the boulder. The analyses are normalised to 100% water-free (water content ~1–2% in most samples). High sodium and chlorine values possibly indicate that the samples were not cleaned adequately before analysis. But even when taking this into account, the pumice still appears to have a strange composition. It was initially thought that the pumice might be phonolitic, so the results were given to Rob Stewart, associate professor of earth sciences at Massey University, for comment. His response was:

> This comes out as a phonolite alright, but there are some peculiarities. I would expect about 7–8% Na_2O max. The chlorines look rather high at just under 1% – I would expect < about 0.1%, which might explain some of the high Na. Apparently no sulphate though. Peculiar. The normative analysis shows about 25% nepheline, which indicates that it is strongly under-saturated wrt [with respect to] silica. The other peculiarity is that it is a pumice; most phonolites are crystalline. Phonolite would suggest one of the oceanic islands like Tristan de Cunha, Kerguelen, Heard Island, etc. (pers. comm. to Holt, 2012)

X-ray fluorescence and neutron activation analyses of the glass fraction

In order to get the most reliable results across a wide range of elements, both wavelength-dispersive X-ray fluorescence (XRF) analysis and neutron activation analysis (NAA) were carried out, the former at the Geochemistry Laboratory, Department of Geological Sciences, University of Canterbury, and the latter at the Department of Environmental, Earth and Atmospheric Sciences at the University of Massachusetts Lowell. The results are given in Tables 2 and 3. Initial comments on these results were as follows:

> This specimen has a very strange composition – my first reaction was that this is not a natural magmatic composition. The silica suggests a trachybasalt composition but the alkalis are astonishingly high. I note that it is described as a 'floater' on the sample bag – does that mean that it is floating pumice? Analysis of floating pumice often includes a significant contribution from sea salt – just an idea. It is peralkaline – the Zr, Nb and Th confirm that but the Al is very high which smacks of feldspar accumulation. (Steve Weaver, pers. comm. to Leach, 5 March 2013)

A number of colleagues who are experts in the field of geochemical analysis of volcanic glasses (Ray Macdonald, University of Lancaster; Peter Kelly, United States Geological Survey Volcano Emissions Project; and Christian Reepmeyer and Wallace Ambrose, both of Australian National University) were provided with the XRF and NAA results and consulted for their opinions. All commented on the

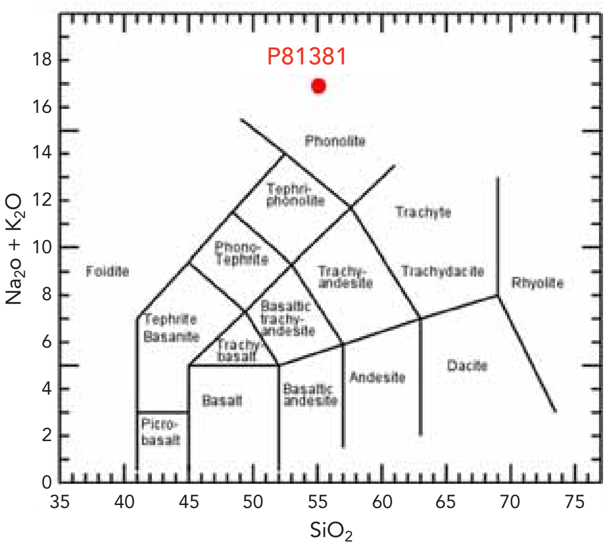

Fig. 3 The floater from the Chatham Islands (P81381) is definitely a phonolite according to the International Union of Geological Sciences classification of volcanic rocks.

unusual composition and none could identify the source. One authority thought the glass fraction might even be a man-made glass. The composition of the specimen was unquestionably different from the earlier-studied obsidian artefacts from the Chatham Islands that could not be matched to known volcanic sources.

Before trying to track down the volcanic source of this floating object, it was necessary to clarify some basic characteristics of the object.

Trachybasalt or phonolite? Alkaline or peralkaline?

The first thing that needed clarification was the kind of rock this glass came from. A commonly used system for the classification of volcanic rocks was proposed by the International Union of Geological Sciences (IUGS), called the total alkali versus silica (TAS) schema (Le Bas & Streckeisen 1991: 830, fig. 5). By this classification, the floater from the Chatham Islands is clearly phonolite (Fig. 3).

The next thing that needed clarification was whether the rock is peralkaline or not. This was also easily decided – if the agpaitic index of a rock is greater than 1.0, then it is peralkaline. The agpaitic index is the molar ratio of (Na_2O + K_2O)/Al_2O_3). Using the XRF results for P81381 in Table 3, it can be seen that Na_2O = 11.50%, K_2O = 5.50%, and Al_2O_3 = 20.33%. The molecular weights of the three

Table 2 Neutron activation analysis of various samples, including the Chatham Islands obsidian floater (P81381), carried out and presented by the Department of Environmental, Earth and Atmospheric Sciences at the University of Massachusetts Lowell. Details of samples are given in Appendix 1 (dash = not determined; nd = not detected).

Element	5105	ANU 306	ANU 306	5145	5145	302	302	AI 1991	AI 1991	GX 219	MAC 18E	P 81381	RGM-1	STM-1	Units
Fe	3.23	2.26	2.3	0.85	0.92	1.03	1.03	1.44	1.5	40063	46482	29004	1.28	3.72	ppm
Na	3.33	4.47	4.56	2.97	3.04	3.75	3.94	3.64	3.71	27239	33106	81501	3	6.53	ppm
K	—	—	—	—	—	—	—	—	—	5295	9535	49672	—	—	ppm
Sc	0.29	5.4	5.55	4.12	4.36	2.93	3.04	4.3	4.47	22.515	19.535	1.483	4.5	0.63	ppm
Cr	9.1	nd	nd	nd	nd	nd	nd	2.1	2.3	nd	0.893	8.167	3.4	1.9	ppm
Mn	445	372	371	134	126	145	146	215	217	—	—	—	272	1671	ppm
Co	0.5	0.52	0.51	0.61	0.67	0.5	0.5	1.43	1.49	7.57	5.24	2.97	1.97	0.8	ppm
Ni	—	—	—	—	—	—	—	—	—	nd	9	13	—	—	ppm
Zn	93	61	60	32	nd	27	29	35	37	91	129	150	34	105	ppm
Rb	129	128	112	54	54	136	130	146	141	4.4	24.6	213	147	120	ppm
Cs	4.7	4.5	4.5	1.5	1.6	3.9	4.1	1.8	2.1	0.69	0.94	6.65	9.8	1.5	ppm
Sr	nd	nd	nd	176	196	89	74	nd	47	96	160	137	128	718	ppm
Ba	58	286	266	551	568	895	877	734	737	215	453	nd	832	573	ppm
La	1679	51.3	52.4	13.3	14.1	31.5	32.7	39.2	39.7	4.5	10	121	24.8	142	ppm
Ce	2046	109	116.3	27.7	30.8	61.9	64.9	73.7	76.9	12	24.6	170	47.3	246	ppm
Nd	499	53.7	53	14.6	15.2	32.6	30.3	29.1	34.7	10.7	19.7	44.6	22	82	ppm
Sm	40.9	10.2	10.1	2.98	3.09	5.06	4.89	5.61	5.9	3.61	6.11	5.92	4.1	12.4	ppm
Eu	4.84	0.57	0.56	0.65	0.67	0.87	0.91	0.98	1.01	1.15	1.82	1.02	0.59	3.4	ppm
Gd	32	8.8	9	3.1	3.1	4	4.5	5.3	5.8	5.5	8.2	5.1	4	9.1	ppm
Tb	4.31	1.87	1.86	0.46	0.48	0.69	0.69	1.02	1.05	0.92	1.27	0.85	0.63	1.56	ppm
Ho	—	—	—	—	—	—	—	—	—	1.3	1.8	1.15	—	—	ppm
Tm	2.2	1.18	1.23	0.27	0.29	0.36	0.41	0.55	0.56	0.6	0.8	0.46	0.37	0.7	ppm
Yb	13.7	9.27	9.18	2.45	2.49	2.52	2.57	4.21	4.31	4.3	5.3	3.5	2.62	4.59	ppm
Lu	1.79	1.23	1.25	0.38	0.38	0.38	0.37	0.58	0.59	0.62	0.81	0.47	0.4	0.62	ppm
Zr	885	588	603	125	149	262	263	225	197	34	98	2350	205	1112	ppm
Hf	24.6	20.4	20.8	3.65	3.89	7.39	7.87	8.29	8.36	2.24	3.7	35	5.87	27.8	ppm
Ta	5.97	1.86	1.85	0.16	0.16	0.79	0.79	3.15	3.26	0.048	0.087	13.74	0.99	19.1	ppm
Th	42.7	18.7	18.9	2.7	2.79	12.52	13	11.5	11.7	0.61	1.38	52	14.8	30.5	ppm

continued on following page

Table 2 Neutron activation analysis of various samples, including the Chatham Islands obsidian floater. *Continued from previous page*

Element	5105	ANU 306	ANU 306	5145	5145	302	302	AI 1991	AI 1991	GX 219	MAC 18E	P 81381	RGM-1	STM-1	Units
U	4.62	5.19	5.11	1.75	1.5	3.59	3.39	2.81	2.89	0.2	0.49	15.3	5.75	8.4	ppm
As	—	—	—	—	—	—	—	—	—	5.3	2.2	6.6	—	—	ppm
Sb	0.4	0.4	0.5	0.3	0.3	0.2	0.3	0.3	0.2	0.17	0.01	0.57	1.3	1.7	ppm
W	—	—	—	—	—	—	—	—	—	0.19	nd	10.7	—	—	ppm
Ir	—	—	—	—	—	—	—	—	—	nd	4.8	5.2	—	—	ppb
Au	—	—	—	—	—	—	—	—	—	nd	3.5	nd	—	—	ppb

Chondrite normalised values (Nakamura 1974)

Element	5105	ANU 306	ANU 306	5145	5145	302	302	AI 1991	AI 1991	GX 219	MAC 18E	P 81381	Nakamura
La	5087.9	155.5	158.8	40.3	42.7	95.5	99.1	118.8	120.3	13.6	30.3	366.7	0.33
Ce	2365.3	126.0	134.5	32.0	35.6	71.6	75.0	85.2	88.9	13.9	28.4	196.5	0.865
Nd	792.1	85.2	84.1	23.2	24.1	51.7	48.1	46.2	55.1	17.0	31.3	70.8	0.63
Sm	201.5	50.2	49.8	14.7	15.2	24.9	24.1	27.6	29.1	17.8	30.1	29.2	0.203
Eu	62.9	7.4	7.3	8.4	8.7	11.3	11.8	12.7	13.1	14.9	23.6	13.2	0.077
Gd	115.9	31.9	32.6	11.2	11.2	14.5	16.3	19.2	21.0	19.9	29.7	18.5	0.276
Tb	91.7	39.8	39.6	9.8	10.2	14.7	14.7	21.7	22.3	19.6	27.0	18.1	0.047
Ho	nd	nd	nd	nd	nd	nd	nd	nd	nd	18.6	25.7	16.4	0.07
Tm	73.3	39.3	41.0	9.0	9.7	12.0	13.7	18.3	18.7	20.0	26.7	15.3	0.03
Yb	62.3	42.1	41.7	11.1	11.3	11.5	11.7	19.1	19.6	19.5	24.1	15.9	0.22
Lu	52.6	36.2	36.8	11.2	11.2	11.2	10.9	17.1	17.4	18.2	23.8	13.8	0.034

molecules are 61.98, 94.20 and 101.96, respectively. The agpaitic index for this rock is therefore (0.1855 (11.50/61.98) + 0.0584 (5.50/94.2))/0.1994 (20.33/101.96) = 1.223. This makes it definitely peralkaline, thereby helping to narrow down the search for the source.

One other useful thing to consider is the rare earth element pattern (REE). Comparison of these patterns has often been found useful in matching a specimen to its source (Collerson & Weisler 2007: 1910).[1] The REE pattern of various obsidians is illustrated in Fig. 4. The obsidian from the Chatham Islands floater shows clear Eu depletion.

The origin of the pumice and glass *a priori* or *a posteriori*?

The Chatham Islands floater is not the first recorded example of a large block of pumice carrying obsidian to distant shores. Spennemann found a similar piece with a maximum dimension of 32 cm during an archaeological survey on Knox Atoll, also known as Nadikdik, in the Marshall Islands in Micronesia. Identification of the source of this piece was quite simple because its chemistry was identical to those of specimens in an existing database of

Table 3 Wavelength-dispersive X-ray fluorescence results from various samples, including the Chatham Islands floater (P81381), presented by the Geochemistry Laboratory, Department of Geological Sciences, University of Canterbury, New Zealand (**35504A**, two small pieces combined from the source on Macauley Island, MAC18A (AH594), 3151 mg, and MAC18D, 2050 mg; **35505A**, part of GX223B from the source on Raoul Island, 12,269 mg; **35506A**, part of P40908, also from the source on Raoul Island, 6584 mg; **35507A**, part of P81381, Chatham Island obsidian floater, 7684 mg).

Element	Unit	35504A	35505	35506A	35507A (P81381)
SiO_2	%	69.31	67.06	67.33	55.03
TiO_2	%	0.65	0.63	0.63	0.48
Al_2O_3	%	13.36	14.71	14.54	20.33
Fe_2O_3T	%	5.67	6.07	6.05	4.35
MnO	%	0.16	0.16	0.16	0.14
MgO	%	0.79	1.45	1.40	0.62
CaO	%	3.36	5.22	5.15	1.49
Na_2O	%	4.65	3.92	3.95	11.50
K_2O	%	1.56	0.61	0.61	5.50
P_2OS	%	0.17	0.15	0.16	0.10
LOI	%	0.18	−0.17	−0.05	0.30
Total	%	**99.86**	**99.81**	**99.92**	**99.83**
V	ppm	24	54	53	22
Cr	ppm	6	7	6	17
Ni	ppm	5	<3	<3	17
Zn	ppm	118	91	92	157
Zr	ppm	155	74	75	2097
Nb	ppm	2	<2	<2	282
Ba	ppm	417	209	234	<20
La	ppm	12	10	8	118
Ce	ppm	38	28	19	205
Nd	ppm	15	13	<10	42
Ga	ppm	16	15	15	47
Pb	ppm	8	5	6	42
Rb	ppm	28	9	9	223
Sr	ppm	171	165	166	114
Th	ppm	3	<1	1	57
Y	ppm	54	40	41	39

obsidian sources. Edax SEM analysis showed the source to have been the Tuluman volcano near Manus Island in Papua New Guinea (Spennemann 1996: 30–31). That is a great-circle distance of about 2800 km. A similar large floating block of obsidian was found on Koil, one of the islands in the Schouten island group in the East Sepik area of Papua New Guinea (Ambrose *in* Spennemann 1996). This specimen was also sourced to the Tuluman volcano, which in this case was relatively nearby.

The chemistry of the Chatham Islands floater is far from familiar and it clearly was not going to be so easy to identify its source. Quite often in the past, following a major volcanic eruption somewhere in the world, pumice has turned up on distant beaches and geologists have collected samples and matched their chemistry to the volcano involved. In cases like this, identification is simple because one has *a priori* information against which to test the object. The situation is quite different when there has been no recent eruption against which to test. In the case of the Chatham Islands sample, the source could be identified only *a posteriori*, that is, after gathering evidence from diverse sources and carrying out some form of definitive comparison and test against each. An important question here is: how big should this universe of sources be? Could this universe be narrowed down or should all possible sources be considered?

Such a situation was presented in a study by Jokiel & Cox (2003), in which they set out to identify the sources of numerous pieces of pumice that had drifted to beaches on Hawaiʻi and Christmas Island over an unknown period of time, and for which they could make no *a priori* assumptions on the original sources that might be involved. They carried out XRF analysis of 41 pumice specimens, about half from each island group. They then used information from a pumice source characterisation study by Frick & Kent

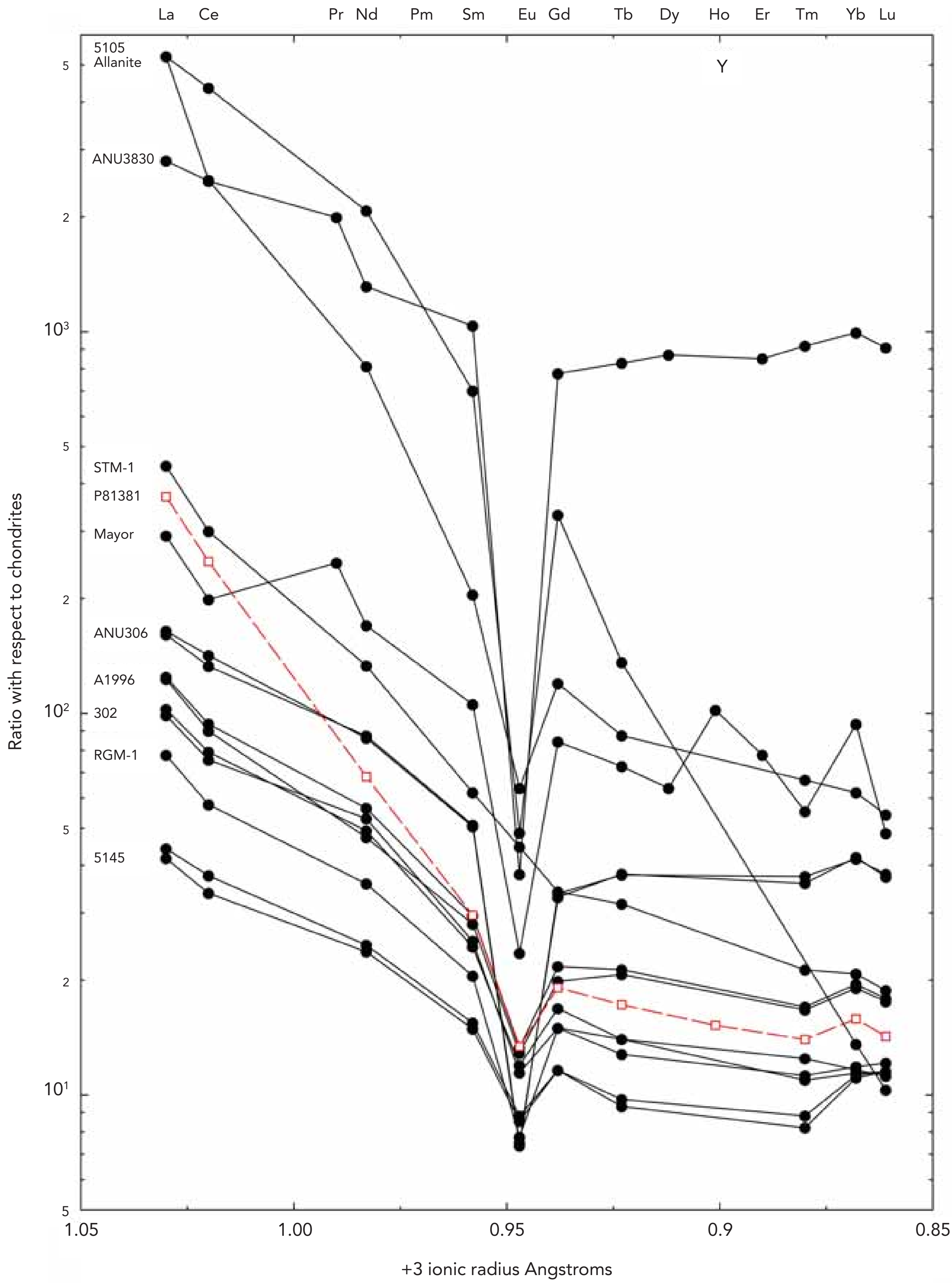

Fig. 4 The floater from the Chatham Islands shows europium (Eu) depletion. Details of samples are given in Appendix 1.

Table 4 Pumice oxide values for six geochemical groups (from Jokiel & Cox 2003).

Group	Fe_2O_3	K_2O	TiO_2	Na_2O/CaO
A: South Sandwich Islands	2.80–3.80	0.50–1.00	0.20–0.35	1.2–2.6
B: South Atlantic Ocean Ridge	1.70–2.50	3.50–7.00	0.20–0.45	8–9
C: South Indian Ocean Ridge	4.00	0.50–1.00	0.40–0.50	1
D: Tonga Trench	5.30–10.00	0.50–1.00	0.40–0.90	0.4–1
E: Krakatau, Indonesia	2.80–4.80	1.60–3.00	0.60–1.00	1.2–2.9
F: San Benedicto Island, Mexico	3.50–5.60	3.20–5.00	0.30–0.60	2.9–10

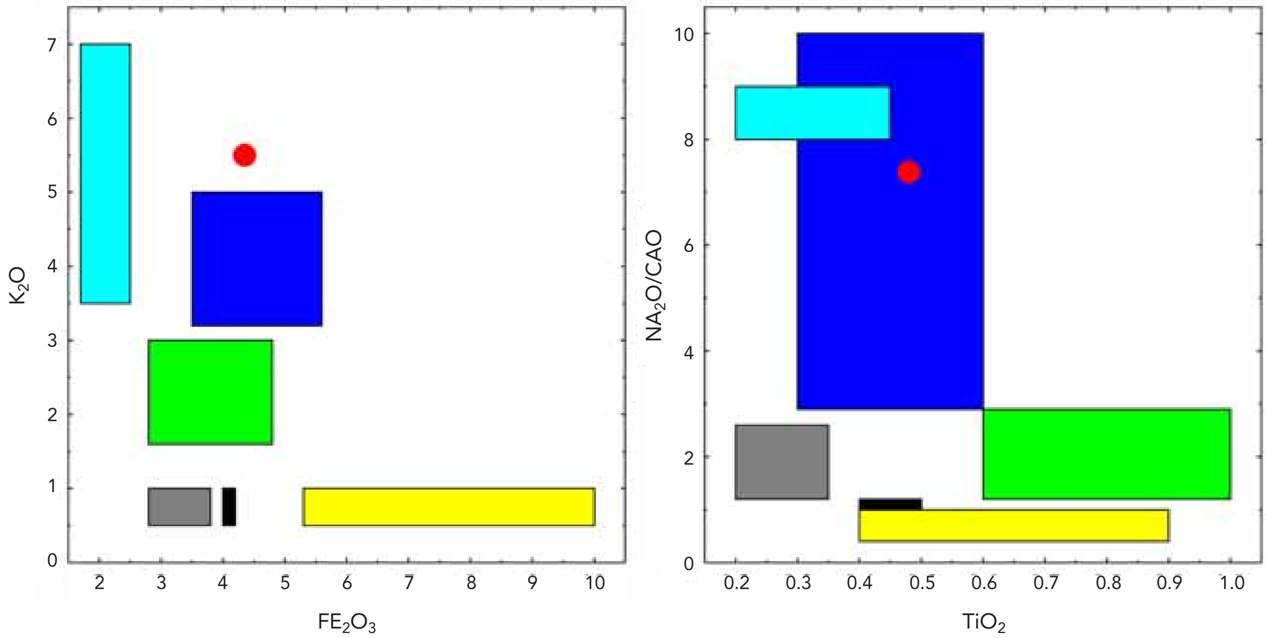

Fig. 5 Classification of major groups of pumices by oxide values: South Sandwich Islands (grey); South Atlantic Ocean Ridge (cyan); South Indian Ocean Ridge (black); Tonga Trench (yellow); Krakatau, Indonesia (green); San Benedicto Island, Mexico (blue). The floater from the Chatham Islands is indicated by the red circle.

(1984), augmented by some newer data, as a database with which to help identify their beach samples. Six geochemical groups were distinguished and linked to eruptions in the Indian, Atlantic and Pacific oceans (Jokiel & Cox 2003: 125, table 2). These are outlined in Table 4. It is a most instructive set of information.

The floater from the Chatham Islands is also plotted on Fig. 5, to show its possible allocation to any one of these six groups. In the first part of the graph, the floater plots outside the distribution of any known source group, and in the second it plots inside the distribution of the San Benedicto Island volcanic source in Mexico.

So, can we conclude then that this floater derives from the volcanic source of San Benedicto Island? A more careful look shows that this not so. Jokiel & Cox (2003) obtained the data for their analysis from a paper by A.F. Richards, who describes the lithics on this island as consisting of trachy-basalts, trachyandesites, sodic-trachites and sodic-rhyolites (Richards 1966: 384 ff.), with no mention of phonolites. He provides oxide data for 28 samples from the island, of

Table 5 Oxide values and agpaitic index (AI) of 11 peralkaline pumices from San Benedicto Island, Mexico, compared with the Chatham Islands floater.

Sample	Na_2O	K_2O	Al_2O_3	AI
Chathams	11.50	5.50	20.33	1.22
Benedicto	4.34	2.66	8.53	1.17
Benedicto	4.64	2.64	8.90	1.18
Benedicto	7.30	4.25	15.27	1.09
Benedicto	4.70	3.70	8.47	1.39
Benedicto	4.97	3.76	8.69	1.41
Benedicto	7.58	3.61	14.36	1.14
Benedicto	4.50	3.24	8.21	1.33
Benedicto	6.42	4.98	14.59	1.09
Benedicto	4.75	4.43	7.72	1.63
Benedicto	5.71	4.65	13.96	1.03
Benedicto	4.24	3.86	7.39	1.51

which only 11 are peralkaline. These are listed with the Chatham Islands sample in Table 5, together with the data for Na_2O, K_2O, Al_2O_3 and the agpaitic index. Simple inspection of this table shows that the floater cannot possibly come from this source in Mexico. In short, the classification provided in Fig. 5 is unduly simplistic. In the absence of *a priori* information, such as the knowledge of a recent pumice-bearing volcanic eruption, reliable identification of a single beach-collected specimen of pumice (with or without obsidian attached) is no simple task.

If we accept the identifications that were made of the pumices on the beaches on Hawai‘i, 72% of the pumice had found its way from the subantarctic South Sandwich Islands (Jokiel & Cox 2003: 128), a great-circle distance of 13,600 km. However, in reality the distance would have been a lot greater than that, as the pumice would have had to travel eastward along the Antarctic Circumpolar Current, then northward up the west coast of South America on the Humboldt Current, and then finally westward along the North Equatorial Current. There are many historical examples of very long distance journeys of floating objects on the oceans of the world. For example, one of the famous so-called ‘talking boards’ from Easter Island, carved with hieroglyphics, was found to have been made from European ash (*Fraxinus excelsior*) (Fischer 1997: 497). It was probably originally an oar blade, and may well have found its way on sea currents all the way from some European shore.

So in a case like the floater from the Chatham Islands, the reality is that such a specimen could, in theory, have come from just about any volcano in the world so long as that volcano is close enough to the sea for the pumice it produces to be carried off by ocean currents.

How do we know when we have found the correct answer?

This raises an important question: how can we determine whether a specimen matches a particular source? Whether a source is the origin of an isolated piece partly depends upon having reliable information on the amount of variation of source composition. If the piece has, say, 3.5 ppm of an element and the source being considered has 35 ppm of the same element, could the piece realistically belong to that source, which has 10 times the concentration of the element? That depends entirely on the variability of the source. For example, if the mean concentration is 35 ppm and the standard deviation is 48 ppm, then clearly 3.5 ppm is within the range of variation.

When detailed research has been carried out on the chemical composition of a large number of samples from any particular source of volcanic glass, it is possible to use powerful parametric statistics, including multivariate methods such as discriminant analysis, to provide a probability that such an unknown belongs to this or that source. A simple, and very effective, test would be to ascertain whether the composition of a single element in the unknown is X units of standard deviation from the mean composition of a particular source. If X is, say, more than 3 units of standard deviation from the source mean, it would be reasonable to consider rejecting that source. On the other hand, if it was only 0.5 units of standard deviation from the source mean, then one could start to think that this could be the source. If such a simple test is repeated for several elements, confidence of source may be increased or decreased. Unfortunately, very few sources of volcanic glass have been intensively studied in this manner, effectively prohibiting the use of even simple parametric statistical tests, let alone multivariate ones. Published archaeological literature on sourcing using chemical fingerprinting is filled with examples that ignore this.

The floater that ended up in the Chatham Islands poses quite a challenge, because a large universe may need to be searched to try to find the correct match. What to do?

One possibility is to narrow down the options by devising a simple test that helps to filter out really unlikely volcanic sources in the larger universe so one can focus attention on a smaller number with more similar chemical fingerprints. The test devised here examined the proportional difference between elements of individual specimens against the floater. Thus, a mean and standard deviation were calculated of the proportional difference between pairs of specimens using all elements available.

When comparing the floater with a sample from a single volcanic source, this was the procedure followed: for element 1, the concentration in the floater = C1, and the concentration of a sample from the source being considered = C2. The absolute difference, 1 = abs(C2–C1). The proportional difference is 1/C1. Such a method standardises differences, so that an element at, say, a concentration of 12 ppm will have the same weight as another element that is at 2000 ppm. After calculating this proportional difference for as many elements as possible, one can calculate a mean and standard deviation of the proportional difference. This then is a suitable measure of the overall difference between two individual samples, which for want of a suitable short name will be called the mean proportional difference (MPD). The measure shares some features with the chi-squared test but has no probability distribution. Although it is a crude measure, it should help to narrow down the size of the universe to a smaller set of more likely candidates for the true source. It is important to realise that this measure is very sensitive to the number of elements from which it can be calculated; the more elements involved, the better. Conversely, if only a few elements are involved in a comparison, little credence can be given to low values of mean and standard deviation.

In the case of the Chatham Islands floater, the first comparisons were made using information about volcanic glasses from the general area of New Zealand (Fig. 6). Information is available from NAA analysis for 32 sources and 23 elements (Leach & Warren 1981; Leach 1996). The analysis of the floater produced information on 44 elements when the XRF and NAA data were combined. Of these 44 elements, only 19 of the 23 available from the New Zealand sources are also common to the floater.

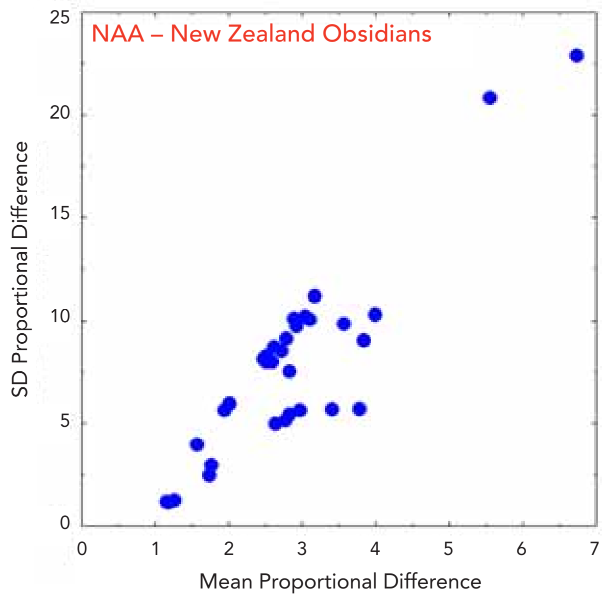

Fig. 6 Comparison of the floater from the Chatham Islands with New Zealand volcanic glasses using neutron activation data. The floater is situated at the origin (x,y = 0,0).

Table 6 Mean proportional differences between Mayor Island (Tuhua) obsidian samples and the Chatham Islands floater using neutron activation analysis data.

Mean	SD	Source
1.259	1.257	Mayor Island (Tuhua) Green
1.153	1.188	Mayor Island (Tuhua) Honey
1.175	1.151	Mayor Island (Tuhua) Yellow

Most of these sources have little similarity with the Chatham Islands floater. The sources whose chemistry is closest to the floater have concentrations that are, on average, more than 100% greater or smaller across all 19 elements (MPD>1.0). Thus, all 32 sources are effectively ruled out. It is of passing interest that the three sources most similar to the floater are the three types of obsidian from Mayor Island (Tuhua), although there is no possibility that one of these could be its source. The element composition of the floater is very different to Mayor Island (Tuhua) obsidian.

The next data considered were from the wider Pacific region. Information on 18 elements is available from PIXE-PIGME analysis of 53 sources through the Pacific (Bird *et al.* 1981; Duerden *et al.* 1979; Duerden *et al.* 1987). Of the

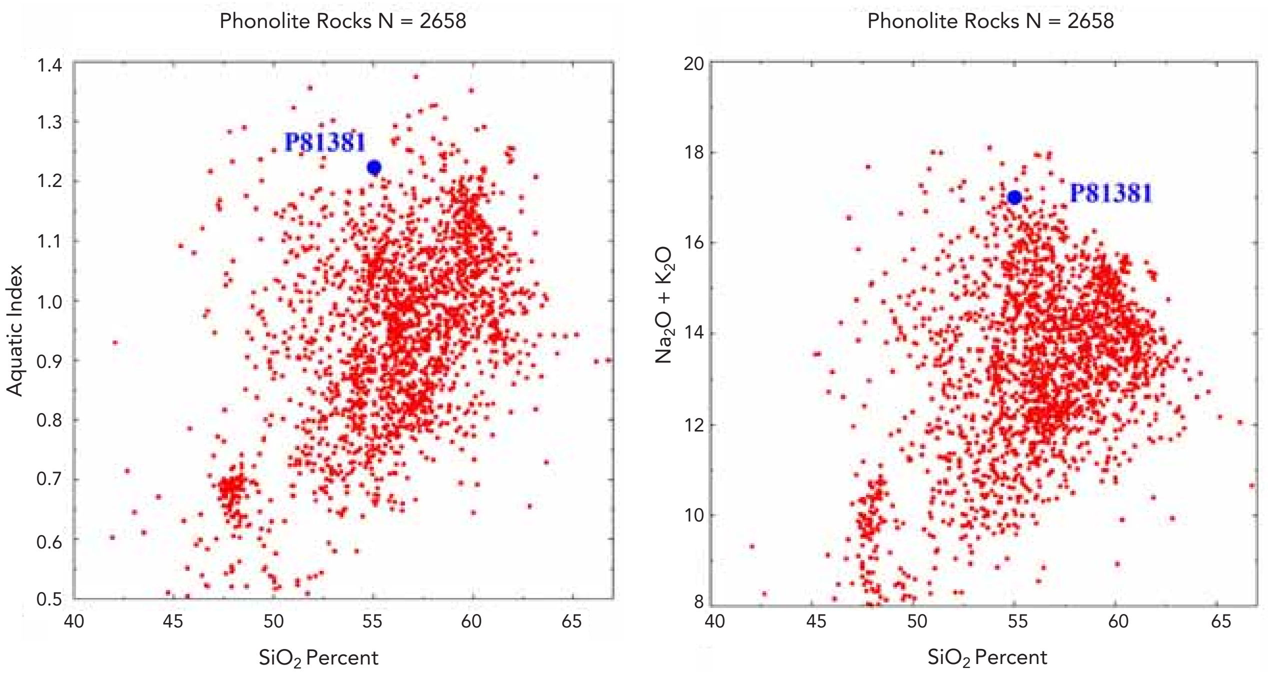

Fig. 7 The floater from the Chatham Islands compared with other phonolites.

44 elements available for the floater, it has only nine in common (Zn, Ga, As, Pb, Rb, Sr, Y, Zr, Nb) with the 18 available for these sources. Although the MPD was calculated for these sources, the nine elements were too few for any useful conclusions to be drawn. This shows the insensitivity of this crude statistic when only a small number of elements is involved. PIXE-PIGME data are also available for the same 18 elements for 15 obsidian sources from the islands of Japan. Once again, though, only nine were in common with those available for the floater, which was inadequate for meaningful comparison using the simple proportional statistic. It was decided to set aside the MPD at this stage and instead try to narrow down the large universe of possible volcanic sources using a different procedure based upon the geochemical character of the floater.

It has already been shown above that the floater is from a phonolite source, it is peralkaline with an agpaitic index of 1.22, and it has a notable Eu depletion in the REE pattern. These three characteristics suggested another approach to narrow down the search for the source. That is, to search among published geochemical data for samples with these specific features. In addition to the published data, there is a large database known as GEOROC (Geochemistry of Rocks of the Oceans and Continents), which is maintained by the Max Planck Institute for Chemistry in Mainz and is available for searching online.[2]

The element composition of as many phonolites as possible was culled from published literature and the GEOROC database. This resulted in the tabulation of element data from 2658 samples of phonolite for careful scrutiny (Fig. 7).

It will be obvious from Fig. 7 that the Chatham Islands floater has very unusual characteristics, plotting out on the periphery of the distribution of phonolites.

Several computer programs were written in Turbo Pascal 5 to select only samples within a certain (fairly large) range of the key elements that were thought to be especially characteristic of the floater. The filters adopted are listed below:

Element	Floater	Minimum	Maximum
SiO_2	55.03%	50	60
Al_2O_3	20.33%	17	23
K_2O	5.50%	4	7
Na_2O	11.50%	9	13
Zr	2097 ppm	1800	3000
Nb	282 ppm	180	400
Th	57 ppm	40	100

All samples that had element concentrations outside all seven of these filters were rejected as possible sources of the floater. It was expected that this would leave a small percentage of the original 2658 specimens. Rather surprisingly, these wide

Table 7 Mean proportional differences between the five closest phonolite samples and the Chatham Islands floater.

Mean	SD	Source
0.739	0.941	MB35.2, Mt Sidley, Antarctica
0.653	0.806	MB35.5, Mt Sidley, Antarctica
0.482	0.715	11290, Ormonde seamount
0.308	0.288	65124, McDonald Island
0.534	0.396	GH11, sryan volcanic field, Libya

filters rejected all but five specimens (Fig. 8, Table 7), the details of which are as follows:

- **MB35.2** from Mt Sidley, Marie Byrd Land, Antarctica (Panter *et al.* 1997: 1231, table 3).
- **MB35.5** from Mt Sidley, Marie Byrd Land, Antarctica (Panter *et al.* 1997: 1231, table 3).
- **11290** from the seamount Ormonde, Gorringe Bank (west of the Strait of Gibraltar) (Bernard-Griffiths *et al.* 1997: 118, table 2).
- **65124** from McDonald Island, near Heard Island (Barling *et al.* 1994: 1024, table 1).
- **GH11** from the Gharyan volcanic field, Libya (Lustrino *et al.* 2012: 221, table 1).

It should not be thought that this MPD statistic alone is adequate to identify the source of an isolated sample, such as this floater. As pointed out above, the MPD is only really useful for rejecting potential sources that are unlikely to be the actual source. In this respect, the MPD statistic proved useful. At this stage, it remained to be seen whether any one of the five remaining samples could be the source of the floater.

The element composition of each of the five specimens is given in Table 8 alongside the values of the floater for direct comparison. The possibility that some volcanic rocks as remote as Libya and a seamount near Gibraltar could have a geochemical signature similar to this floater was initially very surprising, but whether they really were similar remained to be seen. Making sense of such a mass of figures is not easy, and it was useful to calculate the individual proportional difference (IPD) for each element for each sample. The plus or minus difference is 2 = (C2–C1), and

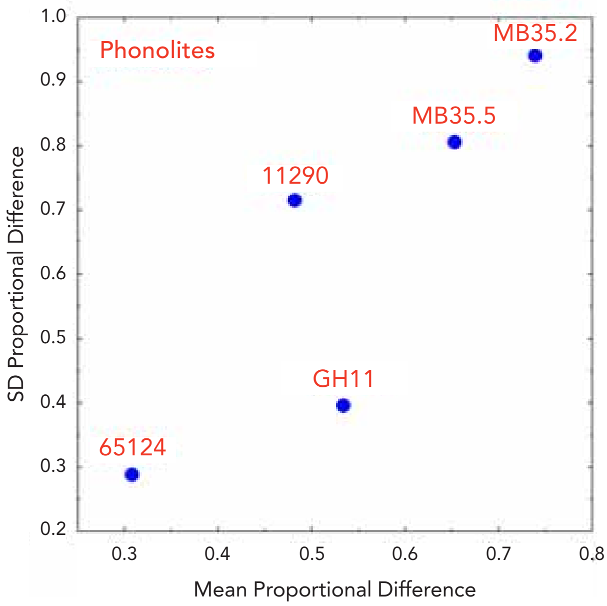

Fig. 8 The difference from the Chatham Islands floater of the five phonolites with the closest chemical composition.

the individual proportional difference is 2/C1. These data are plotted in Fig. 9.

All individual values in Fig. 9 are plotted using the same scale, so that one can make a direct comparison of the pattern from one sample to another. For example, for the Ormonde seamount specimen, barium (Ba) shows a value of +4.05, which means that this specimen contains four times as much Ba as the floater (101 ppm, cf. 20 ppm: (101–20)/20 = 4.05)).

It can readily be seen from this illustration that the specimen from McDonald Island gave the lowest value for the MPD, as the variation around the central line (representing the floater) is much smaller than for any of the other four specimens. The important question is: how big is small? To answer that we must return to the issue raised earlier relating to the use of parametric statistics to assess the probability that McDonald Island is indeed the correct source of the floater.

To the best of our knowledge, chemical data from which to gain some understanding of chemical variation have been published from only four samples of phonolite from McDonald Island. These are given in Table 9 and are taken from Barling *et al.* (1994: 1024, table 1). In spite of the fact that the data in Table 9 are patchy, they could be used to assess the range of results for any one element and, where possible, calculate a mean and standard deviation using Bessel's correction for small samples. It was then possible to

Table 8 Element composition of the Chatham Islands floater (P81381) and the five most similar phonolite samples (note: the values given for P81381 here are the average of the X-ray fluorescence analysis and neutron activation analysis determinations). Details of samples are given in Appendix 1.

Element	P81381	MB35.2	MB35.5	11290	65124	GH11
Na_2O	11.24	9.06	9.41	10.10	10.33	9.61
MgO	0.62	0.04	0.00	0.07	0.17	0.04
Al_2O_3	20.33	19.17	19.49	22.10	20.83	19.88
SiO_2	55.03	57.02	56.71	55.80	57.25	59.80
P_2O_5	0.10	0.15	0.12	0.01	0.05	0.02
K_2O	5.74	5.19	5.39	5.03	6.15	5.24
CaO	1.49	1.43	1.20	0.20	0.94	1.10
Sc	1.48	1.10	0.80	0.00	0.00	0.00
TiO_2	0.48	0.25	0.19	0.30	0.38	0.20
V	22.00	0.00	0.00	37.00	4.00	0.00
Cr	12.58	0.00	0.00	9.00	3.00	0.00
MnO	0.14	0.00	0.00	0.00	0.00	0.00
Fe_2O_3	4.25	0.00	0.00	0.00	0.00	0.00
Co	2.97	0.00	0.00	2.00	0.00	0.00
Ni	15.00	6.00	7.00	5.00	2.00	0.00
Zn	153.50	185.00	186.00	155.00	137.00	177.00
Ga	47.00	44.00	44.00	52.00	41.00	53.00
As	6.60	8.90	8.70	0.00	0.00	0.00
Rb	218.00	234.65	252.80	263.00	145.00	237.00
Sr	125.50	47.96	4.20	77.40	141.00	6.00
Y	39.00	107.00	109.00	17.00	26.00	64.00
Zr	2223.50	1869.00	2018.00	1886.00	2340.00	1957.00
Nb	282.00	341.00	369.00	304.00	297.00	398.00
Sb	0.57	0.50	0.60	0.00	0.00	0.00
Cs	6.65	4.99	6.27	0.00	0.00	3.60
Ba	20.00	105.00	0.00	101.00	1.49	7.00
La	119.50	172.65	176.80	37.60	101.00	243.60
Ce	187.50	312.00	325.00	68.40	149.00	367.50

continued on following page

Table 8 Element composition of the Chatham Islands floater (P81381). *Continued from previous page*

Element	P81381	MB35.2	MB35.5	11290	65124	GH11
Nd	43.30	102.75	112.00	17.60	34.40	79.70
Sm	5.92	18.71	19.88	2.77	4.98	10.60
Eu	1.02	1.77	1.27	0.85	1.39	1.00
Gd	5.10	0.00	0.00	2.82	3.88	8.00
Tb	0.85	2.95	2.91	0.00	0.00	1.50
Ho	1.15	0.00	0.00	0.00	0.00	1.90
Tm	0.46	0.00	0.00	0.00	0.00	1.10
Yb	3.50	11.26	11.90	3.01	2.80	7.20
Lu	0.47	1.59	1.76	0.52	0.43	1.00
Hf	35.00	36.95	40.45	0.00	0.00	40.00
Ta	13.74	21.75	24.20	0.00	0.00	21.80
W	10.70	0.00	0.00	0.00	0.00	0.00
Ir	5.20	0.00	0.00	0.00	0.00	0.00
Pb	42.00	27.00	26.00	27.00	0.00	22.20
Th	54.50	42.80	47.70	43.00	53.00	48.70
U	15.30	12.70	14.50	18.10	0.00	16.20

examine the individual element values of the floater and obtain a probability that each result was consistent with the four samples from McDonald Island. The results of this test are presented in Table 10. For example, if the element value for the floater lies within the McDonald Island mean ± 2SD, it is within the 95% probability range, or $p = 0.05$. In cases where the floater was within the simple range of the minimum and maximum for McDonald Island, this is simply taken to be $p = 0.10$, since probability calculation would be meaningless.

