– ARTICLE –

Ecological Consequences of Pre-Contact Harvesting of Bay of Islands Fish and Shellfish, and other Marine Taxa, based on Midden Evidence

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ABSTRACT

Midden contents – especially those that have associated dates – can provide compelling evidence concerning the effects of human harvesting on the diversity, distribution, abundance, and mean individual-size of shallow-water marine stocks. Archaeological Site Recording Scheme Site Record Forms for the 767 Bay of Islands middens as of August 2014 were summarised according to contents; these included 28 calibrated dates associated with 16 individual sites. The oldest site was first settled possibly as early as the 13th Century. By the time of European contact, the population of the Bay of Islands was possibly as great as 10,000 (over half the resident population today), yet it seems that the 500 years of harvesting pressure left no lasting legacy on Bay of Islands' fish and shellfish resources – with the probable exception of the fishing-out of local populations of the Cook Strait limpet, and possibly the overfishing of hapuku in shallow waters. Marine mammal and seabird bones were only reported from Early and Early/Middle Period middens, consistent with the rapid extirpation and extinction of taxa after human arrival in the northeast of the North Island.

Keywords: Bay of Islands, middens, fish, shellfish, seabird, marine mammal, ecological impact

INTRODUCTION

Māori were prodigious consumers of fish and shellfish, so much so that missionary William Colenso was moved to refer to them as 'true ichthyophagi' (Colenso 1869: 1). Also, at least in early times, marine mammals and seabirds featured significantly in the diets of Māori peoples (Smith 2011, 2013).

Although plagued with technical issues (such as variable longevity of taxa in the ground), midden-contents nevertheless provide insight into local marine resources and harvesting strategies, and even social arrangements, of the time (Anon 2014). But because people seldom consume foods available to them in the proportion in which they occur, middens are more a harvest record rather than saying anything categoric about natural abundance (Anderson 1981).

Māori had more than 300 words for 'Mollusc', and close to 200 for 'Fish' (Strickland 1990). Charles Darwin's error during his visit in 1835, when he declared the 'great piles of shells' in the Bay of Islands simply too extensive to be middens – instead being evidence of land rising or sea-level falling (Armstrong 1992: 19) – says a lot about the quantities of shellfish harvested. Indeed, middens in Kerikeri and Waikino inlets (Figure 1) – later mined and kiln-burnt to sweeten local soils (Nevin 1984; NAR 2004) – were so prominent as to be singled out in the 1922 geological chart (Ferrar & Cropp 1922). Similarly, for fish, at the great 1843 hakari at Kororipo Pa (head of Kerikeri Inlet) the fare included 2000 baskets of dried fish (perhaps 3 t, and two to three times that in green weight) (Mulcare 2013).

In the most comprehensive study of dated northern New Zealand sites, data from 75 Hauraki Gulf (defined as Whananaki, a little south of Cape Brett, to Waihi Beach just north of Tauranga) midden assemblages were used to demonstrate the range of finfish, shellfish, marine bird and marine mammal harvested, and the relative importance of each over time (Smith 2013). Quite early in the piece, marine mammals and birds declined markedly in abundance, or disappeared altogether – human harvesting the likely cause. In contrast, changes in the composition of finfish and shellfish harvests probably reflected changes in location and organisation of settlements. Shellfish were present in all middens, but the variety narrowed over time and there was a shift from those rocky shore to estuarine (cockles and pipi) and open sandy beach ones (tuatua) (for shellfish scientific names, see Table 1). Snapper or tāmure, *Pagrus auratus*, was the main finfish throughout, but the proportion of middens in which finfish occurred declined from all of them in the Early Period (before 1450 AD) to three-quarters or so in the Middle (1450–1650 AD) and Late (1650–1800 AD) periods.

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There are hundreds of middens in and around the Bay of Islands, but the contents of few have been delved into in any detail, or an age formally estimated. Nevertheless, most are almost certainly Middle to Late Period (Kennedy 1969; Nugent & Nugent 1977; Leahy & Walsh 1978; Nevin 1984; Fiske 2004). Glenis Nevin's sampling was the most extensive with 260 sites recorded during 1984 (Nevin 1984). Notable observations derived during Nevin's survey included the following. 1) Cockles predominated, being present in essentially all middens irrespective of distance from harvestable stocks, and suggesting they were a preferred species. Very large cockles (55–58 mm long) were present in the lower Waikare and Te Puna inlets, with smaller ones (generally 22–28 mm) in upper estuaries. 2) Apparently pipi were not a preferred species as their presence and abundance in middens was generally in proportion to today's local occurrence. Kawakawa River was anomalous, with several middens containing 20–60% pipi and yet only two extant pipi beds were located. Nevin believed the former pipi beds had disappeared after having become buried by silt from 'logging, forest clearance and farming activities of the last 150 years' (Nevin 1984: 75). 3) Waikare Inlet and Waikino Creek middens often contained up to 1% mudsnail; several in Te Puna and Kerikeri inlets contained 2% blue mussel. The other shellfish occasionally present, including rocky shore species, generally reflected those available nearby.