The results in Table 10 give some confidence that McDonald Island could well be the source of the floater. However, there are four elements that have suspiciously high ppm values in the floater. These are shown in Table 11.

The value for the element rubidium (Rb) in the floater is almost double that of the four McDonald Island samples. These four values are certainly very close to each other and may not be fully representative of the true range for the source. When an extensive series of analyses is undertaken for any one source of volcanic glass, a much larger range is found. For example, Weaver's analyses of 149 pieces of Mayor Island obsidian shows an order of magnitude range for Rb of 11–164 ppm (mean and standard deviation = 114.7 and 37.1) (Weaver, pers. comm. to Leach, 2013). Two values are available for the floater, and these are perfectly consistent: XRF = 223 ppm and NAA = 213 ppm, giving an average of 218 ppm. In spite of the reservation that if more data were available the range of Rb might be higher for McDonald Island phonolites, the value for the floater does look too large to be from this source.

The differences between the floater and the McDonald Island samples for the elements yttrium (Y), caesium (Cs) and gadolinium (Gd) are much smaller, but even here there is cause for concern. One more point needs to be made:

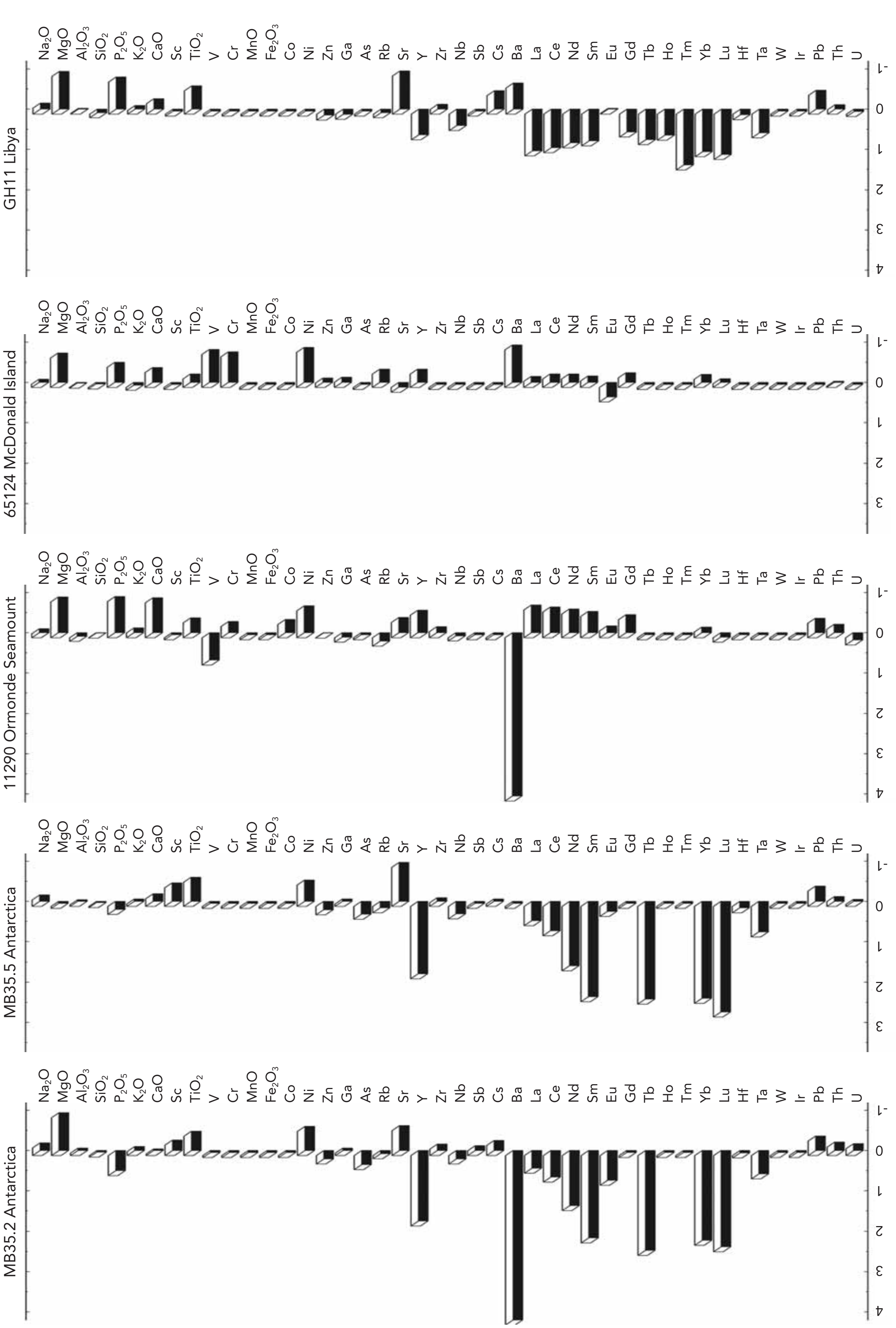

Fig. 9 The individual proportional differences of the elements for each of the five most similar samples to the Chatham Islands floater. Proportional values to the left of the central line are greater than the floater, while those to the right are less than the floater.

Table 9 Analyses of McDonald Island phonolites (from Barling *et al.* 1994).

Element	Unit	65119	65133	65124	65125
SiO_2	Wt%	54.36	57.14	57.25	57.33
TiO_2	Wt%	1.65	0.77	0.38	0.92
B_2O_3	Wt%	0	0	0	0
Al_2O_3	Wt%	19.43	21.7	20.83	19.73
Cr_2O_3	Wt%	0	0	0	0
Fe_2O_3	Wt%	0.88	0.57	0.62	0.64
FeO	Wt%	4.47	2.91	3.16	3.27
FeOT	Wt%	0	0	0	0
CaO	Wt%	3.6	1.7	0.94	2.15
MgO	Wt%	1.8	0.84	0.17	1.26
MnO	Wt%	0.08	0.08	0.11	0.1
K_2O	Wt%	6.5	6.93	6.15	5.99
Na_2O	Wt%	6.75	7.22	10.33	8.36
P_2O_5	Wt%	0.48	0.14	0.05	0.24
V	ppm	81	23	4	46
Cr	ppm	15	11	3	16
Ni	ppm	16	15	2	13
Cu	ppm	16	9	3	13
Zn	ppm	81	87	137	87
Ga	ppm	26	30	41	34
Rb	ppm	144	142	145	143
Sr	ppm	1129	1027	141	775
Y	ppm	21	19	26	16
Zr	ppm	738	1008	2340	1228
Nb	ppm	135	163	297	120
Cs	ppm	1.19	0	0	2.48
Ba	ppm	401	162	1.49	204
La	ppm	69.8	72	101	58.62
Ce	ppm	136	134	149	100.09

continued on following page

Table 9 Analyses of McDonald Island phonolites (from Barling *et al.* 1994). *Continued from previous page*

Element	Unit	65119	65133	65124	65125
Nd	ppm	52.1	0	34.4	32.41
Sm	ppm	8.47	0	4.98	5.33
Eu	ppm	2.71	0	1.39	1.62
Gd	ppm	0	0	3.88	3.35
Dy	ppm	4.54	0	3.99	3.14
Er	ppm	2.12	0	2.66	1.6
Yb	ppm	1.67	0	2.8	1.65
Lu	ppm	0.245	0	0.43	0.264
Pb	ppm	0	0	0	32
Th	ppm	15	22	53	30
U	ppm	0	0	0	4

Table 10 Probability that the source of the Chatham Islands floater (P81481) is a McDonald Island phonolite ('above' = greater or less than 2 sigma from mean).

Element	Unit	P81481	N	Min	Max	Mean	SD	Prob
Na_2O	Wt%	11.24	4	6.75	10.33	8.17	1.59	$p = 0.05$
MgO	Wt%	0.62	4	0.17	1.80	1.02	0.69	$p = 0.10$
Al_2O_3	Wt%	20.33	4	19.43	21.70	20.42	1.04	$p = 0.10$
SiO_2	Wt%	55.03	4	54.36	57.33	56.52	1.44	$p = 0.10$
P_2O_5	Wt%	0.10	4	0.05	0.48	0.23	0.19	$p = 0.10$
K_2O	Wt%	5.74	4	5.99	6.93	6.39	0.42	$p = 0.05$
CaO	Wt%	1.49	4	0.94	3.60	2.10	1.12	$p = 0.10$
TiO_2	Wt%	0.48	4	0.38	1.65	0.93	0.53	$p = 0.10$
MnO	Wt%	0.14	4	0.08	0.11	0.09	0.02	$p = 0.01$
Fe_2O_3	Wt%	4.25	0	0.00	0.00	0.00	0.00	—
Sc	ppm	1.48	0	0.00	0.00	0.00	0.00	—
V	ppm	22.00	4	4.00	81.00	38.50	33.13	$p = 0.10$
Cr	ppm	12.58	4	3.00	16.00	11.25	5.91	$p = 0.10$
Co	ppm	2.97	0	0.00	0.00	0.00	0.00	—

continued on following page

Table 10 Probability that the source of the Chatham Islands floater (P81481). *Continued from previous page*

Element	Unit	P81481	N	Min	Max	Mean	SD	Prob
Ni	ppm	15.00	4	2.00	16.00	11.50	6.45	$p = 0.10$
Zn	ppm	153.50	4	81.00	137.00	98.00	26.15	$p = 0.01$
Ga	ppm	47.00	4	26.00	41.00	32.75	6.40	$p = 0.01$
As	ppm	6.60	0	0.00	0.00	0.00	0.00	—
Rb	ppm	218.00	4	142.00	145.00	143.50	1.29	Above
Sr	ppm	125.50	4	141.00	1129.00	768.00	443.69	$p = 0.05$
Y	ppm	39.00	4	16.00	26.00	20.50	4.20	Above
Zr	ppm	2223.50	4	738.00	2340.00	1328.50	703.48	$p = 0.10$
Nb	ppm	282.00	4	120.00	297.00	178.75	80.82	$p = 0.10$
Sb	ppm	0.57	0	0.00	0.00	0.00	0.00	—
Cs	ppm	6.65	2	1.19	2.48	1.84	0.64	Above
Ba	ppm	20.00	4	1.49	401.00	192.12	164.34	$p = 0.10$
La	ppm	119.50	4	58.62	101.00	75.35	18.07	$p = 0.01$
Ce	ppm	187.50	4	100.09	149.00	129.77	20.88	$p = 0.01$
Nd	ppm	43.30	3	32.41	52.10	39.64	10.84	$p = 0.10$
Sm	ppm	5.92	3	4.98	8.47	6.26	1.92	$p = 0.10$
Eu	ppm	1.02	3	1.39	2.71	1.91	0.71	$p = 0.05$
Gd	ppm	5.10	2	3.35	3.88	3.62	0.27	Above
Tb	ppm	0.85	0	0.00	0.00	0.00	0.00	—
Ho	ppm	1.15	0	0.00	0.00	0.00	0.00	—
Tm	ppm	0.46	0	0.00	0.00	0.00	0.00	—
Yb	ppm	3.50	3	1.65	2.80	2.04	0.66	$p = 0.01$
Lu	ppm	0.47	3	0.24	0.43	0.31	0.10	$p = 0.05$
Hf	ppm	35.00	0	0.00	0.00	0.00	0.00	—
Ta	ppm	13.74	0	0.00	0.00	0.00	0.00	—
W	ppm	10.70	0	0.00	0.00	0.00	0.00	—
Ir	ppm	5.20	0	0.00	0.00	0.00	0.00	—
Pb	ppm	42.00	1	32.00	32.00	0.00	0.00	—
Th	ppm	54.50	4	15.00	53.00	30.00	16.51	$p = 0.05$
U	ppm	15.30	1	4.00	4.00	0.00	0.00	—

Table 11 Four elements in the Chatham Islands floater (P81381) have suspiciously greater values compared to the only available results for phonolite samples from McDonald Island.

Element	P81381	65119	65133	65124	65125
Rb	218	144	142	145	143
Y	39	21	19	26	16
Cs	6.65	1.19	0	0	2.48
Gd	5.1	—	—	3.88	3.35

it will be recalled that the floater shows an Eu anomaly (Fig. 4), whereas a plot of these samples of phonolite from McDonald Island does not give the same result. In summary, at this point, even though McDonald Island did look as if it might be the source of the floater, little confidence could be had in this on the basis of the existing published information about McDonald Island. It was therefore necessary to delve further.

Jane Barling's published data (Barling *et al.* 1994) derive from her Ph.D. thesis (Barling 1990), and there have been other expeditions to the island and its vicinity since then. It seemed possible that more samples might have been collected from the area, but not fully published. A great deal has been published about the Kerguelen Plateau, which is the submarine feature on which McDonald Island lies. It has even been suggested that this plateau is the fabled Atlantis that featured in the dialogues of Greek philosopher Plato, including *Timaeus* (*c.* 360 BC). A wider literature search revealed an alkali versus silica plot that had 19 specimens labelled as McDonald Island phonolites (Verwoerd *et al.* 1990: fig. F6.3). Data for only one specimen were published by the authors – sample 65125 – which is one of the specimens cited above from Barling's research. Verwoerd had retired 20 years previously but was kind enough to provide additional information to the effect that the samples in question may have derived from a trip in 1980: 'Since their initial sighting in 1854 there have been only two recorded landings on the McDonald islands: The first in 1971 and the second in 1980. It was during the latter visit that the only samples from the islands were collected, by Clarke (Clarke *et al.* 1983)' (Verwoerd *et al.* 1990: 441).

The paper by Clarke *et al.* (1983) gives a similar alkali versus silica plot from what are probably the same phonolite specimens, but provides no data.

There was a more recent expedition to McDonald Island, in March 1997, and a related reference was found to an unpublished paper by Collerson (1997). The librarian of the Australian Antarctic Division reported, 'Unfortunately, we do not hold this unpublished report. It was not deposited with Library Services nor AAD's Records area' (Egan Library manager, pers. comm. to Leach 2014). There are also several citations of a paper by Collerson *et al.* (1998), but this contained a graph with no data. Kenneth Collerson was written to in order to obtain the data referred to in the paper, but he could not find them. Marcel Regelous, one of the junior authors of the paper, was then approached. This time some really useful information was forthcoming. Further geochemical analysis of samples from the area had been carried out, but had never been published. The analyses were of both pumice and rock samples: 'The very fresh pumice samples we analyzed were collected in 1997 by an Australian research ship from the sea in the neighbourhood of McDonald Island, which was apparently active at the time. I was not on the ship, but was given the samples to analyze' (Regelous, pers. comm. to Leach, 2014). The unpublished data related to six pumice samples taken from the sea close to McDonald Island and 33 rock samples from Heard Island. The REE pattern is given in Fig. 10.

The REE pattern of the floater is indistinguishable from those of the other pumice samples. The Eu depletion, previously noticed in the floater, is present in these pumices and absent in the phonolite rocks. The NAA analysis of the floater did not resolve concentrations for praseodymium (Pr), dysprosium (Dy) or erbium (Er), which explains the small deviations from the lines of the pumice samples in Fig. 10. The results of two pumice samples are almost identical to two others, which is why only four pumice specimens are clearly distinguishable on the plotted data.

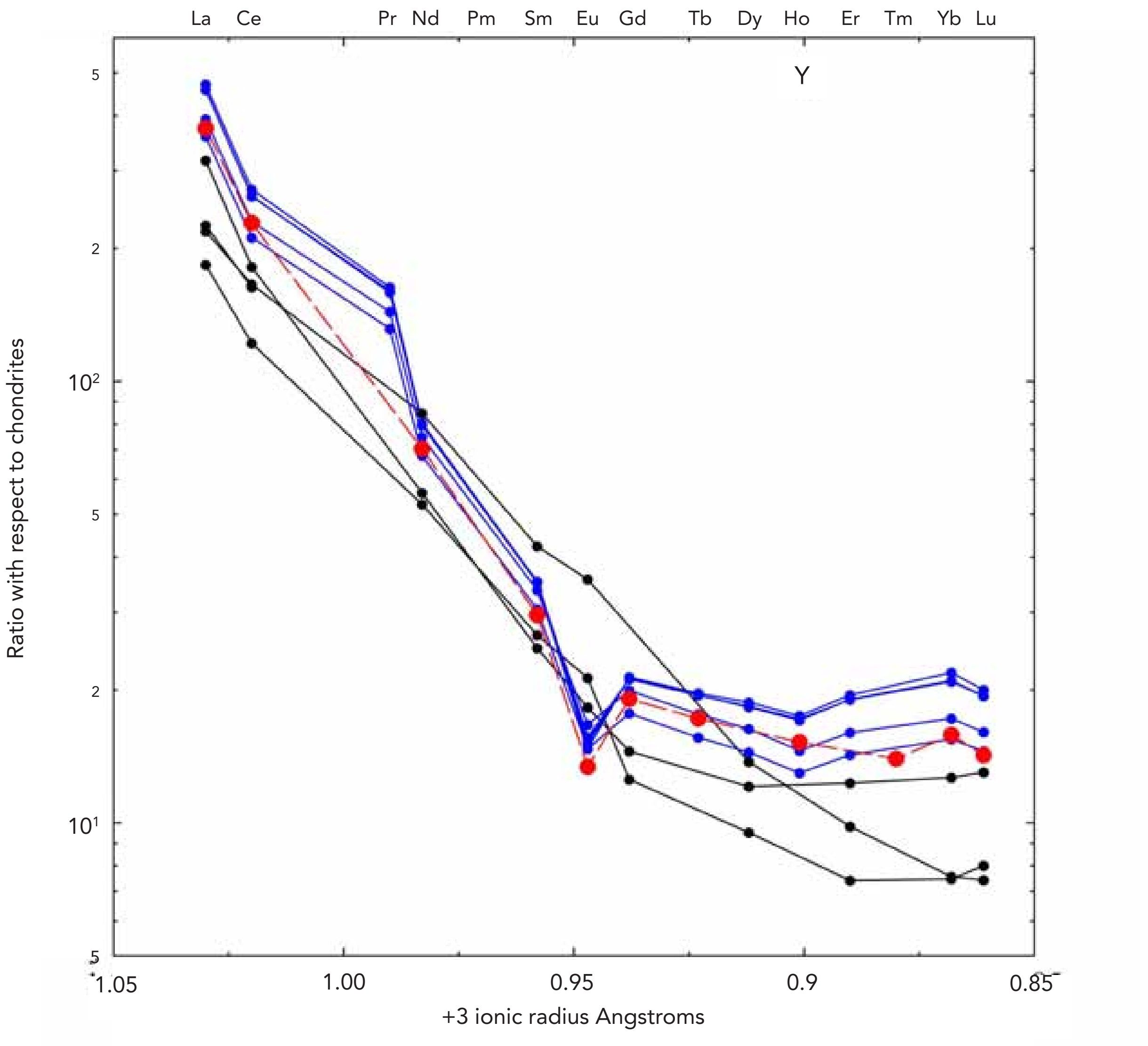

Fig. 10 Rare earth element plot of six pumice samples (blue) taken from the sea off McDonald Island March 1997 (courtesy of Marcel Regelous), together with three phonolites (black) from McDonald Island collected by Ian Clarke in 1980 and published by Barling *et al.* (1994). The red sample is the floater from the Chatham Islands. (Note that the results for two pumice samples are almost identical to two others, which is why only four blue plots are visible on the graph.)

The alkali and silica data of these pumices were compared with those of the floater glass and pumice fractions (Table 12), and plotted in Fig. 11. As with the floater, all pumice specimens are both phonolite and peralkaline (agpaitic index ranging from 1.29 to 1.65). The spread of values in the plot gives considerable confidence that the floater is consistent with this source.

The geochemical data for these six pumice specimens are presented in Table 13, together with means and standard deviations, and the average values for the floater. It remains to assess how similar the floater is to these pumices. Table 13 is a bewildering mass of figures and one must adopt a systematic method of checking the data from one object against the data amassed from a possible source; simple eye-balling is not good enough. As mentioned above, discriminant functions are often used by archaeologists to ascertain the source of obsidian artefacts, but this is reliable only when the underlying assumptions of this method are met. One of these is a uniform variance and covariance matrix across all variables. A glance at Table 13 shows this to be manifestly false (the standard deviation values range more than two orders of magnitude). A revised discriminant

Table 12 The alkali and silica data of six pumices collected in 1997 from the sea in the neighbourhood of McDonald Island compared with those of the glass and pumice fractions of the Chatham Islands floater (data provided by Regelous, pers. comm. to Leach, 2014).

Catalogue no.	SiO_2	Al_2O_3	K_2O	Na_2O	$Na_2O + K_2O$	Agpaitic index
HI1	52.30	18.55	3.58	16.29	19.87	1.65
HI2	54.46	19.82	5.69	12.45	18.14	1.34
HI3	54.64	20.04	5.87	11.96	17.83	1.30
HI4	51.54	18.25	4.06	19.10	23.16	1.96
HI5	54.89	20.22	5.83	12.04	17.87	1.29
HI6	54.58	19.39	5.11	12.64	17.75	1.36
Floater glass	55.03	20.33	5.74	11.24	16.98	1.22
Floater pumice	55.80	20.05	5.91	11.16	17.07	1.23

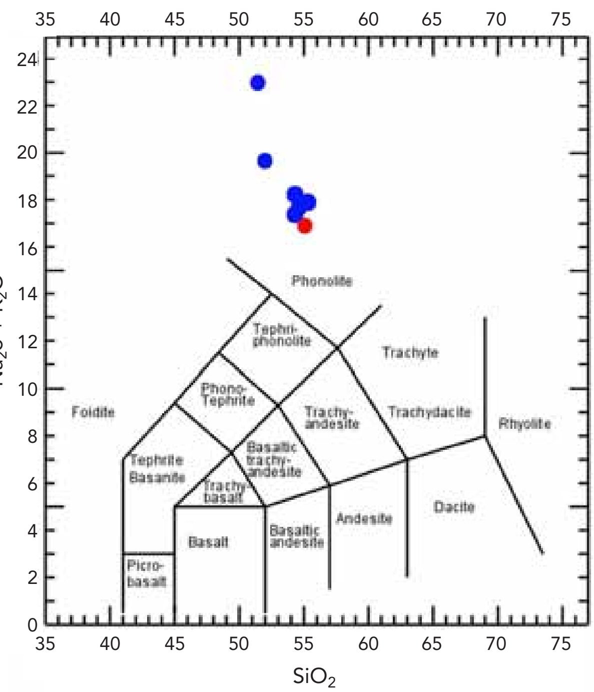

Fig. 11 Six pumice specimens from McDonald Island (blue) and the floater from the Chatham Islands (red).

function method called Popper's razor helps to overcome some of these objections (Leach & Manly 1982), but in this case information was available for only six specimens of the putative source and it hardly seemed appropriate to resort to such a complex method. A simpler approach was therefore adopted.

This was similar to what was done before when looking at the individual proportional differences between a series of samples. In this case, however, there is just one sample (the floater), and six samples that are known to belong to one source. Therefore, the means and standard deviations of the source samples were calculated. The standard deviations were then standardised as a proportion of the mean for each element. This permits us to visualise the variability of any one element using a standard point of reference. This is presented in Fig. 12. For clarification, take Na_2O as an example. From Table 13, we can see that the mean is 14.08% with a standard deviation of 2.95%. The standard deviation as a proportion of the mean is 0.21. So the 95% confidence limits are the mean ± 0.42. This is similar to so-called standard scores, or Z-scores. Also plotted on Fig. 12 is the difference between the value for the floater and the mean of the six pumices, as a proportion of the mean. This allows us quickly to visualise where any problems might lie in matching the specimen to the source. The sum of all proportional differences is −0.87 across 32 elements, averaging −0.03. This shows that the floater is very slightly lighter on average than the pumices.

Happily, all but one value lies within the 95% confidence limits of the distribution for each of the 32 elements plotted. The one outlier is vanadium (V). The individual values of

Table 13 The six McDonald Island pumice samples and the Chatham Islands floater (P81381).

Element	HI1	HI2	HI3	HI4	HI5	HI6	Mean	SD	P81381
SiO_2	52.30	54.46	54.64	51.54	54.89	54.58	53.74	1.43	55.03
TiO_2	0.63	0.53	0.54	0.29	0.47	0.54	0.50	0.11	0.48
Al_2O_3	18.55	19.82	20.04	18.25	20.22	19.39	19.38	0.81	20.33
Fe_2O_3	4.89	4.80	4.60	4.55	4.42	4.97	4.71	0.21	4.25
MnO	0.14	0.15	0.14	0.17	0.14	0.16	0.15	0.01	0.14
MgO	1.49	0.52	0.58	0.87	0.46	0.89	0.80	0.38	0.62
CaO	1.99	1.49	1.52	1.15	1.44	1.61	1.53	0.27	1.49
Na_2O	16.29	12.45	11.96	19.10	12.04	12.64	14.08	2.95	11.24
K_2O	3.58	5.69	5.87	4.06	5.83	5.11	5.02	0.98	5.74
P_2O_5	0.15	0.09	0.11	0.03	0.08	0.10	0.09	0.04	0.10
Li	58.15	59.38	58.77	47.78	42.73	64.73	55.26	8.25	0.0
Be	23.06	23.89	23.47	18.37	16.55	25.76	21.85	3.57	0.0
Sc	1.19	1.25	1.22	5.16	4.75	1.01	2.43	1.96	1.48
V	8.26	8.50	8.38	17.40	13.48	5.67	10.28	4.31	22.00
Cr	10.21	10.43	10.32	11.08	19.44	6.21	11.28	4.36	12.58
Co	3.23	3.20	3.22	4.58	6.55	2.01	3.80	1.57	2.97
Ni	16.24	16.10	16.17	10.75	35.19	5.43	16.65	10.05	15.00
Cu	9.90	10.35	10.12	12.47	10.04	8.09	10.16	1.40	0.0
Zn	173.22	173.91	173.57	144.69	130.54	176.45	162.06	19.49	153.50
Ga	51.32	52.75	52.04	45.05	42.86	55.11	49.86	4.79	47.00
Ge	0	0	0	0	0	0	0	0	0.0
As	0	0	0	0	0	0	0	0	6.60
Rb	242.10	243.79	242.94	224.75	215.93	256.96	237.75	14.81	218.00
Sr	72.81	72.87	72.84	154.75	132.13	47.30	92.12	41.59	125.50
Y	37.27	37.22	37.24	32.78	29.67	38.83	35.50	3.51	39.00
Zr	2868.25	2884.37	2876.31	2285.03	2089.13	3002.64	2667.62	380.54	2223.50
Nb	348.27	350.82	349.54	278.92	255.85	364.63	324.67	45.35	282.00
Sb	0	0	0	0	0	0	0	0	0.57
Cs	5.62	5.62	5.62	4.46	3.99	5.89	5.20	0.78	6.65

continued on following page

Table 13 The six McDonald Island pumice samples and the Chatham Islands floater (P81381). *Continued from previous page*

Element	HI1	HI2	HI3	HI4	HI5	HI6	Mean	SD	P81381
Ba	31.66	31.76	31.71	83.07	59.05	19.43	42.78	23.67	20.00
La	146.00	146.10	146.05	125.23	114.62	150.11	138.02	14.50	119.50
Ce	215.37	215.90	215.64	188.64	173.70	223.27	205.42	19.59	187.50
Pr	19.42	19.25	19.33	17.41	15.94	19.77	18.52	1.51	0.0
Nd	49.05	48.91	48.98	46.03	41.75	49.50	47.37	3.02	43.30
Sm	7.05	7.00	7.03	6.74	6.10	7.03	6.83	0.37	5.92
Eu	1.19	1.15	1.17	1.27	1.12	1.12	1.17	0.06	1.02
Gd	5.65	5.67	5.66	5.33	4.73	5.71	5.46	0.38	5.10
Tb	0.96	0.96	0.96	0.87	0.77	0.97	0.92	0.08	0.85
Dy	6.06	6.04	6.05	5.39	4.77	6.19	5.75	0.56	0.0
Ho	1.30	1.29	1.29	1.10	0.98	1.32	1.21	0.14	1.15
Er	4.11	4.12	4.12	3.46	3.08	4.21	3.85	0.47	0.0
Tm	0	0	0	0	0	0	0	0	0.46
Yb	4.62	4.64	4.63	3.81	3.42	4.84	4.33	0.57	3.50
Lu	0.64	0.64	0.64	0.53	0.48	0.66	0.60	0.07	0.47
Hf	49.80	50.05	49.92	39.71	35.76	51.81	46.17	6.70	35.00
Ta	17.40	17.42	17.41	14.15	13.01	18.07	16.24	2.11	13.74
W	0	0	0	0	0	0	0	0	10.70
Ir	0	0	0	0	0	0	0	0	5.20
Pb	50.75	50.59	50.67	42.61	38.10	52.68	47.57	5.82	42.00
Bi	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.0
Th	70.84	70.12	70.48	55.22	49.76	71.96	64.73	9.66	54.50
U	19.12	18.95	19.04	15.03	13.57	19.56	17.55	2.56	15.30

this element for the six pumices are: 8.26, 8.50, 8.38, 17.40, 13.48 and 5.67, with a mean of 10.28 and standard deviation of 4.31; and the floater was 22 ppm. The difference from the mean is 11.72 ppm, which as a proportion is 1.14. The standard deviation expressed as a proportion from the mean is 0.42. So, the floater is 2.7 units from the mean (1.14/0.42). That is, between 95% and 99% confidence limits, which is still within acceptable statistical limits to the source, but only just. In passing, it is worth mentioning that the four phonolite rocks from McDonald Island had a large range of values for V: 81 ppm, 23 ppm, 4 ppm and 46 ppm (Table 9).

We think we can safely say that this match of object to source is definitely as good as it gets. The REE pattern fits, the type of rock fits, and the major and trace element values fit. It can be stated with a strong sense of certitude that the

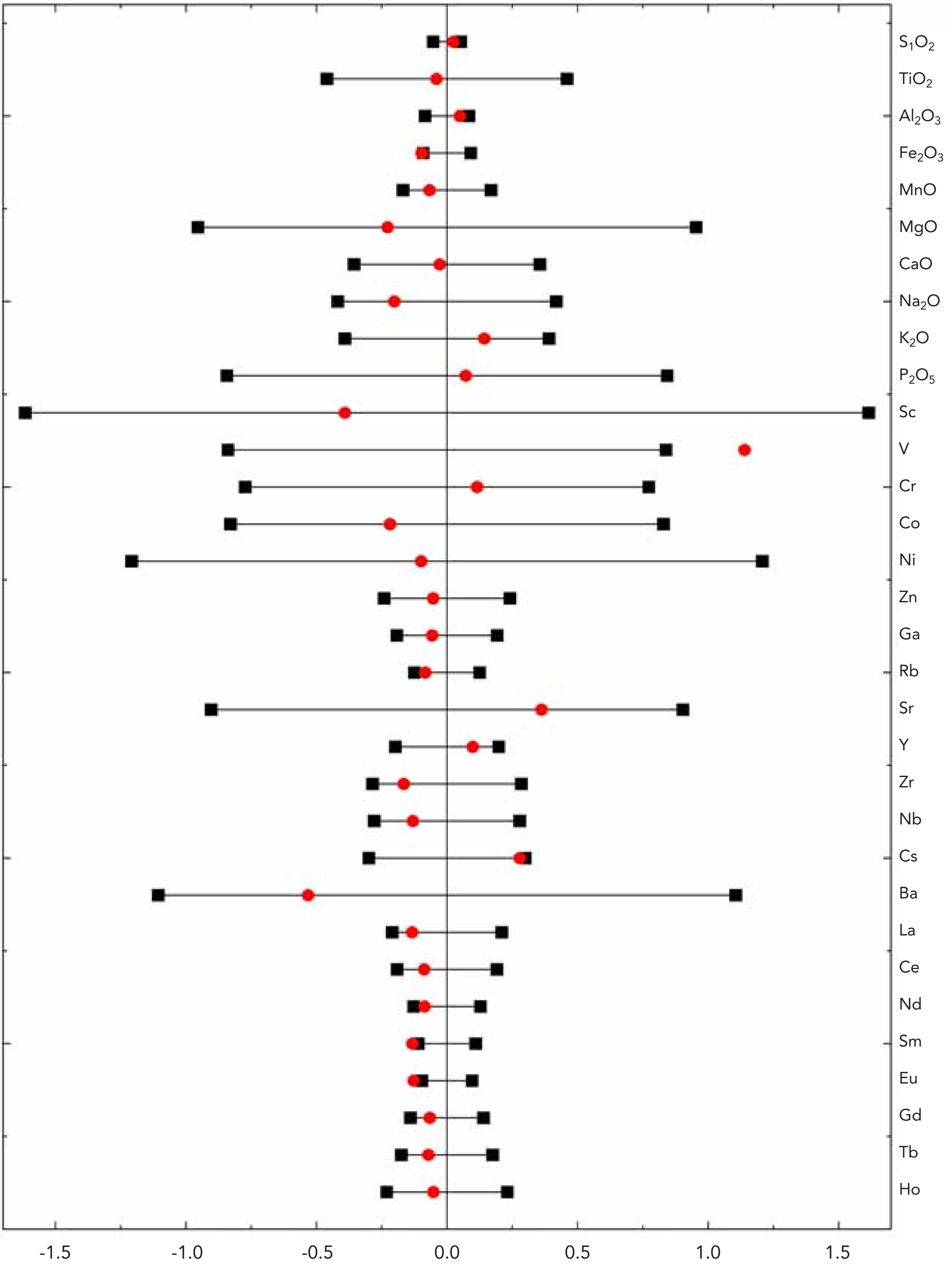

Fig. 12 Standardised plot of the mean and two standard deviations ranges of the McDonald Island pumices. The red dots are the floater from the Chatham Islands plotted on the same scale.

Fig. 13 (*left*) Map of McDonald Island before the recent volcanic activity (photo: Heritage Expeditions 2002).

Fig. 14 (*right*) McDonald Island as it appears today (photo: Google Earth/Digital Globe).

floater found in the Chatham Islands came from the same source as the six pumice specimens collected in the sea at McDonald Island.

Some further observations

McDonald Island is a small island in the South Indian Ocean at 53°2'S and 72°36'E, lying 45 km to the west of the larger Heard Island. Fig. 13 shows how the island appeared before 2001.

A detailed description of the history of the two islands can be found in Quilty & Wheller (2000). It appears that McDonald Island has been visited only twice. There are reports of large quantities of pumice being washed up on the shores of Heard Island in 1992, which were stated to be chemically identical to the phonolite rocks on McDonald Island. At the time, it was thought that these rafts may have been from a submarine eruption, but in 1997 active steam plumes were seen at the north end of McDonald Island, suggesting subaerial eruption (Quilty & Wheller 2000: 3).

In 1997, two passing ships in the area reported eruptive behaviour on McDonald Island, and a satellite image in 2001 showed that the island had doubled in size (compare Figs 13 and 14). Stephenson *et al.* (2005) documented these huge changes when they sailed within about 1 km of McDonald Island on their way to Heard Island on board the cruise ship *Akademik Shokalskiy*, operated by Heritage Expeditions of New Zealand.

It should be noted that pumice from McDonald Island is not the only pumice to have washed ashore on Heard Island. The 1962 eruption in the South Sandwich Islands in the southern Atlantic released vast quantities of pumice (Gass *et al.* 1963), and some of this found its way to Heard Island, about 6400 km distant, in 1963. Chemical analysis showed this to be dacite high in silica. This same pumice also turned up on Australian coasts from 1963 to 1967, and on the Juan Fernández Islands off Chile in 1965 (Sutherland & Olsen 1968). It has also turned up in New Zealand (Coombs & Landis 1966) and Hawai‘i (Jokiel & Cox 2003).

These landfalls are bound to have been made courtesy of the Antarctic Circumpolar Current (Fig. 15), which sweeps around Antarctica in a clockwise direction and is one of the largest ocean currents. Sailors frequently make use of the current and its associated westerly winds, which assist any voyage from west to east in southerly waters.

It is therefore not surprising that this piece of pumice with glass attached from McDonald Island ended up in the Chatham Islands, a great-circle distance of at least 7400 km. The pumice was presumably ejected during the massive changes that took place on McDonald Island sometime

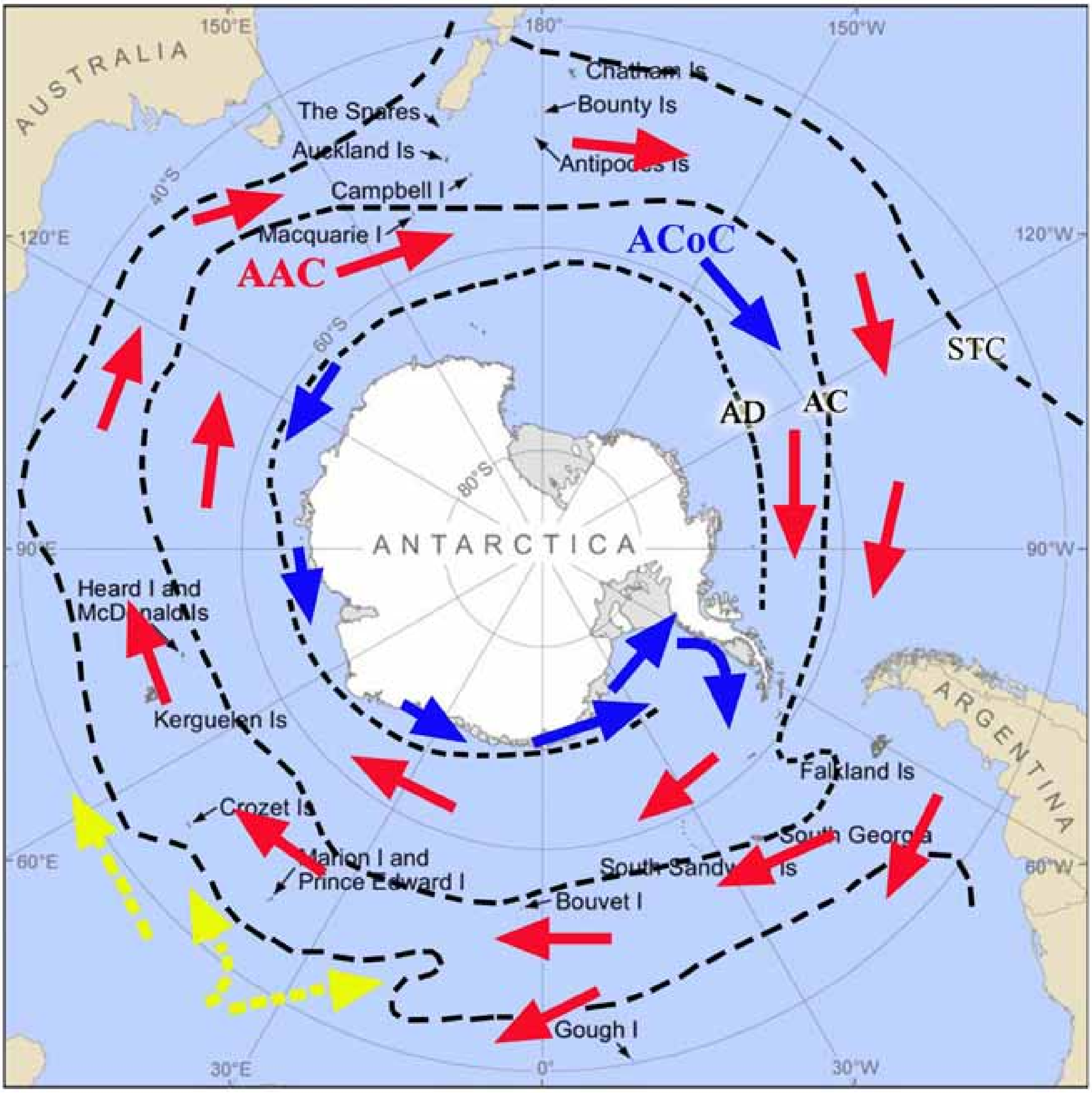

Fig. 15 Major currents and fronts in the Southern Ocean and subantarctic region: Antarctic Circumpolar Current (AAC), Antarctic Coastal Current (ACoC), Antarctic Divergence (AD), Antarctic Convergence (AC), Subtropical Convergence (STC).

between 1997 and 2001. According to Rhys Richards, the pumice was found some years before it was retrieved for analysis in 2008–09. Unfortunately, we will probably never know exactly how long it took to make the journey.

Acknowledgements

The senior author would like to thank his colleagues for their contributions to this complex research project: Rhys Richards for permission to carry out analysis of the obsidian floater from the Chatham Islands; Hamish Campbell for access to the specimen and his enthusiasm for the project; Katherine Holt for EMP analysis of the pumice; Steve Weaver for XRF analyses; Nelson Eby for NAA analysis; and Marcel Regelous for the unpublished geochemical data of samples from McDonald Island. Thanks are also due to Barry Weaver of the School of Geology and Geophysics, University of Oklahoma, USA, for supplying analytical data on obsidian from Ascension Island. Finally, the assistance of Janet Davidson is acknowledged for her help with checking and editing the content of this paper.

Notes

1 A europium (Eu) anomaly occurs when there is a striking difference in the concentration of Eu relative to the other rare earth elements. It is said to be positive if Eu is enriched, or negative if it is depleted. Some rocks are known to have a negative or positive Eu anomaly and some not.

2 http://georoc.mpch-mainz.gwdg.de/georoc.

References

Barling, J., Goldstein, S.L. and Nicholls, I.A. (1994). Geochemistry of Heard Island (southern Indian Ocean): characterization of an enriched mantle component and implications for enrichment of the sub-Indian Ocean mantle. *Journal of Petrology* 35: 1017–1053.

Bernard-Griffiths, J., Gruau, G., Cornen, G., Azambre, B. and Mace, J. (1997). Continental lithospheric contribution to alkaline magmatism: isotopic (Nd, Sr, Pb) and geochemical (REE) evidence from Serra De Monchique and Mount Ormonde complexes. *Journal of Petrology* 38: 115–132.

Bird, J.R., Duerden, P., Ambrose, W.R. and Leach, B.F. (1981). Pacific obsidian catalogue. Pp. 31–43. *In*: Leach, B.F. and Davidson, J.M. (*eds*). Archaeological studies of Pacific stone resources. *BAR International Series* 104. Oxford: British Archaeological Reports. 237 pp.

Clarke, I., McDougall, I. and Whitford, D.J. (1983). Volcanic evolution of Heard and McDonald islands, southern Indian Ocean. Pp. 631–635. *In*: Oliver, R.L., James, P.R. and Jago, J.B. (*eds*). *Antarctic earth science*. Canberra: Australian Academy of Science. 697 pp.

Collerson, K.D., Regelous, M., Frankland, R.A., Wendt, I. and Wheller, G. (1998). 1997 eruption of McDonald Island (southern Indian Ocean): new trace element and Th-Sr-Pb-Nd isotopic constraints on Heard–McDonald Island magmatism. *Journal of the Geological Society of Australia, Abstracts* 49. 14th Australian Geological Convention, Townsville.

Collerson, K.D. and Weisler, M.I. (2007). Stone adze compositions and the extent of ancient Polynesian voyaging and trade. *Science* 317: 1907–1911.

Coombs, D.S. and Landis, C.A. (1966). Pumice from the South Sandwich eruption of March 1962 reaches New Zealand. *Nature* 209: 289–290.

Duerden, P., Clayton, E., Bird, J.R., Ambrose, W. and Leach, B.F. (1987). Obsidian composition catalogue. Pp. 232–238. *In*: Ambrose, W.R. and Mummery, J.M.J. (*eds*). *Archaeometry: further Australasian studies*. Canberra: Department of Prehistory, Australian National University. 350 pp.

Duerden, P., Cohen, D.D., Clayton, E., Bird, J.R. and Leach, B.F. (1979). Elemental analysis of thick obsidian samples by proton induced Xray emission spectrometry. *Analytical Chemistry* 51(14): 2350–2354.