Far less is known for the Bay of Islands about the consumption of other marine taxa. Nevertheless, marine mammals were significant to northern diets in early times, even though by the time of European contact Māori interest had become largely confined to the occasional beached whale (Cruise 1921: 131; Best 1929: 58). An as-yet-to-be-named 'sister lineage' distinct from today's sea lion or pakekē, *Phocarctos hookeri*, once lived and bred along the entire coast of mainland New Zealand (Collins *et al.* 2014) – but was hunted to extinction (Smith 1989). Their bones have been found associated with living sites both north and south of the Bay of Islands – on Aupouri Peninsula, in the Auckland-Hauraki Gulf area, and on Coromandel Peninsula (see Figure 1) – all being confined to early prehistoric times. Even more important in early diets of the north were New Zealand fur seals or kekeno, *Arctocephalus forsteri* (Smith 1989; Furey 2002). In many places the fur seal was second only to fish as a source of meat for the new settlers – and unmatched for its available energy (Smith 2002). Some of the richest sealing sites (which included breeding adults and their pups) had been in Northland where exploitation was locally intensive, and serial depletion of colonies meant that by about 1500 fur seals had disappeared from the northern North Island (Smith 1989). Dolphins – mainly the smaller species – also

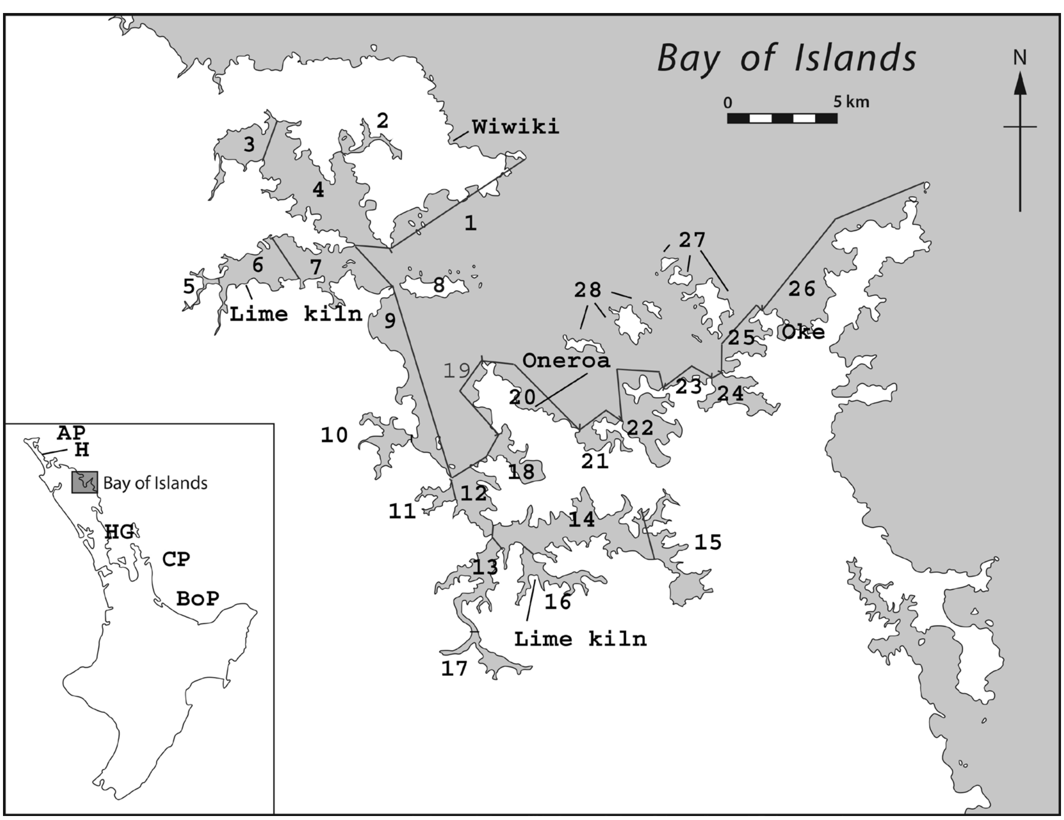

Figure 1. Compartments by which shellfish in Bay of Islands middens were analysed. AP, Aupouri Peninsula; BoP, Bay of Plenty; CP, Coromandel Peninsula; H, Houhora; HG, Hauraki Gulf. For locality names, see Table 2.