Fischer, S.R. (1997). *RongoRongo, the Easter Island script: history, traditions, texts*. Oxford and New York, NY: Oxford University Press. 714 pp.

Frick, C. and Kent, L.E. (1984). Drift pumice in the Indian and South Atlantic oceans. *Transactions of the Geological Society of South Africa* 87: 19–33.

Gass, I.G., Harris, P.G. and Holdgate, M.W. (1963). Pumice eruption in the area of the South Sandwich Islands. *Geological Magazine* 100: 321–330

Haast, J. von (1885). On the stone weapons of the Moriori and the Maori. *Transactions of the New Zealand Institute* 18: 24–30.

Heritage Expeditions (2002). McDonald Islands. *In*: *Remote islands of the southern Indian Ocean, 14th November–14th December 2002* [website]. Retrieved on 18 February 2016 from www.farvoyager.com/siov/mcd2.html.

Jokiel, P.L. and Cox, E.F. (2003). Drift pumice at Christmas Island and Hawaii: evidence of oceanic dispersal patterns. *Marine Geology* 202: 121–133.

Le Bas, M.J. and Streckeisen, A.L. (1991). The IUGS systematics of igneous rocks. *Journal of the Geological Society* 148: 825–833.

Leach, B.F. (1996). New Zealand and oceanic obsidians: an archaeological perspective using Neutron Activation Analysis. *Journal of the Royal Society of New Zealand* 26(1): 79–105.

Leach, B.F., Anderson, A.J., Sutton, D.G., Bird, J.R., Duerden, P. and Clayton, E. (1986). The origin of prehistoric obsidian artefacts from the Chatham and Kermadec islands. *New Zealand Journal of Archaeology* 8: 143–170.

Leach, B.F. and Manly, B. (1982). Minimum Mahalanobis distance functions and lithic source characterisation by multielement analysis. *New Zealand Journal of Archaeology* 4: 77–109.

Leach, B.F. and Warren, S.E. (1981). Neutron activation analysis of New Zealand and oceanic obsidians: towards a simple screening technique. Pp. 151–166. *In*: Leach, B.F. and Davidson, J.M. (*eds*). Archaeological studies of Pacific stone resources. *BAR International Series* 104. Oxford: British Archaeological Reports. 237 pp.

Lustrino, M., Cucciniello, C., Melluso, L., Tassinari, C.C.G., de Gennaro, R. and Serracino, M. (2012). Petrogenesis of Cenozoic rocks in the NW sector of the Gharyan volcanic field, Libya. *Lithos* 155: 218–235.

Nakamura, N. (1974). Determination of REE, Ba, Fe, Mg, Na, and K in carbonaceous and ordinary chondrites. *Geochimica et Cosmochimica Acta* 38: 757–775.

Panter, K.S., Kyle, P.R. and Smellie, J.L. (1997). Petrogenesis of a phonolite–trachyte succession at Mount Sidley, Marie Byrd Land, Antarctica. *Journal of Petrology* 38: 1225–1253.

Quilty, P.G. and Wheller, G. (2000). Heard Island and the McDonald Islands: a window into the Kerguelen Plateau. *Papers and Proceedings of the Royal Society of Tasmania* 133(2): 1–12.

Richards, A.F. (1966). Geology of the Islas Revillagigedo, Mexico. II. Geology and petrography of Isla San Benedicto. *Proceedings of the California Academy of Sciences* 33: 361–414.

Spennemann, D.H.R. (1996). Gifts from the waves: a case of marine transport of obsidian to Nadikdik Atoll and the occurrence of other drift materials in the Marshall Islands. *Johnstone Centre of Parks, Recreation and Heritage Report* 23. Albury: Charles Sturt University. 61 pp.

Stephenson, J., Budd, G.M., Mannings, J. and Hansbro, O. (2005). Major eruption-induced changes to the McDonald Islands, southern Indian Ocean. *Antarctic Science* 17(2): 259–266.

Sutherland, F.L. and Olsen, A.M. (1968). Persistence of drift pumice in southern Australasian waters. *Papers and Proceedings of the Royal Society of Tasmania* 102: 1–6.

Verwoerd, W.J., Chevallier, L. and Thomson, J.W. (1990). Oceanic islands on the Antarctic Plate. Pp. 396–463. *In*: LeMasurier, W.E., Thomson, J.W., Baker, P.E., Kyle, P.R., Rowley, P.D., Smellie, J.L. and Verwoerd, W.J. (*eds*). *Volcanoes of the Antarctic Plate and southern oceans*. Washington, DC: American Geophysical Union. 487 pp.

Unpublished sources

Barling, J. (1990). The petrogenesis of the newer lavas of Heard Island, southern Indian Ocean. Ph.D. thesis, Monash University, Melbourne. 496 pp.

Collerson, K.D. (1997). Field studies at Heard and McDonald Island in March 1997. Unpublished report of the Australian National Antarctic Research Expedition (ANARE).

Appendix 1: Details of samples in this report

11290	Ormonde seamount, Gorringe, Strait of Gibraltar
302	Igwageta, Fergusson Island
35504A	Macauley Island source
35505A	Raoul Island source
35506A/P40908	Raoul Island source
35507A/P81381	Chatham Island floater
5105	Emily Bay, Norfolk Island artefact, Atholl Anderson
5145	DAFF site, Papua New Guinea, Matt Spriggs
65119, 65124, 65125, 65133	McDonald Island
AI991	Wekwok standard 2000
ANU306	Numanuma, East Fergusson Island
ANU3830	Nowak 3, Choiseul, Papua New Guinea, Matt Spriggs
GH11	Gharyan, Libya
GX219	Raoul Island source
MAC18E	Macauley Island source
Mayor Island	Obsidian standard
MB35.2	Mt Sidley, Marie Byrd Land, Antarctica (Panter *et al.* 1997)
MB35.5	Mt Sidley, Marie Byrd Land, Antarctica (Panter *et al.* 1997)
P81381	Chatham Islands floater
RGM-1	USGS Geochemical Standard: rhyolite, Glass Mountain
STM-1	USGS Geochemical Standard: peralkaline nepheline syenite, Table Mountain

Tuhinga 27: 50–55 Copyright © Museum of New Zealand Te Papa Tongarewa (2016)

Re-evaluation of the taxonomic status of *Christella dentata* (Thelypteridaceae) supports recognition of one species in New Zealand

Pat Brownsey* and Leon Perrie

* Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington, New Zealand
(patb@tepapa.govt.nz)

ABSTRACT: Several publications over the last 30 years have suggested that there may be more than one species of *Christella* in New Zealand: one with creeping rhizomes found in Northland and the Kermadec Islands, referable to the widespread species *C. dentata*; and another of uncertain status with short-creeping or erect rhizomes, confined to thermal regions in the North Island and the Kermadec Islands. The taxonomic status of these plants has been re-evaluated based on collections in the main New Zealand herbaria and field observations from botanists who have collected them. Analysis of frond and rhizome morphology, spore size and cytology indicates that the only difference between the two groups is the nature of the rhizome. Based on current knowledge, we conclude that only one rather variable species, *C. dentata*, is indigenous to New Zealand, and that it shows similar variation to the species in Australia. In addition, there are a few populations naturalised in northern New Zealand, some of which are slightly different in appearance to the indigenous plants and have probably been introduced from overseas sources, and others that may have originated from indigenous plants brought into cultivation.

KEYWORDS: *Christella dentata*, Thelypteridaceae, New Zealand flora, taxonomy.

Introduction

The family Thelypteridaceae was first recognised in New Zealand by Allan (1961), who included all five indigenous species within the broadly construed genus *Thelypteris*. Previously, they had been assigned to various genera within the Polypodiaceae (Hooker 1867; Cheeseman 1906, 1925). Subsequently, Holttum (1971), in the Old World, and Smith (1971), in the New World, revolutionised our understanding of the family, defining many new genera and species in the Thelypteridaceae.

Holttum (1976) recognised *Christella* as a distinct genus with about 50 species, mostly in the Paleotropics but with one species in New Zealand. He distinguished the genus principally by the presence of a thick, elongate, blunt unicellular hair on the stalks of the sporangia (Holttum 1971). In addition, he noted that the lower pinnae are gradually reduced, the aerophores at the base of the pinnae are not swollen, acicular hairs are usually present on both surfaces of the lamina, short capitate hairs are often present, thick red or orange glandular hairs are sometimes present (but not in New Zealand), sessile spherical glands are absent, the basal veins from adjacent pinnules usually join, and the sori are indusiate (Holttum 1977). Smith (1971) and Smith *et al.* (2006) included *Christella* within a more broadly circumscribed *Cyclosorus*, but recent work suggests that *Christella* is polyphyletic, with most Paleotropical species, including *Christella dentata*, not congeneric with Neotropical species (Almeida *et al.*, 2016). Since clear generic boundaries have not yet been established, Holttum's classification is followed here for consistency within the Australasian and Pacific regions.

Allan (1961) recognised a single species of what we now call *Christella* in New Zealand, making the new combination *Thelypteris dentata* (Forssk.) Allan. Given (1981) was the first to suggest that plants of *Christella dentata* from thermal areas might be different to those from around Kaitaia, which he related to '*C. dentata* of the tropics', but did not elaborate on how the two could be distinguished. Pursuing this idea, Brownsey, Given and Lovis (1985: 441) listed two taxa, *C. dentata* and *C.* sp., noting 'that two species of *Christella* may occur in New Zealand, one in thermal areas and the Kermadec Islands, and one in North Auckland'. Brownsey & Smith-Dodsworth (1989) further distinguished the thermal plant by its shorter rhizome and smaller fronds (stipes 90–350 mm long, laminae 200–700 mm long and 80–250 mm wide) compared to Northland plants (stipes 200–600 mm long, laminae 300–1000 mm long and 130–400 mm wide), but noted that 'its taxonomic status and affinities are not yet determined'. Davison (1995) investigated *Christella* in New Zealand for an M.Sc. thesis at the University of Auckland, but the results of her work have never been published. de Lange *et al.* (2010: 85) stated that 'Populations of *Christella* from geothermally active parts of the North Island and from the crater region of Raoul Island lack the long, creeping rhizome typical of northern New Zealand and most Raoul Island *C. dentata*, instead producing over time a small, erect trunk. These plants also have narrower, hairier fronds.' They concluded that 'these plants are not the same as *C. dentata*, and appear to represent another possibly unnamed variant' but cautioned that further research was still needed. The status of these two forms is re-evaluated here.

In New Zealand, *Christella dentata sensu lato* extends from the Kermadec Islands to just south of Lake Taupo in the central North Island. It has been recorded in lowland sites on Raoul, Macauley and Cheeseman islands in the Kermadec Islands (Sykes 1977; de Lange 2015a,b). In the far north of the North Island, it is known from Te Paki (Spirits Bay, Te Huka Bay, Akura Stream and Waitangi Stream), and from a few localities near Awanui north of Kaitaia. It occurs in thermal regions from Rotorua to Tokaanu, and has also been collected from near Kawhia Harbour and from Paemako near Piopio in northern Taranaki. A few populations in Auckland and Hamilton are naturalised. Plants from the Kermadec Islands, Northland and thermal areas of the North Island are all indigenous, but the status of the plants in the western Waikato and north Taranaki is uncertain.

Outside New Zealand, *Christella dentata* is widely distributed in the tropics and subtropics of the Old World, from Africa (Roux 2009) to India, Asia, Australia (Bostock 1998) and most of the islands of the Pacific (Holttum 1977). It extends north to the Azores, Madeira and Crete (Brownsey & Jermy 1973), and the name of the species is based on a type from Yemen (Forsskål 809, C 10002814, Botanical Museum, University of Copenhagen). It is now naturalised throughout the Neotropics (Smith 1971; Holttum 1976) and Hawai'i (Palmer 2003). Strother & Smith (1970) noted that it was a common fern of greenhouses and botanical gardens but was collected in the New World only twice before 1930. It was first recorded in Hawai'i in 1887 but has since spread widely (Palmer 2003).

The species is uniformly tetraploid with $n = 72$ throughout its range (see Löve *et al.* 1977 for original references). In New Zealand, counts have been obtained from a geothermal population near Taupo ($n = 72$, Brownlie 1961, as *Christella nymphalis*) and from Foley's Bush, Awanui, Northland ($2n = 144$, de Lange *et al.* 2004). In Australia, four tetraploid counts have been obtained (Tindale & Roy 2002). Based on work by Ghatak & Manton (1971), Holttum (1976) noted that the closely related species *C. hispidula* (Decne.) Holttum is diploid in the Old World, whilst Smith (1971, as *Thelypteris quadrangularis*) showed that it is also diploid in the New World.

The question of whether there are one or two taxa of *Christella* in New Zealand is important because the genus reaches its southernmost limit in northern New Zealand, and plants are rare. *Christella dentata* was given a conservation status of 'At Risk/Naturally Uncommon' by de Lange *et al.* (2013), and further assessment of its status depends on whether it encompasses one or more different species. In preparing the treatment of Thelypteridaceae for the electronic *Flora of New Zealand* (Brownsey & Perrie, submitted), we have re-evaluated the taxonomic status of *C. dentata* in New Zealand. Our observations are presented here and will be summarised in the electronic *Flora* treatment.

Materials and methods

Over 230 herbarium sheets of *Christella dentata* in the Auckland War Memorial Museum Herbarium (AK), the Allan Herbarium at Landcare Research–Maanaki Whenua (CHR) and the Museum of New Zealand Te Papa Tongarewa Herbarium (WELT) were examined, and collection data noted. Measurements of rhizome, stipe, lamina and pinna dimensions were taken from 50 specimens, and separated, as far as possible, into two groups representing, on one hand, *C. dentata* from Northland and non-crater regions of the Kermadec Islands, and, on the other, the geothermal

Table 1 Range of morphological variation in populations of *Christella dentata* from Northland and non-crater regions of the Kermadec Islands compared to those from thermal areas of the Kermadec Islands and central North Island. Extreme sizes for individual specimens are given parenthetically. For rhizome measurements, reported figures in brackets are taken from collectors' data or field observations rather than from herbarium specimens.

Character	**Northland and non-crater Kermadec Is plants (23 specimens)**	**Thermal area plants (27 specimens)**
Rhizome	Creeping to 150 mm long (reported up to 1000 mm long)	Short-creeping to 55 mm long, or erect to 70 mm tall (reported up to 1000 mm tall)
Origin of stipes	Tufted near apex, 2–10 mm apart	Tufted at apex, 1–8 mm apart
Frond length (mm)	397–980	415–1020 (1195)
Stipe length (mm)	110–350	(75) 120–334
Lamina length (mm)	290–710	242–730 (945)
Lamina width (mm)	110–350	88–215 (275)
Lamina length/width	(1.09) 1.88–3.71	1.95–4.75
No. of pinna pairs	16–40	8–35 (40)
Longest pinna length (mm)	60–155 (240)	45–135 (150)
Longest pinna width (mm)	13–31	10–24
Pinna length/width	3.84–8.16	3.2–7.89
Basal pinna length (mm)	8–60 (89)	5–55 (72)
Pinnule length (mm)	7–15	5–12
Incision length (mm)	2.5–11.5	2.5–8.5
% divided to costa	31–77	35–82

populations from the central North Island and the crater region of Raoul Island, together with one population from Te Paki. Observations were also made of the hairiness of the plants.

Additional field observations of plants on the Kermadec Islands and in Northland, especially by Peter de Lange and Jeremy Rolfe, are recorded where appropriate.

Measurements of the exospore were made from spores mounted in gum chloral. Twenty spores were measured from each of five populations representing *Christella dentata* from Northland and non-crater regions of the Kermadec Islands, and from geothermal populations.

Results

The results of the morphological analysis are presented in Table 1, and the comparison of spore size in Table 2.

The results of the morphological analysis (Table 1) show that, apart from the rhizome character, there is substantial overlap in the measurements for different characters from the two groups. Only in stipe length, lamina width, length of the longest pinna and length of the basal pinna are there any substantive differences at all between the two groups. However, the differences are so slight in the context of the overlapping ranges that they could not be used to distinguish separate taxa.

Table 2 Range of variation in spore size in populations of *Christella dentata* from Northland and non-crater regions of the Kermadec Islands compared to those from thermal areas of the Kermadec Islands and central North Island.

Character	**Northland and non-crater Kermadec Is plants (5 specimens)**	**Thermal area plants (5 specimens)**
Spore length (µm)	37.8–42.7	37.8–42.9
Spore width (µm)	25.3–29.8	26.5–29.5

Of the qualitative characters, the hairiness of the fronds does not appear to vary significantly between the two groups and certainly not in any consistent way that could be used to discriminate them. Quantitative measurement of the degree of hairiness has not been attempted, but simple observation does not suggest any difference between the two groups.

Measurements of spores from five populations of both groups (Table 2) show that their dimensions are virtually identical. Chromosome counts have previously been made from single populations of the two groups of plants (Brownlie 1961; de Lange *et al.* 2004) and both are tetraploid. There is no evidence to indicate that New Zealand plants are anything other than tetraploid.

The only difference between the two groups concerns the nature of the rhizome. Measurements from herbarium specimens show that the Northland and non-crater Kermadec Islands group had creeping rhizomes up to 150 mm long, with the stipes arising 2–10 mm apart (two specimens), whereas those attributed to the thermal group had rhizomes either short-creeping to 55 mm long, with the stipes arising 1–8 mm apart, or erect and up to 70 mm tall (nine specimens). In both groups the stipes were tufted near the apices of the rhizomes. However, because these are rare or threatened plants, very few collections have been made of rhizomes, and herbarium specimens do not necessarily provide an accurate reflection of the plants in the wild. Additional observational data from notes on herbarium specimens, and from personal observations in the field, indicate that the Northland and non-crater Kermadec Island populations sometimes have creeping rhizomes up to 1000 mm long (de Lange 2015c), while plants attributed to the thermal group occasionally produce rhizomes up to 1000 mm tall (Te Huka Bay, Te Paki, de Lange 9203, AK 314009).

Discussion

It is clear from the results of the analysis that there is no quantitative frond measurement that could be used to distinguish two separate taxa. This contradicts the descriptions of the fronds of the two groups given by Brownsey & Smith-Dodsworth (1989), who suggested that the thermal plants had shorter stipes, and shorter and narrower laminae. Although Brownsey & Smith-Dodsworth (1989) gave no indication of how many specimens were examined, their measurements were made entirely from material in WELT. It is now apparent that this limited sampling is not supported by examination of a wider and more comprehensive range of specimens.

The analysis of spore size, combined with the previously reported chromosome numbers, strongly suggests that the populations in New Zealand are uniformly tetraploid. This is consistent with results in other parts of the world. In particular, there is no evidence that the morphologically similar diploid species *Christella hispidula* is present in New Zealand. That species is recorded for Australia, where it is said to be 'difficult to distinguish from *C. dentata*' (Bostock 1998), and its occurrence in New Zealand was a possibility that needed to be considered.

A preliminary genetic investigation also found no differences. DNA sequences for the chloroplast *rps4* locus (*rps4* gene and *rps4-trnS* spacer) for a sample from Taupo (Perrie 6263, WELT P027368) were identical to those for a sample from a non-thermal site on the Kermadec Islands (de Lange s.n., AK 307043).

Recognition of two separate groups within indigenous populations of New Zealand *Christella dentata* therefore depends entirely on the rhizome differences. Herbarium specimens and especially observational field data indicate that there are plants with rhizomes that creep up to

1000 mm and that tend to occur in coastal wetlands, along riverbanks and in alluvial forest remnants, and plants with rhizomes that develop over time into a small erect trunk and that occur mostly in geothermally active parts of northern New Zealand (de Lange *et al.* 2010). However, in both groups, the rhizomes are fundamentally similar in that they produce tufts of fronds near the apex, rather than fronds that are widely spread along the rhizome (as in families with long-creeping rhizomes such as Dennstaedtiaceae, Hymenophyllaceae or Polypodiaceae). Similar variation in rhizome behaviour occurs in other ferns, notably *Cyathea dealbata* and *Cyathea colensoi* in New Zealand (Brownsey & Perrie 2015), and *Hypolepis tenuifolia* in the Pacific (Brownsey 1987). Whether the rhizome is prostrate or erect may not be of great taxonomic significance, and may simply be a reflection of different habitats in which the plants are found.

Similar variation has been reported in Australian populations of *Christella dentata.* Bostock (1998: 346–347) described the rhizomes as 'short-creeping, indistinctly suberect or erect', and noted that 'plants vary greatly in size, colour and texture of lamina and pinnae, and slightly in the depth of lobing of the pinnae'. This exactly mirrors the range of variation seen in New Zealand populations.

Without any further evidence to the contrary, we conclude that there is only one rather variable species indigenous to New Zealand, similar to that in Australia, which is correctly identified as *Christella dentata.* However, if further morphological, cytological or genetic differences can be found that correlate with the rhizome character, there may yet be a case for recognising two different taxa.

Some naturalised plants of *Christella dentata* in New Zealand have a slightly different appearance to those that are indigenous, and complicate the picture still further. *Christella dentata* is naturalised in the Neotropics (Smith 1971; Holttum 1976) and in Hawai'i (Palmer 2003). Plants from these areas have distinctive purple stipes that are very similar to those of some naturalised plants in New Zealand (e.g. Seaview Terrace, Mt Albert, Auckland, de Lange 7937 *et al.*, AK 305922, WELT P023359) and to some that are of uncertain status (e.g. near Kawhia, de Lange 1733, AK 212348, WELT P017566). It is likely that some naturalised plants in New Zealand have established as escapes from cultivation, originally introduced from overseas. The earliest record is the plant grown from spore collected near Kawhia by Peter de Lange in 1987 (AK 212348), but other plants have been collected from 1991 onwards. Given the aggressive naturalisation of this plant in the Americas, it is likely that it will spread in New Zealand unless carefully controlled. A few populations naturalised in Auckland and Hamilton (e.g. Jesmond Terrace, Mt Albert, Auckland, de Lange 7938, AK 305923, WELT P023360) lack the characteristic purple stipes and may have originated from indigenous plants brought into cultivation at various sites nearby.

Acknowledgements

This research was supported by Core funding for Crown Research Institutes from the Ministry of Business, Innovation and Employment's Science and Innovation Group. We are especially grateful to Peter de Lange and Jeremy Rolfe for collections, observational data and photographs of *Christella dentata* from Northland and the Kermadec Islands, and to Jessie Prebble for help with DNA sequencing. We also thank staff at the Auckland War Memorial Museum Herbarium (Auckland, New Zealand), the Allan Herbarium at Landcare Research–Maanaki Whenua (Lincoln, New Zealand) and the Museum of New Zealand Te Papa Tongarewa Herbarium (Wellington, New Zealand) for access to collections in their care, and Peter Bostock and Alan Smith for their comments as referees of the manuscript.

References

Allan, H.H. (1961). *Flora of New Zealand. Vol. 1. Indigenous Tracheophyta. Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledones.* Wellington: Government Printer. 1085 pp.

Almeida, T.E., Hennequin, S., Schneider, H., Smith, A.R., Batista, J.A.N., Ramalho, A.J., Proite, K. and Salino, A. (2016). Towards a phylogenetic generic classification of Thelypteridaceae: additional sampling suggests alterations of neotropical taxa and further study of paleotropical genera. *Molecular Phylogenetics and Evolution* 94: 688–700.

Bostock, P.D. (1998). Thelypteridaceae. *Flora of Australia* 48: 327–358.

Brownlie, G. (1961). Additional chromosome numbers – New Zealand ferns. *Transactions of the Royal Society of New Zealand (Botany)* 1: 1–4.

Brownsey, P.J. (1987). A review of the fern genus *Hypolepis* (Dennstaedtiaceae) in the Malesian and Pacific regions. *Blumea* 32: 227–276.

Brownsey, P.J., Given, D.R. and Lovis, J.D. (1985). A revised classification of New Zealand pteridophytes with a synonymic checklist of species. *New Zealand Journal of Botany* 23: 431–489.

Brownsey, P.J. and Jermy, A.C. (1973). A fern collecting expedition to Crete. *British Fern Gazette* 10: 331–384.

Brownsey, P.J. and Perrie, L.R. (2015). Cyatheaceae. *In*: Breitwieser, I., Heenan, P.B., Wilton, A.D. (*eds*). *Flora of New Zealand – ferns and lycophytes.* Fascicle 13. Lincoln: Manaaki Whenua Press. Retrieved on 26 January 2016 from http://dx.doi.org/10.7931/B10595

Brownsey, P.J. and Perrie, L.R. (submitted). Thelypteridaceae. *In*: Breitwieser, I., Heenan, P.B. and Wilton, A.D. (*eds*). *Flora of New Zealand – ferns and lycophytes.* Lincoln: Manaaki Whenua Press.

Brownsey, P.J. and Smith-Dodsworth, J.C. (1989). *New Zealand ferns and allied plants.* Auckland: David Bateman. 168 pp.

Cheeseman, T.F. (1906). *Manual of the New Zealand flora.* Wellington: Government Printer. 1199 pp.

Cheeseman, T.F. (1925). *Manual of the New Zealand flora.* 2nd edn. Wellington: Government Printer. 1163 pp.

de Lange, P.J. (2015a). Recent vegetation succession and flora of Macauley Island, southern Kermadec Islands. *Bulletin of the Auckland Museum* 20: 115–137.

de Lange, P.J. (2015b). The flora and vegetation of Cheeseman Island, southern Kermadec Islands. *Bulletin of the Auckland Museum* 20: 232–240.

de Lange, P.J. (2015c). Soft fern (*Christella dentata*). *In*: *NatureWatch NZ* [website]. Retrieved on 26 January 2016 from www.naturewatch.org.nz/observations/1463496.

de Lange, P.J., Heenan, P.B., Norton, D.A., Rolfe, J.R. and Sawyer, J. (2010). *Threatened plants of New Zealand.* Christchurch: Canterbury University Press. 471 pp.

de Lange, P.J., Murray, B.G. and Datson, P.M. (2004). Contributions to a chromosome atlas of the New Zealand flora – 38. Counts for 50 families. *New Zealand Journal of Botany* 42: 873–904.

de Lange, P.J., Rolfe, J.R., Champion, P.D., Courtney, S.P., Heenan, P.B., Barkla, J.W., Cameron, E.K., Norton, D.A. and Hitchmough, R.A. (2013). *Conservation status of New Zealand indigenous plants*, 2012. Wellington: Department of Conservation. 70 pp.

Ghatak, J. and Manton, I. (1971). Further cytological and taxonomic observations on some members of the *Cyclosorus parasiticus* complex. *British Fern Gazette* 10: 183–192.

Given, D.R. (1981). *Rare and endangered plants of New Zealand.* Wellington: Reed. 154 pp.

Holttum, R.E. (1971). Studies in the family Thelypteridaceae III: a new system of genera in the Old World. *Blumea* 19: 17–52.

Holttum, R.E. (1976). The genus *Christella* Léveillé, sect. *Christella.* Studies in the family *Thelypteridaceae*, XI. *Kew Bulletin* 31: 293–339.

Holttum, R.E. (1977). The family Thelypteridaceae in the Pacific and Australasia. *Allertonia* 1: 169–234.

Hooker, J.D. (1867). *Handbook of the New Zealand flora.* London: Reeve. 798 pp.

Löve, Á., Löve, D. and Pichi Sermolli, R.E.G. (1977). *Cytotaxonomical atlas of the Pteridophyta.* Vaduz: Cramer. 398 pp.

Palmer, D.D. (2003). *Hawai'i's ferns and fern allies.* Honolulu: University of Hawai'i Press. 324 pp.

Roux, J.P. (2009). Synopsis of the Lycopodiophyta and Pteridophyta of Africa, Madagascar and neighbouring islands. *Strelitzia* 23. Pretoria: South African National Biodiversity Institute. 296 pp.

Smith, A.R. (1971). Systematics of the neotropical species of *Thelypteris* section *Cyclosorus. University of California Publications in Botany* 59: 1–143.

Smith, A.R., Pryer, K.M., Schuettpelz, E., Korall, P., Schneider, H. and Wolf, P.G. (2006). A classification for extant ferns. *Taxon* 55: 705–731.

Strother, J.L. and Smith, A.R. (1970). Chorology, collection dates and taxonomic responsibility. *Taxon* 19: 871–874.

Sykes, W.R. (1977). Kermadec Islands Flora. An annotated check list. *New Zealand Department of Scientific and Industrial Research Bulletin* 219: 1–216.

Tindale, M.D. and Roy, S.K. (2002). A cytotaxonomic survey of the Pteridophyta of Australia. *Australian Systematic Botany* 15: 839–937.

Unpublished sources

Davison, A.C. (1995). Studies on the genus *Christella* Léveillé in New Zealand. M.Sc. thesis, University of Auckland, New Zealand. 114 pp.

 Copyright © Museum of New Zealand Te Papa Tongarewa (2016)

A review of the distribution and size of prion (*Pachyptila* spp.) colonies throughout New Zealand

Sarah E. Jamieson,*‡ Alan J.D. Tennyson,* Kerry-Jayne Wilson,** Elizabeth Crotty,* Colin M. Miskelly,* Graeme A. Taylor*** and Susan M. Waugh*

* Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington, New Zealand
** West Coast Penguin Trust, PO Box 70, Charleston, West Coast, New Zealand
*** Department of Conservation, PO Box 10420, Wellington, New Zealand
‡ Current address: Wildlife Research and Monitoring Section, Ministry of Natural Resources and Forestry, c/o Trent University, 2140 East Bank Drive, Peterborough, ON K9L 0G2, Canada

ABSTRACT: Prions are among of the most numerous birds of the Southern Ocean, and yet their populations are poorly documented. New Zealand has breeding populations of four of the six recognised species, all with large population sizes. The remaining two species occur naturally in the New Zealand zone but do not breed there. This review reports data collated from the scientific literature, government archives and unpublished information about the population sizes of prions gathered since earliest scientific records in New Zealand (1773, during James Cook's second voyage) until the present day. The study focuses on breeding populations, and reports data about population size and presence or absence of prion populations from sites throughout the New Zealand region. The summary presented provides a solid baseline for future population assessments and identifies priority sites where future surveys are warranted.

KEYWORDS: prions, *Pachyptila*, population sizes, population distribution, Procellariiformes, range, seabirds, New Zealand.

Introduction

Seabirds are one of the most globally threatened groups of birds (Croxall *et al.* 2012). They face a multitude of pressures, such as interactions with commercial fisheries, pollution, climate change, plastic ingestion and disturbances on the breeding grounds, from both humans and invasive species (Carney & Sydeman 1999; Gregory 2009; Hilton & Cuthbert 2010; Anderson *et al.* 2011). For many seabird species, adequate knowledge of their distribution is lacking (Croxall *et al.* 2012). This paucity of the most basic of data inhibits the conservation of these species. Furthermore, a poor understanding of a species' range makes it difficult to collect the baseline data necessary for robust evaluations of its population trends and conservation status.

Many seabird species rely on remote islands for breeding and nest in burrows, making the collection of even the most basic data challenging. Further, in New Zealand access to many of the southern nearshore islands is severely restricted to anyone other than traditional owners or occupiers, and then often limited to the March–May muttonbirding season (Moller *et al.* 2009), a period that does not coincide with the breeding season of many seabird species, including prions.

Prions (*Pachyptila* spp.) are small petrels (120–200 g average weight; Miskelly 2013a,b), are nocturnal on land, and nest in burrows or crevices, mostly on remote predator-free islands. Globally, there are six species of prion, all of which breed on islands in the Southern Ocean: broad-billed prion (*P. vittata*), Salvin's prion (*P. salvini*), Antarctic prion (*P. desolata*), thin-billed prion (*P. belcheri*), fairy prion (*P. turtur*) and fulmar prion (*P. crassirostris*). Although they are one of the most abundant groups of seabirds (up to 95 million individuals; Brooke 2004) and are all listed by the International Union for Conservation of Nature as of 'Least Concern' (IUCN 2016), they still face significant population threats.

First, prions are among the most common species of seabird to succumb to beach-wreck (e.g. Harper 1980; Post 2007; Powlesland 1989). For example, during a severe weather event in July 2011, approximately 250,000 prions (approximately 200,000 of which were broad-billed prions) blew ashore and died along the west coast of New Zealand (Miskelly 2011a; Tennyson & Miskelly 2011). Climate-change models forecast that such storms are likely to increase in both frequency and intensity (Easterling *et al.* 2000; Alley *et al.* 2003). This could have significant detrimental effects on population numbers of prions. Second, prions are surface-feeders that rely on planktonic crustaceans, molluscs and fish. It has been predicted that over the next 90 years there will be a 6.3% decline in ocean productivity (Yool *et al.* 2013). Much of this decline will be due to a significant decrease in key nutrient levels in surface waters, resulting in large-scale effects on the lower trophic levels. In turn, this could resonate throughout the ecosystem (Yool *et al.* 2013) and lead to diminished feeding opportunities for surface-feeding birds. Monitoring even abundant species such as prions for assessing changes in marine ecosystems is thus clearly important; as apex predators, prions are sensitive indicators of change throughout these systems. And third, introduced mammalian predators have extirpated populations of small seabirds from many islands in New Zealand since scientific records began 250 years ago (Taylor 2000a).

Accurate and detailed information about the distribution and abundance of seabirds from the earliest days of scientific recording to today would enable these changes to be documented and their impact on species' conservation status to be assessed (Warham 1996). However, globally there is a lack of baseline data for most prion populations, with just a few exceptions (e.g. Catry *et al.* 2003; Taylor 2011). The first step in determining prion population trends is establishing the distribution of the species, which is best done during the breeding season, when they are ashore.

In this paper we collate data from a wide variety of sources to describe the distribution of prions breeding within the New Zealand region, and if the data were available, we report information on population numbers and trends. From this information we make recommendations for monitoring prion populations with the aim of identifying colonies that cover the geographic range of each species, but also those that are the most practical to monitor owing to relative accessibility. Our priority list includes those sites that have already had some history of monitoring. We also recommend that the population size for each recorded colony is estimated. As initial counts of all colonies are completed, other priority sites for long-term monitoring will become apparent. This review does not provide information about the biology of prions, nor their distributions outside of New Zealand. While we have attempted to include both published and unpublished records to provide a comprehensive overview, it is inevitable that some information will have been missed.

Methods

A literature review was conducted using primary, secondary and unpublished sources (sources and methods are described in Waugh *et al.* 2013). Raw data were also gleaned from the authors' personal field notebooks and those of other contributing researchers. We follow the taxonomy and nomenclature of Gill *et al.* (2010) and present the results in taxonomic order.

We report records of birds on land only, omitting observations of birds on the water, in the air or reported as beach-wrecks. We assumed that the presence of birds ashore signified breeding; however, birds found in skua middens may have been killed elsewhere (e.g. on the water) and transported to land. Depending on the information available in the original source, we described records as individuals (when no information on breeding status was given), breeding pairs (when some indication of breeding was provided and we note the presence of eggs or chicks) or burrows (when we had information only on the nesting structures themselves, with no information on bird occupancy; note that most prion nests are in soil burrows, and while in some cases the birds also nest in crevices, such nests are usually also reported as burrows, as most authors did not distinguish between nest types). If some level of systematic surveying was conducted, then the sampling protocol was described as a 'count', otherwise it was recorded as an 'observation'. A few individual records of live birds on islands well outside their

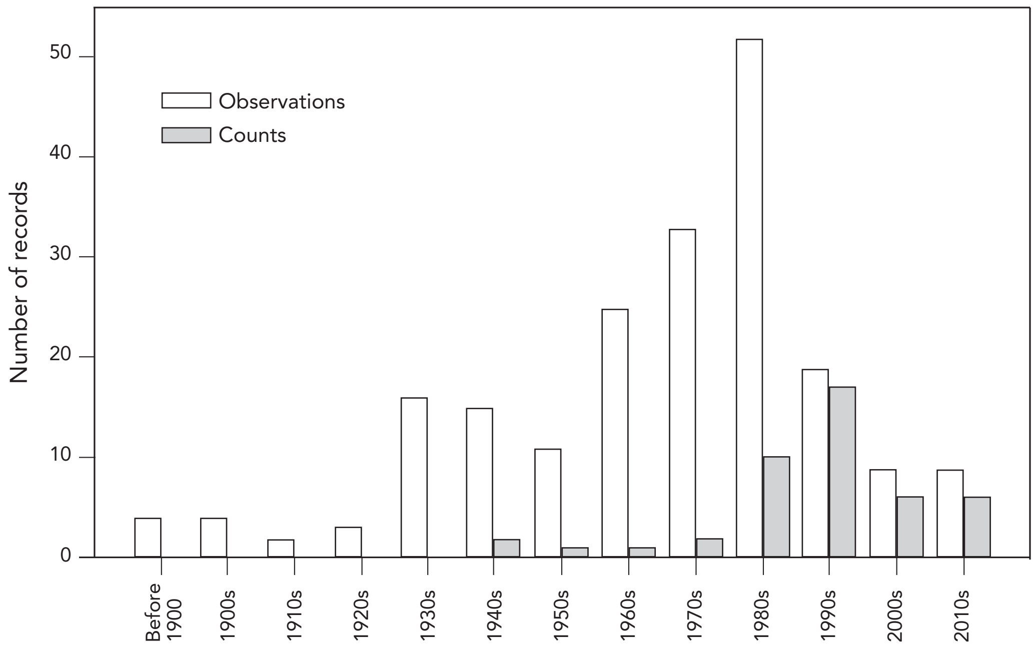

Fig. 1 Temporal distribution of population records for prion (*Pachyptila* spp.) colonies within New Zealand.

known breeding range (e.g. a broad-billed prion on Motunau I., Canterbury (Cox *et al.* 1967) and an Antarctic prion on Houruakopara I., Chatham Is (Imber 1994)) were considered to be vagrants. Brief observations that did not add any significant data to more comprehensive observations were not listed (e.g. there are some records of a species being present on an island when there are other records of actual population estimates from a similar time).

We used the names of localities as they are reported by Land Information New Zealand (Land Information New Zealand 2012; Harriss 2016). Island and islands are abbreviated to 'I.' and 'Is', respectively. In some cases, text in parentheses after the site name gives information to indicate the location of a small islet, or to reduce ambiguity about the location, such as where multiple sites with the same name exist.

The data set associated with this research, including detailed latitude and longitude information of the sites, is available to researchers and management groups on request from Susan Waugh at the Museum of New Zealand Te Papa Tongarewa (Te Papa; susan.waugh@tepapa.govt.nz).

Results

We located 304 records of prion colony observations in the New Zealand region from the literature and data review; half of these related to fairy prions. We report 100, 21, 152 and 31 records for broad-billed, Antarctic, fairy and fulmar prions, respectively. Prions were found on all major offshore island groups except the Kermadec Is. There were no records of Salvin's or thin-billed prions breeding on New Zealand islands. This was expected, as they are not known to breed in the southwest Pacific Ocean (Marchant & Higgins 1990), but it is noted that thin-billed prions were recorded as possibly breeding at Macquarie I. (Brothers 1984). Fairy prions had the most expansive New Zealand range, spanning 1650 km in distribution from north to south. Antarctic prions had the most restricted range; they were found almost exclusively at the Auckland Is. 'Observations' far outnumbered 'counts' (251 versus 51; Fig. 1). The number of 'observations' peaked during the 1980s, and 'counts' peaked during the 1990s, after which the number of each decreased (likely due to limited resources), but the casual observations were as numerous as formal counts after the 1990s (Fig. 1).

Broad-billed prion

We report broad-billed prions at 48 different locations (Table 1). Their colonies spanned from the Chatham Is to the Snares Is/Tini Heke, a distance of *c.* 1400 km. Of the 100 records for broad-billed prions, only seven colonies had total population estimates based on counts.