Table 1. *All reef and soft-shore shellfish, additional to cockles (Austrovenus stutchburyi), pipi (Paphies australis), tuatua (Paphies subtriangulata) and rock oysters (Saccostrea glomerata), reported across Bay of Islands middens, irrespective of midden-age. Name and shell size are based on Cook (2010).*

Reef species			Soft-shore species			
Exposed	**Sheltered**	**Widespread**	**Exposed**	**Sheltered**	**Sheltered cont.**	**Widespread**
Cellana denticulata (gastropod Cook Strait limpet, 50–60 mm)	*Diloma aethiops* (gastropod spotted black top shell, 20–28 mm)	*Cellana radians* (gastropod radiate limpet, 25–40 mm)	*Tonna tankervillii* (gastropod common cask shell, to 240 mm)	*Diloma subrostrata* (gastropod mudflat top shell, 15–30 mm)	*Tucetona laticostata* (bivalve large dog cockle, 60–80 mm)	*Struthiolaria papulosa* (gastropod large ostrich foot, to 60 mm)
Haliotis iris (gastropod paua, to 110 mm)	*Sigapatella novaezelandiae* (gastropod circular slipper limpet, to 33 mm)	*Lunella smaragdus* (gastropod catseye, 40–60 mm)	*Crassula aequilatera* (bivalve triangle shell, 60–70 mm)	*Maoricolpus roseus* (gastropod turret shell, to 80 mm)	*Purpurocardia purpurata* (bivalve purple cockle, 35–45 mm)	*Alcithoe arabica* (gastropod Arabic volute, to 100 mm)
Cookia sulcata (gastropod Cook's turban, 65–80 mm)	*Limnoperna securis* (bivalve brackish water mussel, to 40 mm)	*Maoricrypta monoxyla* (gastropod white slipper limpet, to 30 mm)	*Dosinia anus* (bivalve ringed dosinia, 60–80 mm)	*Cominella adspersa* (gastropod speckled whelk, to 45 mm)	*Cyclomactra ovata* (bivalve oval trough shell, 65–85 mm)	*Pecten novaezelandiae* (bivalve scallop, 80–120 mm)
Nerita melanostragus (gastropod black nerita, 20–25 mm)		*Dicathais orbita* (gastropod white rock shell, to 70 mm)		*Cominella glandiformis* (gastropod mud whelk, to 25 mm)	*Macomona liliana* (bivalve wedge shell, 45-65 mm)	
Limnoperna pulex (bivalve little black mussel, to 30 mm)		*Haustrum haustorium* (gastropod brown rock shell, to 55 mm)		*Cominella maculosa* (gastropod spotted whelk, to 35 mm)	*Dosina zelandica* (bivalve dosina, 45–55 mm)	
Perna canaliculus (bivalve green-lipped mussel, 100–150 mm)		*Mytilus galloprovincialis* (bivalve blue mussel, 40–80 mm)		*Amphibola crenata* (gastropod mudsnail, 20–25 mm)	*Ruditapes largillierti* (bivalve oblong venus shell, 40–60 mm)	

appear in early northern middens, together with the occasional non-breeding southern elephant seal or ihupuku, *Mirounga leonina* (Smith 1989).

Early Polynesians were renowned bird-hunters, using snares and spears, as well as directly harvesting burrow-nesting birds and seabirds that lived in colonies (Orbell 1985). Yet petrel bones – ubiquitous in the natural fossil remains – are essentially absent from the archaeological record on mainland New Zealand (Holdaway 1999: 207). Either people derived most of their protein from moa and marine mammals, eschewing the smaller birds, or more likely, that the petrels were not available, at least not in useful numbers, to any but the earliest of the settlers, and supportive of very early extinction or extirpation of these seabirds (Holdaway 1999). Indeed, almost half of all bird species (together with at least half the frogs, and unknown proportions of the lizards and invertebrates) disappeared soon after the arrival of East Polynesians, almost certainly as a result of predation by the commensal Pacific rat or kiore, *Rattus exulans* (Holdaway *et al.* 2001). Petrels – together with small ground-dwellers – bore the brunt of the extinctions, resulting in an unusually strong bias towards marine species able to persist on offshore islands (Holdaway *et al.* 2001: 120).

There appears to be no human-population trajectory specific to the Bay of Islands available, but there does appear to be consensus today that the total Māori population of New Zealand at European contact was near what James Cook and/or John Forster estimated in 1769, about 100,000 (Pool 1991: 42–43; King 2007: 81), with perhaps 15% living in Northland (Pool 1991: 51; Leach 2006: 207).

Smith (2013: 13–14) estimated a population of 12,150 (10,800–13,500) living in the Hauraki Gulf region in the Late Period (centred on 1750 AD), from an Early Period (centred on 1400 AD) population of 1800 (500–2500). Intuitively the population of the Bay of Islands would have been far smaller than the adjacent, and much more extensive, Hauraki Gulf region, perhaps up to half (around 6000) being a reasonable estimate of Bay of Islands' population in 1750 AD.