There were very few repeated observations at any one site over time, but the few that there were suggested population

Table 1 Population data for broad-billed prions (*Pachyptila vittata*) nesting in New Zealand (FLD = Fiordland; STW = Stewart I./Rakiura and Foveaux Strait; CIS = Chatham Is; SNI = Snares Is/Tini Heke; dash = no data or comments; see 'Methods' for sampling protocol).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Hawea I., Breaksea Sound[a]	FLD	Mar–Apr 1986	10s	Burrows	Norway rats (*Rattus norvegicus*) eradicated Apr 1986	Observation	G. Taylor, unpub. data
Wairaki I., Breaksea Sound[a]	FLD	Mar–Apr 1986	10s	Burrows	Seals limiting	Observation nesting sites	G. Taylor, unpub. data
Gilbert Is (western island), Breaksea Sound[a]	FLD	Mar–Apr 1986	100s	Burrows	Dense colony	Observation	G. Taylor, unpub. data
Dusky Sound	FLD	1986	–	Pairs	Breeding	Observation	K. Morrison *in* Gaze 1988
Petrel Is, Dusky Sound	FLD	1785	–	Pairs	–	Observation	Begg & Begg 1968
Anchor I., Dusky Sound	FLD	Mar–May 1773	1000s	Pairs	–	Observation	Medway 2011
		1785	–	Individuals	Immense numbers	Observation	Medway 2002
		Apr 1900	0	Individuals	–	Observation	Medway 2011
Seal Is, Dusky Sound	FLD	1773	1000s	Pairs	–	Observation	Medway 2011
Chalky Inlet	FLD	1986	–	Pairs	Breeding	Observation	K. Morrison *in* Gaze 1988
Solander I. (Hautere)	FLD	Jul 1948	–	Burrows	Adults 'in numbers'; weka patrolling	Observation	Falla 1948
		Nov 1973	2	Individuals	Corpses	Observation	Cooper *et al.* 1986
		Feb 1996	100s	Pairs	Many weka killed	Observation	A. Tennyson & G. Taylor, unpub. data
Little Solander I.	FLD	Jul 1985	Several	Individuals	Seen in flight	Observation	Cooper *et al.* 1986
Raratoka I. (Centre I.)	STW	Oct 1989	–	Pair	1 chick	Observation	Cooper 1991
Codfish I./ Whenua Hou	STW	Dec 1934	–	Pairs	Small numbers	Observation	Wilson 1959: 75
		Dec 1966	–	Pairs	–	Observation	Blackburn 1968
		2000s	10s	Burrows	At least 10s of scattered burrows	Observation	G. Taylor, unpub. data
Sealers Bay stacks, Codfish I./ Whenua Hou	STW	1935	–	Pairs	–	Observation	E. Stead *in* Blackburn 1968
		Dec 1966	–	Pairs	–	Observation	Blackburn 1968

continued on following page

Table 1 Population data for broad-billed prions (*Pachyptila vittata*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Sealers Bay stacks, Codfish I./ Whenua Hou [*contd*]		Nov 1991	1000–2000	Burrows	–	Observation	G. Taylor & A. Tennyson *in* O'Donnell & West 1998
Trig I.	STW	Dec 2011	500	Burrows	Mostly inactive	Count	Miskelly 2011b
		Dec 2011	10	Pairs	10 chicks	Count	Miskelly 2011b
Green I., nr Ruapuke I.	STW	Nov–Dec 1941	1000s	Pairs	Many thousands	Observation	Stead 1953
		Dec 2012	–	Pairs	Reported to be present; weka present	Observation	Miskelly 2013c, unpub. data
Bird I., nr Ruapuke I.		Mar 1965	–	Individuals	Large numbers	Observation	Blackburn 1965
North I., Titi/Muttonbird Is	STW	Oct 1911	–	Individuals	–	Observation	Guthrie-Smith 1914
Jacky Lee I. (Pukeokaoka)	STW	Dec 1932	'fairly plentiful'	Pairs	Many chicks taken by weka	Observation	Wilson 1959
		Dec 1940	'a mere handful'	Individuals	Decimated by weka	Observation	Wilson 1959
Herekopare I. (Te Marama)	STW	Oct 1911	1000s	Individuals	–	Observation	Guthrie-Smith 1914
		May 1942	100s	Individuals	Cat predation observed	Observation	Richdale 1944a
		Dec 1968	0	Individuals	–	Observation	Adams & Cheyne *in* Fitzgerald & Veitch 1985
		Apr–May 1970	1	Individual	–	Observation	Fitzgerald & Veitch 1985
Halfmoon Bay Islet	STW	1939/40	16	Individuals	Skua midden	Observation	B. Marples *in* Anonymous 1953
Whero Rock	STW	1941	50	Pairs		Count	Richdale 1942
		1942/43	200	Individuals	–	Count	Richdale 1944a
		Nov 2010	0	Individuals	Nesting site destroyed by shags	Count	Peat 2011
Pukeweka I.	STW	1931	–	Individuals	–	Observation	Wilson 1959
Kundy I.	STW	Nov 1929	–	Pairs	–	Observation	Wilson 1959
		Mar 2011	50	Individuals	Also 52 in skua middens	Observation	C. Miskelly, unpub. data
Big I.	STW	Mar 1965	–	Individuals	Common	Observation	Blackburn 1965
Mokiiti/. Little Moggy I	STW	2006	–	Pairs	–	Observation	M. Charteris, unpub. data

continued on following page

Table 1 Population data for broad-billed prions (*Pachyptila vittata*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Mokinui/ Big Moggy I.	STW	2007	–	Pairs	–	Observation	M. Charteris, unpub. data
Putauhinu I.	STW	Mar 2011	1	Individual	Heard at night	Observation	C. Miskelly, unpub. data
Tamaitemioka I.	STW	Mar 1965	–	Individuals	Skua middens	Observation	Blackburn 1965
Rerewhakaupoko I. (Solomon)	STW	Nov 1931	–	Pairs	–	Observation	Wilson 1959
		Mar 2012	7	Individuals	At night	Observation	C. Miskelly, unpub. data
Pohowaitai I.	STW	Mar 1965	–	Individuals	Skua middens	Observation	Blackburn 1965
Weka I.	STW	Nov 1931	–	Pairs	–	Observation	Wilson 1959
Taukihepa/ Big South Cape I.	STW	Jun 1955– May 1956	–	Individuals	–	Observation	Falla *in* Blackburn 1965
The Sisters (Rangitatahi) (middle island)	CIS	Oct 1973	1	Pair	1 chick	Observation	Imber 1994
		Sep 1976	1	Pair	1 egg	Observation	Imber 1994
S of Owenga, Chatham I.	CIS	Apr 1983	–	Burrows	15 adults killed by cats	Observation	Imber 1994
Stack off Cascades	CIS	Apr 1981	15	Burrows	–	Count	Imber 1994
Blyth's Stack	CIS	Nov 1983	18	Pairs	Chicks	Observation	Imber 1994
Houruakopara I.	CIS	Aug 1980	2	Pairs	–	Observation	Imber 1994
		Nov 1987	300	Pairs	–	Count	Plant 1989
Pitt I. (Rangiauria)	CIS	1871/72	> 100	Individuals	Preyed upon by cats	Observation	Travers & Travers 1872
		1923/24	–	Pairs	–	Observation	Archey & Lindsay 1924
		1937	–	Pairs	–	Observation	Fleming 1939
		1951–53	–	Pairs	Preyed upon by cats	Observation	Bell 1955
		Apr 1967	–	Individuals	–	Observation	Imber 1994
		Apr 1993	5	Individuals	Appeared to be killed by cats (A. Tennyson, pers. obs.)	Observation	AV36939, Canterbury Museum
Star Keys	CIS	1960s–70s	25	Individuals	–	Observation	Imber 1978
		Feb 1988	Many	Individuals	Killed by skuas; probably few nesting	Observation	A. Tennyson, unpub. data
Rabbit I.	CIS	Nov 1980	> 100	Pairs	–	Observation	Imber & Lovegrove 1982

continued on following page

Table 1 Population data for broad-billed prions (*Pachyptila vittata*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Kokope I.	CIS	–	–	–	Breeding	Observation	Imber 1994
		Dec 1997	150	Pairs	Heavily preyed on by weka	Observation	A. Tennyson, unpub. data
Mangere I.	CIS	1871/72	–	Burrows	?Breeding	Observation	Tennyson & Millener 1994
		1923/24	–	Burrows	–	Observation	Archey & Lindsay 1924
		1937	–	Pairs	Abundant	Observation	Fleming 1939
		1957 [b]	–	Pairs	–	Observation	Tennyson & Millener 1994
		1981/82	–	Pairs	Many large chicks	Observation	D. Crouchley *in* Booth 1983
		1987/88	10,000	Pairs	–	Count	Tennyson 1989
Little Mangere I. (Tapuaenuku) The Fort	CIS	1937	–	Pairs	Abundant	Observation	Fleming 1939
Rangatira (South East I.)	CIS	Dec 1937	–	Pairs	Abundant	Observation	Fleming 1939
		Jul 1975	–	Individuals	Huge numbers	Observation	Imber 1994
		1981/82	–	Pairs	Many large chicks	Observation	D. Crouchley *in* Booth 1983
	CIS	1989/90	330,000	Pairs	–	Count	West & Nilsson 1994
		1989/90	$0.34/m^2$	Burrows	Assumed prion burrows	Count	West & Nilsson 1994
		1989/90	$1.34/m^2$	Burrows	All burrows	Count	West & Nilsson 1994
		Apr 1993	–	Individuals	Huge numbers	Observation	Imber 1994
		Mar 1999	$0.31/m^2$	Burrows	Assumed prion burrows	Count	Sullivan & Wilson 2001
		Apr 2002	$1.19 \pm 0.10/m^2$	Burrows	All burrows	Count	Roberts *et al.* 2007
Western Nugget, Murumuru Is	CIS	Dec 1987	20	Pairs	Densely burrowed; partial count	Observation	Tennyson *et al.* 1993
North East I.	SNI	Jan 1977	–	Pair	1 chick	Observation	Sagar 1977a
		1986	2000–5000	Pairs	–	Observation	Miskelly *et al.* 2001
		1986	265	Individuals	Skua middens	Count	Tennyson 2013
		Dec 2013	103	Individuals	Skua middens	Count	Tennyson 2013
(South Bay)		Feb 1986	350	Individuals	–	Observation	Miskelly *et al.* 2001
		Nov 1986	60	Pairs	Chicks; partial count	Observation	Miskelly *et al.* 2001
		Dec 2013	6	Pairs	Chicks; partial count	Count	Tennyson 2013
Rocky Islet	SNI	1971/72	3	Pairs	–	Observation	Horning & Horning 1974
		Dec 1976	2	Pairs	2 chicks	Observation	Sagar 1977a
		Dec 1984	1	Pair	1 chick	Observation	Miskelly *et al.* 2001

continued on following page

Table 1 Population data for broad-billed prions (*Pachyptila vittata*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Alert Stack	SNI	Feb 1985	1	Individual	–	Observation	Miskelly *et al.* 2001
Broughton I.	SNI	Nov 1976	–	Individuals	Killed by skuas	Observation	P. Sagar *in* Edgar 1977
		Feb 1984	–	Individuals	–	Observation	Miskelly *et al.* 2001
Toru Islet[c]	SNI	Dec 1984	2	Pairs	2 chicks	Observation	Miskelly 1997
		Jan 1986	3	Pairs	1 egg, 2 chicks	Observation	Miskelly *et al.* 2001

(a) Gaze (1988) and Marchant & Higgins (1990) noted breeding observations from unspecified locations in Breaksea Sound; we provide more detailed observations from this area.
(b) Apparently, the year was incorrectly given as 1961 in Tennyson & Millener (1994: table 1), as Lindsay visited in 1957 (Lindsay *et al.* 1959). However, Lindsay's diary of this trip, supposedly held in Te Papa's archives (Tennyson & Millener 1994), could not be located in 2015 (J. Twist, pers. comm.).
(c) Note that while broad-billed prions have been reported from skua middens on Rima Islet (Snares Is/Tini Heke; Sagar 1977b), there is no evidence that the species breeds there (C. Miskelly, unpub. data).

declines. For example, thousands of birds were believed to have been nesting on Anchor I. in Dusky Sound, Fiordland, during James Cook's visit in 1773; however, by 1900 a breeding population was no longer present there (Medway 2011). Similar declines resulting in localised extinction are suspected at the colony on the neighbouring Seal Is (Medway 2011). To the east on Kokope I. (Chatham Is), and at Solander I. (Hautere) and Jacky Lee I. (Pukeokaoka) (both in the Stewart I./Rakiura region), the populations were being heavily depredated by weka (*Gallirallus australis*). Prions trying to nest on Chatham I. were reported to be heavily preyed upon by cats (*Felis catus*; Imber 1994). On Herekopare I. (Te Marama), off Stewart I./Rakiura, the population went from thousands of individuals in 1911 to a single individual in 1970, reportedly due to cat predation (Guthrie-Smith 1914; Fitzgerald & Veitch 1985). The entire population on Whero Rock was extirpated after colonisation by the New Zealand endemic Stewart Island shag (*Leucocarbo chalconotus*), whose nesting activity destroyed the small cap of vegetation on the islet (Richdale 1944a; Peat 2011). The Chatham Is host the largest portion of New Zealand's breeding population of broad-billed prions, yet there have not been any repeated counts at the large colony at Mangere I. and only a limited number of counts conducted at Rangatira (South East I.), the most recent being in 2002. Despite huge colonies of prions formerly being present in southern New Zealand, the largest known documented remaining colonies in recent times are at the Snares Is/Tini Heke (2000–5000 pairs in 1986) and on the Sealers Bay stacks off Codfish I./Whenua Hou (1000–2000 burrows in 1991; Table 1). However, the number of birds in the Fiordland and Stewart I./Rakiura regions is poorly known and more detailed surveys are warranted there.

Antarctic prion

The Auckland Is are the stronghold of Antarctic prions breeding in New Zealand (Table 2); the species has been reported from eight different islands in the group. However, there are no substantive data from which to assess population size among the 19 records for the species in the group, and so we are unable to draw conclusions about their population status or trends.

Fairy prion

With numbers of breeding pairs in the millions, fairy prions are among the most common seabird species nesting in New Zealand (sooty shearwater, *Puffinus griseus*, is the most abundant; see Waugh *et al.* 2013 for a population assessment). They are also one of the most widespread New Zealand seabird species, with a geographic range extending from the Poor Knights Is in Northland to Stewart I./Rakiura and the Antipodes Is. (Table 3). The largest colony within New Zealand, and likely the world, is on Stephens I./Takapourewa in the Marlborough Sounds, which has about 1.4 million pairs (Craig 2010). The limited information available suggests that the second-largest colony in the New Zealand region is on Mangere I. in the Chatham Is, with

Table 2 Population data for Antarctic prions (*Pachyptila desolata*) nesting in New Zealand (AKI = Auckland Is; CBL = Campbell I./Motu Ihupuku; dash = no data or comments; see 'Methods' for sampling protocol).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Auckland Is[a]	AKI	1984	100,000–1,000,000	Pairs	–	Unknown	Robertson & Bell 1984
		1990	350,000–750,000	Pairs	–	Unknown	Marchant & Higgins 1990
Enderby I.	AKI	1944	–	Pairs	Common	Observation	Turbott 2002
		Jan 1966	–	Burrows	–	Observation	Taylor 1971
		Dec 1976	–	Individuals	Skua middens	Observation	Bartle & Paulin 1986
		Feb 1988	–	Pairs	Calling from burrows, 1 adult seen in burrow	Observation	G. Taylor, unpub. data
Rose I.	AKI	Jan 1966	–	Burrows	–	Observation	Taylor 1971
Auckland I.	AKI	1907	–	Burrows	Common[b]	Observation	Waite 1909
		1944	–	Pairs	Common	Observation	Turbott 2002
		Feb 1973	–	Pairs	Most common petrel	Observation	Challies 1975
		Feb–Mar 1982	100+	Individuals	Killed by cats	Observation	Thompson 1986
		Feb 1988	–	Individuals	Many birds killed by cats outside burrows	Observation	G. Taylor, unpub. data
Ocean I.	AKI	1972	4	Individuals	–	Observation	K.-J. Wilson, unpub. data
		Feb 1988	–	Pairs	Calling from burrows	Observation	G. Taylor, unpub. data
Shoe I.	AKI	1903	–	Burrows	–	Observation	Waite 1909
Disappointment I.	AKI	Nov 1907	–	Individuals	Remains only	Observation	Waite 1909
Adams I.	AKI	1944	–	Pairs	Common	Observation	Turbott 2002
		Nov 1989	–	Pairs	–	Observation	Buckingham *et al.* 1991
Masked I.	AKI	Nov 2013	2	Pairs	–	Count	K.-J. Wilson, unpub. data
Northwest Bay stack	CBL	Jan 1986	1	Individual	Found in a burrow; probably this species	Observation	D. Cunningham, pers. comm. to G. Taylor
Eboulé Peninsula, Campbell I./Motu Ihupuku	CBL	Jan 2006	1	Individual	Fledgling in skua midden; not clear evidence of breeding at this site	Observation	Miskelly & Fraser 2006

(a) Te Papa holds specimens of Antarctic prions that indicate additional or probable breeding islands in the Auckland Islands group: 1 egg (NMNZ OR.14749, collected 4 Dec 1943) and 1 chick (NMNZ OR.13031, collected 14 Jan 1943) from Figure of Eight Island; 2 adults (NMNZ OR.17547 and OR.17548, both collected 8 Jan 1973) from Ewing Island; 1 complete skeleton (NMNZ OR.19794, collected 21 Feb 1973) from Monument Island.

(b) Waite (1909) was uncertain if the burrows were created by Antarctic or broad-billed prions; the latter have never been observed in AKI, so we have assumed the burrows were made by Antarctic prions. Also, Antarctic prions were reported by Waite (1909) as being on the Antipodes Is but likely a case of misidentification, as only fairy prions have been sighted there by other observers (Tennyson *et al.* 2002).

Table 3 Population data for fairy prions (*Pachyptila turtur*) nesting in New Zealand (NL = Northland; KAP = Kapiti coast; MLS = Marlborough Sounds; WCN = west coast, North I.; WCS = west coast, South I.; CTC = Canterbury coastal; OTC = Otago coastal; FLD = Fiordland; STW = Stewart I./Rakiura; CIS = Chatham Is; SNI = Snares Is/Tini Heke; ANT = Antipodes Is; dash = no data or comments; see 'Methods' for sampling protocol).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Poor Knights Is	NL	1930s	–	Pairs	Burrows and eggs	Observation	Falla 1934
Tawhiti Rahi I., Poor Knights Is	NL	Jan 1943	–	Pairs	Small numbers	Observation	Buddle 1946
		Aug 1958	–	Individuals	Moderate numbers	Observation	Kinsky & Sibson 1959
		Dec 1958	1	Pair	Downy chick	Observation	Kinsky & Sibson 1959
		Sep 1980	1000s	Pairs	Many thousands	Observation	McCallum 1981
Aorangi I., Poor Knights Is	NL	Nov 1940	–	Pairs	Vast numbers	Observation	Buddle 1941
		Aug 1958	–	Individuals	Moderate numbers	Observation	Kinsky & Sibson 1959
		1964–75	40,000	Individuals	Extrapolation from plot surveys	Count	Harper 1976
		Nov 1990	–	Pairs	Many; some eggs	Observation	R. Parrish *in* Taylor & Parrish 1992
		Dec 2011	–	Pairs	Widespread	Observation	G. Taylor & A. Tennyson, unpub. data
Te Haupa I. (Saddle I.), off Great Barrier I. (Aotea I.)	NL	Prior to 1934	–	Pairs	Chicks	Observation	Falla 1934
		Apr 1990	0	Individuals	Ship rats present	Observation	G. Taylor & A. Tennyson, unpub. data
		Nov 1994	0	Individuals	Ship rats present	Observation	A. Tennyson & K. McConkey, unpub. data
Hauturu/ Little Barrier I.	NL	1886	–	Individuals	–	Observation	Reischek 1887
		Nov 1960	1	Individual	Presumed vagrant	Observation	Bishop 1963
		Dec 1962	1	Individual	Presumed vagrant	Observation	Bishop 1963
		1978–2015	0	–	No recent sightings	Observation	A. Tennyson, G. Taylor & C. Miskelly, unpub. data
Mana I.	KAP	2005	1	Nest	–	Count	Miskelly & Gummer 2013
		2008	3	Pairs	–	Count	Miskelly 2010
		2012	6	Pairs	–	Count	Miskelly & Gummer 2013
Stephens I. (Takapourewa)	MLS	1925	100,000s	Burrows	–	Observation	Guthrie-Smith 1936
		May 1974–Apr 1975	0.2–4.5/m^2	Burrows	Range	Count	Walls 1978
		1985	1,000,000	Individuals	–	Unknown	Harper 1985
		1990	500,000	Individuals	–	Unknown	Daugherty *et al.* 1990
		Jun–Dec 1994	0.5±0.3–1.4±0.2/m^2	Burrows	Varied by habitat (means ± SEs)	Count	Markwell 1997

continued on following page

Table 3 Population data for fairy prions (*Pachyptila turtur*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Stephens I. (Takapourewa) [*contd*]		Jun–Dec 1994	0.4±0.1–1.1±0.2/m^2	Pairs	Varied by habitat (means ± SEs)	Count	Markwell 1997
		Aug 1994	0.095/m^2 (0–0.371/m^2)	Burrows	Mean (range)	Count	Craig 2010
		Aug 1994	1,830,523	Burrows	–	Count	Craig 2010
		Aug 1994	1,418,665[a]	Pairs	Occupancy rate 0.775 (Craig 2010: table 14)	Count	Craig 2010
		1998	0.84/m^2 (0–3/m^2)	Burrows	Mean (range)	Count	Mulder & Keall 2001
Jag Rocks	MLS	1961	–	Individuals	–	Observation	B. Bell, unpub. data
		Apr 1987	–	Burrows	Abundant	Observation	G. Taylor, unpub. data
Middle Trio I., Trio Is (Kuru Pongi)	MLS	Apr 1963–Jan 1964	–	Pairs	Numerous	Observation	Campbell 1967
		1990	–	Individuals	–	Observation	Daugherty *et al.* 1990
Sentinel Rock	MLS	Apr 1987	–	Individuals	Feathers common in crevices	Observation	G. Taylor, unpub. data
Ninepin Rock, nr Chetwode Is	MLS	Aug 1993	–	Burrows	Numerous	Observation	D. Brown *in* O'Donnell 1995
The Haystack (Moturaka), nr Chetwode Is	MLS	Aug 1993	–	Burrows	Numerous	Observation	D. Brown *in* O'Donnell 1995
North Brother I.	MLS	Aug 1950–Feb 1951	–	Pairs	In great numbers	Observation	Sutherland 1951
		Oct 1990	1000	Pairs	–	Count	Gaston & Scofield 1995
		Oct 1990	0.03/m^2 (0–5/m^2)	Pairs	Mean (range)	Count	Gaston & Scofield 1995
		Oct 1990	1.4/m^2 (0–14/m^2)	Burrows	Mean (range)	Count	Gaston & Scofield 1995
		Feb 1993	1750	Burrows	Medium reliability	Count	K.-J. Wilson, unpub. data
South Brother I.	MLS	Early 1960s	–	Individuals	–	Observation	B. Bell & I. Crook, unpub. data
The Twins	MLS	1961	–	Individuals	–	Observation	B. Bell, unpub. data
Motungarara I.	MLS	1961	–	Individuals	–	Observation	B. Bell, unpub. data
Wall I.	WCS	Dec 2013	1255	Pairs	–	Count	R Lane & M. Charteris *in* R. Lane, unpub. data
		Dec 2015	1400	Pairs	–	Count	R. Lane, unpub. data

continued on following page

Table 3 Population data for fairy prions (*Pachyptila turtur*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Motukiekie Rocks	WCS	2000	–	Burrows	–	Observation	G. Wood, unpub. data
(islet)		Jan 1995	8	Nests	8 chicks	Observation	B. Stuart-Menteath *in* O'Donnell & West 1996
Murphy Beach stacks	WCS	Mar 2010	2	Nests	1 egg, 1 chick	Observation	OR.029176 and OR.029213, Te Papa
Arnott Point islet	WCS	Mar 2010	1	Nest	1 chick	Observation	OR.029177, Te Papa
Taumaka I., Open Bay Is	WCS	1907	–	Nests	See note b	Observation	Waite 1909
		Feb 1973	–	Nests	Uncommon	Observation	K.-J. Wilson, unpub. data
		Oct 1980	–	Nests	Uncommon	Observation	K.-J. Wilson, unpub. data
		Aug 1986	10s	Nests	Some weka predation	Observation	A. Tennyson, unpub. data
		1994/95	–	Nests	Chick remains	Observation	Miller 1997
Barn Is	WCS	Mar 2011	–	Burrows	Numerous	Observation	Lettink *et al.* 2013
Motunau I.	CTC	1958	9900	Burrows	–	Observation	Cox *et al.* 1967
		1962	14,000	Burrows	–	Count	Cox *et al.* 1967
		1961–63	27,500	Individuals	Very rough estimate	Count	Cox *et al.* 1967
		Dec 1983	–	Pairs	Many	Observation	J. Fennell & P. Sagar *in* Gaze 1985
		Dec 1996–Jan 1997	14,000	Burrows	–	Count	Beach *et al.* 1997
		2004	–	Individuals	Harrier midden	Observation	Hawke *et al.* 2005
Crown I. (Le Bons Bay to Pompeys Pillar)	CTC	1960	–	Pairs	Nesting densely	Observation	B. Bell *in* Wilson 2008[c]
		Dec 2000	255	Burrows	–	Count	Wilson 2008
Islet, Redcliffe Nook	CTC	Dec 2000	30	Pairs	–	Count	Wilson 2008
Islet, Island Nook	CTC	1960	–	Pairs	–	Observation	B.Bell *in* Wilson 2008
		Dec 2000	150	Pairs	–	Count	Wilson 2008
Islet, Island Bay	CTC	1960	–	Pairs	–	Observation	B.Bell *in* Wilson 2008
		Dec 2000	300	Pairs	–	Count	Wilson 2008
Wharekakahu	OTC	Nov 1983	2000–3000	Burrows	Occupancy rate 70% at plot examined	Count	Ward & Munro 1989
Gull Rocks	OTC	1990s	–	Pairs	–	Observation	Loh 2000

continued on following page

Table 3 Population data for fairy prions (*Pachyptila turtur*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Green I.	OTC	1980s	–	Pairs	Important breeding area	Observation	Ward & Munro 1989
		No date	–	Pairs	–	Observation	Loh 2000
Tunnel Beach (Prion Cave)	OTC	Feb 1997	8	Burrows	–	Count	Loh 2000
		Aug 1996	–	Individuals	–	Observation	Loh 2000
(Prion Cleft)		Jan 1993	70	Individuals	14 potential nests	Count	Loh 2000
(Prion Cliff)		Oct 1998	160	Individuals	Artificial nests installed from 1994	Count	Loh 2000
Rock stacks, Catlins	OTC	No date	–	Pairs	'Small colonies'	Observation	Loh 2000
Solander I. (Hautere)	FLD	Jul 1948	–	Burrows	Weka patrolling	Observation	Falla 1948
		Jan 1973	–	Individuals	Bones	Observation	Wilson 1973
		Nov 1973	–	Pairs	Small colony	Observation	Cooper *et al.* 1986
		Nov 1976	–	Individuals	Small numbers	Observation	Cooper *et al.* 1986
		Feb 1996	100s	Pairs	Many killed by weka	Observation	A. Tennyson & G. Taylor, unpub. data
		Jul 1997	–	Pairs	Scattered in areas inaccessible to weka	Observation	G. Taylor, unpub. data
Little Solander I.	FLD	Jul 1948	–	–	Remains in 'skua and (or) hawk castings'	Observation	Falla 1948
		Nov 1976	–	Individuals	Small numbers	Observation	Cooper *et al.* 1986
		Jul 1985	1	Individual	Seen in flight	Observation	Cooper *et al.* 1986
Codfish I./ Whenua Hou	STW	Dec 1934	–	Pairs	Small numbers	Observation	Wilson 1959: 75
		1991–2011	0	–	No recent sightings	Observation	G. Taylor, A. Tennyson & C. Miskelly, unpub. data
Green I.	STW	Nov 1941	1,000,000 ($<1/m^2$)	Burrows	–	Count	Stead 1953
		Nov 1941	1,500,000[d]	Pairs	–	Count	Wilson 1959
		Dec 2012	–	Individuals	Only 6 corpses; weka present	Observation	Miskelly 2013c, unpub. data
North I., Titi/ Muttonbird Is	STW	Oct 1911	–	Individuals	–	Observation	Guthrie-Smith 1914
Jacky Lee I. (Pukeokaoka)	STW	Dec 1932	–	Pairs	'Fairly plentiful'; many taken by weka	Observation	Wilson 1959
		Dec 1940	–	Individuals	'A mere handful'; decimated by weka	Observation	Wilson 1959
Herekopare I. (Te Marama)	STW	Oct 1911	1000s	Individuals	–	Observation	Guthrie-Smith 1914
		Aug 1941	10s	Individuals	Some dozens	Observation	Richdale 1944b
		Dec 1968	–	Pairs	A very large population	Observation	Adams & Cheyne *in* Fitzgerald & Veitch 1985

continued on following page

Table 3 Population data for fairy prions (*Pachyptila turtur*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Halfmoon Bay Islet	STW	1939/40	44	Individuals	Skua midden	Observation	Anonymous 1953
Bench I.	STW	Nov 1971	1	Individual	–	Observation	K.-J. Wilson, unpub. data
Whero I.	STW	1940s	1000	Individuals	–	Count	Richdale 1965
		1941	400	Pairs	–	Count	Richdale 1942
		2010	0	Individuals	–	Count	Peat 2011
Kundy I.	STW	Nov 1929	–	Pairs	–	Observation	Wilson 1959
		Mar 2011	1000s	Individuals	Also 44 in skua middens	Observation	C. Miskelly, unpub. data
Mokiiti/ Little Moggy I.	STW	2007	–	Pairs	NW and NE headlands	Observation	M. Charteris, unpub. data
Big I.	STW	Mar 1965	–	Individuals	Carcasses	Observation	Blackburn 1965
Kaimohu I.	STW	Feb 1965	–	Individuals	Skua middens	Observation	Blackburn 1965
Putauhinu I.	STW	Mar 2011	1	Individual	Heard at night	Observation	C. Miskelly, unpub. data
Tamaitemioka I.	STW	Mar 1965	–	Individuals	Skua middens	Observation	Blackburn 1965
Rerewhakaupoko I. (Solomon)	STW	Nov 1931	–	Pairs	–	Observation	Wilson 1959
		Jan 1955–May 1956	–	Individuals	–	Observation	Falla *in* Blackburn 1965
Pohowaitai I.	STW	Dec 1929	–	Pairs	In burrows	Observation	E. Stead diary (C. Miskelly, unpub. data)
		Mar 1965	–	Individuals	Skua middens	Observation	Blackburn 1965
Taukihepa/ Big South Cape I.	STW	Jun 1955–May 1956	–	Individuals	–	Observation	Falla *in* Blackburn 1965
		Apr 1961	–	Individuals	Common	Observation	Bell & Merton *in* Blackburn 1965
		Aug 1964	–	Individuals	–	Observation	Bell & party *in* Blackburn 1965
Chatham Is	CIS	1871/72	–	Pairs	'Immense numbers'	Observation	Travers & Travers 1872
The Sisters (Rangitatahi) (western island)	CIS	No date	–	Pairs	–	Observation	Imber 1994
(middle island)		Jan 1954	2	Pairs	–	Observation	Dawson 1955; Marchant & Higgins 1990
		Jan 1974	1	Nest	1 chick	Observation	Imber 1994
Star Keys	CIS	1960s–70s	25	Individuals	–	Observation	Imber 1978
		Feb 1988	Many	Individuals	Killed by skuas; probably few nesting	Observation	A. Tennyson, unpub. data

continued on following page

Table 3 Population data for fairy prions (*Pachyptila turtur*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Rabbit I.	CIS	Oct–Nov 1980	100s	Individuals	Eggs noted	Observation	Imber & Lovegrove 1982; Imber 1994
		Apr 1981	–	Individuals	Many visiting	Observation	Imber 1994
Kokope I.	CIS	No date	–	Pairs	–	Observation	Imber 1994
		Dec 1997	0	Individuals	–	Observation	A. Tennyson, unpub. data
Mangere I.	CIS	1871/72	–	Individuals	Probably in 'immense numbers'	Observation	Travers & Travers 1872
		1923/24	–	Burrows	Numerous	Observation	Archey & Lindsay 1924
		1937	–	Pairs	–	Observation	Fleming 1939
		Jul 1975	–	Individuals	Abundant	Observation	Imber 1994
		Oct 1980	1000s	Pairs	Some thousands	Observation	T.G. Lovegrove *in* Booth 1982
		1987/88	30,000	Pairs	–	Count	Tennyson 1989[e]
Little Mangere I. (Tapuaenuku) The Fort	CIS	1937	–	Pairs	–	Observation	Fleming 1939
Western Nugget, Murumuru Is	CIS	Dec 1987	1	Nest	Partial count	Observation	Tennyson *et al.* 1993
Daption Rocks (north)	SNI	Feb 1977	–	Individuals	Killed by skuas	Observation	Miskelly *et al.* 2001
(south)		Nov 1976	–	Pairs	–	Observation	Miskelly *et al.* 2001
North East I.	SNI	1985–87	3500	Pairs	–	Count	Miskelly *et al.* 2001
Rocky Islet	SNI	Dec 1971	3	Individuals	–	Observation	K.-J. Wilson, unpub. data
		Dec 1976	–	Pairs	–	Observation	Miskelly *et al.* 2001
		Dec 1984	3	Pairs	3 eggs	Observation	Miskelly *et al.* 2001
Alert Stack	SNI	Dec 1976	–	Pairs	–	Observation	Miskelly *et al.* 2001
Broughton I.	SNI	Feb 1984	–	Individuals	–	Observation	Miskelly *et al.* 2001
		Mar 1992	500	Pairs	–	Observation	Miskelly *et al.* 2001
Antipodes Is (all islands)	ANT	Jan–Mar 1969	0	Individuals	Unable to find any on land	Observation	Warham & Bell 1979
		Apr 2001	–	Individuals	Scores	Observation	Imber *et al.* 2005
Antipodes I.	ANT	Nov–Dec 1978	20+	Pairs	Not in large numbers	Observation	Imber 1979, 1983
		Nov 1995	1000–5000	Pairs	–	Observation	Tennyson *et al.* 2002
Bollons I.	ANT	Nov–Dec 1978	–	Pairs	–	Observation	Imber 1979, 1983

continued on following page

Table 3 Population data for fairy prions (*Pachyptila turtur*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Archway I.	ANT	Nov–Dec 1978	–	Individuals	–	Observation	Imber 1979

(a) This value differs from the population total of 2,160,017 pairs in Craig (2010). Craig's total assumes that burrow count equals nesting population, but values from her table 14 suggest a burrow occupancy rate of 0.775, and hence a population of 1,418,665 breeding pairs (1,850,523 × 0.775) is more accurate.
(b) Listed as probably Antarctic prions but assumed to be fairy prions as they are the only species to have been recorded nesting in the area by other observers.
(c) A fledgling was collected by E. Stead and A. Brooks Jr. in 1935 at an 'Islet near Akaroa Inlet' (Museum of Vertebrate Zoology, Berkeley (MVZ Birds 72373), retrieved on 9 April 2014 from http://arctos.database.museum/guid/MVZ:Bird:72373) – this location is probably one of the islets discussed by Wilson (2008).
(d) Assumed to be primarily fairy prions, although there are likely to be some broad-billed prions included in this count as Stead (1953) estimated a ratio of one broad-billed prion to every 12 fairy prions.
(e) An estimate of 40,000 pairs (Taylor 2000b; Aikman & Miskelly 2004) is based on a misquotation of Tennyson (1989), which states 30,000 pairs.

30,000 pairs (Tennyson 1989), followed by Aorangi I. in the Poor Knights Is, with 40,000 individuals (Harper 1976), then Motunau I. in Canterbury, with 14,000 burrows (Cox *et al.* 1967), although admittedly some of these data are decades old and the current sizes of these colonies may have changed significantly. More than 2000 pairs are also likely to nest on Tawhiti Rahi I. in the Poor Knights Is (McCallum 1981), Wharekakahu in Otago (Ward & Munro 1989), Herekopare I. (Te Marama) and Kundy I., both in the Stewart I./Rakiura region (Guthrie-Smith 1914; C. Miskelly, unpub. data), North East I. in the Snares Is/Tini Heke (Miskelly *et al.* 2001) and Antipodes I. (Tennyson *et al.* 2002).

Although the species was reported in 66 locations from 152 records, population trends can be estimated at only nine colonies. The largest apparent increase was at Stephens I. (Takapourewa), where reported numbers went from 1 million individuals in 1985 to 1.4 million pairs in 1994 (Harper 1985; Craig 2010; this study). A five- to sixfold increase in population size over nine years is highly improbable, so these differences presumably reflect differing methodologies. However, a more detailed examination of data reported by Walls (1978) and Mulder & Keall (2001) does indicate that the population on Stephens I. (Takapourewa) has grown over time. Both studies conducted surveys in the same area of the island (Keeper's Bush), and found that the density of burrows increased from 0.70/m^2 in 1975 to 0.95/m^2 in 1998 (note that the numbers reported in Table 3 are for the entire island, not just Keeper's Bush). This population increase is presumably happening as a result of land being retired from farming and the habitat improvements associated with extensive planting of new forest areas (currently coordinated by the Department of Conservation). Stock trampling of burrows in the past would have reduced burrow densities over large parts of the island (Taylor, pers. obs.).

Fairy prion numbers appear to have remained stable at Wall I. in Westland, with between 1255 and 1400 pairs recorded in 2013 and 2015 (R. Lane, unpub. data). The tiny Mana I. colony has been slowly growing after it was established using translocated chicks (Miskelly & Gummer 2013). The Motunau I. population appears to have remained stable from 1962 to 1996 (Cox *et al.* 1967; Beach *et al.* 1997). In contrast, six other colonies appear to have decreased in size or been extirpated.

The most substantial decline occurred on Green I., northeast of Stewart I./Rakiura. An estimated 1.5 million pairs were nesting on the island in November 1941 (Wilson 1959), yet in December 2012 there was very little sign of any nesting prions (Miskelly 2013c). Weka are present on the island (Miskelly 2013c), but it is unclear if weka predation could have caused such a massive decline in prion numbers. On nearby Jacky Lee I. (Pukeokaoka), where weka were not harvested by muttonbirders, the dense weka population all but extirpated fairy prions within a few decades (Wilson 1959). On neighbouring Whero I., the population declined from 1000 individuals in the 1940s to a total absence in 2010 after an expanding colony of Stewart Island shags destroyed the vegetation on the islet (Richdale 1965; Peat

Table 4 Population data for fulmar prions (*Pachyptila crassirostris*) nesting in New Zealand (CIS = Chatham Is; BIS = Bounty Is; SNI = Snares Is/Tini Heke; AKI = Auckland Is; dash = no data or comments; see 'Methods' for sampling protocol).

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Chatham Is (total for all islands)	CIS	1984	1000– 5000	Pairs	–	Unknown	Robertson & Bell 1984
Motuhara (Forty-Fours)	CIS	1974	–	Individuals	–	Observation	Imber 1994
		Dec 1983	–	Pairs	Many	Observation	Imber 1994
The Pyramid (Tarakoikoia)	CIS	Dec 1937	–	Pairs	Numerous carcasses, 2 nests	Observation	Fleming 1939
		Nov 1974	–	Pairs	–	Observation	Imber 1994
		Dec 1987	7	Pairs	Partial count	Observation	Tennyson *et al.* 1993
Bounty Is (total for all islands)	BIS	1888	–	Nests	See note a	Observation	A. Reischek *in* Robertson & van Tets 1982
		1907	–	Nests	See note a	Observation	Waite 1909
		Nov 1978	76,000	Pairs	'Impossible to census'	Observation	Robertson & van Tets 1982
		1997	29,354	Pairs	Medium reliability	Count	Booth & Schmechel in Taylor 2000a
		1997	0.21/m^2	Nests	Medium reliability	Count	Booth *in* Taylor 2000a
Proclamation I.	BIS	Dec 1997	1235	Pairs	Good reliability	Count	Booth *in* Taylor 2000a
Toru Islet	SNI	Dec 1972	–	Pairs	–	Observation	Fleming & Baker 1973
		Nov 1976	–	Pairs	–	Observation	Sagar 1977b

continued on following page

2011). In 1934, a small fairy prion colony was apparently present on Codfish I./Whenua Hou (Wilson 1959), but weka and Pacific rats (*Rattus exulans*) were also present and the species has not been reported since, despite extensive research and management work at the site.

In 1886, fairy prions were reported to be present on Hauturu/Little Barrier I. (Reischek 1887), but again they have not been reported since. Cats and Pacific rats were present, so the colony may have been extirpated by them. The population on Te Haupa (Saddle I.), off Great Barrier I. (Aotea I.) appears to have been extirpated (reportedly by ship rats, *Rattus rattus*), although there are no data on the initial size of the population (Falla 1934). This suggests that the geographically isolated population currently nesting on the Poor Knights Is is a remnant of a more widespread northern New Zealand population. A fairy prion colony supposedly on the Marotere Is in Northland in the nineteenth century was probably misreported or a mis-identification of another petrel species (see Falla 1934; Skegg 1964).

Breeding fairy prions were reported on Kokope I. in the Chatham Is by Imber (1994), but the species was not found ashore in 1997 and there was considerable evidence of predation on other petrel species by weka (A. Tennyson, unpub. data).

Fulmar prion

Fulmar prion colonies were reported on the Chatham Is, Bounty Is, Snares Is/Tini Heke and Auckland Is (Table 4), but from only eight individual islands within these groups, and with counts from just two sites of the total 31 records. The Bounty Is are home to the largest population of breeding birds (29,354 pairs in 1997; Booth & Schmechel *in* Taylor 2000a). This was a significant decline from the

Table 4 Population data for fulmar prions (*Pachyptila crassirostris*) nesting in New Zealand. *Continued from previous page*

Locality name	Area	Dates	Counts	Status	Occurrence comments	Sampling protocol	Reference
Toru Islet [*contd*]		Feb 1984	300–400	Pairs	Later doubted by author	Observation	Miskelly 1984; Miskelly *et al.* 2001
		Dec 1984	4	Pairs	2 eggs, 2 chicks	Observation	Miskelly *et al.* 2001
		Jan 1986	6	Pairs	2–6 eggs and chicks	Observation	Miskelly *et al.* 2001
		Sep–Oct 2010	–	Individuals	Low numbers, widely distributed	Observation	Carroll & Charteris 2010
		Nov 2013	100s	Pairs	–	Observation	A. Tennyson & C. Miskelly, unpub. data
Rima Islet	SNI	Nov 1976	–	Pairs	–	Observation	Sagar 1977b
		Feb 1984	100–200	Pairs	–	Observation	Miskelly 1984
		Sep 2010	–	Individuals	Low numbers, widely distributed	Observation	Carroll & Charteris 2010
Auckland Is (total for all islands)	AKI	1984	1000–5000	Pairs	–	Unknown	Robertson & Bell 1984
		1998	<1000	Pairs	–	Observation	Tennyson & Bartle 2005
Rose I.	AKI	1943	–	Pairs	Small numbers	Observation	Taylor 1971
		Nov 1972–Mar 1973	–	Individuals	–	Observation	Bell 1975
		1998	Few 100	Pairs	Estimate based on densities nearby	Observation	Tennyson & Bartle 2005
Ocean I.	AKI	Jun 1998	<100	Pairs	–	Observation	Tennyson & Bartle 2005
Ewing I.	AKI	Nov 1972–Mar 1973	–	Individuals	–	Observation	Bell 1975
		Nov 1989	–	Individuals	–	Observation	Moore & McClelland 1990
		Jun 1998	100–400	Pairs	–	Observation	Tennyson & Bartle 2005

(a) Listed as *Pachyptila turtur* [= fairy prion] in Robertson & van Tets (1982) and *Prion desolatus* [=Antarctic prion] in Waite (1909) but assumed to be fulmar prions as they are the only species to have been recorded nesting at this island group by other observers.

1978 population estimate of 76,000 pairs, although as the researchers described them as 'impossible to census' (Robertson & van Tets 1982) it is difficult to be certain that the apparent decline is real. Apart from the colony at Proclamation I., the distribution of nesting islands within the Bounty Is group has not yet been reported. The population nesting on the Auckland Is in 1984 was estimated to be 1000–5000 pairs, but less than 1000 pairs 14 years later (Robertson & Bell 1984; Tennyson & Bartle 2005). Because such a wide range was reported for the 1984 estimate (and no information was given about the sampling protocol used), this difference cannot be considered real, and clearly there is a need for new and accurate surveys of the prion populations for this island group.

Discussion

We located 304 records of prions breeding on islands throughout New Zealand and its subantarctic and offshore islands, except the Kermadec Is. There are no population

Table 5 Population sizes and trends, and quality of information for four species of prion (*Pachyptila* spp.) nesting in the New Zealand region.

Species	Total population estimate (breeding pairs)	Estimated number of breeding sites (number of sites with population estimates or counts since 1995)	Trend information	Quality of information
Broad-billed prion	350,000	44 (6)	Unknown	Poor
Antarctic prion	350,000–1,000,000	8 (0)	Unknown	Poor
Fairy prion	1,500,000	64 (1)	Unknown	Poor
Fulmar prion	31,000–36,000	8 (4)	Unknown	Poor

estimates or counts for the majority of prion breeding sites and the data consist of five times more 'observations' than 'counts'. Moreover, there were very few sites where repeat counts have been conducted. For fairy and broad-billed prions, only 17% and 14% of colonies, respectively, have had their breeding populations estimated within the last 20 years (Table 5). No Antarctic prion colony estimates exist other than broad overall population estimates from more than 25 years ago, with no reference to how these numbers were attained.

This lack of data severely limited our ability to draw any conclusions about population sizes or to assess population trends. The paucity of information emphasises the need to collect baseline data. Without reliable information on population size and trend, decisions about management of threats are problematic. It is concerning that the number of population records has decreased since the 1980s–1990s, but offsetting this is the fact there has been an increase in the accuracy and repeatability of surveys since the 1980s.

There was evidence of population declines at several of the few broad-billed prion colonies where data allowed us to assess population trends. Population declines were due to both predation and habitat destruction by other seabirds. For example, the population on Anchor I. was likely to have been extirpated by stoats (*Mustela erminea*; see Medway 2011). On Herekopare I. (Te Marama), cats extirpated the broad-billed prion population (Fitzgerald & Veitch 1985), and cats continue to cause significant damage to wildlife populations at other sites, such as Chatham I. (Imber 1994). The populations of both broad-billed and fairy prions on Whero Rock were extirpated due to habitat destruction caused by Stewart Island shags (Peat 2011). However, the causes of decline are not always obvious. For instance, Rangatira (South East I.) is free of introduced predators (Aikman & Miskelly 2004), yet the density of broad-billed prion burrows between 1989 ($0.34/m^2$) and 1999 ($0.31/m^2$) has decreased by 8% and the rate of decline is even steeper if burrows of all sizes ($1.34/m^2$ in 1989, $1.19/m^2$ in 2002) are included (11%). There are no obvious reasons for this change. Western Gilbert I. (Fiordland), Sealers Bay stacks and Trig I. (Stewart I./Rakiura region), Mangere I. and Rangatira (South East I.) (Chatham Is), and North East I. (Snares Is/Tini Heke) may be good candidates for establishing regular long-term survey plots. They are widely dispersed throughout the broad-billed prion's New Zealand range. Furthermore, each site already has some level of baseline data and most are regularly visited by seabird researchers.

Due to the lack of data, it is impossible to estimate the current size of the New Zealand's breeding population of Antarctic prions. Estimates as high as 750,000 (Harper *in* Marchant & Higgins 1990) and 1 million pairs (Robertson & Bell 1984) have been published, but neither of these accounts provides any information about how the figures were determined. Within the New Zealand region, Antarctic prions have been confirmed nesting only on the Auckland Is. In the nineteenth century, these islands saw the arrival of sealers and whalers. This led to the introduction of mammals such as European rabbits (*Oryctolagus cuniculus*), cats, house mice (*Mus musculus*) and pigs (*Sus scrofa*) (Taylor 1971), which today remain predators of ground-nesting birds or cause significant habitat destruction. Some islands in this group (including Adams I. and Disappointment I.) have remained free of introduced mammals. Enderby I. and Rose I. had diverse introduced mammal communities, but these mammal species were eradicated in the early 1990s (Torr 2002). Auckland I. is the most heavily impacted by introduced mammals of all the islands in the group, and is the only island still supporting introduced mammals (pig, cat and house mouse) (Taylor 1968; Taylor 2000a). Monitoring Antarctic prions on Enderby I. and Adams I. is considered a high priority, particularly as these sites are regularly visited by researchers, while at Ewing I. the recent expansion of the *Olearia* forest (K.-J. Wilson, pers. obs.) indicates changes occurring at the site, which have potential to impact on the prion numbers.