On the other hand, various early accounts suggest many more people may have been present in the Bay of Islands at European contact (http://southseas.nla.gov.au/). For example, 1) Cook declared, after having just sailed from the Firth of Thames in the Hauraki Gulf, how 'The Inhabitants of this Bay [of Islands] are far more numerous than at any other place we have yet been…'(Cook's journal entry for 5 December 1769); 2) in the course of entering the Bay of Islands on 29 November, Cook estimated 'not less than four or five hundred of the Natives alongside and on board the ship' (journal entry for 27 November 1769); 3) soon after, Joseph Banks reported 37 canoes (containing 300–400 individuals, according to Cook) about them as they anchored off Motuarohia (journal entry for 29 November 1769); and then 4) 200–300 present according to Cook when they landed on Motuarohia (journal entry for 30 November 1769; 500–600 if the ship-crew's estimate is to be believed). Although these numbers cannot simply be summed and extrapolated across the landscape, they did apply to just one day for one part of coastal Bay of Islands, let alone those in other parts and in the hinterland.

In the winter of 1772, when the French were camped in the Bay of Islands, it appears 4000–5000 lived near Te Rawhiti alone (Clunie n.d.: 36), the southeast of the Bay having 'a truly immense population for a Māori district' (Shawcross 1967: 244). By the early 1800s, it appears 'many thousands' of Māori were living on either side of Kerikeri Inlet (Middleton 2014: 114); and 'several thousand' were associated with Pouerua in the immediate hinterland (Clunie n.d.: 104).

Based on these figures, a total Māori population for the Bay of Islands in 1750 AD on the order of 10,000 may not be unreasonable, This is more than half today's population resident on and near the shores of the Bay (and about one quarter of Bay of Islands' total population (http://atlas.idnz.co.nz/far-north)), and whose fishing pressure has contributed to a very degraded shallow-water marine ecosystem (Booth 2016). Accordingly, it would be remarkable if pre-Contact Māori fishing pressure had not had at least local impacts on the diversity, distribution, abundance, and individual mean-size of shallow-water coastal marine stocks, in particular, of the Bay of Islands. Any such impacts must be considered in light of climatic variation, the 'Polynesian Warm Period', from 1150 to 1450 or 1500 AD, being followed by the Little Ice Age, between 1500 and 1900 AD (Anderson *et al.* 2014: 121).

Recent comprehensive regional analyses of reported midden-contents (with associated changes over time) are useful in establishing environmental histories yet are relatively few and far between for New Zealand. This paper summarises the contents of Bay of Islands (35° 12′ S, 174° 10′ E) middens and enquires into what they tell us concerning any impact harvesting had on the ecology of fish and shellfish, as well as other marine taxa.

METHODS

Bay of Islands was divided into 28 compartments based on physical attributes (Figure 1; Table 2), and the reported midden-contents of the 767 middens on the New Zealand Archaeological Association's Site Recording Scheme Site Record Forms (http://www.archsite.org.nz/) as of August 2014 allocated among them. Midden contents in each compartment were summarised according to the presence of four key species (cockles, pipi, tuatua and rock oysters). Other reef species were recorded, in three categories: those confined to exposed places, sheltered places, or which were widespread (similarly for the other soft-shore shellfish) (Table 1). There were no comprehensive measurements of individual animal-size available that might have been used to infer the effects of harvesting pressure over time on specific taxa.

Consultant-archaeologist reports, and other documents, held by Heritage New Zealand Kerikeri and Department of Conservation Kerikeri were scrutinised for additional information on Bay of Islands' middens, particularly concerning dated objects and sites. Putative CRA dates were accepted at face value and presented without specific regard to suitability of material examined, reliability of stratigraphic position, or clarity of cultural context. Dates were calibrated by Ian Smith, University of Otago, with Calib 6.1, using the SH04 calibration curve for terrestrial samples, and the Marine 09 calibration curve for marine samples with delta R set at 7 ± 45; obsidian hydration dates were expressed as 2 SD calendrical ages.

RESULTS AND DISCUSSION

Midden analyses

Shellfish were overwhelmingly the dominant taxon present in the middens (Tables 2 and 3); below I focus mainly on key findings concerning them additional to those of Nevin (1984).

1. Shellfish were present in all middens. Bone of any sort was reported most often from early middens that had been subject to formal archaeological examination.
2. With the exception of cockles and tuatua, the data are consistent with the hypothesis that most shellfish were harvested within the immediate vicinity of the midden. Cockles were typically overrepresented in that they were present in all but one of the 767 middens, many of these middens being well removed from estuaries; tuatua were sometimes found well inland from their exposed-beach habitat (Wiwiki, Oneroa and Oke in Figure 1).
3. In contrast, the abundant and easily harvested pipi was

rarely found in middens any distance from typical pipi habitat. This may be because this shellfish often contains grit, and many pre-Contact Māori suffered heavy, often debilitating, tooth wear (George 2013).

4. With rock oysters in only 15% of the middens, and then usually in trifling proportions, it might be decided they were uncommon and/or not particularly favoured – but in fact probably reflects difficulties in removing this shellfish from the rocks without the shell breaking.
5. Occasionally, less well-known shellfish dominated middens. One at Waitangi had a high proportion of purple cockles, a shellfish of semi-exposed soft bottoms, perhaps harvested in nearby Te Ti Bay (Prince 2013a). The oblong venus shell dominated two middens in the eastern Bay of Islands (NAR 2009).
6. Many shellfish in the middens were of species that reach no great size. Some, such as the circular and the white slipper limpets, may have arrived attached to larger shellfish, but this is unlikely for diminutive species such as the mudsnail, speckled, spotted and mud whelk, spotted black and mudflat top shells, and black nerita. Possibly such shellfish were considered particularly good-eating, perhaps being cooked on top of vegetables so that their juices permeated through the food below; or they may have been consumed as condiments with other food.
7. Middens alongside certain beaches, still known today for abundant and sometimes large cockles, often contained very small cockles, the valves invariably still articulated. This may reflect the use of a kete or dredge, drawn through surface layers of soft sediment, the contents rinsed ('stoop, scoop, rinse and take all'; Bill Edwards pers. comm.), and then placed on embers to cook, with only the larger shellfish disarticulated for their meat.
8. Cockles formed such extensive middens in Kerikeri Inlet and Waikino Creek that, much later, lime kilns were used to convert the shell into agricultural dressing (see Figure 1). These mainly medium to large shellfish were almost certainly collected en masse, to be cooked and dried for storage or trade.
9. The presence of tuatua in middens far from where they were harvested (e.g., Upper Kerikeri Inlet and Waitangi) suggests wide-ranging expeditions, trade, or gifting.

Dated early sites

A handful of dated early sites of occupation have been identified in the Bay of Islands (Figure 2; Table 3); because of their significance, each is briefly described. It is likely they were among just a few major villages (each vacated once local resources had been exhausted, but sometimes returned to later), with outposts, some of which were seasonally attended according to the foods available (Smith 2013). It was only among these early sites that seabird and marine mammal bones were reported, and always together with moa remains. These sites sometimes also contained quantities of the Mayor Island obsidian, and the Tahanga basalt from the Coromandel Peninsula, typical of early east-coast North Island sites as far south as eastern Bay of Plenty (Furey *et al.* 2008).

1. Mangahawea (1 in Figure 2 and Table 3) may be the earliest-settled spot in the Bay of Islands. Jan McKay's 1981 University of Auckland excavation has not been published, but field notes (DOC 1981) describe a deep horizon of subsistence living.

   > First (?) [layer of] human occupation involves depositing beach pebbles on this soil (could be natural process). Moa bone is obtained (for making fishhooks) – ? from mainland. Local rocky shore is exploited for shells to work (shell fishhooks?)…. Several occupations are involved. The last occupation [of the second phase] (layer 2) involves much local shellfish gathering – in contrast to early layers, where the emphasis was on fishing and industry (moa bone, shell)…

   The single radiocarbon date from the earliest occupation layer, based on a rock oyster shell, is (at 1 SD) between 1268 and 1356 AD. But apparently no Kaharoa Tephra was evident, suggesting people had not lived at Mangahawea until after 1314 AD.
2. Leigh Johnson investigated Opunga Bay (4), a couple of ridges over from Mangahawea and settled by the AD 1400s, contemporaneously with adjoining Hahangarua (3) (NAR 1997, 1998). The lowest horizon had early East Polynesian characteristics. Of the bones, most were sea mammal – particularly fur seals, with unidentified others. But there were birds too – petrel, and a large moa; and snapper bones. There was also a wide variety of both bivalves and gastropods – all of which are found there today – but with pipi predominating.
3. Early habitation on the other side of the Bay of Islands, at Wairoa Bay (2), was reported by Simon Best (2003). For one small site:

   > A minimum number of four snapper were consumed, three of these quite large in size, along with the leg of a small moa [about the size of a large turkey] and part of a dog, and together with a few shellfish…. The feature could well represent just one meal and the activities that were carried on around it, that took place some 600 years ago.
4. A Waitangi (5) midden examined by Don Prince (2013a) contained hard- and soft-shore shellfish and fish bone, with a pipi shell dating to 1436–1516 AD. Nearby were midden remains more recent by up to 250 years (22 in Figure 3), illustrating how rich and deep the record of human occupation is here (Prince 2013b).
5. Another dated site on the cusp of the Middle Period of occupation, and the first associated with the inner Bay of Islands, is Patunui (7). Dating to 1448–1497 AD, the variety of food consumed was typical of the Early Period. Mark McCoy and Thegn Ladefoged (2012) found at least six species of fish and 16 estuarine soft- and