Fairy prions are the most numerous and widespread species of prion nesting in New Zealand. The largest population, on Stephens I. (Takapourewa), numbers approximately 1.4 million pairs and appears to be growing (Craig 2010). While a few smaller colonies have declined or been extirpated, the vast majority of colonies lack data that would allow assessment of population trends. However, on Green I., near Stewart I./Rakiura, which was reported to have a population of more than a million pairs in the 1940s (Stead 1953; Wilson 1959), densities had declined to low levels by 2012 (Miskelly 2013c, unpub. data). This is likely to have been the largest single population in the region, and so it can be assumed that the number of fairy prions nesting around Stewart I./Rakiura is also likely to be small compared with populations of 70 years ago.

It is recommended that regular surveys of sites throughout the fairy prion's range are implemented. These are best done at Aorangi I. (Northland), Stephens I. (Takapourewa) (Marlborough Sounds), North Brother I. (Marlborough Sounds), Wall I. (West Coast), Motunau I. (Canterbury), Wharekakahu I. (Otago), Tunnel Beach (Otago), Mangere I. (Chatham Is), North East I. (Snares Is/Tini Heke) and Antipodes I. These islands provide geographic coverage throughout the range of colonies where quantitative data exist. Ideally, at least two populations in the Stewart I./Rakiura region should be monitored (e.g. Kundy I. and Herekopare I. (Te Marama)) as this region holds the most important fairy prion populations for the southern part of the species' New Zealand range. These are both traditional muttonbirding islands with restricted access; monitoring at these sites could potentially be undertaken by people with muttonbirding rights on the islands, but would require visits outside the March–May muttonbirding season.

Fulmar prion populations are poorly known. Brooke (2004) suggests a global population of 50,000–100,000 pairs, with all but the 1000–10,000 pairs estimated to be nesting on Australia's Heard I. nesting in New Zealand (Tennyson & Bartle 2005). However, our analysis suggests that the global population estimate is likely to be too high: the Bounty Is, where most fulmar prions breed, are estimated to have a nesting population of approximately 30,000 pairs (Taylor 2000a). The only other colonies of significant size are in the Chatham Is and Auckland Is, both of which Robertson & Bell (1984) estimated at 1000–5000 pairs. Robertson & Bell (1984) gave no information about how these numbers were arrived at, and more recent work by Tennyson & Bartle (2005) suggests that the Auckland Is population is less than 1000 pairs. The remaining site where the species is known to breed is the Western Chain of the Snares Is/Tini Heke, which is thought to hold less than 1000 pairs, resulting in a maximum global population of less than 47,000 pairs. This lower population estimate cannot be attributed to a population decline and the data are not accurate enough to enable trends to be determined – quantitative information about population sizes has only been collated since the 1990s. Further, there are significant challenges in surveying fulmar prions, which – unlike the other New Zealand nesting prion species – nest mostly in crevices and caves on very remote, seldom-visited islands, making them extremely difficult to survey. However, efforts should be made to monitor at least one colony at each island group where the species occurs in numbers, e.g. The Pyramid (Tarakoikoia) (Chatham Is), Proclamation I. (Bounty Is), Toru Islet (Snares Is/Tini Heke) and Ewing I. (Auckland Is).

While historical and recent counts reveal several significant changes in numbers at prion colonies, the Late Pleistocene/Holocene fossil record reveals some longer-term changes for fairy and broad-billed prions. There is evidence of prehistoric fairy prion colonies on the mainland of New Zealand, with abundant fossils at some South I. sites (Holdaway *et al.* 2001). All except a handful of birds nesting on the coast of Otago (Loh 2000) have been extirpated, presumably by introduced mammalian predators. While there is evidence for broad-billed prions formerly breeding on mainland South I., there is a suggestion that the species may be a recent colonist at the Chatham Is (Tennyson & Millener 1994; Holdaway *et al.* 2001).

Our review of published and unpublished data revealed that very little is known about the population status of any species of prion nesting in New Zealand, which is particularly concerning in light of the loss of 250,000 birds during the 2011 wreck (see above). For each species reviewed, the conclusions are similar – there is a lack of reliable data on which to assess the population size, status or trends. There is a need for population monitoring, even at large colonies, to ensure that further localised extinctions are not occurring. We strongly encourage baseline data to be collected at all major colonies, and the initiation of regular monitoring programmes for all species. This is particularly important for fulmar prions due to their small population size and sub-specific diversity (Tennyson & Bartle 2005). We recommend that surveys employ the methodologies promoted by the Population and Conservation Status Working Group of the Agreement on the Conservation of Albatrosses and Petrels (Wolfaardt & Phillips 2013). In brief, we consider that delineating permanent quadrats at representative habitat types throughout key colonies is necessary. Repeated estimates are needed every 5–10 years, counting all burrows within each quadrat and checking each burrow's occupancy. These data will allow for the calculation of habitat-specific density estimates, which can then be used to assess population trends and determine conservation statuses.

Acknowledgements

We thank Brian Bell for sharing his unpublished records and for his helpful discussion on the state of information; Robin Blyth for her work extracting data from New Zealand archives; Matt Charteris for contributions of unpublished data; Christine Kiddey (Te Papa) for locating references; and Jennifer Twist (Te Papa) for assisting with locating archives. Data collation was assisted by funding from the Department of Conservation's Terrestrial and Freshwater Biodiversity Information System (TFBIS) fund, while other funding for the project was contributed by Te Papa. We thank the many people who helped gather data in the field and contributed data to enable this review to be undertaken. We also thank Nicholas Carlisle and an anonymous reviewer of the paper.

References

Aikman, H. and Miskelly, C. (2004). *Birds of the Chatham Islands.* Wellington: Department of Conservation. xii + 116 pp.

Alley, R.B., Marotzke, J., Nordhaus, W.D., Overpeck, J.T., Peteet, D.M., Pielke Jr., R.A., Pierrehumbert, R.T., Rhines, P.B., Stocker, T.F., Talley, L.D. and Wallace, J.M. (2003). Abrupt climate change. *Science* 299: 2005–2010.

Anderson, O.R.J., Small, C.J., Croxall, J.P., Dunn, E.K., Sullivan, B.J., Yates, O. and Black, A. (2011). Global seabird bycatch in longline fisheries. *Endangered Species Research* 14: 91–106.

Anonymous. (1953). Annual report 1939–1940. Pp. 3–33. *In*: *Reports and bulletins (1939–1942) of the Ornithological Society of New Zealand.* xii + 98 pp.

Archey, G. and Lindsay, C. (1924). Notes on the birds of the Chatham Islands. *Records of the Canterbury Museum* 2: 187–201.

Bartle, J.A. and Paulin, C.D. (1986). Bird observations, Auckland Islands, December 1976. Pp. 51–61. *In*: Penniket, A., Garrick, A. and Breese, E. (*compilers*). *Preliminary reports of expeditions to the Auckland Islands Nature Reserve 1973–1984.* Wellington: Department of Lands and Survey Reserve Series. 231 pp.

Beach, G.S., Wilson, K.-J. and Bannock, C.A. (1997). A survey of the birds, lizards and mammals of Motunau Island, Canterbury, New Zealand. *Lincoln University Wildlife Management Report* 14. 19 pp.

Begg, A.C. and Begg, N.C. (1968). *Dusky Bay.* Christchurch: Whitcombe & Tombs. 240 pp.

Bell, B.D. (1975). Report on the birds of the Auckland Islands Expedition 1972–73. Pp. 136–142. *In*: Yaldwyn, J.C. (*compiler*). *Preliminary results of the Auckland Islands Expedition 1972–1973.* Wellington: Department of Lands and Survey Reserves Series. 447 pp.

Bell, L.C. (1955). Notes on the birds of the Chatham Islands. *Notornis* 6: 65–68.

Bishop, L.J. (1963). Partial confirmation of two of Reischek's Little Barrier records. *Notornis* 10: 306.

Blackburn, A. (1965). Muttonbird islands diary. *Notornis* 12: 191–207.

Blackburn, A. (1968). The birdlife of Codfish Island. *Notornis* 15: 51–65.

Booth, D.F. (*compiler*) (1982). Classified summarised notes 30 June 1980 to 30 June 1981. *Notornis* 29: 49–74.

Booth, D.F. (*compiler*) (1983). Classified summarised notes 30 June 1981 to 30 June 1982. *Notornis* 30: 34–68.

Brooke, M. de L. (2004). *Albatrosses and petrels across the world.* Oxford: Oxford University Press. 499 pp.

Brothers, N.P. (1984). Breeding, distribution and status of burrow-nesting petrels at Macquarie Island. *Australian Wildlife Research* 11: 113–131.

Buckingham, R.P., Elliott, G.P. and Walker, K.J. (1991). Bird and mammal observations on Adams Island and Southern Auckland Island. *Science and Research Internal Report* 105. Wellington: Department of Conservation. 16 pp.

Buddle, G. (1941). The birds of the Poor Knights. *Emu* 41: 56–68.

Buddle, G. (1946). A second visit to the Poor Knights. *Emu* 45: 315–318.

Carney, K.M. and Sydeman, W.J. (1999). A review of human disturbance effects on nesting colonial waterbirds. *Waterbirds* 22: 68–79.

Catry, P., Campos, A., Segurado, P., Silva, M. and Strange, I. (2003). Population census and nesting habitat selection of thin-billed prion *Pachyptila belcheri* on New Island, Falkland Islands. *Polar Biology* 26: 202–207.

Challies, C.N. (1975). Feral pigs (*Sus scrofa*) on Auckland Island: status, and effects on vegetation and nesting sea birds. *New Zealand Journal of Zoology* 2: 479–490.

Cooper, W.J. (1991). Birds of Centre Island. *Notornis* 38: 103–109.

Cooper, W.J., Miskelly, C.M., Morrison, K. and Peacock, R.J. (1986). Birds of the Solander Islands. *Notornis* 33: 77–89.

Cox, J.E., Taylor, R.H. and Mason, R. (1967). Motunau Island Canterbury, New Zealand; an ecological survey. *New Zealand Department of Scientific and Industrial Research Bulletin* 178. Wellington: Department of Scientific and Industrial Research. 112 pp.

Croxall, J.P., Butchart, S.H.M., Lascelles, B., Stattersfield, A.J., Sullivan, B., Symes, A. and Taylor, P. (2012). Seabird conservation status, threats and priority actions: a global assessment. *Bird Conservation International* 22: 1–34.

Daugherty, C.H., Towns, D.R., Atkinson, I.A.E. and Gibbs, G.W. (1990). The significance of the biological resources of New Zealand islands for ecological restoration. Pp. 9–21. *In*: Towns, D.R., Daugherty, C.H. and Atkinson, I.A.E. (*eds*). Ecological restoration of New Zealand islands. *Conservation Sciences Publication* 2. Wellington: Department of Conservation. 325 pp.

Dawson, E.W. (1955). The birds of the Chatham Islands 1954 expedition. *Notornis* 6: 78–82.

Easterling, D.R., Meehi, G.A., Parmesan, C., Changnon, S.A., Karl, T.R. and Mearns, L.O. (2000). Climate extremes: observations, modeling, and impacts. *Science* 289: 2068–2074.

Edgar, A.T. (*compiler*) (1977). Classified summarised notes. *Notornis* 24: 246–279.

Falla, R.A. (1934). The distribution and breeding habits of petrels in northern New Zealand. *Records of the Auckland Institute and Museum* 1: 245–260.

Falla, R.A. (1948). Birds of the Solanders. *New Zealand Bird Notes* 3: 52–55.

Fitzgerald, B.M. and Veitch, C.R. (1985). The cats of Herekopare Island, New Zealand; their history, ecology and affects on birdlife. *New Zealand Journal of Zoology* 12: 319–330.

Fleming, C.A. (1939). Birds of the Chatham Islands. Part I. *Emu* 38: 380–413.

Fleming, C.A. and Baker, A.N. (1973). The Snares Western Chain. *Notornis* 20: 37–45.

Gaston, A.J. and Scofield, P. (1995). Birds and tuatara on North Brother Island, Cook Strait, New Zealand. *Notornis* 42: 27–41.

Gaze, P.D. (*compiler*) (1985). Classified summarised notes, South Island, 1 July 1983 to 30 June 1984. *Notornis* 32: 140–151.

Gaze, P.D. (*compiler*) (1988). Classified summarised notes, South Island 1 July 1986 to 30 June 1987. *Notornis* 35: 311–323.

Gill, B.J., Bell, B.D., Chambers, G.K., Medway, D.G., Palma, R.L., Scofield, R.P., Tennyson, A.J.D. and Worthy, T.H. (2010). *Checklist of birds of New Zealand, Norfolk and Macquarie Islands, and the Ross Dependency, Antarctica.* 4th edn. Wellington: Te Papa Press in association with the Ornithological Society of New Zealand. x + 501 pp.

Gregory, M.R. (2009). Environmental implications of plastic debris in marine settings – entanglement, ingestion, smothering, hanger-on, hitch-hiking and alien invasions. *Philosophical Transactions of the Royal Society B* 364: 2013–2025.

Guthrie-Smith, H. (1914). *Mutton birds and other birds.* Christchurch: Whitcombe & Tombs. xii + 208 pp.

Guthrie-Smith, H. (1936). *Sorrows and joys of a New Zealand naturalist.* Dunedin: A.H. & A.W. Reed. 252 pp.

Harper, P.C. (1976). Breeding biology of the fairy prion (*Pachyptila turtur*) at the Poor Knights Islands, New Zealand. *New Zealand Journal of Zoology* 3: 351–371.

Harper, P.C. (1980). The field identification and distribution of the prions (genus *Pachyptila*), with particular reference to the identification of storm-cast material. *Notornis* 27: 235–286.

Harper, P.C. (1985). Fairy prion. p. 87. *In*: Robertson C.J.R. (*ed.*). *Reader's Digest complete book of New Zealand birds.* Auckland: Reed Methuen. 319 pp.

Harriss, G. (2016). *NZ topo map* [website]. Retrieved on 24 February 2016 from www.topomap.co.nz.

Hawke, D.J., Clark, J.M. and Challies, C.N. (2005). Verification of seabird contributions to Australasian harrier diet at Motunau Island, North Canterbury, using stable isotope analysis. *Notornis* 52: 158–162.

Hilton, G.M. and Cuthbert, R.J. (2010). The catastrophic impact of invasive mammalian predators on birds of the UK Overseas Territories: a review and synthesis. *Ibis* 152: 443–458.

Holdaway, R.N., Worthy, T.H. and Tennyson, A.J.D. (2001). A working list of breeding bird species of the New Zealand region at first human contact. *New Zealand Journal of Zoology* 28: 119–187.

Horning, D.S. and Horning, C.J. (1974). Bird records of the 1971–1972 Snares Islands, New Zealand, expedition. *Notornis* 21: 13–24.

Imber, M.J. (1978). Recent petrel research. *Wildlife – a Review* 9: 9–15.

Imber, M.J. (1979). Petrels of the Antipodes Islands. *Wildlife – a Review* 10: 11–15.

Imber, M.J. (1983). The lesser petrels of Antipodes Islands, with notes from Prince Edward and Gough Islands. *Notornis* 30: 283–298.

Imber, M.J. (1994). Seabirds recorded at the Chatham Islands 1960 to May 1993. *Notornis* (*Supplement*) 41: 97–108.

Imber, M.J., Bell, B.D. and Bell, E.A. (2005). Antipodes Islands birds in autumn 2001. *Notornis* 52: 125–132.

Imber, M.J. and Lovegrove, T.G. (1982). Leach's storm petrels (*Oceanodroma l. leucorhoa*) prospecting for nest sites on the Chatham Islands. *Notornis* 29: 101–108.

International Union for Conservation of Nature (2016). *The IUCN red list of threatened species 2015-4* [website]. Retrieved on 10 January 2016 from www.iucnredlist.org.

Kinsky, F.C. and Sibson, R.B. (1959). Notes on the birds of the Poor Knights Islands. *Notornis* 8: 132–141.

Land Information New Zealand (2012). *The New Zealand gazetteer of official geographic names* [website]. Retrieved on 15 January 2014 from www.linz.govt.nz/placenames/find-names/nz-gazetteer-official-names/index.aspx.

Lettink, M., Hopkins, G. and Wilson, R.L. (2013). A significant range extension and sanctuary for the rare Open Bay Island skink (*Oligosoma taumakae*). *New Zealand Journal of Zoology* 40: 160–165.

Lindsay, C.J., Phillipps, W.J. and Watters, W.A. (1959). Birds of Chatham Island and Pitt Island. *Notornis* 8: 99–106.

Loh, G. (2000). A mainland breeding population of fairy prions (*Pachyptila turtur*), South Island, New Zealand. *Notornis* 47: 119–122.

Marchant, S. and Higgins, P.J. (*eds*) (1990). *Handbook of Australian, New Zealand and Antarctic birds. Ratites to petrels. Vol. 1, part A.* Melbourne: Oxford University Press. 736 pp.

Markwell, T.J. (1997). Video camera count of burrow-dwelling fairy prions, sooty shearwaters, and tuatara on Takapourewa (Stephens Island), New Zealand. *New Zealand Journal of Zoology* 24: 231–237.

McCallum, J.M. (1981). Birds of Tawhiti Rahi Island, Poor Knights Group, Northland, New Zealand. *Tane* 27: 59–66.

Medway, D.G. (2002). A critical review of the prions (genus *Pachyptila*) collected and observed on Cook's voyages. *Notornis* 49: 59–75.

Medway, D.G. (2011). The broad-billed prion (*Pachyptila vittata*) nesting colonies recorded during Cook's visit to Dusky Sound in 1773. *Notornis* 58: 165–168.

Miller, C.J. (1997). Occurrence and ecology of the Open Bay Islands leech, *Hirudobdella antipodium*. *Science for Conservation* 57. Wellington: Department of Conservation. 16 pp.

Miskelly, C.M. (1984). Birds of the Western Chain, Snares Islands 1983–84. *Notornis* 31: 209–223.

Miskelly, C.M. (1997). Biological notes on the Western Chain, Snares Islands, 1984–85 and 1985–86. *Conservation Advisory Science Notes* 144. Wellington: Department of Conservation. 12 pp.

Miskelly, C. (2010). *Mana Island ecological restoration plan review.* Wellington: Department of Conservation. 45 pp.

Miskelly, C.M. (2011a). Riders of the storm – thousands of seabirds perish on New Zealand shores. Te Papa blog post, 18 July. Retrieved on 8 April 2014 from http://blog.tepapa.govt.nz/2011/07/18/riders-of-the-storm-thousands-of-seabirds-perish-on-new-zealand-shores.

Miskelly, C.M. (2011b). Riders of the storm – the severely depleted next generation. Te Papa blog post, 13 December. Retrieved on 8 April 2014 from http://blog.tepapa.govt.nz/2011/12/13/riders-of-the-storm-the-severely-depleted-next-generation.

Miskelly, C.M. (2013a). Fairy prion. *In*: Miskelly, C.M. (*ed.*). *New Zealand birds online* [website]. Retrieved on 29 April 2014 from www.nzbirdsonline.org.nz/species/fairy-prion.

Miskelly, C.M. (2013b). Broad-billed prion. *In*: Miskelly, C.M. (*ed.*) *New Zealand birds online* [website]. Retrieved on 29 April 2014 from www.nzbirdsonline.org.nz/species/broad-billed-prion.

Miskelly, C. (2013c). Green Island (Papatea) – 1941 and 2012 – in the footsteps of Edgar Stead (Part 8). Te Papa blog post, 8 January. Retrieved on 30 October 2014 from http://blog.tepapa.govt.nz/2013/01/08/green-island-1941-and-2012-in-the-footsteps-of-edgar-stead-part-8.

Miskelly, C. and Fraser, J. (2006). *Campbell Island snipe survey, January 2006.* Wellington: Department of Conservation. 28 pp.

Miskelly, C.M. and Gummer, H. (2013). Attempts to anchor pelagic fairy prions (*Pachyptila turtur*) to their release site on Mana Island. *Notornis* 60: 29–40.

Miskelly, C.M., Sagar, P.M., Tennyson, A.J.D. and Scofield, R.P. (2001). Birds of the Snares Islands, New Zealand. *Notornis* 48: 1–40.

Moller, H., Charleton, K., Knight, B. and Lyver, P. (2009). Traditional ecological knowledge and scientific inference of prey availability: harvests of sooty shearwater (*Puffinus griseus*) chicks by Rakiura Maori. *New Zealand Journal of Zoology* 36: 259–274.

Moore, P.J. and McClelland, P.J. (1990). Notes on birds of the Auckland Islands, November–December 1989. *Science and Research Internal Report* 93. Wellington: Department of Conservation. 13 pp.

Mulder, C.P. and Keall, S.N. (2001). Burrowing seabirds and reptiles: impacts on seeds, seedlings and soils in an island forest in New Zealand. *Oecologia* 127: 350–360.

O'Donnell, C.F.J. (*compiler*) (1995). Classified summarised notes, South Island, 1 July 1993 to 30 June 1994. *Notornis* 42: 263–279.

O'Donnell, C.F.J. and West, J.A. (*compilers*) (1996). Classified summarised notes, South Island and the Chatham Islands, 1 July 1994 to 30 June 1995. *Notornis* 43: 165–186.

O'Donnell, C.F.J. and West, J.A. (*compilers*) (1998). Classified summarised notes, South Island and outlying islands, 1 July 1995–30 June 1996. *Notornis* 45: 1–30.

Peat, N. (2011). *Seabird genius – the story of L.E. Richdale, the royal albatross, and the yellow-eyed penguin.* Dunedin: Otago University Press. 288 pp.

Plant, A.R. (1989). Incubation and early chick-rearing in the grey-backed storm-petrel (*Garrodia nereis*). *Notornis* 36: 141–147.

Post, P.W. (2007). Observations of prion (*Pachyptila*) wrecks on the west coast of South America. *Notornis* 54: 220–225.

Powlesland, R.G. (1989). Seabirds found dead on New Zealand beaches in 1986 and a review of *Pachyptila* species recoveries since 1960. *Notornis* 36: 125–140.

Reischek, A. (1887). Description of the Little Barrier or Hauturu Island, the birds which inhabit it, and the locality

as a protection to them. *Transactions and Proceedings of the New Zealand Institute* 19: 181–184.
Richdale, L.E. (1942). Whero Island: home of petrels and other birds. *Emu* 42: 85–105.
Richdale, L.E. (1944a). The parara or broad-billed prion *Pachyptila vittata* (Gmelin). *Emu* 43: 191–217.
Richdale, L.E. (1944b). The titi wainui or fairy prion *Pachyptila turtur*. *Transactions of the Royal Society of New Zealand* 74: 32–48.
Richdale, L.E. (1965). Breeding behaviour of the narrow-billed prion and broad-billed prion on Whero Island, New Zealand. *Zoological Society of London* 31: 87–155.
Roberts, C.M., Duncan, R.P. and Wilson, K.-J. (2007). Burrowing seabirds affect forest regeneration, Rangatira Island, Chatham Islands, New Zealand. *New Zealand Journal of Ecology* 31: 208–222.
Robertson, C.J.R. and Bell, B.D. (1984). Seabird status and conservation in the New Zealand region. Pp. 573–586. *In*: Croxall, J.P., Evans, P.G.H. and Schreiber, R.W. (*eds*). Status and conservation of the world's seabirds. *International Council for Bird Preservation Technical Publication* 2. Cambridge: International Council for Bird Preservation. 778 pp.
Robertson, C.J.R. and van Tets, G.F. (1982). The status of birds at the Bounty Islands. *Notornis* 29: 311–336.
Sagar, P.M. (1977a). Birds of the 1976-77 Snares Islands expedition. *Notornis* 24: 205–210.
Sagar, P.M. (1977b). Birds of the Western Chain Snares Islands, New Zealand. *Notornis* 24: 178–183.
Skegg, P.D.G. (1964). Birds of the Hen and Chicken Islands. *Notornis* 11: 159–176.
Stead, E. (1953). Birds on the islands around Stewart Island. Pp. 68–70. *In*: *Reports and bulletins (1939–1942) of the Ornithological Society of New Zealand.* xii + 98pp.
Sullivan, W. and Wilson, K.-J. (2001). Differences in habitat selection between Chatham petrels (*Pterodroma axillaris*) and broad-billed prions (*Pachyptila vittata*): implications for management of burrow competition. *New Zealand Journal of Ecology* 25: 65–69.
Sutherland, J.H. (1951). Bird notes from the Brothers Island. *Notornis* 4: 136–137.
Taylor, G.A. (2000a). Action plan for seabird conservation in New Zealand. Part A: Threatened seabirds. *Threatened Species Occasional Publication* 16. Wellington: Department of Conservation. 234 pp.
Taylor, G.A. (2000b). Action plan for seabird conservation in New Zealand. Part B: non-threatened seabirds. *Threatened Species Occasional Publication* 17. Wellington: Department of Conservation. 203 pp.
Taylor, G.A. (2011). Massive seabird mortality event. *Southern Bird* 47: 10–11.
Taylor, G.A. and Parrish, G.R. (*compilers*) (1992). Classified summarised notes, North Island 1 July 1990 to 30 June 1991. *Notornis* 39: 161–210.
Taylor, R.H. (1968). Introduced mammals and islands: priorities for conservation and research. *Proceedings of the New Zealand Ecological Society* 15: 61–67.
Taylor, R.H. (1971). Influence of man on vegetation and wildlife of Enderby and Rose Islands, Auckland Islands. *New Zealand Journal of Botany* 9: 225–268.
Tennyson, A.J.D. (2013). Were broad-billed prions from The Snares part of the massive die-off of this species in 2011? Te Papa blog post, 19 December. Retrieved on 8 April 2014 from http://blog.tepapa.govt.nz/2013/12/19/were-broad-billed-prions-from-the-snares-part-of-the-massive-die-off-of-this-species-in-2011.
Tennyson, A.J.D. and Bartle, J.A. (2005). A scientific name for fulmar prions nesting at Auckland and Heard Islands. *Notornis* 52: 47–55.
Tennyson, A.J.D., Mayhill, R.C. and Clark, G.S. (1993). A visit to The Pyramid and the Murumurus, Chatham Islands. *Tane* 34: 171–179.
Tennyson, A.J.D. and Millener, P.R. (1994). Bird extinctions and fossil bones from Mangere Island, Chatham Islands. *Notornis* (*Supplement*) 41: 165–178.
Tennyson, A.J.D. and Miskelly, C.M. (2011). An unprecedented prion wreck. *Southern Bird* 47: 11.
Tennyson, A.J.D., Taylor, R., Taylor, G., Imber, M. and Greene, T. (2002). Unusual bird records from the Antipodes Islands in 1978–1995, with a summary of other species recorded at the island group. *Notornis* 49: 241–245.
Thompson, P. (1986). Bird observations, Auckland Islands, February–March 1982. Pp. 75–77. *In*: Penniket, A., Garrick, A. and Breese, E. (*compilers*). *Preliminary reports of expeditions to the Auckland Islands Nature Reserve 1973–1984.* Wellington: Department of Lands and Survey Reserve Series. 231pp.
Torr, N. (2002). Eradication of rabbits and mice from subantarctic Enderby and Rose Islands. Pp. 319–328. *In*: Veitch, C.R. and Clout, M.N. (*eds*). *Turning the tide: the eradication of invasive species.* Cambridge: IUCN SSC Invasive Species Specialist Group. 422 pp.
Travers, H.H. and Travers, W.T.L. (1872). On the birds of the Chatham Islands, with introductory remarks on the avifauna and flora of the islands in their relation to those of New Zealand. *Transactions and Proceedings of the Royal Society of New Zealand* 5: 212–222.
Turbott, E.G. (2002). *Year away: wartime coastwatching on the Auckland Islands, 1944.* Wellington: Department of Conservation. xiv + 152 pp.
Waite, E.R. (1909). Vertebrata of the subantarctic islands of New Zealand. Pp. 542–600. *In*: Chilton, C. (*ed.*). *The subantarctic islands of New Zealand.* Wellington: Philosophical Institute of Canterbury. 848 pp.
Walls, G.Y. (1978). The influence of the tuatara on fairy prion breeding on Stephens Island, Cook Strait. *New Zealand Journal of Ecology* 1: 91–98.
Ward, G. and Munro, C.M. (1989). Otago II; biological survey of reserves. *Biological Survey of Reserves Series* 20. Wellington: New Zealand Department of Conservation. 356 pp.

Warham, J. (1996). *The behaviour, population biology and physiology of the petrels*. London: Academic Press. 613 pp.
Warham, J. and Bell, B.D. (1979). The birds of Antipodes Island, New Zealand. *Notornis* 26: 121–169.
Waugh, S.M., Tennyson, A.J.D., Taylor, G.A. and Wilson, K.-J. (2013). Population sizes of shearwaters (*Puffinus* spp.) breeding in New Zealand, with recommendations for monitoring. *Tuhinga* 24: 159–204.
West, J.A. and Nilsson, R.J. (1994). Habitat use and burrow densities of burrow-nesting seabirds on South East Island, Chatham Islands, New Zealand. *Notornis* (*Supplement*) 41: 27–37.
Wilson, G.J. (1973). Birds of the Solander Islands. *Notornis* 20: 318–323.
Wilson, K.-J. (2008). A brief survey of breeding seabirds on 4 islets off Banks Peninsula, South Island, New Zealand. *Notornis* 55: 101–103.
Wilson, R.A. (1959). *Bird islands of New Zealand*. Christchurch: Whitcombe & Tombs. vii + 202 pp.
Wolfaardt, A. and Phillips, R. (2013). Guideline census methodologies for albatrosses and petrels. *In*: *Agreement on the Conservation of Albatrosses and Petrels* [website]. Retrieved on 6 May 2014 from http://acap.aq/index.php/en/resources/acap-conservation-guidelines/doc_download/2187-census-guidelines.
Yool, A., Popova, E.E., Coward, A.C., Bernie, D. and Anderson, T.R. (2013). Climate change and ocean acidification impacts on lower trophic levels and the export of organic carbon to the deep ocean. *Biogeosciences* 10: 5837–5854.

Unpublished sources

Campbell, D.J. (1967). The Trio Islands, Marlborough Sounds: an ecological study of a bird modified island. M.A. thesis, Victoria University of Wellington. 216 pp.
Carroll, J. and Charteris, M. (2010). Trip report – Western Chain of the Snares Island Group September 25–October 14 2010. Unpublished NIWA report. 20 pp.
Craig, E.D. (2010). Takapourewa titiwainui (fairy prion; *Pachyptila turtur*): how nest site selection affects breeding success, with applications for translocation. M.Sc. thesis, University of Otago, Dunedin. 106 pp.
Tennyson, A.J.D. (1989). Sexual dimorphism in the calls of Procellariiformes. M.Sc. thesis, University of Auckland. 184 pp.

Tuhinga 27: 81–115 Copyright © Museum of New Zealand Te Papa Tongarewa (2016)

Legal protection of New Zealand's indigenous aquatic fauna – an historical review

Colin M. Miskelly

Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington, New Zealand
(colin.miskelly@tepapa.govt.nz)

ABSTRACT: At least 160 different pieces of New Zealand legislation affecting total protection of species of aquatic fauna (other than birds) have been passed since 1875. For the first 60 years, legislation focused on notification of closed seasons for New Zealand fur seals (*Arctocephalus forsteri*), for which the last open season was in 1946. All seal species (families Otariidae and Phocidae) have been fully protected throughout New Zealand continuously since October 1946. The first aquatic species to be fully protected were the southern right whale (*Eubalaena australis*) and pygmy right whale (*Caperea marginata*) within 3 nautical miles (5.6 km) of the coast in 1935. Attempts to protect famous dolphins (including Pelorus Jack in 1904 and Opo in 1956) were *ultra vires*, and there was no effective protection of dolphins in New Zealand waters before 1978. The extinct New Zealand grayling (*Prototroctes oxyrhynchus*) was fully protected in 1951, and remains New Zealand's only fully protected freshwater fish. Nine species of marine fishes are currently fully protected, beginning in 1986 (spotted black grouper, *Epinephelus daemelii*). Protection of corals began in 1980. The reasons why aquatic species were protected are explained, and their protection history is compared and contrasted with the history of protection of terrestrial species in New Zealand.

KEYWORDS: Environmental legislation, history of legal protection, marine mammals, marine reptiles, fish, sharks, coral, wildlife, animal protection, New Zealand.

Introduction

Legal protection is a necessary first step in protecting endangered species from exploitation, and has a long history of application in New Zealand (Galbreath 1989, 1993; McDowall 1994; Miskelly 2014). The first indigenous species to be granted full protection was the tūī (*Prosthemadera novaeseelandiae*) in 1878, and more than 130 native New Zealand bird species were absolutely protected by 1906 (Miskelly 2014). Full protection was extended to the terrestrial reptile tuatara (*Sphenodon punctatus*) in 1907, native frogs (*Leiopelma* spp.) in 1921 and native bats (*Mystacina* spp. and *Chalinolobus* spp.) in 1922. However, marine mammals, marine reptiles and fishes were among the faunal groups excluded from protection in the Animals Protection and Game Act 1921–1922, and of these, only marine reptiles were (implicitly) covered by the Wildlife Act 1953 (Miskelly 2014).

In contrast to the early absolute protection of many terrestrial animal species, exploitation of marine and freshwater species in New Zealand was managed initially through regulation of harvest season lengths and bag limits, rather than complete prohibition of harvest (McDowall 1994; Paul 2000; Young 2004). This contrast between management approaches for terrestrial and aquatic species reflected a similar situation for protection of habitats, where creation of marine reserves in New Zealand lags about a century behind protection of land habitats (Ballantine 1991; Young 2004; Enderby & Enderby 2006).

This review summarises legislation providing full protection for New Zealand's indigenous marine and freshwater fauna. It does not include the extensive legislation limiting harvests in New Zealand's fisheries, apart from any legislation prohibiting both commercial and amateur harvest of a species throughout the entire country for a year or longer. Nor does it include legislation providing protection for marine or freshwater areas (e.g. marine reserves). For introductions to New Zealand fisheries management and marine reserves, see Paul (2000: 173–238) and Enderby & Enderby (2006), respectively.

The main purpose of the review is to provide a database of when each species or species group received legal protection (and under which piece of legislation), as a resource for environmental managers and researchers. This review complements a previous review of legislation protecting New Zealand's terrestrial fauna (Miskelly 2014), and likewise includes information on why protection was sought for those species for which it has been granted. Together, the two reviews provide an insight into the development of a conservation ethos in New Zealand, based on public submissions to relevant government ministers and their departments, and the responses of government employees and ministers to demands for protection (or renewed harvest) of New Zealand wildlife.

Methods

Legislation and context relevant to the legal protection of New Zealand's aquatic wildlife were located through searches of paper-based, digital and online archives. The main paper-based archives searched were bound volumes of *Rules, Regulations and By-Laws Under New Zealand Statutes* (Volumes 1–13, 1910–36), *Statutory Regulations* (1936–2014) and *New Zealand Parliamentary Debates* (*NZPD*), held at the National Library and Wellington City Library, Wellington; archived files of government departments held at Archives New Zealand, Wellington; and subsequent files held at the Department of Conservation (DOC) and Ministry for Primary Industries (MPI) national offices in Wellington. Digital copies of the *New Zealand Gazette* (*NZG*, the official organ of the New Zealand legislative assembly) at the National Library and at Archives New Zealand were searched for keywords using optical character recognition. The main web-based source of New Zealand statutes searched was the New Zealand Legal Information Institute *NZLII Databases* (New Zealand Legal Information Institute n.d.), particularly 'New Zealand Acts as Enacted (1841–2007)', with citation details confirmed by inspection of bound copies of the *Statutes of New Zealand* and the *Statutes of the Dominion of New Zealand* held at Wellington City Library, Wellington.

Table 1 The principal Acts providing legal protection to New Zealand's aquatic wildlife.

Protection of Animals Act 1873
Seals Fisheries Protection Act 1878
Fisheries Conservation Act 1884
Sea-fisheries Act 1894
Fisheries Act 1908
Animals Protection and Game Act 1921–1922
Whaling Industry Act 1935
Wildlife Act 1953
Marine Mammals Protection Act 1978
Fisheries Act 1983
Fisheries Act 1996

All legislation found that contained information relating to legal protection of indigenous aquatic fauna was compiled in a chronological database, along with citation details and a summary of relevant information contained therein (Appendix 1). Correspondence files relating to most of the more significant pieces of legislation were located via the Archives New Zealand *Archway* website (www.archway.archives.govt.nz; accessed 19 July 2014) or with the assistance of DOC or MPI staff.

Results

Part 1: The main pieces of legislation and their impact on the protection of New Zealand's aquatic wildlife

Protection of New Zealand indigenous aquatic wildlife has been covered by 11 principal Acts (Table 1), plus 6 minor Acts, 6 Amendment Acts, 73 Statutory Regulations (including Notices and Orders), and at least 65 Orders in Council or *New Zealand Gazette* notices. A chronological list of legislation, with citation details, is provided as Appendix 1.

The legislation falls into two main groups: regulation of fisheries (including former seal and whale 'fisheries') by the government department responsible for fisheries management; and 'no-take' legislation administered by DOC (and, before 1987, the Wildlife Service of the Department of

Internal Affairs). However, there were exceptions, most notably the 'no-take' Marine Mammals Protection Act 1978, which was initially administered by the Ministry of Agriculture and Fisheries (MAF) until it was included among the responsibilities of the newly formed DOC in 1987.

The main legislation controlling the sealing and whaling industries

The earliest New Zealand legislation that referred to aquatic fauna was the Protection of Animals Amendment Act 1875, which restricted hunting of seals to four months (June to September). Hunting of New Zealand fur seals (*Arctocephalus forsteri*) for their skins was the basis for New Zealand's first export industry, beginning in 1792 (Grady 1986: 16). The industry was unregulated by New Zealand statutes for its first 83 years, leading to the near extirpation of fur seals by the 1830s (Harcourt 2005). The 1875 Amendment Act was followed by the Seals Fisheries Protection Act 1878, before regulation of the seal fishery became founded on wider fisheries legislation from 1884 to 1978 (Fisheries Conservation Act 1884, Sea-fisheries Act 1894, Sea-fisheries Act 1906, Fisheries Act 1908). Details of open and closed seasons for seals is provided in Appendices 1 and 2.

Whaling in New Zealand waters was unregulated by New Zealand legislation before the Whaling Industry Act 1935 came into force, protecting southern right whales (*Eubalaena australis*) and pygmy right whales (*Caperea marginata*). The Whaling Industry Regulations 1949 imposed a September to April closed season for baleen whales, reaffirmed in 1961. The Whaling Industry Regulations 1961, Amendment No. 1 (enacted in 1964), provided full protection for humpback whales (*Megaptera novaeangliae*), and a May to August closed season for sperm whales (*Physeter macrocephalus*).

The Fisheries Act 1908 (and its preceding Acts) made no mention of marine mammals other than seals, until the Fisheries Amendment Act 1956 provided for the Governor-General to make regulations protecting all marine mammals. All marine mammals throughout New Zealand and New Zealand fisheries waters (up to 200 nautical miles, or 370.4 km from the coast) have been fully protected since the enactment of the Marine Mammals Protection Act 1978.

Legislation protecting marine reptiles

Sea snakes and sea turtles have been recognised as part of the New Zealand fauna since 1837 and 1885, respectively (Gill & Whitaker 1996). The Animals Protection and Game Act 1921–1922 protected a single reptile species only (tuatara, *Sphenodon punctatus*), but Section 3.2 provided a mechanism for further reptile species to be added to the schedule of absolutely protected wildlife. The green turtle (*Chelonia mydas*) and leathery turtle (*Dermochelys coriacea*) were added to the schedule in March 1939 by a notice under the Regulations Act 1936. All marine reptiles were protected when the Wildlife Act 1953 was enacted; the Act covered 'any reptile' throughout New Zealand, and then excluded skinks and geckos only.

Protection of sea turtles in commercial fisheries was extended to all New Zealand fisheries waters (i.e. out to 200 nautical miles/370.4 km from the coast) by fisheries regulation in August 1990. All marine reptiles received full protection out to 200 nautical miles (370.4 km) from October 1996, when the Fisheries Act 1996 extended the provisions of the Wildlife Act 1953 to cover New Zealand fisheries waters.

The main legislation protecting fishes, shellfish and corals

The first species protected in the three remaining groups were all covered initially by fisheries regulations under the Fisheries Act 1908 or the Fisheries Act 1983.

The New Zealand grayling (*Prototroctes oxyrhynchus*) was the first fish species protected, under the Freshwater Fisheries Regulations 1951 (reaffirmed in 1983). It remains the only fully protected freshwater fish. The spotted black grouper (*Epinephelus daemelii*) was the first marine fish protected, in both commercial and amateur fishing regulations, in September 1986. Its protection was initially confined to the Auckland and Kermadec fishery management areas (i.e. covering its core New Zealand range), but this was extended to national protection when spotted black grouper was included in Schedule 7A ('Marine species declared to be animals') of the Wildlife Act 1953, created by the Fisheries Act 1996. Eight further species of marine fishes were added to Schedule 7A by Wildlife Orders in 2007 (great white shark, *Carcharodon carcharias*), 2010 (deepwater nurse or sandtiger shark, *Odontaspis ferox*; whale shark, *Rhincodon typus*; manta ray, *Manta birostris*; spinetail devil ray, *Mobula japanica*; giant (or Queensland) grouper, *Epinephelus lanceolatus*; and basking shark *Cetorhinus maximus*), and 2012 (oceanic whitetip shark, *Carcharhinus longimanus*). Great white shark, basking shark and oceanic whitetip shark are further protected under the Fisheries Act 1996 (by regulation), which provides protection from fishing by New Zealand vessels on the high seas.

The Toheroa Regulations 1955 established a closed season for the large bivalve shellfish toheroa (*Paphies ventricosa*). Subsequent amendments varied the closed season, but allowed at least some commercial or amateur harvest each year through to 1980. Toheroa became fully protected by the Toheroa Regulations 1955, Amendment No. 19 (1 September 1980), which stipulated a closed season from 1 December 1980 to 30 November 1983. This closed season has continued to the present in broader fisheries regulations, apart from open days for non-commercial harvest on Oreti Beach, Southland, on 8 September 1990 (Fisheries (Amateur Fishing) Regulations 1986, Amendment No. 2; *SR* 1990/217) and 18 September 1993 (Fisheries (Amateur Fishing) Regulations 1986, Amendment No. 5; *SR* 1993/284). The Fisheries (Amateur Fishing) Regulations 1986 provided a mechanism whereby persons representing a Māori community could take fish (including shellfish, *sensu* the Fisheries Act 1983) otherwise protected by fisheries regulations, for hui, tangi or other approved purposes, provided conditions listed in the permit were met. Although no species were named, in practice this allowed a limited take of toheroa each year from 1986. This provision was continued in the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992, the Fisheries (South Island Customary Fishing) Regulations 1998 and 1999, and the Fisheries (Amateur Fishing) Amendment Regulations (No. 2) 2005.

Black corals (initially all species in the genus *Aphanipathes*, and from 1984 all species in the order Antipatharia) were first protected in December 1980 by the Fisheries (General) Regulations 1950, Amendment No. 34 (*SR* 1980/245), and subsequently in fisheries notices and regulations in 1983, 1984, 1986, 1988, 1989 and 1991. Red hydrocorals (order Stylasterina, now order Anthomedusae) were protected in commercial fishing regulations for the South-East, Southland and Sub-Antarctic fishery management areas in October 1989, and in corresponding amateur fisheries regulations in April 1991. Black corals and all species of 'red corals' became absolutely protected throughout New Zealand fisheries waters when included in the newly created Schedule 7A of the Wildlife Act 1953 by the Fisheries Act 1996. The Wildlife Order 2010 removed confusion over the meaning of 'red coral' by restricting protection to hydrocorals (all species in the family Stylasteridae). The Wildlife Order 2010 also added gorgonian corals (all species in the order Gorgonacea [Alcyonacea]) and stony corals (all species in the order Scleractinia) to Schedule 7A, thereby granting them absolute protection.