Table 2. *Analysis of shellfish in Bay of Islands middens according to compartments shown in Figure 1. Coastline length was measured on NABIS maps (www.nabis.govt.nz/) with bar-scale at 1000 m, leading to crude estimates of middens per kilometre. Other reef spp. and Other soft[-shore] spp. are given in Table 1. %, proportion of middens in which particular shellfish or shellfish groups were present, irrespective of numbers. % pred, proportion of middens in which particular shellfish were,*

Part	Location	Coast		Middens		Cockles		Pipi		Tuatua		Oysters		Other reef spp.		
		Exposure	Physical	No.	No./ km	%	% pred	%	% pred	%	% pred	%	% pred	% Exposed	% Sheltered	% Wide-spread
1	Rangihoua	Exposed	Beach to reef	10	0.69	100	63	0	0	38	0	13	0	50	0	38
2	Poukoura	Sheltered	Mudflat	13	0.85	100	91	0	0	0	0	0	0	0	0	0
3	Upper Te Puna	Sheltered	Mudflat to reef	18	1.77	100	100	17	0	0	0	6	0	0	0	11
4	Te Puna	Sheltered	Mudflat to reef	28	0.78	100	95	48	5	0	0	33	5	5	0	29
5	Upper Kerikeri	Sheltered	Mudflat to reef	19	1.89	100	83	6	0	11	0	28	0	0	0	0
6	Mid Kerik-eri	Sheltered	Mudflat to reef	62	3.96	100	90	8	0	2	0	32	5	7	12	17
7	Lower Kerikeri	Sheltered	Mudflat to reef	79	3.79	100	86	6	0	0	0	26	6	13	18	12
8	Moturoa	Exposed	Beach to reef	3	0.38	33	0	0	0	0	0	33	0	33	0	33
9	Wairoa	Exposed	Beach to reef	22	1.46	94	56	44	6	6	0	6	0	11	6	28
10	Waitangi	Sheltered	Mudflat to reef	93	6.54	98	86	64	7	2	0	9	0	4	0	7
11	Te Haumi	Sheltered	Mudflat	26	2.81	100	73	88	0	0	0	31	0	0	0	8
12	Veronica	Sheltered	Mudflat to reef	36	3.06	100	94	64	0	0	0	15	0	3	0	3
13	Kawakawa	Sheltered	Mudflat to reef	71	3.31	100	55	90	38	0	0	4	0	0	0	1
14	Waikare	Sheltered	Mudflat to reef	40	1.04	100	93	50	10	0	0	8	0	0	0	0
15	Upper Waikare	Sheltered	Mudflat	39	1.56	100	97	5	0	0	0	15	0	0	0	0
16	Waikino	Sheltered	Mudflat to reef	23	1.26	100	100	22	0	0	0	9	0	0	0	4
17	Upper Kawakawa	Sheltered	Mudflat	7	0.55	83	83	67	17	0	0	0	0	0	0	0
18	Pomare	Sheltered	Mudflat to reef	20	1.7	100	95	35	5	10	0	10	0	0	0	0
19	Russell	Semi-exposed	Beach to reef	7	1.28	100	100	14	0	14	0	14	0	0	0	0
20	Oneroa	Exposed	Beach to reef	6	0.83	83	67	33	0	33	33	0	0	0	0	0
21	Paroa	Exposed to sheltered	Mudflat to reef	48	4.33	96	90	19	0	0	0	19	0	2	0	8
22	Manawaora	Exposed to sheltered	Mudflat to reef	34	1.74	97	64	76	3	0	0	15	0	6	0	15
23	Omarino	Exposed	Beach to reef	5	2	100	40	20	0	0	0	0	0	20	0	0
24	Parekura	Sheltered	Mudflat to reef	25	1.74	100	52	64	0	0	0	8	0	4	0	8
25	Rawhiti	Exposed to sheltered	Beach to reef	5	0.61	100	40	40	0	0	0	20	0	0	0	20
26	Cape Brett	Exposed	Reef	1	0.04	0	0	0	0	0	0	0	0	100	0	100
27	Outer islands	Exposed to sheltered	Beach to reef	18	0.84	100	23	23	8	0	0	8	0	15	0	8
28	Inner islands	Exposed to sheltered	Beach to reef	9	0.51	67	22	78	33	22	11	22	0	44	11	44

Table 2 continued.
according to the Site Record Forms, predominant. Standout points, and departures from premise that shellfish in a particular midden was sourced from its immediate vicinity, are highlighted. Low midden density is <1 midden per kilometre; high is >3 middens per kilometre.

Part	Other soft spp.			
	% Exposed	% Sheltered	% Wide-spread	Standout points
1	0	0	38	Low midden density; cockles & oysters imported from sheltered shores (Te Puna Inlet?); tuatua harvested at nearby Wiwiki Beach (Figure 1)?
2	0	7	0	Low midden density; pipi and other sheltered, soft-shore species underrepresented
3	0	33	0	Pipi, and oysters and other reef species, underrepresented
4	0	24	10	Low midden density; cockles overrepresented
5	0	0	0	Tuatua in 11% of middens; sheltered-shore species underrepresented
6	2	10	0	High midden density; cockles overrepresented; pipi underrepresented
7	0	4	0	High midden density; cockles overrepresented; pipi underrepresented; brackish water mussel abundant in many middens, and dominating one
8	0	0	0	Very low midden density; significant presence of cockles from harvesting of sheltered soft shores
9	6	44	6	Cockles overrepresented; oysters underrepresented; tuatua in 6% of middens; catseye predominant in one midden
10	0	12	0	Very high midden density; oysters underrepresented
11	0	35	0	High pipi presence, pointing probably to less-silted conditions than now
12	0	15	0	High midden density; cockles overrepresented; oysters underrepresented
13	0	30	1	High midden density; high pipi presence (predominating 38% of middens) points to a less-silted environment than now; oysters underrepresented
14	0	35	3	High pipi presence (50% of middens) points to less-silted conditions than now; oysters under-represented
15	0	23	0	Midden contents reflect local resources
16	0	30	0	High pipi presence points to less-silted conditions than now; oysters underrepresented.
17	0	0	0	Low midden density, dominated by cockles; pipi overrepresented, pointing to less-silted conditions than now; other sheltered soft-shore species underrepresented
18	0	5	0	Oysters underrepresented; tuatua probably from Oneroa Bay (Figure 1); other sheltered-shore species underrepresented
19	0	0	0	Cockles over-represented; absence of other reef species; tuatua probably from Oneroa Bay
20	0	0	0	Low midden density; cockles and pipi over-represented; absence of other reef species
21	2	21	0	High midden density
22	0	24	0	Oysters underrepresented; oblong venus shell dominating two middens at Huruhi Bay points to less-silted conditions than now (NAR 2009)
23	0	40	0	Cockles overrepresented
24	0	20	0	Oysters underrepresented
25	0	0	0	Low midden density; low presence, or absence, of other reef and soft-shore species
26	0	0	0	Very low midden density.
27	0	8	8	Low midden density; cockles & pipi overrepresented
28	22	44	33	Low midden density; cockles & tuatua overrepresented

Table 3. *Dated archaeological sites in the Bay of Islands (read rows across this and next page). Some dates' probability ranges are highly scattered; for simplicity, the central tendency of such probabilities is given here. For Era, E=Early Period (before 1450); M=Middle Period (1450–1650); L=Late Period (1650–1800); H=Historical Period (after 1800) when both 1-SD and 2-SD ranges fell within respective period, or when the 2-SD range extended by <50 years across the era boundary. Italics indicate site's estimated age does not readily fit within era boundaries. Under Enquiry, Full indicates comprehensive reporting*