The Wildlife Amendment Act 1980 created a mechanism for protection of freshwater invertebrates (by adding them to the newly created Seventh Schedule of the Wildlife Act 1953), but to date no such species have been included in the schedule, and so all freshwater invertebrates remain unprotected.

Territorial sea and fisheries waters

Protection of marine fauna at sea requires spatial definition of the waters covered by the legislation. This has varied over time and between legislation, partly reflecting changing definitions of New Zealand waters, territorial sea and fisheries waters.

The Fisheries Conservation Act 1884 defined 'waters' to include any salt, fresh or brackish waters in the colony, or on the coasts or bays thereof. The Sea-fisheries Act 1894 stipulated an outer limit of 'waters of the colony' of one marine league (equivalent to 3 nautical miles, or 5.6 km) from the coast, and the same delimitation was used in the Fisheries Act 1908 and the Whaling Industry Act 1935. This was extended to a 12 nautical mile (22.2 km) 'fishing zone' in 1965 (Territorial Sea and Fishing Zone Act 1965), with the innermost 3 nautical miles (5.6 km) defined as 'territorial sea'. Territorial seas were extended to 12 nautical miles (22.2 km) in 1977 (Territorial Sea and Exclusive Economic Zone Act 1977), surrounded by the newly created Exclusive Economic Zone of New Zealand (EEZ), which extended to 200 nautical miles (370.4 km) from the coast. This same Act further defined 'New Zealand fisheries waters' as including all waters in the EEZ, which was the spatial extent covered by the Marine Mammals Protection Act 1978, the Fisheries Act 1983 and the Fisheries Act 1996.

Both the Animals Protection and Game Act 1921–1922 and the Wildlife Act 1953 referred to wildlife as being protected 'throughout New Zealand', without defining whether this included any adjacent sea. This ambiguous wording was never tested in court, but was interpreted by some commentators as meaning that the provisions of the Wildlife Act 1953 ceased at the low-water mark (e.g. Lello 1980 and Ministry for the Environment 1988), while others considered the Act to include territorial sea (i.e. to 12 nautical miles/22.2 km offshore; see, for example, Ministry of Agriculture and Fisheries [1990] and Tennyson 1990, followed by Miskelly 2014). Staff of the former Wildlife Service, DOC, and the Royal Forest and Bird Protection Society (Forest & Bird) considered the Wildlife Act 1953 to include territorial sea, based on several unpublished reports and submissions in Ministry of Fisheries files (now held by MPI), and on emails to the author from Brian Bell and Mark Bellingham (August 2014). This confusion was cleared up by the Fisheries Act 1996, which extended the provisions of the Wildlife Act 1953 to cover New Zealand fisheries waters (i.e. out to 200 nautical miles/370.4 km).

Part 2: Why were aquatic wildlife species protected (or not)?

The reasons why aquatic species were protected, or why protection was removed, are mainly found in archived files from the relevant government departments. Most of the information quoted was sourced from Marine Department files (series M1, M2, M42 and M46), Department of Internal Affairs files (series IA46), and Department of Tourist and Health Resort files (series T&H25) held at Archives New Zealand (ANZ), Wellington (a total of 15 files quoted herein); Ministry of Fisheries files held by the MPI national office, Wellington (seven files quoted); and DOC files held at the DOC national office, Wellington (eight files quoted).

The compilation of rationale for protection (or removal of protection) of aquatic wildlife species presented here is incomplete, as a few files were missing or not found, and surviving files mainly contain written correspondence and replies. Any changes to protection status resulting from in-house deliberations may not have left a complete paper trail. However, the majority of decisions affecting the protected status of native aquatic wildlife between 1904 and 2012 (other than closed seasons for harvested species) can be linked to specific written requests, or to government department reports.

Famous dolphins: 1904, 1945 and 1957

New Zealand has had a succession of individual dolphins that became famous for their sustained interactions with people or boats. Three of these individuals prompted the provision of special protective legislation.

The most famous New Zealand dolphin – at least in terms of international awareness at the time – was also our first celebrity dolphin. 'Pelorus Jack' accompanied vessels across the mouth of Admiralty Bay (east of D'Urville Island, outer Marlborough Sounds) for at least 24 years, between 1888 and 1912 (Fig. 1; see Alpers 1960). Efforts to protect Pelorus Jack began in November 1903, at the behest of the Reverend Daniel Bates (clerk of the Meteorological Department of the Colonial Museum). Bates wrote to his

Fig. 1 Pelorus Jack (a Risso's dolphin, *Grampus griseus*) accompanies a vessel in Admiralty Bay, 1901–09 (photo: James McDonald, purchased 2009, Te Papa C.025085).

manager in the Department of Tourist and Health Resorts, suggesting that the dolphin be protected (unpublished manuscript by Anthony Alpers in ANZ M42/9/2 Part 1). Thomas Donne, superintendent of the Department of Tourist and Health Resorts, agreed, and wrote to Hugh Pollen, under-secretary of the Colonial Secretariat, on 4 December 1903: 'Being informed that this fish is not protected, and as it is now of national interest, I consider that some steps should be taken to protect it as far as possible' (ANZ M2/12/34). Pollen referred the matter to the Marine Department, stating that Sir James Hector had informed him that Pelorus Jack was 'an antarctic white whale (Beluga Kingii) [now considered a junior synonym of *Delphinapterus leucas* (beluga)]'. Pollen continued, 'It would perhaps be desirable to formally protect Pelorus Jack against capture or injury as he might be killed by some collector of curiosities for the sake of his skeleton or wantonly destroyed or injuried [*sic*] by ignorant or mischievous persons … Kindly say whether there is power in the Sea Fisheries Acts to protect whales in New Zealand waters' (letter, 30 December 1903, ANZ M2/12/34). George Allport, secretary of the Marine Department, wrote his reply at the bottom of the same letter the following day: 'Subsection 14 of Section 5 of the Sea-fisheries Act 1894 provides that the Governor in Council may prohibit the taking of any fish for such period as he thinks fit. The Antarctic white whale (Beluga Kingii) could therefore be protected by a prohibition against the taking of them being issued.'

A draft Order in Council, 'Prohibiting Taking of Antarctic White Whale in Cook Strait, &c.', dated 26 January 1904, was prepared by the Government Printer, but it was never published, as within a day Bates wrote to both Donne and Allport stating that he was sure that Pelorus Jack was 'neither Beluga nor Ziphius [i.e. Cuvier's beaked whale]'. Bates further stated: 'Until I may be able to see the fish and verify some observations, although I now feel certain about his species, I do not like to define and try to prove it. I will try to go soon' (ANZ M2/12/34, and similar wording in ANZ T&H25/7). However, on 30 January 1904, Bates provided a report to Donne concluding that Pelorus Jack was a Risso's dolphin (*Grampus griseus*) (report in ANZ T&H25/7). Their minister (Sir Joseph Ward) referred the report to the Minister of Marine (William Hall-Jones), and a letter was sent to Bates in mid-February advising that the Minister of Marine considered 'that as there is a difference of opinion as to the real species to which this fish belongs it has been decided to take no action at present in regard to Gazetting it as protected' (ANZ T&H25/7).

Thomas Donne wrote to the Colonial Secretariat's office again on 4 March 1904 (ANZ M2/12/34), providing a further draft Order in Council to protect Pelorus Jack as a named individual (i.e to avoid naming the species). Pollen forwarded the request again to the Marine Department, with the comment 'I think it would be better to protect the species rather than the individual even if there is power to do so, which is doubtful' (marginal note on Donne's letter, dated 7 March 1904). Allport replied to Donne on 21 March 1904, stating that Crown Law Officers had advised the Marine Department 'that the power to prohibit the taking of any fish contained in section 5 of "The Sea-fisheries Act, 1894," refers to fish as a species or kind, and not to any individual fish. There is therefore no power to issue the proposed Order in Council to protect "Pelorus Jack" by name' (ANZ T&H25/7).

Donne then changed tack, and wrote to his own minister (Sir Joseph Ward) on 25 March 1904, stating that 'As the whale family are mammals I would suggest that an effort be made to protect Pelorus Jack under the Animals Protection Act. Will you please refer the question for an opinion of the Crown Law Office' (ANZ T&H25/7). The reply was 'In my opinion this cannot be done' (marginal note on Donne's letter, dated 31 March 1904).

The matter sat for a further six months, until an article in the *Lyttelton Times* dated 16 September 1904 stated that Pelorus Jack had been 'declared by Captain [Frederick] Hutton to be a goose-beak whale (Ziphius cavirostris)' ('"Pelorus Jack": his classification' 1904), based on information supplied by Mr P.C. Threlkeld of Ohoka. This prompted Bates to reveal his hand publicly, and the following day the *New Zealand Times* ran an article that presented Bates's conclusions that Pelorus Jack was a Risso's dolphin, and stated 'the Government will protect the fish as classed by that gentleman' ('"Pelorus Jack": his genus decided' 1904). Bates based his identification on a 'remarkable' photograph taken by the Attorney-General, the Honourable Colonel Albert Pitt, presumably while travelling between his home in Nelson and Parliament in Wellington. Pitt agreed with Bates's identification, and requested the Marine Department to proceed with a protection order for Pelorus Jack as a Risso's dolphin (memo to the Minister of Marine from his undersecretary, George Allport, dated 21 September 1904, ANZ M2/12/34). The Order in Council (published in the *New Zealand Gazette* on 29 September 1904) covered a period of five years, and stated: 'it shall not be lawful for any person to take the fish or mammal of the species commonly known as Risso's dolphin (*Grampus griseus*) in the waters of Cook Strait, or the bays, sounds, and estuaries adjacent thereto'. This was renewed for a further five years on 31 May 1906, when the fisheries regulations were consolidated and amended, and again on 4 May 1911.

Uncertainty over the identity of Pelorus Jack is demonstrated by comparing the first three editions of Frederick Hutton and James Drummond's *The animals of New Zealand*. The first edition (1904: 51) followed Hector in stating that it was a beluga (*Delphinapterus leucas*), a species now recognised as confined to Arctic waters. In the second edition (1905: 47), Hutton and Drummond concluded that Pelorus Jack was a goose-beak whale (now known as Cuvier's beaked whale, *Ziphius cavirostris*). When preparing the third edition (following Captain Hutton's death), Drummond followed the 1904 Order in Council in considering Pelorus Jack to be a Risso's dolphin (Hutton & Drummond 1909: 18, 62–63). Debate over the identity of Pelorus Jack continued for more than seven decades.

Troughton (1931) concluded that it was not reconcilable with *Grampus*, and suggested that it was 'probably a large Dolphin of an allied genus', while Gaskin (1972) concluded that it must have been a bottlenose dolphin (*Tursiops truncatus*), before Baker (1974) reassessed historical photographs to reaffirm Bates's identification of Pelorus Jack as being a Risso's dolphin.

Reference to Pelorus Jack as being a 'fish or mammal' did not pass unnoticed by zoologists. Constance Barnicoat worked as a New Zealand government secretary and shorthand reporter before sailing to England in 1897 (McCallum 2012). In 1905 she was working for the *Review of Reviews* in London, and wrote to New Zealand Premier Richard Seddon on 30 May, stating that an 'English authority on fishes and to a certain extent on animals in general has made considerable fun of the "fish or mammal" clause; Pelorus Jack is, he says undoubtedly a mammal, and I have wondered whether a proclamation is valid in which the Governor in Council protects a mammal under an Act for the protection of seafishes' (ANZ M2/12/34). It is evident that legislators were employing a sleight of hand in referring to Risso's dolphin as a fish, as neither the Sea-fisheries Act 1894 nor the subsequent Fisheries Act 1908 made any provision for protection of marine mammals other than seals (see below).

Pelorus Jack was last seen in 1912 (Alpers 1960). In September 1944, the Marine Department received information that a second pale dolphin, dubbed 'Pelorus Jack II', was accompanying boats in Pelorus Sound, this time in Hikapu Reach ('The latest picture of Pelorus Jack II' 1944; Oliver 1946). Ernest Lawrence of the Portage, Pelorus Sound, wrote to the Marine Department describing the behaviour of the 'white porpoise' and suggesting that some measure of protection should be given to it (ministerial advice, 1 November 1944, ANZ M2/12/34). The Marine Department sought the assistance of Reginald (W.R.B.) Oliver, the director of the Dominion Museum, who visited Hikapu Reach with Lawrence in the last week of September 1944, and identified the animal as a 'coast porpoise [Hector's dolphin], Cephalorhynchus hectori' (letter from Oliver to the secretary, Marine Department, 9 October 1944, ANZ M2/12/34). Oliver considered the animal to be 'of sufficient interest to have some measure of protection, and accordingly recommend that an Order-in-Council be Gazetted as was done in the case of "Pelorus Jack".' The letter was referred to Arthur Hefford, Chief Inspector of Fisheries, who replied 'I think an O/C for its protection would be desirable' (marginal note on Oliver's letter, dated 11 October 1944).

On 1 November 1944, Richard Gerard (Member of Parliament for Mid-Canterbury) asked the Minister of Marine in the House of Representatives 'Whether he proposes having an Order in Council issued for the protection of the blue and grey porpoise in French Pass, recently reported to be showing a desire for association with man?' (ANZ M2/12/34). James O'Brien, the minister, replied that 'The question of protection of this porpoise has already been investigated by officers of the Dominion Museum and the Marine Department, and action is being taken in that direction' (ibid.). Regulation 10 of the Sea-Fisheries Regulation 1939, Amendment No. 16 (*SR* 1945/14, 28 February 1945), stated: 'During a period of three years from the 31st day of January, 1945, no person shall take or attempt to take any porpoise of the species commonly known as white porpoise [Hector's dolphin] (*Cephalorhynchus hectori*) in the waters of Cook Strait, including the bays, sounds, and estuaries adjacent thereto.' This was renewed for four further periods of three years in May 1947, August 1950, February 1956 and March 1966, before being revoked in June 1968.

The third famous dolphin was Opo, a young bottlenose dolphin that frequented Hokianga Harbour from early 1955 to March 1956, interacting with bathers and people in small boats (Fig. 2; see Alpers 1960). On 15 December 1955, H. Chappell, the secretary of the Hokianga Harbour Board, wrote to the secretary of the Marine Department stating that the board was 'of the opinion, that immediate action should be taken to give [the dolphin] protection and has directed me to inform you of the position, in order that your Department can investigate the matter and take such action it might consider necessary to guard this sea mammal against destruction' (ANZ M42/9/2 Part 1). Gerald O'Halloran, secretary of the Marine Department, replied on 20 December 1955, saying, 'I regret that I see no way in which to provide special protection for the dolphin' (letter also in file ANZ M42/9/2 Part 1, as is all the following correspondence regarding protection of dolphins).

On 20 February 1956, A.M. Brierley, secretary of the Whangarei District Progressive Society, wrote to Sidney Smith, Minister of Internal Affairs, asking that the Opononi dolphin 'be protected against vandals and other ill-intentioned persons', and requesting that he 'take the necessary steps to have such a Protection Order published in the New Zealand Gazette'. File notes indicate that Smith discussed the request with John McAlpine, Minister of Marine, and that McAlpine instructed O'Halloran via telephone to prepare an Order in Council protecting the

Fig. 2 Children playing with Opo (a bottlenose dolphin, *Tursiops truncatus*), Opononi, 1956 (photo: Eric Lee-Johnson, purchased 1997 with New Zealand Lottery Grants Board funds, © Te Papa CC BY-NC-ND licence, Te Papa O.007809/04).

dolphin. Other cabinet ministers were also being lobbied – see for example, the letter from Alison Dunne to Ronald Algie, dated 27 February 1956, expressing concern at a letter in the *New Zealand Herald* (Admirer, Opononi 1956) describing how 'two visitors tried to lift [Opo] bodily out of the water'. The same letter to the editor commended 'Mr Algie and Mr Smith on the move they have made to have "Opo" the dolphin protected'.

O'Halloran sought advice from the Solicitor General, Crown Law Office, on 28 February 1956, stating that the Chief Inspector of Fisheries 'is of the opinion that protection cannot be given under section 5 of the Fisheries Act 1908 as the animal is a mammal and not a fish … Mr E.G. Turbott of the Auckland Museum has stated that the animal is a very young bottle-nosed dolphin'. There was considerable ministerial pressure being applied to the Marine Department, as on the same day O'Halloran sent a draft Order in Council to protect the dolphin to his minister:

> In accordance with your telephonic instructions … You are aware, of course, that there is no statute under which this provision can be given and that even if the provisions of the Fishery Act [*sic*] are to be adopted as was done in the case of Pelorus Jack in 1904 the species but not single fish requires to be protected. In this case it has not been ascertained to which species this particular dolphin belongs, so in order to prevent any possibility of error the phrase 'all dolphins inhabiting the Hokianga Harbour' should be inserted in the Order in Council.

O'Halloran wrote another memo to the Solicitor General on 2 March, stating that since writing [on 28 February] 'I have been advised that Cabinet has decided that Regulations are to be made urgently. Consequently I have forwarded a copy of the draft regulations to the Law Draftsman for urgent revision … However, I should be glad if you would still let me have your opinion on this matter.'

Also on 2 March, O'Halloran drafted a cabinet briefing memo for McAlpine's signature, worded as follows:

> **Fisheries Hokianga Dolphin Protection Regulations 1956**
>
> The above regulations, a copy of which is attached, have been prepared following on representations for some formal protection to be given to the Dolphin now frequenting the Hokianga Harbour in the vicinity of Opononi.
>
> The regulations are made following on the precedent of 'Pelorus Jack' which was first protected by an Order in Council dated 26th September, 1904, and made under Section 5 of the Sea Fisheries Act 1894, now Section 5 of the Fisheries Act 1908.

> You are aware, of course, that these regulations may not be valid as a dolphin is a mammal and not a fish. However, as an expediency measure I think they should suffice.
>
> The species and not a single fish requires to be protected and as it has not been ascertained to which species this dolphin belongs, all dolphins in the Hokianga Harbour are to be protected from being taken or molested for a period of five years.
>
> These regulations have been reviewed by the Law Draftsman and have been submitted to the Attorney General for his approval for submission to Cabinet. No other Department is affected. It is recommended that Cabinet approve these regulations.

The Fisheries (Dolphin Protection) Regulations 1956 (*SR* 1956/25) were issued on 7 March 1956, and notified in the *New Zealand Gazette* on 8 March. Sadly, Opo probably died that same day; she was found dead, trapped in a tide pool, on 9 March – the day the regulations came into effect (Alpers 1960).

It is unlikely that news of Opo's death had reached Wellington before E.J. Haughey, Crown Solicitor, replied (on 9 March) to O'Halloran's memo of 28 February:

> Although in a loose and popular sense the word 'fish' is sometimes used to include mammals living exclusively in the water and having a fish-like form (cetacea) such as whales, porpoises and dolphins, it strictly means and is restricted to 'vertebrate animals, provided with gills throughout life, and cold-blooded; the limbs, if present, being modified into fins' … It is in this latter sense, I think, that the term 'fish' must be deemed to have been used in section 2 of the Fisheries Act 1908; and I am therefore of opinion that the draft Order in Council submitted by you herein (which I see from the Press has now been enacted) is ultra vires … As I know of no other statutory provision or rule of law under which this dolphin can be afforded adequate legal protection I can only suggest that special legislation should be enacted by Parliament for this purpose.

On 13 March, M.W. Young, the Chief Inspector of Fisheries, wrote a memo stating that he considered the Order in Council to be *ultra vires* in two ways, because (1), 'the Act does not give power to make regulations for dolphins' and (2), 'the term of the protection is for five years, whereas the maximum period [allowed in the Act] is three years … To repair the damage of (1) amend Section 5 of the principal Act by the amendment of (h) by adding after the word "seals" in both places the words "or other mammal found in New Zealand waters" and do the same for 5 (o).' These suggested amendments to the Fisheries Act 1908 were forwarded to the Law Drafting Office in a letter by O'Halloran on 29 March 1956 and resulted in the changes implemented when the Fisheries Amendment Act 1956 was enacted on 26 October 1956 [i.e. replacing the word 'seals' with 'marine mammals (including seals)'].

Following Opo's death, the Fisheries (Dolphin Protection) Regulations 1956, referring to dolphins in Hokianga Harbour, were revoked on 6 March 1957, as Marine Department staff remained concerned about their validity (memo from O'Halloran to Richard Gerard, Minister of Marine, 19 December 1956). In a curious twist, the Fisheries Amendment Act 1956 did result in some dolphins being protected immediately. It was enacted on 26 October 1956, eight months after the Fisheries (General) Regulations 1950 had been reprinted, 'protecting' Hector's dolphins in Cook Strait for three years from 1 March 1956. The Fisheries Amendment Act 1956 legitimised Regulation 110 (protecting Hector's dolphins), and so the first legally protected dolphins in New Zealand were Hector's dolphins in Cook Strait and its adjoining waters, for 28 months between 26 October 1956 and 1 March 1959. The Fisheries (General) Regulations 1950 were again reprinted in March 1966, thereby protecting Hector's dolphins in Cook Strait for a further three years from 17 March 1966. However, the Fisheries (General) Regulations 1950, Amendment No. 10 revoked Regulation 110, meaning that this localised protection of Hector's dolphins lasted only a further 15½ months, from 17 March 1966 to 4 July 1968. It is unlikely that 'Pelorus Jack II' (first reported in 1944) benefited from these two belated periods of protection. The maximum lifespan of a Hector's dolphin is about 20 years (Slooten 1991), and on 13 April 1956, Gerald O'Halloran wrote that 'none has been sighted in recent years' in the vicinity of Pelorus Sound (letter to F.C. Rhodes, Brisbane). The amended Fisheries Act 1908 was not used further to protect marine mammals (other than seals) before the Marine Mammals Protection Act 1978 was enacted.

Twentieth-century New Zealand fur seal harvests: 1923–29 and 1946

Few details are available regarding the reasons why closed seasons were set for fur seals from 1882 onwards, possibly due to the destruction of Marine Department files in the Hope Gibbons fire in 1952. The main advisers on seal stocks during this period were the captains of government steamers, which regularly visited the subantarctic islands until 1929, and continued servicing lighthouse stations around the

New Zealand coast after that date (e.g. report by Captain John Bollons to the secretary for Marine, 5 July 1919, ANZ IA46/33/7). New Zealand fur seals took many decades to recover from their near extirpation in the early nineteenth century, and from 1875 the New Zealand government closely regulated their harvest, with closed seasons in 51 of 71 years up until the last open season in 1946 (see Appendices 1 and 2). The correspondence and reports that survive are mainly in relation to open seasons on Campbell Island/ Motu Ihupuku in the 1920s, and around southern New Zealand in 1946.

Sealing on Campbell Island/Motu Ihupuku during the 1920s was linked with attempts to achieve economic viability of sheep farming on the island. Attempts to farm the island began in the late 1890s, and in 1916 the lease was transferred to a Dunedin-based syndicate led by James Patrick and John Mathewson (Dingwall & Gregory 2004). In March 1922, Sir Francis Bell, the acting Minister of Marine, granted the Campbell Island Syndicate permission to kill up to 400 bull seals per annum 'on the understanding that your Company will make every endeavour to prevent poaching of seals on the Island' (letter, 11 March 1922, ANZ M2/6/1 Part 3). A total of 278 skins was taken in the first year, and brought to the mainland on the government steamer *Tutanekai* in early April 1923 (telegram from Captain John Bollons to the secretary for Marine, 3 April 1923, ANZ M2/6/1 Part 3).

A second permit, with no limit on numbers, ages or sexes, was issued for a further year by James Anderson, Minister of Marine, on 18 April 1923. However, regulations for the seal fishery on Campbell Island/Motu Ihupuku published in the *New Zealand Gazette* on 15 March 1923 stipulated that no more than 400 seals be taken, and that no females and no animals under the age of one year be taken. A further 67 seal skins from Campbell Island/Motu Ihupuku were delivered to the Collector of Customs in Dunedin via the whaling vessel *Sir James Clark Ross* in mid-March 1925 (letter from George Godfrey, secretary for Marine, to James Anderson, Minister of Marine, 30 March 1925, ANZ M2/6/1 Part 3). Inspection of the cargo revealed multiple breaches of the licence and regulations, and an attempt was made to prosecute the syndicate for taking seals after their permit had expired, and for taking females and young animals. A settlement was reached that included the Campbell Island Syndicate paying the Marine Department's expenses of £28 2s. 0d. (letter from George Godfrey to James Anderson, 4 September 1925, ANZ M2/6/1 Part 3), and the following day the syndicate applied to have their licence renewed. The request was declined (letter from James Anderson to the secretary of the Campbell Islands Syndicate, 29 September 1925, ANZ M2/6/1 Part 3). A report by George Godfrey, secretary of the Marine Department, to his minister dated 14 December 1925 concluded that the seal population at Campbell Island/Motu Ihupuku was too small to sustain harvest (noting that only 67 skins were taken, when 400 were permitted), and that Captain Bollons did not consider the seal herds on the subantarctic islands to be large enough for 'general re-opening of sealing' (ANZ M2/6/1 Part 3). He continued:

> As to the Campbell Island Syndicate, I have no sympathy whatever with them. So far as the Marine Department is concerned they have done nothing but 'winge' and complain – they seem to regard the Government as a charitable institution especially constituted to remit or reduce charges for transport services rendered to them. They have about 28,000 acres of land at a rental of £50 a year and want us to carry their produce at a loss to yourselves … As a concession, they were given a valuable sealing license subject to certain conditions and they failed to play the game.

The Campbell Island/Motu Ihupuku grazing lease was purchased by John Warren in early 1927 (Dingwall & Gregory 2004). In July 1928, Warren sought the right to take seals on the island, as 'he is making a loss on his farming operations and he is extremely doubtful if he can make a success of it without being able to increase his revenue by means of sealing' (letter from Messrs Wright, Stephenson & Co., Ltd to Sir Francis Bell, Minister of Marine, 17 July 1928, ANZ M2/6/1 Part 4). A permit was duly issued on 15 November 1928, with the same conditions as in 1923: 'A special condition in regard to the issue of the license is that those who hold it shall protect the islands as far as possible against poachers, and shall give full information to the Government as to the names of ships and persons ascertained by them to be engaged in poaching' (letter from Sir Francis Bell, Minister of Marine, to Messrs Wright, Stephenson & Co., Ltd, 11 September 1928, ANZ M2/6/1 Part 4). The licence took a further nine months to reach Warren on Campbell Island/Motu Ihupuku (August 1929), but he took 102 seal skins in what remained of the period allowed, and delivered them to Bluff aboard the *Tamatea* in August 1931 (letter from Warren to John Cobbe, Minister of Marine, 20 August 1931, ANZ M2/6/1 Part 4). Warren continued, 'When I arrived back at Bluff early this month

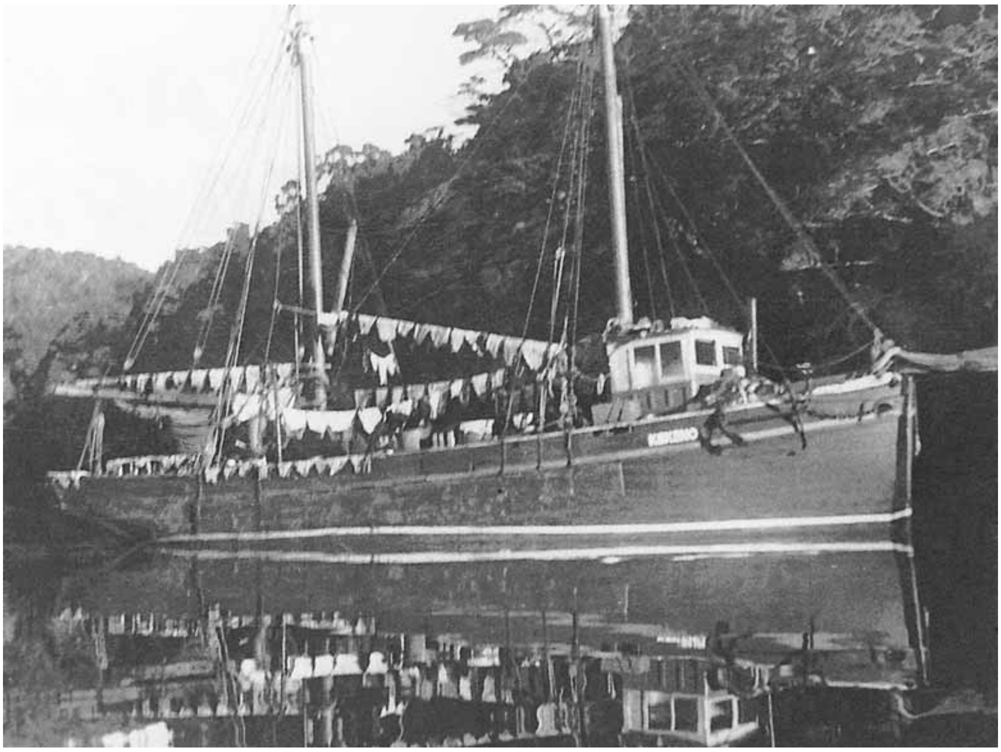

Fig. 3 New Zealand fur seal (*Arctocephalus forsteri*) skins drying in the rigging of FV *Kekeno*, Luncheon Cove, Dusky Sound, 6 July 1946. The crew of the *Kekeno* took 1181 skins during a 13-day trip in June–July 1946 (photo: Harold Roderique, reproduced with the permission of the Roderique family).

by the s.s. 'Tamatea', I found that owing to the depression, the skins were worth only five shillings each [when royalty of £1 per skin was required to be paid], so that all our work has gone for nothing.' The skins were duly forfeited to customs for non-payment of royalties two months later, signalling the end of both sealing and farming on Campbell Island/Motu Ihupuku.

Requests to reopen the southern fur seal fishery began again in the late 1930s, largely from Southland and Stewart Island/Rakiura fishermen, supported by local politicians. A deputation comprising the Reverend A.E. Waite (mayor of Bluff), the Hon. T.F. Doyle and fisherman Harry Roderique met with Peter Fraser, Minister of Marine, at Bluff on 14 January 1937, arguing for an open season for seals on economic grounds, and because they considered that there were 'thousands of seals in the southern waters' (quote from Roderique in minutes of the meeting, date-stamped 1 February 1937, ANZ M2/6/1 Part 5). In late 1944, the Marine Department received reports of fur seals and sea lions taking fish from set nets and lines around Stewart Island/Rakiura, along with claims that their increasing numbers were responsible for depleted fish stocks (two letters from R.H. Thomson dated 22 November 1944, ANZ M2/6/1 Part 5). Further 'numerous and continued complaints from fishermen' concerning perceived impacts of fur seals on the blue cod fishery around Stewart Island/Rakiura were received in 1945 (Sorensen 1969). William Denham, the Member of Parliament for Invercargill, raised the matter with James O'Brien, Minister of Marine, on 15 August 1945, asking 'Whether he will favourably consider permitting the killing of seals with a view to increasing the fish supply for the domestic market?' On the same date, O'Brien received a report from the acting secretary for Marine, W.C. Smith, recommending that he 'approve in principle the opening of the season … under a licensing system controlled by our Inspector of Fisheries at Bluff' (Sorensen 1969). The resulting Seal-fishery Regulations were gazetted on 29 May 1946, authorising the issue of licences conferring the right to take seals through to 30 September 1946, for specified parts of Otago, Southland, Fiordland, and Stewart Island/Rakiura and offshore islands. There was no restriction on the ages or sexes of seals that could be taken, as the primary goal was to reduce their numbers. At least 6187 seals were killed (Sorensen 1969, and see Fig. 3).

The decision to open a limited season for killing seals was publically criticised by Robert Falla, director of Canterbury Museum (letters from Falla to the secretary of the Marine Department, 4 and 12 July 1946, ANZ M2/6/1 Part 5; 'Fur seal season' 1946; Sorensen 1969), and the Canterbury naturalist Edgar Stead (Stead 1946), among many others (clippings in ANZ M2/6/1 Part 6a). The main concerns expressed were the absence of direct evidence of seals impacting on the blue cod fishery, and lack of evidence of a general population recovery, along with concerns about the economic viability of the harvest model proposed. Survey of stomach contents of 91 of the animals killed in 1946 failed to identify any blue cod remains (A.M. Rapson *in* Sorensen 1969). Despite occasional requests for removal of protection (e.g. by Sir Tipene O'Regan in 1996; Scadden 1996), all New Zealand seal species have remained fully protected since the closing of the 1946 limited season.

Right whales and humpback whales: 1935 and 1964

The earliest request for protection of whales retained in Marine Department files is a letter from Miss M. Lavington Glyde to the manager of the Department of Tourist and Health Resorts, dated 15 July 1916, containing a copy of a letter she had sent to the Wellington *Evening Post* (the letter was published two days later; ANZ M2/9/4). The published letter requested protection for all whale species in New Zealand waters. Glyde argued that whales were almost extinct due to 'their ruthless destruction, and unless something is done, and done at once, this last of the living wonders of the world will be lamented in vain', and that the world could get on just as well without the commodities extracted from slaughtered whales. The letter was referred to George Allport, secretary of the Marine Department, who sought advice from Lake Ayson, Chief Inspector of Fisheries. Allport's reply to Glyde (4 August 1916, ANZ M2/9/4) pointed out that protection could be given only to whales within 3 miles (5.6 km) of the shore (i.e. territorial seas) as the Dominion had no power to legislate or apply regulations outside such limit, and that international agreement might be necessary in order to achieve effective protection outside the 3-mile limit. Glyde replied that 'even such an enactment by New Zealand to protect whales within our own waters would create a precedent for other countries to follow' (5 August 1916, ANZ M2/9/4).

Initiation of protection for whales did eventually proceed through an international agreement negotiated by the Economic Committee of the League of Nations, seeking to protect right whales 'which have become extremely rare', including the southern right whale (League of Nations Economic Committee 1929). The resolution, which was expanded to include the pygmy right whale, was adopted by the League of Nations on 24 September 1931 (ANZ M2/9/3 Part 3a). Despite signing this Convention for the Regulation of Whaling, the New Zealand government did not ratify the convention until 30 August 1935, shortly before Parliament passed the Whaling Industry Act 1935 (on 24 October), giving effect to the convention in respect to territorial waters of New Zealand and the Ross Dependency (ANZ M2/9/3 Part 3a). Southern right whales were a rare sight in New Zealand coastal waters in the early twentieth century, with only 13 taken by shore-based whaling stations between 1916 and the last capture of two animals in 1926 (Gaskin 1972).

Humpback whales continued to be hunted from New Zealand shore-based stations through to the early 1960s (Gaskin 1972). The International Whaling Commission (IWC) first met in 1949, and initiated protection for humpback whales in the North Atlantic in 1955. At its 15th meeting (London, July 1963), the IWC further prohibited the taking of humpback whales in all waters south of the Equator, due to concern at their rapidly declining stocks (International Whaling Commission 1965). The proposal was put forward by the Commissioner for Canada, and seconded by Norway. However, Australia and New Zealand moved that protection be limited to south of latitude 40°S, which would have allowed whaling to continue north of Bass Strait and Cook Strait. This amendment was lost, but the main proposal was passed, and became binding on all contracting governments on 9 October 1963 (International Whaling Commission 1965). By this date, the population of humpback whales migrating through New Zealand waters had crashed, as revealed by the numbers of whales killed at the two remaining New Zealand whaling stations, Tory Channel in Cook Strait and Whangamumu on Great Barrier Island (Aotea Island). Between 109 and 318 humpback whales were taken each year from 1951 to 1959, followed by 361 in 1960, 81 in 1961, 35 in 1962, 9 in 1963 and none in 1964 (Gaskin 1972). The Whangamumu station ceased operating after the 1962 season, and the Tory Channel station in 1964 (Fig. 4), the latter having focused on sperm whales during its last two seasons of operation (Gaskin 1972). Humpback whales were therefore economically extinct in New Zealand waters before Parliament ratified the 1963 IWC decision. The Whaling Industry Regulations 1961, Amendment No. 1 (passed on 1 July 1964), prohibited the

Fig. 4 A humpback whale (*Megaptera novaeangliae*) being processed at Perano whaling station, Fishing Bay, Tory Channel, *c.* July 1948 (photo: Dr W. Arriens, *New Zealand Free Lance*, Alexander Turnbull Library, PAColl-8163-38).

taking of humpback whales within 3 nautical miles (5.6 km) of the New Zealand coast.

The Territorial Sea and Fishing Zone Act 1965 redefined New Zealand fisheries waters as extending to 12 nautical miles (22.2 km) from the New Zealand coast. As the enactments applied to the Whaling Industry Act 1935, southern right whales, pygmy right whales and humpback whales gained protection within this expanded zone.

Sea turtles: 1939 and 1990

In early 1939, Miss E. Katie Pickmere of Whangarei wrote to the Department of Internal Affairs seeking protection for sea turtles. The original letter, and the date it was written, has not been located, but on 9 February 1939, Joseph Heenan (Internal Affairs under-secretary) wrote to the secretary of the Marine Department, quoting the following from Pickmere's letter (ANZ M2/12/155):

> We read in the Newspapers that yet another turtle has been seen in the vicinity of Cape Brett. A pair has already been captured up there (a pair that frequented those waters for many years) and sent to the Museum by someone apparently wishing for cheap publicity.
>
> In your Ministerial position, could you not do something to protect these (in N.Z. waters) rare and interesting creatures, and prevent further slaughter.

Heenan wrote that 'the species could be afforded protection under the Animals Protection and Game Act, 1921–22, but before submitting a report to my Minister, I should be pleased to have the views of your Department, together with any information which your Department may have to the species, and whether there is evidence of others having been observed'.

L.S. Campbell, secretary of the Marine Department, sought advice from Arthur Hefford, Chief Inspector of Fisheries, and was advised that the director of the Auckland Museum or possibly Reginald Oliver of the Dominion Museum could provide information on the identity of the turtle (hand-written notes by Hefford on the margins of Heenan's 9 February letter, ANZ M2/12/155):

> My view is that they are abnormal & infrequent visitors to N.Z. coastal waters & that therefore a measure for their protection would probably be a waste of time … One deplores the pointless slaughter of any creature, rare or common, but specimens cannot be sent to a Museum for identification & study unless they are killed. Until the species is (or are) known it would appear to be impossible to make a protection regulation without prohibiting the killing of any Chelonian (which would be pointless).

Hefford further suggested that the turtle was probably a leathery turtle, based on a press report (ibid.).

Campbell's reply to Heenan (21 February 1939, ANZ M2/12/155) recommended that advice be sought from the Auckland Museum or Dominion Museum. However, neither institution has a record of the correspondence and Internal Affairs file 46/88 cannot be located. Advice was apparently received that the green turtle and leathery turtle were the predominant or only species known to occur in New Zealand, as these two species were added to the First Schedule (absolutely protected species) of the Animals Protection and Game Act 1921–1922 on 24 March 1939.

All sea turtles were protected by the Wildlife Act 1953, but it is unclear whether this provided protection within territorial waters (3 nautical miles/5.6 km offshore up until 1977, then 12 nautical miles/22.2 km), or whether this protected turtles only when ashore. Extension of protection throughout New Zealand fisheries waters (i.e. to 200 nautical miles/370.4 km offshore) was initiated by an enquiry from DOC's Rangitikei District Office to their Protected Species Policy Division in May 1989 (MPI 10/19/1 Vol. 1). Pam Cromarty from DOC phoned MAF on 16 May, asking whether the Fisheries Act 1983 provided any protection to marine turtles in New Zealand waters. The reply from MAF (letter from Karen Chant, economic analyst, 16 May 1989, MPI file 10/19/1 Vol. 1) stated that there was no such provision, but that the Act provided for such regulations to be made: 'If you would wish the protection of marine turtles to be provided for within the Fisheries Act 1983, please provide a submission to the Director-General of Agriculture and Fisheries outlining the specific need and degree of protection required for this species.'

DOC's submission seeking protection of marine turtles under Section 89(2) of the Fisheries Act 1983 was dated 13 September 1989 (MPI file 10/19/1 Vol. 1). This stated DOC's understanding of the spatial extent of the Wildlife Act 1953: 'This protection extends as far as the territorial waters of New Zealand or 12 nautical miles from the baseline, as defined in the Territorial Sea and Exclusive Economic Zone Act 1977.' The reasons given for further protection were founded in the threat ranking assigned to all five marine turtle species known in New Zealand waters, based on listings by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the Trade in Endangered Species Act 1989. The submission considered the highest threat to marine turtles in New Zealand to be incidental capture in shrimp and prawn trawls, squid nets and other nets, but also targeted fishing to meet international trade demands for turtle soup, tortoise-shell accessories, turtle oil and turtle-skin leather.

The submission was approved by the MAFFish Board on 13 December 1989 (file 10/19/1 Vol. 1); their support resulted in the Fisheries (Commercial Fishing) Regulations 1986, Amendment No. 7 (*SR* 1990/186), prohibiting commercial fishers taking or possessing marine turtles within New Zealand fisheries waters. There were no equivalent regulations for amateur fishers before the Fisheries Act 1996 extended the provisions of the Wildlife Act 1953 out to 200 nautical miles (370.4 km).

New Zealand grayling: 1951

The New Zealand grayling was a medium-sized (maximum length at least 45 cm) freshwater fish that formerly occurred in rivers and large streams throughout the North Island and South Island (Allen 1949; McDowall 1990; McDowall & Stewart 2015). It is believed to have been adversely affected by land-use changes and the introduction of brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). The last authenticated records of grayling were in the 1920s (McDowall 1990).

Both Marine Department and Internal Affairs files provide background information on the 1951 protection of the grayling (example below), however, none of them includes reference to any particular request or trigger for protection. Protection may have been prompted by Gerald Stokell's (1941) stinging reference to the (nearly extinct) position of the grayling as a 'standing reproach on the administration of wildlife in New Zealand and a monument to the indifference with which many natural resources of this country have been treated'. It is also possible that K. Radway Allen's 1949 paper on possible causes of extinction of the grayling was a contributing factor to the initiation of protection measures the same year. A memo by Derisely Hobbs, Senior Fishery Officer, dated 7 September 1949, referred to consultation on draft freshwater fishery regulations that included the suggestion that 'the taking of native grayling, now very rare, will be prohibited' (ANZ M1/5/31 Part 3). The explanatory notes for the 1951 regulations sent to the Minister of Marine on 3 January 1951 included:

> REGULATION 99: Indigenous Fish. Before the amendment of the Fisheries Act in 1948 it was not possible, without special legislation, to afford permanent protection to any fish. It is proposed, belatedly, to give protection to the native grayling which is now extremely rare or possibly extinct. The chief practical end of the regulation is to ensure notice will be obtained should this fish be found in any district. Should it be found, a study of its life history with a view to its rehabilitation would be warranted.

The New Zealand grayling has been fully protected since 9 February 1951 (Freshwater Fisheries Regulations 1951, *SR* 1951/15).

Further protection for marine mammals: 1978

Demand for additional protection for marine mammals came from several sources during the 1970s. Baden Norris, Honorary Fisheries Officer, Christchurch, wrote to Colin Moyle, Minister of Agriculture and Fisheries, on 29 October 1973 expressing concern over reports of dolphins being harpooned for human consumption off the Canterbury coast: 'I am distressed to discover that no protection is afforded by the [Fisheries] Act' (ANZ M42/9/2 Part 1). Fisheries scientist Mike Hine wrote to Duncan Waugh, director of the Fisheries Research Division, MAF, on 19 December 1973, primarily concerned with the potential for dolphins being caught in purse-seine nets, and stating, 'Legislation protecting all marine mammals in New Zealand waters is strongly recommended' (ANZ M42/9/2 Part 1). Fisheries Management Division staff expressed a diversity of opinions in response. Ron Lundy (District Inspector of Fisheries, Wellington, 24 December 1973, ANZ M42/9/2 Part 1) stated that he believed 'that these marine mammals [dolphins] should be absolutely protected', and that he had heard of fishermen shooting them (because, like seals, they eat fish) and using them for bait. James Reade, District Inspector of Fisheries, Auckland, stated on 3 January 1974 that he had heard no reports of dolphins being taken for food, 'nor do we see any need for legislation to protect them'. The reply sent to Norris in late January 1974, under Moyle's signature, stated: 'While I am personally of the opinion that it is undesirable for these sea mammals to be taken for food I am not in favour of introducing regulations except when clearly essential to conserve a fish species. However, porpoises and dolphins may represent a special case and I propose to discuss the problem with the Fishing Industry' (ANZ M42/9/2 Part 1).

Concerns were also raised about dolphin by-catch by United States super-seiners fishing for skipjack tuna (*Katsuwonus pelamis*) in New Zealand waters during 1974 (memo to Colin Moyle, 28 January 1974, ANZ M42/9/2 Part 1). Fishermen in the eastern tropical Pacific tuna fishery had developed the technique of using the presence of dolphins to indicate where the schools of tuna were, resulting in large numbers of dolphins being caught when the purse-seine net was closed (Martin Cawthorn report, *c.* April 1974, ANZ M42/9/2 Part 2). While protection by itself would not prevent by-catch, it would require fishermen to release dolphins unharmed if any were caught (file note by R. Beatty, dated 25 January 1974, ANZ M42/9/2 Part 1).

An additional stimulus for increased protection of marine mammals was the clandestine (though not illegal) export of more than 100 specimens of stranded whales and dolphins to a Dutch museum by marine mammologist Frank Robson between 1970 and 1975, which was brought to the attention of MAF in late 1975 (Baker 1997; letter from Richard Dell, the director of the National Museum, to the Director-General of MAF, 10 September 1975, and file note dated 24 October 1975, ANZ M42/9/2 Part 2). New Zealand Customs were alerted, but it was recognised that broad legislation to control the harassing, killing, and souvenir scavenging of marine mammals was required (Baker 1997).

MAF Fisheries Management Division staff contacted stakeholders (including the Nature Conservation Council, and Alan Baker at the National Museum) in June 1974 seeking their views on proposals to protect all marine mammals (ANZ M42/9/2 Part 2 and 36/1/95). Government action reflected increasing public demands for the protection of whales in particular. This was exemplified by a petition from Ecology Action (Christchurch) Incorporated, 'Praying for protection of cetacean species of whale', signed by Graham King and 8000 others, received by the House of Representatives in June 1975 (ANZ M42/9/2 Part 2). The petition – which was supported by Ecology Action (Wellington), Action for the Environment, and Project Jonah (Wellington) – requested that the government ban all import of goods containing whale products where substitutes were available, to call upon whaling nations to impose a 10-year ban on commercial hunting of whales, and to enact a law protecting cetaceans from commercial exploitation in New Zealand fishing waters. The Petitions Committee of Parliament noted that most of the items in the petition were 'under consideration by the Government' (importation of whale products was banned a few weeks later), and the Cabinet Committee on Legislation and Parliamentary Questions (CCLPQ) requested a report from the Minister of Agriculture and Fisheries recommending what action, if any, should be taken (letter from C.J. Hill, secretary of the CCLPQ, to Colin Moyle, Minister of Agriculture and Fisheries, 16 June 1975, ANZ M42/9/2 Part 2). Moyle's reply (10 July 1975) noted the intention to protect all species of mammals through inclusion of protection proposals in a Fisheries Amendment Bill in 1976, and copies of the draft proposals were circulated among interested parties for perusal and comment in September 1975 (ibid.). Following analysis of submissions, this expanded into development of a separate Marine Mammals Protection Bill (letters, 5 and 6 November 1975, ANZ M42/9/2 Part 2).

The Marine Mammals Protection Bill was drafted in early 1976 (ANZ 36/1/95). A subsequent draft was provided to the Parliamentary Counsel in November 1976, and introduced to the House on 3 August 1978 (New Zealand Parliamentary Debates 1978). Provisions in the Bill (which was passed in October 1978) provided for the complete protection of all marine mammals, whether dead or alive, within New Zealand fisheries waters – i.e. within 200 nautical miles (370.4 km) of land.

Toheroa: 1980

Despite increasingly restrictive harvest regulations from 1955, toheroa stocks continued to decline until all fisheries were closed from 1 December 1980 (Stace 1991; Beentjes 2010). Toheroa have never been declared a fully protected species, but there have been no open seasons anywhere since 1993. Provisions for customary harvest by Māori were introduced in 1986. This review has not looked into the details of the rationale for setting successive toheroa closed seasons and harvest limits, which are peripheral to whether the species was fully protected or not.

Coral: 1980, 1989, 1991 and 2010

Protection of coral in New Zealand was triggered by an application to harvest black coral from Fiordland for the manufacture of jewellery. The application was made by Graham, Dave and Ken Mackie of Dunedin, via their accountant George Morton, with the initial enquiry addressed to the Fiordland National Park Board on 16 May 1980 (MPI 10/19/1 Vol. 1). The board replied that they did not have jurisdiction over the waters of the sounds, and suggested that the enquiry be referred to the Marine Division of the Ministry of Transport (letter, 22 May 1980, MPI 10/19/1 Vol. 1). Morton wrote to the Fisheries Management Division of MAF on 1 July 1980, who, in response, clarified that black coral was included in the definition of 'fish' in the Fisheries Amendment Act 1979, and expressed concern at the potential impacts of even limited harvest, due to the slow growth rate of black coral: 'In view of the foregoing there is no possibility of any relaxation of existing controls and in fact to do so would create a dangerous precedent' (letter from B.T. Cunningham, director of the Fisheries Management Division, 7 July 1980, MPI 10/19/1 Vol. 1).

Morton wrote again to the Fisheries Management Division on 18 August 1980 (MPI 10/19/1 Vol. 1), seeking clarification of the exact clauses that controlled the collection of black coral, as he had been unable to find anything controlling harvest of black coral in the Fisheries Act 1908 or subsequent Regulations. An undated memo filed alongside this letter admitted that the ministry had been 'foxing', that there was no prohibition on the taking of black coral in force, and that an application to harvest coral made through proper process could not be refused. Similar concerns were expressed to the Fiordland National Park Board in a letter from R.D. Cooper, Senior Fisheries Management Officer, Marine, dated 23 September 1980 (MPI 10/19/1 Vol. 1), and stating that a regulation to rectify this would be promulgated shortly. Comment on the proposed harvest was also sought from the Southland United Council, and the New Zealand Oceanographic Institute (Department of Scientific and Industrial Research/DSIR). Both agencies expressed concern that black corals were considered endangered by the IUCN, and that black corals formed the principal substrate and source of shelter for numerous other species, and they stressed the scientific importance of the subtidal fjord-wall biota (letters, 15 September and 8 October 1982, respectively, MPI 10/19/1 Vol. 1). A fisheries regulation prohibiting the taking of black coral came into force on 12 December 1980.

As for black corals, red hydrocorals (family Stylasteridae) were considered 'highly collectable and would be eagerly sought after by the tourist trade and other markets if this were permitted' (Coral Issues Summary, 18 April 2007, DOC NHS-01-01-02 HO1). They are similarly slow-growing, occur within reach of divers and share the same vulnerability to any form of harvesting as black coral (file note dated 1 October 1990, MPI A/2/11/B). Protection was initiated in October 1989 through prohibitions on commercial fishers taking or possessing red coral in waters around Southland, southeast New Zealand and the subantarctic (see Appendix 1). A year later, a paper recommending that prohibition be extended to amateur fishers noted that DOC personnel around Fiordland and Stewart Island/Rakiura were concerned about the frequency of 'Removal of red coral as a souvenir of diving trips', and that DSIR studies along the Fiordland coast had confirmed damage occurring to red corals (1 October 1990, MPI A/2/11/B). DOC staff had requested protection of red corals at meetings held in Invercargill and on Stewart Island/Rakiura in February 1990, and this was supported by local representatives of the recreational fishing sector at a meeting in June 1990 (ibid.). Amateur fishing regulations prohibiting taking or possessing red coral in the same fishery management areas as the commercial prohibitions were gazetted in April 1991.

Unlike the Fisheries Act 1908, the succeeding Fisheries Act 1996 was restricted to managing extractive use of living resources on a sustainable basis. This meant that the new Fisheries Act could no longer be used to totally protect species (MPI DFP 5/1/11 Vol. 2b). Ongoing protection of species such as black and red corals (and spotted black grouper, see below) was achieved through the Fisheries Act 1996 amendment of the definition of 'animal' in Section 2 of the Wildlife Act 1953, and creation of Schedule 7A of the Wildlife Act 1953 ('Marine species declared to be animals'), with black corals, all species of red coral and spotted black grouper listed in the schedule. The same schedule of the Fisheries Act 1996 extended most provisions of the Wildlife Act 1953 to include New Zealand fisheries waters, thereby protecting black and red corals out to 200 nautical miles (370.4 km) from the New Zealand coast.

Further protection for corals was raised during consultation on amendments to Schedule 7A of the Wildlife Act 1953, starting in 2005. Initial suggestions were for protection of gorgonian corals (phone and email exchange between Steve O'Shea, Auckland University of Technology, and Michael Gee of DOC, December 2005, DOC NHS-01-01-02 HO1). O'Shea commented that (along with other corals), gorgonian corals were affected by bottom-trawl and dredge fisheries (see Clark & O'Driscoll 2003), and that 'shallower-water coastal representatives are potentially impacted by boat anchors, chains, SCUBA divers, and recreational and commercial fishing gear'. O'Shea further commented that identification of corals even to order level (Scleractinia, Stylasterida, Antipatharia or Gorgonacea [Alcyonacea]) was difficult for non-specialists, with no identification guide available locally that enabled their unambiguous differentiation. He suggested that some species of gorgonian corals needed protection due to their 'apparent scarcity, unrecognised diversity, and susceptibility to damage', and that this would best be achieved by protecting all gorgonian corals, to remove any uncertainty in identification.

An additional incentive for adding gorgonian corals to Schedule 7A was to align with reporting requirements for corals under the Fisheries Act 1996 (internal email, 9 October 2006, DOC NHS-01-01-02 HO1). All scleractinian (stony) corals (along with hydrocorals and black corals) are listed on Appendix II of CITES, meaning that an export permit is required to take them out of New Zealand (Coral Issues Summary, 18 April 2007, DOC NHS-01-01-02 HO1). Protection of both gorgonian and stony corals would mean that fishers could be directed to collect information on the impacts of fisheries by-catch on corals, without the complication of figuring out which species required reporting (i.e. they would have to report all hard corals, with samples returned for expert identification) (internal email, 5 April 2007, DOC NHS-01-01-02 HO1). Provided that the incidental catching of 'protected' corals is reported, and specimens are not retained by fishers, no offence is committed. Reporting of coral by-catch could benefit management of coral through contributing to knowledge of distribution and abundance (Coral Issues Summary, 18 April 2007, DOC NHS-01-01-02 HO1). The main counter-argument for blanket protection of entire orders of coral in New Zealand was the potential adverse impacts on research (as researchers would need to apply for permits to take, hold and transfer specimens), including the need to collect voucher specimens in the field for subsequent identification in the laboratory, and the frequent need for transfer of reference specimens between research agencies, including overseas (ibid.).

While it was recognised that protection under the Wildlife Act 1953 could not address many potential impacts on coral (e.g. pollution, sediment smothering and anchor damage), it was anticipated that protection would assist in mitigating other potential impacts such as commercial trade, collecting by divers and some fishing activities, particularly when protection was applied in tandem with fisheries regulations (Coral Issues Summary, 18 April 2007, DOC NHS-01-01-02 HO1).

Many of these arguments for further protection of corals were presented in a public discussion document seeking submissions on levels of protection for New Zealand wildlife (Department of Conservation 2006). The document also pointed out the ambiguity of the term 'red coral', which can be applied to some gorgonian corals in addition to *Errina* species (hydrocorals in the family Stylasteridae). Sixteen submissions on coral were received, with 15 seeking improved protection (Department of Conservation 2008). The report initially (p. 108) recommended continued protection of black corals and hydrocorals, and new protection for several shallow-water scleractinian corals: the branching coral *Oculina virgosa* and three genera of large cup corals (*Caryophyllia*, *Desmophyllum* and *Stephanocyathus*). However, following a discussion of fishery impacts on deep-water corals, and particularly the practical considerations of reporting requirements, the same report (p. 112) also proposed an alternative regime of protecting all stony corals (order Scleractinia) and all gorgonian corals (order Gorgonacea). All gorgonian corals and stony corals were added to Schedule 7A of the Wildlife Act 1953 in the Wildlife Order 2010 (in force from 8 July 2010), along with a clarification of the taxonomy and nomenclature of red corals (all species in the family Stylasteridae).

Spotted black grouper: 1986

Spotted black groupers are very large reef-dwelling fish that are highly vulnerable to overfishing. In New Zealand, they are mainly found around the subtropical Kermadec Islands, with occasional individuals seen around islands and headlands of the northeast coast of the North Island, and stragglers reaching as far south as Palliser Bay and Westport (Roberts 2015).

The New Zealand Underwater Association introduced a voluntary ban on spearing spotted black grouper in 1982 (letter, 30 April 1986, MPI 9/3/1/28/1 Vol. 4). The Kermadec population was considered to be the world's only remaining unfished population, and concerns over its vulnerability were first expressed in 1985, when the Ministry of Transport introduced changes to survey requirements for inshore fishing vessels, which were expected to result in increased fishing activity in the Kermadec Fishery Management Area (letter to Auckland Fisheries Management Advisory Committee, 30 April 1986, MPI 9/3/1/28/1 Vol. 4). MAF considered that the scientific values of the Kermadec marine area warranted the establishment of a marine park or reserve (Francis 1985), however, 'as this may take some time, MAF considers that controls under the Fisheries Act may be an appropriate way to protect the area [in the interim]' (ibid.). The letter of 30 April 1986 invited members of Auckland Fisheries Management Advisory Committee to provide comment on the protection proposal for spotted black grouper, among a raft of proposed protection initiatives relating to the Kermadec Islands, by 20 June 1986. A briefing note to the Minister of Fisheries dated 28 August 1986 stated that extensive consultations had been held with commercial and recreational groups in the Auckland and Northland area, and that there was an awareness among all those consulted that measures to protect this species were required (MPI 9/2/4/1 Vol. 2). Regulations prohibiting the taking of spotted black grouper by commercial and amateur fishers in the Kermadec and Auckland fishery management areas came into force on 18 September 1986. The spotted black grouper was included in Schedule 7A of the Wildlife Act 1953 (in the Fisheries Act 1996) at the request of Forest & Bird, and the Environment and Conservation Organisations of Aotearoa New Zealand (ECO) (MPI 15/5/2 Vol. 2a).

Great white shark: 2007

Protection of great white sharks in New Zealand waters was preceded by an Australian proposal to list the great white shark and the basking shark in Appendix 1 of CITES (letter, 26 April 1999, DOC NHS-11-07-03-01 HOM-1). The CITES proposal was voted down in April 2000, falling short of the two-thirds majority required. Australia had granted protection to great white sharks in 1999, and was therefore able to list the species on Appendix III of CITES (requiring other parties to assist in controlling trade) in October 2001 (letter, 6 March 2003, DOC NHS-07-01 HOM-1), and the IUCN listed the species as 'Vulnerable' in 2000.

In September 2002, New Zealand attended the (Seventh) Conference of Parties to the Convention for the Conservation of Migratory Species of Wild Animals (CMS) for the first time. The meeting agreed to an Australian proposal to list the great white shark on Appendices I and II of CMS. The listing obligated New Zealand (as one of the 'Parties that are Range States' for great white sharks) to prohibit deliberate taking of the species (including by recreational fishers) and to prohibit sale of their body parts, including fins and jaws (briefing note, 22 May 2003, DOC ICC-05-08 HO1). However, no regulatory action had been taken before the capture of a 6 m-long pregnant female great white shark in a commercial set net off Waiheke Island in November 2003 led Chris Carter, Minister of Conservation, to request a briefing paper on whether it was time for New Zealand to follow the United States, Australia and South Africa in protecting the species (email from DOC CEO Alastair Morrison, 12 December 2003, DOC NHS-07-01 HOM-1). Although great white sharks were not a quota species (i.e. a permissible catch) for commercial fisheries in New Zealand, there was a market for their jaws, and there were concerns that international anglers were travelling to the Chatham Islands to obtain trophy jaws (briefing to Chris Carter, 3 February 2004, DOC LCV-01-15-01-04 HO1).

Chris Carter issued a press release on 6 June 2004 stating the intention of the Ministry of Fisheries and DOC to protect the great white shark, in order to meet New Zealand's obligations under the CMS (DOC NHS-07-01 HOM-1). This was given further impetus in October 2004, when the great white shark was listed on Appendix II of CITES (on the second attempt), further obligating New Zealand to prohibit trade in great white shark body parts. However, progress was slow, with a ministerial briefing on 13 July 2005 recommending that the Minister of Conservation and Minister of Fisheries agree to consult with interested parties on options for the best way to provide full protection to great white sharks in New Zealand waters and from the activities of New Zealand vessels (DOC NHS-01-01-02 HO1). The options paper to stakeholders was released on 3 March 2006, with a 3 May deadline for responses (DOC NHS-01-01-02 HO1). There was overwhelming support for protection from those consulted, with 18 of the 22 submitters in favour of protection, and 12 explicitly supporting combined use of the Wildlife Act 1953 and the Fisheries Act 1996 to achieve protection (summary of recommendations, October 2006, DOC NHS-01-01-02 HO1 and LCA-08-05-01 HO1). Note that the Fisheries Act 1996 provided for regulations controlling New Zealand vessels on the high seas, whereas the Wildlife Act 1953 (since 1996) applied only to New Zealand fisheries waters. The Ministry of Fisheries and DOC jointly recommended to their ministers that the great white shark be protected under both the Wildlife Act 1953 and the Fisheries Act 1996 (DOC LCA-08-05-01 HO1). This was achieved through the Wildlife (White Pointer Shark) Order 2007, adding the great white shark to Schedule 7A of the Wildlife Act 1953 (26 February 2007), and a week later the Fisheries (Southland and Sub-Antarctic Areas Amateur Fishing) Amendment Regulations 2007, removing the great white shark from the schedule of species able to be taken in the Southland and Sub-Antarctic fishery management areas, and the Fisheries (White Pointer Shark – High Seas Protection) Regulations 2007, prohibiting use of New Zealand ships on the high seas to take great white sharks.

Additional marine fish species: 2010 and 2013

Two separate initiatives led to the full protection of seven further species of marine fishes in New Zealand waters in 2010 and 2013. In July 2006, DOC initiated a review of the schedules of the Wildlife Act 1953, by releasing the public discussion document *Review of level of protection for some New Zealand wildlife*. This included consideration of expanding Schedule 7A ('Marine species declared to be animals' for the purposes of the Act). At the same time, DOC staff were seeking to implement further obligations flowing from New Zealand being a party to the CMS, CITES, and the Western and Central Pacific Fisheries Commission (WCPFC).

The CMS (or Bonn Convention) aims to conserve terrestrial, aquatic and avian migratory species throughout their ranges. All migratory bird and whale species that visit New Zealand are automatically protected by the Wildlife Act 1953 or the Marine Mammals Protection Act 1978, but migratory fish species are not protected unless they are included in Schedule 7A of the Wildlife Act 1953, and/or are protected by regulations under the Fisheries Act 1996.

Both DOC and Forest & Bird had advocated for protection of certain migratory shark and ray species since the early 1990s. A DOC submission on bag limits for amateur fishers in coastal fisheries dated 13 December 1991 requested that it be made illegal to kill, injure, capture or otherwise harass basking sharks and manta rays (genera *Manta* and *Mobula*) (DOC COA 0052), and an August 1992 article in *Forest & Bird* magazine argued that 'basking sharks deserved full protection under the law' (Tennyson 1992). Reasons given for basking shark protection included evidence of declining numbers, their presumed very slow reproductive rate, their potential as a focus for ecotourism, their vulnerability to commercial fishing for their fins and livers and to accidental capture in set nets, and their intrinsic value as one of New Zealand's most impressive fish species (Taylor 1992; Tennyson 1992).

The United Kingdom initiated a proposal to list the basking shark on Appendix II of CITES at the April 2000 Conference of the Parties to the Convention (email, 20 April

2000, DOC NHS-11-07-03-01 HOM-1). The initial proposal was voted down, but it received the required two-thirds support (along with a proposal to list the whale shark) in February 2003 (Convention on International Trade in Endangered Species of Wild Fauna and Flora 2013). As New Zealand is a range state for both species, this obligated it to pass legislation prohibiting sale of these sharks or their body parts (briefing to Minister of Conservation, 12 February 2004, DOC NHS-07-01 HO-1). The obligation increased further to a requirement for full protection when the basking shark was added to Appendices I and II of the CMS in November 2005.

Initiatives to protect further species of *Epinephelus* grouper species (in addition to spotted black grouper) began in December 2001, when Sandra Lee, Minister of Conservation, wrote to Pete Hodgson, Minister of Fisheries, stating that Roger Grace and others had written to her seeking protection for any members of the genus occurring in New Zealand waters, and citing an example of a 115 kg giant or Queensland grouper killed in a spear-fishing competition in Northland (MPI 10/15/18 Vol. 1). The three *Epinephelus* species occurring occasionally in New Zealand waters were giant grouper, convict grouper (or eightbar grouper; *E. octofasciatus*) and half-moon grouper (*E. rivulatus*). Lee stated her intention to seek protection for *Epinephelus* grouper species under the Wildlife Act 1953, and sought Hodgson's support for protection via regulations under the Fisheries Act 1996. Hodgson acknowledged her concerns, but did not believe that 'convict, Queensland or half moon grouper are targeted by recreational fishers' (letter, 25 February 2002, MPI 10/15/18 Vol. 1). A DOC report dated 24 March 2005 (DOC NHS-01-01-02 HO1) recommended that giant grouper be protected due to 'their low resilience to fishing pressure, vulnerability to spear and line fishers, small population size and intermittent recruitment' to waters around islands north and northeast of New Zealand, south to the Aldermen Islands. As giant grouper can be confused with spotted black grouper, the DOC report suggested that protection of giant grouper would provide additional protection for spotted black grouper.

Whale sharks are summer migrants to northern New Zealand waters, occasionally ranging as far south as Fiordland and South Canterbury (Duffy 2002; DOC report, 24 March 2005, NHS-01-01-02 HO1). They were listed on Appendix II of the CMS in 1999 (International Union for Conservation of Nature 2015), and Appendix II of CITES in February 2003 (Convention on International Trade in Endangered Species of Fauna and Flora 2013). The CMS listing obligated protection in the waters of signatory range states (briefing to Minister of Conservation, 12 February 2004, DOC NHS-07-01 HO-1).

The earliest record of a suggestion to protect the deepwater nurse shark is in the DOC report dated 24 March 2005 (NHS-01-01-02 HO1), stating that the species appeared to be naturally rare and was vulnerable to deepwater line and net fisheries at aggregation sites. Within New Zealand waters there are isolated records from the Norfolk Ridge, New Plymouth, the Kermadec Islands, Volkner Rocks, Whakaari/White Island, Gisborne, the Mahia Peninsula and Lachlan Banks (ibid.). Although prohibited as a commercial target species (Francis & Shallard 1999), deepwater nurse sharks could be utilised commercially if taken as by-catch, and were occasionally caught in bottom trawls and deep-set gill nets, including attempts to capture them for display at Kelly Tarlton's Underwater World (DOC report, 24 March 2005, DOC NHS-01-01-02 HO1).

The same 24 March 2005 DOC report (DOC NHS-01-01-02 HO1) also recommended protection for the two species of mobulid rays known from New Zealand waters: the manta ray and spinetail devil ray. Spinetail devil rays are common to abundant beyond the shelf break off northern New Zealand in summer, while manta rays are recorded more rarely over the shelf (Stewart 2002; Duffy & Abbott 2003). Although not targeted by commercial or recreational fisheries in New Zealand, at least 234 spinetail devil rays were landed as by-catch in the skipjack tuna purse-seine fishery of northern New Zealand between 1977 and 1981 (Paulin *et al.* 1982), and it was considered that protection in New Zealand waters would assist protection efforts for mobulid rays elsewhere (DOC report, 24 March 2005, DOC NHS-01-01-02 HO1).

Five of these marine fish species (i.e. giant grouper, whale shark, deepwater nurse shark, manta ray and spinetail devil ray) were included as the only fish discussed as potential additions to Schedule 7A of the Wildlife Act 1953 in the public discussion document released in August 2006 (Department of Conservation 2006). Basking shark and great white shark were excluded, as they were both considered commercial fishery by-catch species requiring a different consultation process, including potential amendments to regulations under the Fisheries Act 1996 (ibid.). Submissions on the report were overwhelmingly in favour of all five species being added to Schedule 7A, although the resulting report recommended that all species of manta and mobula rays be protected in New Zealand waters, to safeguard against misidentifications and taxonomic changes (Department of Conservation 2008). This last recommendation was not followed, but all five species were listed in Schedule 7A in the Wildlife Order 2010 (June 2010).

The Ministry of Fisheries and DOC continued to consider protection options for the basking shark during the review of Wildlife Act 1953 schedules. The New Zealand national plan of action for the conservation and management of sharks, published by the Ministry of Fisheries in October 2008, stated that consultation would soon be initiated on full protection for the basking shark (Ministry of Fisheries 2008). In August 2010, a 'final advice' paper on basking shark protection prepared for their ministers summarised submissions, and recommended that the species be included in Schedule 7A of the Wildlife Act 1953, that regulations be made under Section 297 of the Fisheries Act 1996 to restrict the take of basking sharks by New Zealand-flagged vessels operating on the high seas, and that amendments be made to the Fisheries (Reporting) Regulations 2001 to require fishers to report take of basking sharks on the protected species catch return (Ministry of Fisheries 2010). The resulting amendments to fisheries regulations and the Wildlife Act 1953 came into force on 16 December 2010.

The seventh and final species of fish to receive full protection in New Zealand waters during 2010–13 was the oceanic whitetip shark. This arose through New Zealand's membership of the WCPFC. The oceanic whitetip shark is a highly migratory species that, in New Zealand, has been recorded near the Kermadec Islands and off the northeast coast of the North Island south to Mahia Peninsula (DOC NHS-07-01 HO-1). Although it was formerly abundant throughout most of the world's tropical and warm-temperate oceans, targeted fishing plus by-catch in tuna longline and driftnet fisheries led to large reductions in its relative abundance and a listing as 'Vulnerable' by the IUCN in 2006 (ibid.). The background to the joint protection initiative by DOC and MPI was laid out in an initial position paper released in July 2012 (DOC NHS-07-01 HO-1). (MPI was formed in April 2012 through the merger of three former ministries, including the Ministry of Fisheries.) In response to concerns about a rapid decline in oceanic whitetip shark abundance, the United States proposed a draft measure to prohibit any landings or sales of the species within the WCPFC area, effective from 1 January 2013. The measure was adopted at the WCPFC's annual meeting in March 2012, obligating New Zealand to implement protection measures for oceanic whitetip sharks, regardless of whether there was evidence of New Zealand fisheries impacting on the local population (ibid.). Submissions on proposed protection measures were invited from stakeholders, and all four submissions received supported the proposal (DOC submission to Kate Wilkinson, Minister of Conservation, 13 September 2012, DOC NHS-07-01 HO-1). The resulting amendments to the Wildlife Act 1953 and fisheries regulations came into force on 3 January 2013.

Discussion

This review provides a chronological database that allows comparison of when and why legal protection was initiated between different faunal groups, particularly when contrasted with the protection histories for New Zealand's terrestrial fauna (Miskelly 2014). The most striking contrast is the much later implementation of full legal protection of any marine species (right whales in 1935), 57 years after the first terrestrial species (tūī , in 1878; Miskelly 2014). Most native New Zealand birds have had ongoing full protection since at least 1910. Equivalent blanket protection for marine reptiles (at least on New Zealand shores) was granted in 1953, for marine mammals in 1978, and for hard corals in 2010 – a full century after birds. Absolute protection of marine fishes remains limited to nine iconic species, and was initiated in the 1980s. This is similar in both timing and proportional extent to the protection history for terrestrial invertebrates: 29 species and two genera were granted absolute protection in 1980, with further species and genera added in 2010 (Meads 1990; Miskelly 2014).

With the exception of analyses of legislation regulating fur seal closed seasons (Sorensen 1969; Crawley & Wilson 1976; Grady 1986: 45), and discussion of protection of celebrity dolphins (see below), few authors have touched on the legal protection of New Zealand's marine and freshwater fauna. Part of the reason for the limited reporting of the processes by which other species of New Zealand's aquatic fauna gained protection is that much of the activity, particularly relating to protection of marine fishes and corals, has been recent, with details retained in active or recently closed files held by DOC and MPI. This contrasts with the much earlier correspondence leading to the protection of most of New Zealand's terrestrial fauna, which is in files held by Archives New Zealand, and therefore is more accessible to researchers (e.g. examples quoted in Barlow 1972; Galbreath 1989; Young 2004; Cree 2014; Miskelly 2014).

The absence of published detail on how, why and when aquatic species were protected is most apparent in the extensive literature on whale and dolphin conservation in New Zealand, which focuses more on the actions of conservation groups since the 1970s than on the earlier history of regulated harvest, and reasons for the stepwise protection for cetaceans in New Zealand (e.g. Dawson 1985; Baker 1990; Cox 1990; Donoghue & Wheeler 1990; Todd 2007, 2014). Most of these publications gloss over how recently most cetacean species have been protected in New Zealand waters (1978), and all fail to mention the Australian and New Zealand governments' attempts to limit proposed protection of humpback whales in the southern hemisphere as recently as 1963 (International Whaling Commission 1965).

There has also been ready acceptance of flawed attempts to protect famous individual dolphins (Baker 1990; Cox 1990; Lee-Johnson & Lee-Johnson 1994; Young 2004: 104, 153; King & Morris 2008; Peat 2010: 64; Todd 2014: 174–175). Before October 1956, New Zealand Acts contained no provision for protection of marine mammals other than seals, a shortcoming that was recognised by public servants and politicians at the time. Notwithstanding this, they prepared and approved Orders in Council and Regulations claiming to protect Pelorus Jack (in September 1904, May 1906 and May 1911), Pelorus Jack II (in February 1945, May 1947, August 1950 and February 1956) and Opo (in March 1956). Gerald O'Halloran's memo of 2 March 1956 (ANZ M42/9/2 Part 1) – 'You are aware, of course, that these regulations may not be valid as a dolphin is a mammal and not a fish. However, as an expediency measure I think they should suffice' – makes it clear that the government was more concerned about the appearance of taking measures to satisfy public demands for protection of these dolphins than they were about ensuring that their efforts were legally valid. Alpers (1960: 117) and Peart (2013: 24) commented on the questionable validity of legislation purporting to protect Pelorus Jack. However, there has been less scrutiny of the 'protection' of Pelorus Jack II and Opo, or comment on the retrospective implications of the passing of the Fisheries Amendment Act 1956, seven months after Opo's death. This Amendment Act provided for the Governor-General to make regulations protecting all marine mammal species (cf. seals only) – an admission by Parliament that the eight different Orders in Council and Regulations passed between 1904 and 1956 that were intended to protect these three dolphins had all exceeded the powers of the Sea-fisheries Act 1894 and subsequent Fisheries Act 1908.

The New Zealand fur seal has been the subject of more legislation and species-specific New Zealand Gazette notices than any other fully protected indigenous species (83 examples listed in Appendix 1). The effort that the New Zealand government invested in legislation to protect fur seals and to regulate their harvest reflected the economic significance of seal skins to the early New Zealand economy, and the hope that seal stocks would recover sufficiently to allow resumption of harvest (Crawley & Wilson 1976; Grady 1986). A similar (and equally ineffective) approach was applied to regulation of toheroa harvest, with at least 24 increasingly restrictive regulations applied from 1955 until all fisheries were closed in December 1980 (Stace 1991; Beentjes 2010). However, toheroa management differed from that for fur seals, as there was a high level of recreational harvest of toheroa, continuing long after cessation of commercial harvest in 1969 (Stace 1991).

Ironically, none of the legislation regulating fur seal harvest referred to the species by either its common or scientific name, with all using the generic term 'seal' or simply referring to the activity of sealing. This meant that the legislation covered all eight seal species recorded from New Zealand (King 2005; Miskelly 2015). There is no indication that this wider interpretation of 'seal' was intended before the drafting of the Marine Mammals Protection Act 1978, which specifically protected 'All species of seal (*Pinnipedia*)'.

The processes by which most marine species have become protected were markedly different from the protection histories for New Zealand's terrestrial species. Legal protection of many birds, and also tuatara, bats, frogs and lizards, was reactive, triggered by written requests from individuals, scientific societies, conservation groups or acclimatisation societies (35 examples in Miskelly 2014: table 2). In contrast, among marine species, only the protection of green turtle and leathery turtle in 1939, giant grouper in 2010, and the *ultra vires* protection of the three individual dolphins referred to above can be traced back to written requests to ministers or government departments. Protection of marine species has been predominantly proactive, with government departments initiating processes to protect threatened species from both commercial and recreational harvest. For a few species (notably black coral in 1980 and spotted black grouper in 1986), protective legislation was both proactive and pre-emptive. Opportunities for harvest of these species were closed before fisheries or markets became established.

A final, striking, difference between the protection processes for marine and terrestrial species is the number of marine species that have become protected as a result of obligations stemming from New Zealand being a signatory nation to international commissions and conventions. Protection of three species of whales resulted from New Zealand's membership of the IWC, and protection of four species of sharks resulted from New Zealand being a party to the CMS, CITES and the WCPFC. CMS, CITES and the Agreement on Conservation of Albatrosses and Petrels (ACAP) also create obligations for protection of listed terrestrial species and seabirds by member nations. However, all New Zealand bird and terrestrial reptile species listed in these conventions and agreements were protected by New Zealand legislation long before there was any international obligation to do so (Miskelly 2014).

Acknowledgements

This research was funded by the Museum of New Zealand Te Papa Tongarewa (Te Papa), Wellington, New Zealand. Considerable assistance was provided by library staff at Te Papa, especially Christine Kiddey, and the staff of Archives New Zealand, Wellington, New Zealand. Michael Gee and Keri Ford assisted with providing access to relevant DOC files and reports, and Merryn Jones and Brian Addley provided similar assistance with MPI files. Martin Cawthorn, John Taunton-Clark, David O'Dea and Barry Webster advised on former fisheries staff. Thanks also to Brian Bell, Mark Bellingham, Michael Beentjes, Malcolm Francis, Allen Frazer, Paul Hughes and Alan Tennyson for their comments and suggestions during my research. The manuscript was improved by comments received from Alan Baker, Martin Cawthorn, Clinton Duffy, Malcolm Francis, Allen Frazer, Michael Gee, Clive Roberts, Susan Waugh and Rick Webber.

References

See Appendix 1 for citation details of all Acts, Amendment Acts, Orders, Regulations and *New Zealand Gazette* notices referred to in the text.

Admirer, Opononi (1956). Appeal for 'Opo' [letter to editor]. *New Zealand Herald*, 27 February, p. 8.

Allen, K.R. (1949). The New Zealand grayling: a vanishing species. *Tuatara* 2: 22–27.

Alpers, A. (1960). *A book of dolphins*. London: John Murray. 147 pp.

Baker, A.N. (1974). Risso's dolphin in New Zealand waters, and the identity of 'Pelorus Jack'. *Records of the Dominion Museum* 8: 267–276.

Baker, A.N. (1990). *Whales and dolphins of New Zealand and Australia*. 2nd edn. Wellington: Victoria University Press. 133 pp.

Ballantine, W.J. (1991). Marine reserves for New Zealand. *Leigh Laboratory Bulletin* 25. Auckland: University of Auckland. 196 pp.

Barlow, M. (1972). The establishment, dispersal and distribution of the spur-winged plover in New Zealand. *Notornis* 19: 201–211.

Clark, M.R. and O'Driscoll, R. (2003). Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fishery Science* 31: 441–458.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (2013) Appendices I, II and II. *In*: *Convention on International Trade in Endangered Species of Wild Fauna and Flora* [website]. Retrieved on 17 March 2014 from www.cites.org/eng/app/appendices.php.

Cox, G.J. (1990). *Whale watch: a guide to New Zealand's whales and dolphins*. Auckland: Collins. 40 pp.

Crawley, M.C. and Wilson, G.J. (1976). The natural history and behaviour of the New Zealand fur seal (*Arctocephalus forsteri*). *Tuatara* 22: 1–29.

Cree, A. (2014). *Tuatara; biology and conservation of a venerable survivor*. Christchurch: Canterbury University Press. 583 pp.

Dawson, S. (1985). *The New Zealand whale and dolphin digest*. Auckland: Brick Row. 130 pp.

Department of Conservation (2006). *Review of level of protection for some New Zealand wildlife: public discussion document*. Wellington: Strategy and Policy Group, Department of Conservation. 44 pp.

Dingwall, P.R. and Gregory, G. (*eds*) (2004). *A musterer's sojourn on Campbell Island: the diary of Alfred Austin, 1919–1921*. Wellington: Department of Conservation. x + 135 pp.

Donoghue, M. and Wheeler, A. (1990). *Save the dolphins*. Auckland: David Bateman. 119 pp.

Duffy, C.A.J. (2002). Distribution, seasonality, lengths, and feeding behaviour of whale sharks (*Rhincodon typus*) observed in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research* 36: 565–570.

Duffy, C.A.J. and Abbott, D. (2003). Sightings of mobulid rays from northern New Zealand, with confirmation of the occurrence of *Manta birostris* in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research* 37: 715–721.

Enderby, J. and Enderby, T. (2006). *A guide to New Zealand's marine reserves*. New Zealand: New Holland Publishers. 176 pp.

Francis, M.P. and Shallard, B. (1999) New Zealand shark fishery management. Pp. 480–920. *In*: Shotton, R. (*ed.*)

Case studies in the management of elasmobranch fisheries. *FAO Fisheries Technical Paper* 378(2). Rome: Food and Agriculture Organisation.

Fur seal season; hasty action; Dr. Falla condemns policy (1946). *Evening Post*. 9 July, p. 8.

Galbreath, R. (1989). *Walter Buller: the reluctant conservationist*. Wellington: GP Books. 336 pp.

Galbreath, R. (1993). *Working for wildlife: a history of the New Zealand Wildlife Service*. Wellington: Bridget Williams Books, and Historical Branch, Department of Internal Affairs. 253 pp.

Gaskin, D.E. (1972). *Whales, dolphins, and seals with special reference to the New Zealand region*. Auckland: Heinemann. 200 pp.

Gill, B. and Whitaker, T. (1996). *New Zealand frogs and reptiles*. Auckland: David Bateman. 112 pp.

Grady, D. (1986). *Sealers and whalers in New Zealand waters*. Auckland: Reed Methuen. 308 pp.

Harcourt, R. (2005). New Zealand fur seal. Pp. 225–235. *In*: King, C.M. (*ed*.). *The handbook of New Zealand mammals*. 2nd edn. Melbourne: Oxford University Press. xix + 610 pp.

Hutton, F.W. and Drummond, J. (1904). *The animals of New Zealand: an account of the colony's air-breathing vertebrates*. Christchurch: Whitcombe & Tombs. 381 pp.

Hutton, F.W. and Drummond, J. (1905). *The animals of New Zealand: an account of the colony's air-breathing vertebrates*. 2nd edn. Christchurch: Whitcombe & Tombs. 375 pp.

Hutton, F.W. and Drummond, J. (1909). *The animals of New Zealand: an account of the dominion's air-breathing vertebrates*. 3rd edn. Christchurch: Whitcombe & Tombs. 407 pp.

International Union for Conservation of Nature (2015). *The IUCN red list of threatened species 2015-4* [website]. Retrieved on 8 July 2015 from www.iucnredlist.org.

International Whaling Commission (1965). *Fifteenth report of the Commission (covering the fifteenth fiscal year 1st June, 1963 to 31st May, 1964)*. London: IWC. 72 pp.

King, C.M. (*ed*.) 2005. *The handbook of New Zealand mammals*. 2nd edn. Melbourne: Oxford University Press. xix + 610 pp.

King, C.M. and Morris, R. (2008). *A photographic guide to mammals of New Zealand*. Auckland: New Holland. 119 pp.

League of Nations Economic Committee (1929). *Report to the council on the work of the twenty-ninth session. Held at Geneva from July 1st to 4th, 1929*. C.307.M.106.1926.II. Geneva: League of Nations. 9 pp.

Lee-Johnson, E. and Lee-Johnson, E. (1994). *Opo the Hokianga dolphin*. Auckland: David Ling. 47 pp.

Lello, J.W. (1980). Coastal management in the 80's? *New Zealand Environment* 28: 6–11.

McCallum, J. (2012). Barnicoat, Constance Alice. *In*: Dictionary of New Zealand biography [website]. Retrieved on 15 July 2015 from www.teara.govt.nz.

McDowall, R.M. (1990). *New Zealand freshwater fishes: a natural history and guide*. 2nd edn. Auckland: Heinemann Reed and MAF Publishing Group. 553 pp.

McDowall, R.M. (1994). *Gamekeepers for the nation: the story of New Zealand's acclimatisation societies 1861–1990*. Christchurch: Canterbury University Press. 508 pp.

McDowall, R.M. and Stewart, A.L. (2015). Family Prototroctidae; Southern Hemisphere graylings. Pp. 381–382. *In*: Roberts, C.D., Stewart, A.L. and Struthers, C.D. (*eds*). *The fishes of New Zealand. Vol. 2*. Wellington: Te Papa Press. 2008 pp. [in 4 vols: vol. 1: S1–256; vol. 2: 1–576; vol. 3: 577–1152; vol. 4: 1153–1748].

Meads, M. (1990). *Forgotten fauna: the rare, endangered, and protected invertebrates of New Zealand*. Wellington: DSIR Publishing. 95 pp.

Ministry for the Environment (1988). Coastal legislation: options for reform. *Resource Management Law Reform, Working Paper* 23. Wellington: Ministry for the Environment. vi + 111 pp.

Ministry of Agriculture and Fisheries [1990]. *Marine turtles accidental capture; procedure and guidelines for fishers*. Wellington: MAF Fisheries. 12 pp.

Ministry of Fisheries (2008). *New Zealand national plan of action for the conservation and management of sharks*. Wellington: Ministry of Fisheries. 90 pp.

Miskelly, C.M. (2014). Legal protection of New Zealand's indigenous terrestrial fauna – an historical review. *Tuhinga: Records of the Museum of New Zealand Te Papa Tongarewa* 25: 27–103.

Miskelly, C.M. (2015). Records of three vagrant Antarctic seal species (family Phocidae) from New Zealand: crabeater seal *Lobodon carcinophaga*, Weddell seal *Leptonychotes weddellii*, and Ross seal *Ommatophoca rossii*. *New Zealand Journal of Marine and Freshwater Research* 49: 448–461.

New Zealand Legal Information Institute (n.d.). *NZLII Databases* [website]. Retrieved on 5 October 2014 from www.nzlii.org/databases.html.

New Zealand Parliamentary Debates (1978). Marine Mammals Protection Bill. *NZPD*: 2363–2367.

Oliver, W.R.B. (1946). A pied variety of the coastal porpoise. *Dominion Museum Records in Zoology* 1: 1–4.

Paul, L.J. (2000). *New Zealand fishes: identification, natural history and fisheries*. 2nd edn. Auckland: Reed. viii + 253 pp.

Paulin, C.D., Habib, G., Carey, C.L., Swanson, P.M. and Voss, G.J. (1982). New records of *Mobula japanica* and *Masterus lanceolatus*, and further records of *Luvaris imperialis* (Pisces: Mobulidae, Molidae, Louvaridae) from New Zealand. *New Zealand Journal of Marine and Freshwater Research* 16(1): 11–17.

Peart, R. (2013). *Dolphins of Aotearoa: living with New Zealand dolphins*. Nelson: Craig Potton Publishing. 308 pp.

Peat, N. (2010). *The Tasman: biography of an ocean*. Auckland: Penguin Group (NZ). 240 pp.

'Pelorus Jack'; his classification; goose-beak whale, not white whale (1904). *Lyttelton Times*, 16 September, p. 6.

'Pelorus Jack'; his genus decided; government protection (1904). *New Zealand Times*, 17 September, p. 9.

Roberts, C.D. (2015). Family Serranidae. Pp. 1178–1199. *In*: Roberts, C.D., Stewart, A.L. and Struthers, C.D. (*eds*). *The* *fishes of New Zealand. Vol. 4*. Wellington: Te Papa Press. 2008 pp. [in 4 vols: vol. 1: S1–256; vol. 2: 1–576; vol. 3: 577–1152; vol. 4: 1153–1748].

Scadden, K. (1996). The sealing season 1946. *Seafood New Zealand* October: 84–88.

Slooten, E. (1991). Age, growth and reproduction in Hector's dolphins. *Canadian Journal of Zoology* 69: 1689–1700.

Sorensen, J.H. (1969). New Zealand fur seals with special reference to the 1946 open season. *Fisheries Technical Report* 42. Wellington: New Zealand Marine Department. 80 pp.

Stace, G. (1991). The elusive toheroa. *New Zealand Geographic* 9: 18–34.

Stead, E.F. (1946). Open season for seals. *The Press* [Christchurch], 16 July, p. 4.

Stewart, A. (2002). Mantas and devil rays. *Seafood New Zealand*, April 10(3): 65–68.

Stokell, G. (1941). *Wild life control. Defects in present scheme exposed. Some constructive suggestions*. Presidential address to Royal Society of New Zealand Canterbury Branch. Wellington: Blundell. 21 pp.

Taylor, A. (1992). Shark protection sought. *Evening Post* [Wellington], 26 October, p. 14.

Tennyson, A. (1990). Seabirds in strife. *Forest & Bird* 21: 23–30.

Tennyson, A. (1992). Basking sharks; New Zealand's largest fish. *Forest & Bird* 265: 38–42.

The latest picture of Pelorus Jack II (1944). [Photograph and caption.] *The Dominion* [Wellington], 8 November, p. 6.

Todd, B. (2007). *Whales and dolphins: Kaikoura New Zealand*. Revised edn. Nelson: Nature Down Under. 52 pp.

Todd, B. (2014). *Whales and dolphins of Aotearoa New Zealand*. Wellington: Te Papa Press. 304 pp.

Troughton, E. Le G. (1931). The occurrence of a male and female *Grampus griseus* (Delphinidae) at Sydney, New South Wales. *Proceedings of the Zoological Society of London 1931 Pt 2*: 565–569.

Young, D. (2004). *Our islands, our selves: a history of conservation in New Zealand*. Dunedin: Otago University Press. 298 pp.

Unpublished sources

Baker, A.N. (1997). A history of the New Zealand whale stranding response network, and key factors in its current success. Paper presented at a symposium on whale strandings, held at the National Science Museum, Tokyo, Japan, November 1997. Pou Mataaho 2594119, Museum of New Zealand Te Papa Tongarewa, Wellington. 7 pp.

Beentjes, M.P. (2010). Toheroa survey of Oreti Beach, 2009, and review of historical surveys. New Zealand fisheries internal assessment report 2010/6, National Institute of Water and Atmospheric Research, Dunedin. 40 pp.

Department of Conservation (2008). Review of level of protection for some New Zealand wildlife: preliminary findings and recommendations (excluding Canada goose). Internal report, Policy Group, Department of Conservation, Wellington. 127 pp.

Francis, M.P. (1985). The Kermadec Islands: a marine reserve proposal. Internal report 29, Fisheries Research Division, New Zealand Ministry of Agriculture and Fisheries, Wellington. 33 pp.

Ministry of Fisheries (2010). Management options for basking sharks to give effect to New Zealand's international obligations – final advice. Pp. 29–37. *In*: Review of regulatory measures and other management controls for 1 December 2010. Vol. 1: Final advice papers and summary of recommendations. Report to Ministers, Ministry of Fisheries, Wellington. 37 pp.

Appendix 1: Chronological list of New Zealand legislation relevant to protection of indigenous aquatic wildlife (other than birds)

Legislation prohibiting some or all fishing methods at a particular locality (e.g. creation of marine reserves and marine mammal sanctuaries) is excluded unless explicit mention is made of the species thereby protected. Abbreviations: *NZG* = *New Zealand Gazette*; *SDNZ* = *Statutes of the Dominion of New Zealand*; *SNZ* = *Statutes of New Zealand*; *SR* = *Statutory Regulations*.

The Protection of Animals Act 1873 (37 Victoriae 1873 No. 42; *SNZ* 1873).

Section 8 allowed for additional animals to be proclaimed to come within the operation of the Act. In force from 1 January 1874.

The Protection of Animals Act Amendment Act 1875 (39 Victoriae 1875 No. 18; *SNZ* 1875).

Section 2. No person shall hunt, take or kill any seal except during June–September. In force from 21 September 1875.

The Seals Fisheries Protection Act 1878 (42 Victoriae 1878 No. 43; *SNZ* 1878).

Section 3 set a closed season from 1 October to 1 June. In force from 2 November 1878.

Extending time during which it is prohibited to hunt, catch, or kill seals. *NZG* 84, 20 October 1881: 1306.

Closed season extended from 1 November 1881 to 1 June 1884.

Extending time during which it is prohibited to hunt, catch, or kill seals. *NZG* 64, 29 May 1884: 871.

Closed season extended from 1 June 1884 to 1 June 1886.

The Fisheries Conservation Act 1884 (48 Victoriae 1884 No. 48; *SNZ* 1884).
Section 5. The Governor may make regulations providing for the more effectual protection and management of seals. Section 2 incorporated the Seals Fisheries Protection Act 1878. In force from 10 November 1884.

Regulations under 'The Fisheries Conservation Act, 1884'. *NZG* 20, 2 April 1884: 380–381.
Clause 4. October–May to be a closed season for seals of all kinds, with the current closed season extended to 1 June 1886.

Regulations prescribing the terms upon which leases will be issued for the encouragement of seal fisheries. *NZG* 7, 11 February 1886: 181.
The months of November–June are a closed season for seals.

Extending close season for seals. *NZG* 32, 3 June 1886: 697.
Closed season extended to 1 June 1887.

The Fisheries Conservation Act 1884 Amendment Act 1887 (51 Victoriae 1887 No. 27; *SNZ* 1887).
Section 4. Possession of seals during closed season is sufficient proof that they were taken illegally. In force from 23 December 1887.

Extending close season for seals. *NZG* 26, 21 April 1887: 506.
Closed season extended to 1 June 1888.

Regulations under 'The Fisheries Conservation Act, 1884,' and 'The Fisheries Conservation Act 1884 Amendment Act, 1887'. *NZG* 2, 12 January 1888: 13–14.
The months of October–May are a closed season for seals.

Extending the close season for seals. *NZG* 4, 19 January 1888: 42.
Closed season extended to 1 June 1889.

Extending close season for seals. *NZG* 31, 25 May 1888: 613.
Closed season extended to 1 June 1889.

Prescribing a close season for seals. *NZG* 51, 13 September 1888: 973–974.
Previous closed seasons revoked. September–December 1888 prescribed a closed season for seals.

Extending the close season for seals. *NZG* 69, 20 December 1888: 1401.
Closed season extended to 31 December 1889.

Further extending the close season for seals. *NZG* 1, 2 January 1890: 4.
Closed season extended to 31 December 1890.

Prescribing a close season for seals. *NZG* 5, 23 January 1891: 67.
January–May 1891 prescribed a closed season for seals.

Sealing on Macquarie Island prohibited. *NZG* 33, 7 May 1891: 511.
Taking of seals on Macquarie Island prohibited. Notice received from the Government of Tasmania, published for general information.

Prescribing a close season for seals, and fixing minimum size of seals that may be taken in open season. *NZG* 42, 4 June 1891: 670–671.
June and September–December 1891 prescribed closed seasons for seals. Seals less than 36 in [91 cm] in length protected, as are female seals. [Therefore July–August 1891 was open season.]

Prescribing a close season for seals. *NZG* 98, 31 December 1891: 1486.
January–May 1892 prescribed a closed season for seals.

Prescribing a close season for seals. *NZG* 43, 26 May 1892: 767.
June–December 1892 prescribed a closed season for seals.

Prescribing a close season for seals. *NZG* 102, 29 December 1892: 1740.
January–May 1893 prescribed a closed season for seals.

Prescribing a close season for seals. *NZG* 40, 18 May 1893: 657.
June–December 1893 prescribed a closed season for seals.

Prescribing a close season for seals. *NZG* 1, 4 January 1894: 3.
January–June 1894 prescribed a closed season for seals.

Extending the close season for seals. *NZG* 42, 7 June 1894: 820.
Closed season extended to 30 September 1894.

Revoking Order in Council extending close season for seals, and prescribing fresh close season. *NZG* 64, 30 August 1894: 1361–1362.
Closed season to end 1 September 1894. November–December 1894 to be a closed season.

Varying Order in Council prescribing close season for seals. *NZG* 72, 4 October 1894: 1506.
October–December 1894 to be a closed season between Hokitika River and West Whanganui Inlet.

The Sea-fisheries Act 1894 (58 Victoriae 1894 No. 56; *SNZ* 1894).
Sections 41–44 prescribed conditions and restrictions for the regulation of the taking of seals. In force from 23 October 1894.

Protection of seals on Macquarie Island. *NZG* 82, 16 November 1894: 1666.
Taking of female fur seals and animals under 10 months of age on Macquarie Island prohibited. Notice received from the Government of Tasmania, published for general information.

Extending the close season for seals. *NZG* 1, 7 January 1895: 3–4.
January–June 1895 prescribed a closed season for seals.

Extending the close season for seals. *NZG* 47, 27 June 1895: 998.
Closed season extended to 30 June 1896.

Extending the close season for seals. *NZG* 45, 11 June 1896: 906.
Closed season extended to 30 June 1897.

Extending the close season for seals. *NZG* 37, 15 April 1897: 885.
Closed season extended to 30 June 1898.

Extending the close season for seals. *NZG* 37, 19 May 1898: 864.
Closed season extended to 30 June 1899.

Extending the close season for seals. *NZG* 19, 2 March 1899: 499.
Closed season extended to 30 June 1900.

Extending the close season for seals. *NZG* 24, 29 March 1900: 637.
Closed season extended to 30 June 1901.

Extending the close season for seals. *NZG* 43, 2 May 1901: 985–986.
Closed season extended to 30 June 1902.

Extending the close season for seals. *NZG* 23, 20 March 1902: 670.
Closed season extended to 30 June 1903.

Extending the close season for seals. *NZG* 26, 9 April 1903: 953–954.
Closed season extended to 30 June 1904.

Extending the close season for seals. *NZG* 19, 3 March 1904: 729.
Closed season extended to 30 June 1905.

Prohibiting taking of Risso's dolphin in Cook Strait, &c. *NZG* 79, 29 September 1904: 2302.
For the next five years it shall not be lawful to take Risso's dolphin (*Grampus griseus*) in the waters of Cook Strait and adjacent bays, sounds and estuaries. [*Ultra vires*.]

Extending the close season for seals. *NZG* 41, 4 May 1905: 1049.
Closed season extended to 30 June 1906.

Extending the close season for seals. *NZG* 84, 21 September 1905: 2262.
Closed season extended to 30 June 1906.

Extending the close season for seals. *NZG* 37, 17 May 1906: 1285.
Closed season extended to 30 June 1907.

Regulations under 'The Sea-fisheries Act, 1894'. *NZG* 41, 31 May 1906: 1381–1385.
Regulation 46. For the next five years it shall not be lawful to take the fish or mammal of the species commonly known as Risso's dolphin in the waters of Cook Strait, or the bays, sounds and estuaries adjacent thereto. [*Ultra vires*.] In force from 1 September 1906.

The Sea-fisheries Act 1906 (6 Edward VII 1906 No. 42; *SNZ* 1906).
Section 2. Minister may authorise taking of seals during a closed season for exhibition or for science purposes. In force from 29 October 1894.

Extending the close season for seals. *NZG* 26, 21 March 1907: 983.
Closed season extended to 30 June 1908.

The Fisheries Act 1908 (*SDNZ* 1908, No. 65).
Sections 42–45 prescribed conditions and restrictions for the regulation of the taking of seals.
Section 2 defined New Zealand waters as extending one marine league (equivalent to 3 nautical miles, or 5.6 km) from the New Zealand coast.

Extending the close season for seals. *NZG* 19, 12 March 1908: 846.
Closed season extended to 30 June 1909.

Extending the close season for seals. *NZG* 39, 13 May 1909: 1300.
Closed season extended to 30 June 1910.

Regulations for licenses to take seals. *NZG* 61, 22 July 1909: 1889.
Process for issuing permits to take seals on subantarctic islands.

Amending regulations as to licenses to take seals. *NZG* 94, 11 November 1909: 2891–2892.
Closed season for sea lions on Enderby Island for the following three years.

Extending the close season for seals. *NZG* 21, 10 March 1910: 780.
Closed season extended to 30 June 1911.

Extending close season for fish known as Risso's dolphin (*Grampus griseus*). *NZG* 36, 4 May 1911: 1454.
It shall not be lawful to take Risso's dolphin in the waters of Cook Strait and adjacent bays, sounds and estuaries before 31 May 1914. [*Ultra vires.*] In force from 31 May 1911.

Extending the close season for seals. *NZG* 36, 4 May 1911: 1454.
Closed season extended to 30 June 1912.

Extending the close season for seals. *NZG* 47, 30 May 1912: 1781.
Closed season extended to 30 June 1913.

Prescribing a close season for seals. *NZG* 43, 29 May 1913: 1782.
Closed season set at 1 July 1913 to 1 October 1914; closed season set at 1 October to 31 May each year, starting 1914.

Regulations regarding seals. *NZG* 43, 29 May 1913: 1782.
No females may be taken; no bulls under 12 months old may be taken.

Amending regulations prescribing a close season for seals. *NZG* 47, 19 June 1913: 1922.
Open season prescribed for 1 July to 30 September 1913.

Prescribing a close season for seals. *NZG* 135, 1 December 1916: 3706.
Closed season set at 27 November 1916 to 27 November 1919.

Extending close season for seals. *NZG* 99, 14 August 1919: 2617.
Closed season extended from 27 November 1919 to 27 November 1922.

Animals Protection and Game Act 1921–1922 (12 GEO V 1921 No. 57; *SDNZ* 1921–1922).
Section 3(1) provided for the Governor-General to declare additional animals (including reptiles) to be included in the First Schedule (i.e. absolutely protected throughout New Zealand). [This provided protection to the low-water mark only.] In force from 1 April 1922.

Extending close season for seals. *NZG* 5, 18 January 1923: 139.
Closed season extended from 27 November 1922 to 27 November 1925.

Making regulations for licensing seal-fisheries. *NZG* 24, 15 March 1923: 726.
Closed season does not apply to Campbell Island/Motu Ihupuku, apart from 1 October 1923–31 May 1924.

Varying close season for seals. *NZG* 24, 15 March 1923: 726.
Closed season does not apply to Campbell Island/Motu Ihupuku, backdated to 11 March 1922.

Extending close season for seals. *NZG* 75, 22 October 1925: 2991.
Closed season extended from 27 November 1925 to 27 November 1928.

Revoking Order in Council varying close season for seals. *NZG* 75, 22 October 1925: 2994.
Campbell Island/Motu Ihupuku no longer exempt from closed season.

Extending close season for seals. *NZG* 70, 20 September 1928: 2824.
Closed season extended from 27 November 1928 to 27 November 1931.

Varying close season for seals. *NZG* 71, 27 September 1928: 2888.
Closed season does not apply to Campbell Island/Motu Ihupuku.

Extending close season for seals. *NZG* 90, 26 November 1931: 3388.
Closed season extended from 27 November 1931 to 27 November 1934.

Revoking Order in Council varying close season for seals. *NZG* 90, 26 November 1931: 3392.
Campbell Island/Motu Ihupuku no longer exempt from closed season.

Extending close season for seals. NZG 80, 1 November 1934: 3429.
Closed season extended from 27 November 1934 to 27 November 1937.

International Convention for the Regulation of Whaling. *NZG* 63, 29 August 1935: 2387–2389.
Convention signed at Geneva on 24 September 1931, and duly ratified by New Zealand. Article 4 protected southern right whale (*Eubalaena australis*) and pygmy right whale (*Caperea marginata*).

Whaling Industry Act 1935 (26 GEO V 1935 No. 12; *SDNZ* 1935).
Sections 4 and 5 granted full protection to southern right whale and pygmy right whale within 3 nautical miles (5.6 km) of the New Zealand coast, and prevented treatment of these species by New Zealand factories. Section 5 also protected females accompanied by calves, and immatures of other baleen whale species. In force from 24 October 1935.

The Salt-water Fisheries Amendment Regulations 1937, No. 3 (*SR* 1937/257, 13 October 1937).
Closed season for seals extended by three years from 30 November 1937. In force from 22 October 1937.

Green turtle (Chelonia mydas) and luth or leathery turtle (Dermochelys coriacea) absolutely protected (*SR* 1939/32, 24 March 1939).
Green turtle (*Chelonia mydas*) and leathery turtle (*Dermochelys coriacea*) to be added to the First Schedule of the Animals Protection and Game Act 1921–1922 (i.e. absolutely protected). Apart from a single record of loggerhead turtle, these were the only marine turtle species known from New Zealand at the time (Gill & Whitaker 1996). In force from 31 March 1939.

The Sea-fisheries Regulations 1939 (*SR* 1939/225, 18 October 1939).
Part XVII. Closed season for seals extended to 31 March 1942. In force from 20 October 1939.

The Sea-fisheries Regulations 1939, Amendment No. 13 (*SR* 1942/211, 8 July 1942).
Closed season for seals extended to 31 March 1945. In force from 10 July 1942.

The Sea-fisheries Regulations 1939, Amendment No. 16 (*SR* 1945/14, 28 February 1945).
Part XIXA. No person shall take or attempt to take white porpoise [Hector's dolphin] (*Cephalorhynchus hectori*) in the waters of Cook Strait during 31 January 1945 to 31 January 1948. [*Ultra vires.*] In force from 2 March 1945.

The Sea-fisheries Regulations 1939, Amendment No. 17 (*SR* 1945/45, 6 April 1945).
Closed season for seals extended to 31 March 1948. In force from 3 May 1945.

The Seal-fishery Regulations 1946 (*SR* 1946/83, 29 May 1946).
Closed season declared for seals of every species through to 31 March 1948. Allowed for licences conferring the right to take seals to be issued at the discretion of the Minister through to 30 September 1946 for specified parts of Otago, Southland, Fiordland, Stewart Island/Rakiura and offshore islands. In force from 7 June 1946.

The Fisheries (General) Regulations 1947 (*SR* 1947/82, 28 May 1947).
Regulation 104. No person shall take or attempt to take white porpoise [Hector's dolphin] in the waters of Cook Strait during 1 June 1947 to 1 June 1950. [*Ultra vires.*] In force from 12 June 1947.

The Seal-fishery Regulations 1946, Amendment No. 1 (*SR* 1948/65, 28 April 1948).
Closed season declared for seals of every species through to 31 March 1951. In force from 7 May 1948.

Fisheries Amendment Act 1948 (*SNZ* 1948, No. 11).
Section 11 revised Section 83 of the Fisheries Act 1908 to provide for the Governor-General to make regulations to protect, preserve or develop freshwater fisheries, thereby providing a mechanism to protect freshwater fish species. In force from 26 August 1948.

The Whaling Industry Regulations 1949 (*SR* 1949/149, 28 September 1949).
Closed season for baleen whales set at 1 September to 31 April. In force from 1 November 1949.

The Fisheries (General) Regulations 1950 (*SR* 1950/147, 23 August 1950).
Regulation 110. No person shall take or attempt to take white porpoise [Hector's dolphin] in the waters of Cook Strait during 31 August 1950 to 31 August 1953. [*Ultra vires.*]

The Freshwater Fisheries Regulations 1951 (*SR* 1951/15, 6 February 1951).
Regulation 99 prohibited intentional taking or killing of grayling (or fish of the genus *Prototroctes*). In force from 9 February 1951.

The Seal Fishery Regulations 1946, Amendment No. 2 (*SR* 1951/78, 20 April 1951).
Closed season declared for seals of every species through to 31 March 1954. In force from 13 April 1951.

Wildlife Act 1953 (*SNZ* 1953, No. 31).
Sections 2, 3 and 7(3). All reptiles other than lizards absolutely protected, thereby granting protection to sea snakes (*Pelamis platurus* and *Laticauda* spp.) and marine turtles (Cheloniidae) throughout New Zealand [i.e. to the low-water mark]. In force from 1 April 1954.

The Seal Fishery Regulations 1946, Amendment No. 3 (*SR* 1954/68, 5 May 1954).
Closed season declared for seals of every species through to 31 March 1957. In force from 7 May 1954.

The Toheroa Regulations 1955 (*SR* 1955/206, 7 December 1955).
Closed season established for toheroa (*Paphies ventricosa*), varied by 20 amendments through to 1981, but allowing some harvest each year through to 1980. In force from 15 December 1955.

The Fisheries (General) Regulations 1950 (Reprint) (*SR* 1956/16, 13 February 1956).
Regulation 110. No person shall take or attempt to take white porpoise [Hector's dolphin] in the waters of Cook Strait during 1 March 1956 to 1 March 1959. [*Ultra vires* before 26 October 1956.] In force from 1 March 1956.

The Fisheries (Dolphin Protection) Regulations 1956 (*SR* 1956/25, 7 March 1956).
It shall not be lawful to take or molest any dolphin in the Hokianga Harbour for the next five years. [*Ultra vires* before 26 October 1956.] In force from 9 March 1956.

Fisheries Amendment Act 1956 (*SNZ* 1956, No. 77).
Section 2 provided for the Governor-General to make regulations protecting all marine mammal species (previously seals only were provided for). In force from 26 October 1956.

Revocation of Fisheries (Dolphin Protection) Regulations (*SR* 1957/36, 6 March 1957).
Dolphins cease to be protected in Hokianga Harbour. In force from 7 March 1957.

The Seal Fishery Regulations 1946, Amendment No. 4 (*SR* 1957/90, 16 April 1957).
Closed season declared for seals of every species through to 31 March 1960. In force from 18 April 1957.

The Seal Fishery Regulations 1946, Amendment No. 5 (*SR* 1960/123, 10 August 1960).
Closed season declared for seals of every species through to 31 March 1963. In force from 12 August 1960.

Whaling Industry Regulations 1961 (*SR* 1961/123, 20 September 1961).
Whaling Industry Regulations 1949 revoked. Closed season for baleen whales set from 1 September to 30 April. In force from 28 September 1961.

The Seal Fishery Regulations 1946, Amendment No. 6 (*SR* 1963/38, 18 March 1963).
Closed season declared for seals of every species through to 31 March 1966. In force from 22 March 1963.

Whaling Industry Regulations 1961, Amendment No. 1 (*SR* 1964/94, 1 July 1964).
No person shall take or kill any humpback whale or right whale (latter includes southern right whale and pygmy right whale) within 3 nautical miles (5.6 km) of the New Zealand coast. Closed season for baleen whales set from 1 May to 31 October. Closed season for sperm whales set from 1 May to 31 August. In force from 9 July 1964.

Territorial Sea and Fishing Zone Act 1965 (*SNZ* 1965, No. 11).
Section 8 defined New Zealand fisheries waters as extending to 12 nautical miles (22.2 km) from the New Zealand coast, including outlying islands. Section 11 stated that the enactments apply to the Fisheries Act 1908 (Part I) and the Whaling Industry Act 1935 [and therefore the enactments implicitly did not apply to the Wildlife Act 1953]. Since 1908, 'New Zealand waters' had extended one marine league (equivalent to 3 nautical miles, or 5.6 km) from the New Zealand coast. In force from 1 January 1966.

The Fisheries (General) Regulations 1950 (Reprint) (*SR* 1966/20, 7 March 1966).
Regulation 110. No person shall take or attempt to take white porpoise [Hector's dolphin] in the waters of Cook Strait during 17 March 1966 to 17 March 1969. In force from 17 March 1966.

The Seal Fishery Regulations 1946, Amendment No. 7 (*SR* 1966/26, 14 March 1966).
Closed season declared for seals of every species through to 31 March 1969. In force from 18 March 1966.

The Fisheries (General) Regulations 1950, Amendment No. 10 (*SR* 1968/104, 24 June 1968).
Regulation 18. Revocation of regulation restricting the taking of porpoises in Cook Strait – Regulation 110 of the principal regulations is hereby revoked. In force from 4 July 1968.

The Seal Fishery Regulations 1946, Amendment No. 8 (*SR* 1969/114, 23 June 1969).
Closed season declared for seals of every species through to 31 March 1972. In force from 27 June 1969.

Fisheries Amendment Act 1971 (*SNZ* 1971, No. 72).
Section 2 further defined 'Fish' to include every description of seaweed found in New Zealand fisheries waters, and its spores. In force from 3 December 1971.

The Seal Fishery Regulations 1946, Amendment No. 9 (*SR* 1972/74, 27 March 1972).
Closed season declared for seals of every species from 1 April 1972 to 31 March 1975. In force from 1 April 1972.

The Seal Fishery Regulations 1946, Amendment No. 10 (*SR* 1975/42, 10 March 1975).
Closed season declared for seals of every species from 1 April 1975 to 31 March 1978. In force from 1 April 1975.

Customs Import Prohibition (Whales and Whale Products) Order 1975 (*SR* 1975/205, 4 August 1975). In force from 8 August 1975.

The Customs Import Prohibition (Whales and Whale Products) Order 1975, Amendment No. 1 (*SR* 1977/120, 9 May 1977).
Whale teeth added to prohibited import items. In force from 13 May 1977.

Territorial Sea and Exclusive Economic Zone Act 1977 (*SNZ* 1977, No. 28).
Sections 9 and 10 exercised the sovereign rights of New Zealand to make provision for the conservation of resources within 200 nautical miles (370.4 km) of the New Zealand coast, including outlying islands, and the inclusion of these seas within New Zealand fisheries waters. Section 10(2) stated that the enactments apply to the Fisheries Act 1908 (except Part II) and the Whaling Industry Act 1935 [and therefore the enactments implicitly did not apply to the Wildlife Act 1953]. New Zealand fisheries waters had previously extended 12 nautical miles (22.2 km) only from the coast (see the Territorial Sea and Fishing Zone Act 1965). Sections 22(i) and 27(b) empowered the Governor-General to make regulations prescribing measures for the conservation of fisheries resources and for the protection and preservation of the marine environment within the New Zealand EEZ. Section 22(j) empowered the Governor-General to regulate fishing for particular types of highly migratory species of fish by New Zealand fishing craft beyond the EEZ. In force from 26 September 1977.

The Seal Fishery Regulations 1946, Amendment No. 11 (*SR* 1978/74, 20 March 1978).
Closed season declared for seals of every species from 1 April 1978 to 31 March 1981. In force from 1 April 1978.

Marine Mammals Protection Act 1978 (*SNZ* 1978, No. 80).
Sections 1 and 4 granted absolute protection to all species of seals, whales, dolphins and porpoises in New Zealand fisheries waters and on shore. Section 30 repealed the Whaling Industry Act 1935 and the Fisheries Amendment Act 1956, and revoked the Whaling Industry Regulations 1961; the Whaling Industry Regulations 1961, Amendment No. 1; the Seal Fishery Regulations 1946; the Seal Fishery Regulations 1946, Amendment No. 7; and the Seal Fishery Regulations 1946, Amendment No. 11. In force from 1 January 1979.

Fisheries Amendment Act 1979 (*SNZ* 1979, No. 35).
Section 2 amended Section 2(1) of the Fisheries Act 1908 by defining 'fish' to include every description of fish and shellfish found in New Zealand fisheries waters, and their young or fry or spawn; and to include every description of seaweed found in those waters, and its spores, and every description of fauna and flora naturally occurring seawards of mean high-water spring tides; but not to include salmon, trout, oysters or marine mammals. This allowed for regulations to protect coral. In force from 2 November 1979.

Toheroa Regulations 1955, Amendment No. 19 (*SR* 1980/184, 1 September 1980).
Closed season set from 1 December 1980 to 30 November 1983. In force from 13 September 1980.

The Fisheries (General) Regulations 1950, Amendment No. 34 (*SR* 1980/245, 8 December 1980).
Regulation 12 inserted Regulation '107F. No person shall take any black coral (*Aphanipathes* spp.).' In force from 12 December 1980.

Toheroa Regulations 1955, Amendment No. 20 (*SR* 1981/230, 17 August 1981).
Allowed for open season to be notified via a *New Zealand Gazette* notice. In force from 21 August 1981.

Fisheries Act 1983 (*SNZ* 1983, No. 14).
Section 2 defined New Zealand fisheries waters to include all waters in the New Zealand EEZ (i.e. extending out to

200 nautical miles/370.4 km from the coast). In force from 1 October 1983.

Freshwater Fisheries Regulations 1983 (*SR* 1983/277, 19 December 1983).
Regulation 69 continued protection for New Zealand grayling. In force from 1 January 1984.

The Fisheries (Amateur Fishing) Notice 1983 (*SR* 1983/297, 21 December 1983).
Clause 18 prohibited taking or disturbing toheroa. Clause 22 prohibited taking, selling or possessing black coral. In force from 1 January 1984.

The Fisheries (Fish Species Restrictions) Notice 1983 (*SR* 1983/308, 21 December 1983).
Clause 10 prohibited taking, possessing or conveying toheroa. Clause 25 prohibited taking, selling or conveying black coral (a coelenterate of the genus *Aphanipathes*). In force from 1 January 1984.

The Fisheries (Amateur Fishing) Notice 1984 (*SR* 1984/348, 18 December 1984).
Clause 18 prohibited taking, possessing, conveying or disturbing toheroa. Clause 22 prohibited taking, possessing, conveying or selling black coral (a coelenterate of the order Antipatharia). In force from 1 January 1985.

The Fisheries (Fish Species Restrictions) Notice 1984 (*SR* 1984/351, 18 December 1984).
Clause 13 prohibited taking, possessing, conveying or selling black coral. In force from 4 January 1985.

Fisheries (Commercial Fishing) Regulations 1986 (*SR* 1986/215, 2 September 1986).
Regulation 26 prohibited taking or possession of toheroa by commercial fishermen. Regulation 31 prohibited taking or possession of black coral by commercial fishermen. In force from 18 September 1986.

Fisheries (Auckland and Kermadec Areas Commercial Fishing) Regulations 1986 (*SR* 1986/216, 2 September 1986).
Regulation 20 prohibited taking of spotted black grouper (*Epinephelus daemelii*) by commercial fishers in the Auckland or Kermadec fishery management areas. In force from 18 September 1986.

Fisheries (Amateur Fishing) Regulations 1986 (*SR* 1986/221, 2 September 1986).
Regulation 22 prohibited taking, possessing or disturbing toheroa. Regulation 26 prohibited taking or possessing black coral (order Antipatharia). Regulation 27 provided a mechanism whereby persons representing a Māori community could take fish (including shellfish, *sensu* the Fisheries Act 1983) otherwise protected by the regulations, for hui or tangi, provided listed conditions were met. Although no species were named, in practice this allowed a limited take of toheroa (otherwise fully protected). In force from 18 September 1986.

Fisheries (Auckland and Kermadec Areas Amateur Fishing) Regulations 1986 (*SR* 1986/222, 2 September 1986).
Regulation 10 prohibited taking of spotted black grouper in the Auckland or Kermadec fishery management areas. In force from 18 September 1986.

The Fisheries (Commercial Fishing) Regulations 1986, Amendment No. 2 (*SR* 1988/104, 16 May 1988).
Regulation 7 prohibited selling or possession for sale of black coral. [In error, as appended to the wrong clause.] In force from 1 June 1988.

The Fisheries (Commercial Fishing) Regulations 1986, Amendment No. 3 (*SR* 1988/175, 1 August 1988).
Regulation 2 prohibited selling or possession for sale of black coral. In force from 1 September 1988.

Trade in Endangered Species Act 1989 (*SNZ* 1989, No. 18)
Section 9 referencing the First and Second Schedules prohibited trade in any specimens of listed species, including all species of Cetacea (whales and dolphins), sea turtles, southern fur seals and elephant seals. In force from 1 June 1989.

The Fisheries (South-East Area Commercial Fishing) Regulations 1986, Amendment No. 4 (*SR* 1989/322, 30 October 1989).
Updated Regulation 11A(3) of the 1986 Regulations, prohibiting taking or possession of red coral and also black coral from the waters of Quota Management Areas 3 or 4. In force from 1 December 1989.

The Fisheries (Southland and Sub-Antarctic Areas Commercial Fishing) Regulations 1986, Amendment No. 7 [*sic*] (*SR* 1989/323, 30 October 1989).
Regulation 15C(2) prohibited taking or possession of red coral (a hydrocoral of the order Stylasterina) and also black coral from the waters of Quota Management Areas 5 or 6. In force from 1 December 1989.

The Fisheries (Commercial Fishing) Regulations 1986, Amendment No. 7 (*SR* 1990/186, 30 July 1990).
Taking or possession of marine turtles prohibited within New Zealand fisheries waters (i.e. protection extended to 200 nautical miles/370.4 km). In force from 30 August 1990.

The Fisheries (Amateur Fishing) Regulations 1986, Amendment No. 2 (*SR* 1990/217, 27 August 1990).
Regulation 4 established an open day for toheroa at Oreti Beach, Southland, on 8 September 1990. In force from 8 September 1990.

The Marine Mammals Protection Regulations 1990 (*SR* 1990/287, 8 October 1990).
Conditions governing commercial marine mammal guiding to view. In force from 8 November 1990.

The Fisheries (Southland and Sub-Antarctic Areas Amateur Fishing) Regulations 1991 (*SR* 1991/57, 8 April 1991).
Regulation 6 prohibited taking or possession of red coral (a coelenterate of the order Stylasterina) in the Southland and Sub-Antarctic fishery management areas. In force from 9 May 1991.

The Fisheries (South-East Area Amateur Fishing) Regulations 1986, Amendment No. 2 (*SR* 1991/59, 8 April 1991).
Prohibited taking or possession of red coral from the South-East Fisheries Management Area. In force from 9 May 1991.

The Fisheries (South-East Area Commercial Fishing) Regulations 1986, Amendment No. 8 (*SR* 1991/163, 26 August 1991).
Updated Regulation 11A of the 1986 Regulations, prohibiting taking or possession of red coral and also black coral from the waters of Quota Management Areas 3 or 4. In force from 26 September 1991.

The Fisheries (Southland and Sub-Antarctic Areas Commercial Fishing) Regulations 1986, Amendment No. 11 (*SR* 1991/164, 26 August 1991).
Regulation 15C prohibited taking or possession of black coral or red coral from the waters of Quota Management Areas 5 or 6. In force from 26 September 1991.

The Marine Mammals Protection Regulations 1992 (*SR* 1992/322, 16 November 1992).
Conditions governing commercial marine mammal guiding to view. *SR* 1990/287 revoked. In force from 1 January 1993.

Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 (*SNZ* 1992, No. 121).
Section 37 amended Regulation 27 of the Fisheries (Amateur Fishing) Regulations 1986, thereby providing a mechanism whereby persons representing a Māori community could take fish, aquatic life or seaweed otherwise protected by the regulations, for hui, tangi or other approved purposes, provided listed conditions were met. Although no species were named, in practice this allowed a limited take of toheroa (otherwise fully protected). In force from 23 December 1992.

The Fisheries (Amateur Fishing) Regulations 1986, Amendment No. 5 (*SR* 1993/284, 13 September 1993).
Regulation 8 established an open day for toheroa at Oreti Beach, Southland, on 18 September 1993. In force from 18 September 1993.

Fisheries Act 1996 (*SNZ* 1996, No. 88).
The Twelfth Schedule (Part III, particularly the first and last pages referring to the Wildlife Act 1953) created Schedule 7A of the Wildlife Act 1953, thereby granting absolute protection to black corals, all species of red coral and spotted black grouper. The same schedule extended most provisions of the Wildlife Act 1953 to include New Zealand fisheries waters, thereby protecting sea snakes and marine turtles out to 200 nautical miles (370.4 km) from the New Zealand coast. Amendments included in the Twelfth Schedule (Part III) were deemed to have come into force on 1 October 1995.

Fisheries (South Island Customary Fishing) Regulations 1998 (*SR* 1998/72, 20 April 1998).
Regulation 11 provided a mechanism whereby Māori could take fish, aquatic life or seaweed for customary food-gathering purposes, provided listed conditions were met. Although no species were named, in practice this allowed a limited take of toheroa (otherwise fully protected). In force from 24 April 1998.

Customs Import Prohibition Order 1999 (*SR* 1999/271, 23 August 1999).
Schedule 4 prohibited importation of whales and whale products. In force from 1 October 1999, expired 30 September 2002 [not renewed as duplicated by similar protections in the Marine Mammals Protection Act 1978 and the Trade in Endangered Species Act 1989].

Fisheries (South Island Customary Fishing) Regulations 1999 (*SR* 1999/342, 11 October 1999).
Regulation 11 provided a mechanism whereby Māori

could take fisheries resources for customary food-gathering purposes, provided listed conditions were met. Although no species were named, in practice this allowed a limited take of toheroa (otherwise fully protected). In force from 11 November 1999.

Fisheries (Commercial Fishing) Regulations 2001 (*SR* 2001/253, 17 September 2001).
Regulation 36 prohibited taking or possession of toheroa by commercial fishers. Regulation 44 prohibited taking, possessing, selling or processing for sale of black coral by commercial fishers. Regulation 45 prohibited taking or possession of marine turtles from New Zealand fishing waters by commercial fishers. In force from 1 October 2001.

Fisheries (Amateur Fishing) Amendment Regulations (No. 2) 2001 (*SR* 2001/254, 17 September 2001).
Regulation 9 provided a revised Regulation 22 for the principal (1986) regulations prohibiting taking, possessing or disturbing toheroa. In force from 1 October 2001.

Fisheries (Amateur Fishing) Amendment Regulations (No. 2) 2005 (*SR* 2005/341, 19 December 2005).
Regulations 4 and 5 provided a revised Regulation 27 for the principal (1986) regulations regarding traditional non-commercial fishing use. Although no species were named, in practice this allowed a limited take of toheroa (otherwise fully protected). In force from 1 March 2006.

Wildlife (White Pointer Shark) Order 2007 (*SR* 2007/42, 26 February 2007).
Added great white shark (*Carcharodon carcharias*) to Schedule 7A of the Wildlife Act 1953, thereby granting absolute protection in New Zealand fisheries waters. In force from 1 April 2007.

Fisheries (Southland and Sub-Antarctic Areas Amateur Fishing) Amendment Regulations 2007 (*SR* 2007/47, 5 March 2007).
Regulation 5 removed white pointer (great white) shark from the schedule of species able to be taken in the Southland and Sub-Antarctic fishery management areas. In force from 1 April 2007.

Fisheries (White Pointer Shark – High Seas Protection) Regulations 2007 (*SR* 2007/48, 5 March 2007).
Prohibition on using New Zealand ships on the high seas to take white pointer shark [great white shark]. In force from 1 April 2007.

Fisheries (Commercial Fishing) Amendment Regulations 2008 (*SR* 2008/26, 25 February 2008).
Updated regulations on incidental capture of marine turtles. In force from 1 April 2008.

Wildlife Order 2010 (*SR* 2010/159, 8 June 2010).
Schedule 7A of the Wildlife Act 1953 updated and extended to include:
Cnidaria: Anthozoa (corals and anemones) – black corals (all species in the order Antipatharia); gorgonian corals (all species in the order Gorgonacea [Alcyonacea]); and stony corals (all species in the order Scleractinia); and Cnidaria: Hydrozoa (hydra-like animals) – hydrocorals (all species in the family Stylasteridae).
Chordata: Chondrichthyes (cartilaginous fishes): Lamniformes (mackerel sharks) – deepwater nurse shark (*Odontaspis ferox*) and white pointer [great white] shark; Orectolobiformes (carpet sharks) – whale shark (*Rhincodon typus*); and Rajiformes (skates and rays) – manta ray (*Manta birostris*) and spinetail devil ray (spinetail mobula) (*Mobula japanica*); and Osteichthyes (bony fishes): Perciformes (perch-like fishes): giant grouper (Queensland grouper) (*Epinephelus lanceolatus*) and spotted black grouper. In force from 8 July 2010.

Fisheries (Basking Shark – High Seas Protection) Regulations 2010 (*SR* 2010/401, 15 November 2010).
Prohibition on using New Zealand ships on the high seas to take basking shark (*Cetorhinus maximus*). In force from 16 December 2010.

Wildlife (Basking Shark) Order 2010 (*SR* 2010/411, 15 November 2010).
Added basking shark to Schedule 7A of the Wildlife Act 1953, thereby granting absolute protection to the species in New Zealand fisheries waters. In force from 16 December 2010.

Fisheries (Sharks – High Seas Protection) Regulations 2012 (*SR* 2012/355, 3 December 2012).
Prohibition on using New Zealand ships on the high seas to take basking shark, oceanic whitetip shark (*Carcharhinus longimanus*) or white pointer [great white] shark. In force from 3 January 2013.

Wildlife (Oceanic Whitetip Shark) Order 2012 (*SR* 2012/356, 3 December 2012).
Added oceanic whitetip shark to Schedule 7A of the Wildlife Act 1953, thereby granting absolute protection to the species in New Zealand fisheries waters. In force from 3 January 2013.

Fisheries (Amateur Fishing) Regulations 2013 (*SR* 2013/482, 9 December 2013).
Regulation 25 prohibited taking, possessing or disturbing toheroa. Regulation 32 prohibited taking or possessing black coral. Regulation 67 prohibited taking or possessing spotted black grouper from the Auckland and Kermadec fisheries management areas. Regulations 131 and 150 prohibited taking or possessing red coral from the South-East, Southland and Sub-Antarctic fisheries management areas. Revoked Fisheries (Amateur Fishing) Regulations 1986 (*SR* 1986/221) and Fisheries (Auckland and Kermadec Areas Amateur Fishing) Regulations 1986 (*SR* 1986/222). In force from 1 February 2014.

Appendix 2: Summary of the history of legal protection of New Zealand's marine mammals, marine reptiles, native fish and marine invertebrates

See Appendix 1 for full references for Acts, statutory regulations and *New Zealand Gazette* notices matching the dates given here. F = fully protected throughout New Zealand for all of that calendar year, P = partially protected (i.e. some animals able to be taken that year, with spatial, temporal, numerical and/or demographical restrictions).

Marine mammals
Seals (Pinnipedia; no New Zealand legislation distinguished between seal species) P 1875–81, F 1882–90, P 1891, F 1892–93, P 1894, F 1895–1908, P 1909–13, F 1914, P 1915–16, F 1917–22, P 1923–24, F 1925–28, P 1929, F 1930–45, P 1946, F 1947–current (to 200 nautical miles/370.4 km from coast since January 1979).

Southern right whale (*Eubalaena australis*) and pygmy right whale (*Caperea marginata*) F 1935–current. Humpback whale (*Megaptera novaeangliae*) P 1935–64, F 1965–current. Remaining baleen whales (Balaenopteridae) P 1935–78, F 1979–current. Hector's dolphin (*Cephalorhynchus hectori*) P [Cook Strait] 1956–59, P 1966–68, F 1979–current. Sperm whale (*Physeter macrocephalus*) P 1964–78, F 1979–current. Remaining toothed whales (Odontoceti), including dolphins (Delphinidae), F 1979–current. All legislation to protect dolphins before 1957 (i.e. Pelorus Jack, Pelorus Jack II and Opo) was *ultra vires*. All whale and dolphin species have been protected to 200 nautical miles (370.4 km) from the coast since January 1979.

Reptiles
Green turtle (*Chelonia mydas*) and leathery turtle (*Dermochelys coriacea*) F 1940–current. Remaining sea turtles (Cheloniidae) F 1954–current (to 200 nautical miles/370.4 km from the coast since 1996).

Sea snakes (*Pelamis platurus* and *Laticauda* spp.) F 1954–current (to 200 nautical miles/370.4 km from the coast since 1996).

Fishes
New Zealand grayling (*Prototroctes oxyrhynchus*) F 1952–current.

Spotted black grouper (*Epinephelus daemelii*) F 1987–current. Giant grouper (Queensland grouper) (*E. lanceolatus*) F 2011–current.

Great white shark (*Carcharodon carcharias*) F 2008–current. Whale shark (*Rhincodon typus*), basking shark (*Cetorhinus maximus*), deepwater nurse shark (*Odontaspis ferox*), manta ray (*Manta birostris*) and spinetail devil ray (spinetail mobula) (*Mobula japanica*) F 2011–current. Oceanic whitetip shark (*Carcharhinus longimanus*) F 2013–current.

Marine invertebrates
Toheroa (*Paphies ventricosa*) P 1955–80, F 1981–85, P 1986–current.

Black corals (all species in the order Antipatharia) F 1981–current. Red hydrocorals P 1989–1991, F 1992–current. All remaining species in the family Stylasteridae (order Anthoathecata) F 2011–current. Gorgonian corals (all species in the order Alcyonacea [formerly order Gorgonacea]) and stony corals (all species in the order Scleractinia) F 2011–current.