	Era	Lab no.	Location	Site no.	CRA BP	Cal AD 1 SD	Cal AD 2 SD	Setting	Object	Feature	Enquiry	Markers
1	E		Mangahawea	Q05/682	1066±32 (a)	1268-1356	1223-1417	Midden	Oyster		Full (b)	Cd
2a		Wk13057	Wairoa	P05/853	529±41	1413-1446	1392-1464	Midden	Charcoal	2	Full	
2b	E/M	Wk13056	Wairoa	P05/853	909±37	1385-1475	1320-1507	Midden	Dog cockle	2		
3a		*ANU-543*	*Hahangarua (a)*	*Q05/44*	*510±85 (b)*	*1392-1503*	*1381-1631*	*Garden (c)*	*?*	*Layer 5 (b)*	*Full*	*MI (prob), TB (c)*
3b		NZ0647	Hahangarua (a)	Q05/44	525±89 (b)	1388-1498	1374-1524	Garden (c)	Soil	Layer 5 (b)		
4a		Wk4964	Opunga	Q05/46 & 73	890±60	1384-1500	1306-1573	Garden &	Pipi	Layer 5	Full	TB (pos), MI
4b		AKU68	Opunga	Q05/46 & 73			1408-1538	midden	Obsidian	Layer 5		
5		Wk-37342	Waitangi	P05/1055	839±27	1436-1516	1399-1598	Midden	Pipi		Full	
6		Wk12418	Wairoa	P05/853	454±43	1439-1498	1420-1512	Midden	Charcoal	1	Full	
7		Beta321109 (a)	Patunui	P05/986	440±30 (b)	1448-1497	1437-1510	Midden	Charcoal	Area B	Full	MI
8	M	Wk33848	Oneroa	Q05/1261	787±27	1459-1566	1444-1642	Midden	Cockle	S3	Age	
9			Paroa	Q05/1231		1520-1630	1490-1650	?	?		Age	
10		Wk9449 (a)	Wairoa	P05/853	712±39 (a,b)	1530-1649	1475-1686	Midden	Shell (a)	Lower layer (a)	Full	
11a	M/L	*Wk4963*	*Opunga*	*Q05/46 & 73*	*670±50*	*1544-1682*	*1484-1771*	*Garden*	*Pipi*	*Layer 3*	*Full*	*MI*
11b		AKU67	Opunga	Q05/46 & 73			1626-1727	Garden	Obsidian	Layer 2	Full	
12		Wk36668	Waitangi	P05/1050	684±31	1551-1666	1489-1703	Midden	Cockle	Pit 15	Full	
13		Wk12420	Wairoa	P05/853	674±43	1549-1676	1480-1725	Midden	Cockle	4	Full	
14		*Wk22025*	*Mataka*	*Q04/69*	*615±34*	*1625-1765*	*1533-1840*	*Midden*	*Cockle*		*Age*	
15		*Wk18344/5*	*Rangitane*	*P05/18*	*612-616±35*	*1623-1765*	*1532-1847*	*Midden*	*Cockle (2)*	*Sample 4*	*Full*	
16		*Wk2773*	*Waitangi*	*P05/611*	*620±50*	*1590-1760*	*1519-1868*	*Kainga*	*Cockle*	*Sample 1*	*Age*	
17	L	Wk20302	Haruru	P05/959	242±35	1741-1774	1722-1809		Charcoal	Structure 107	Age	
18	L/H	*Wk23559*	*Kauri Point*	*P04/349*	*545±32*	*1687-1832*	*1666-1905*	*Midden (?)*	*Shell*	*M1 Southside*	*Age*	
19		*Wk12419*	*Wairoa*	*P05/853*	*213±51*	*1723-1809*	*1642-1818*	*Midden*	*Charcoal*	*3*	*Age*	
20		*Wk36431*	*Waipapa*	*P05/454*	*549±30*	*1685-1824*	*1659-1903*	*Midden*	*Cockle*	*Test pit 2*	*Full*	
21		Wk18385	Okura	P05/760	610±38	1635-1775	1535-1857	Midden	Shell	Hangi base	Age	
22		*Wk-36669*	*Waitangi*	*P05/1051*	*551±30*	*1685-1822*	*1656-1903*	*Midden*	*Pipi*	*Pit 11a*	*Full*	
23		*Wk19430*	*Whiorau*	*Q05/376*	*580±32*	*1669-1807*	*1612-1896*	*Midden*	*Cockle*		*Age*	
24a		*Wk31360*	*Paroa*	*Q05/353*	*583±35*	*1665-1808*	*1582-1895*	*Midden*	*Cockle*	*Paroa Pa 2*	*Age*	
24b		*Wk31359*	*Paroa*	*Q05/353*	*476±34*	*1805-1949*	*1713-1949*	*Midden*	*Cockle*	*Paroa Pa 1*	*Age*	
25		*Wk9450 (a)*	*Wairoa*	*P05/854*	*513±38 (b)*	*1708-1870*	*1692-1949*	*Midden*	*Shell (c)*	*Lower layer (c)*	*Full*	
26		*Wk23558*	*Kauri Point*	*P04/346*	*521±31*	*1702-1856*	*1686-1909*	*Midden*	*Shell*	*F1*	*Age*	
27a		Wk20300	Haruru	P05/959	212±35	1727-1805	1718-1813		Charcoal	Structure 107	Age	
27b	H	Wk20301	Haruru	P05/959	160±35	1830-1891	1796-1952		Charcoal	Structure 107	Age	
28		*Wk29759*	*Paihia*	*Q05/1293*	*575±33*	*1672-1810*	*1618-1903*	*Midden*	*Cockle*	*4 & 5*	*Full*	

hard-bottom shellfish (the second widest shellfish assemblage reported for any site in the Bay of Islands).

Dated later sites

Three dated sites in the Bay of Islands are Middle Period, with double this number from the Early/Middle and Middle/Late periods (Figure 3; Table 3). Not surprisingly, there is 'smudging' evident in the faunal signatures, for this was the time of change towards a smaller variety of seafoods. Some sites seem characteristic of the Late Period – dominated by cockles and, to a lesser extent, pipi – yet in fact are pre-1650. The remainder are similar to the Early Period middens in containing several other shellfish species as well.

By the Late Period the variety of animal-food types had shrunk to a handful, probably because there was now greater emphasis on gardening. The nine dated Late- and Late/Historical-Period sites were overwhelmingly dominated by cockles (Figure 3; Table 3), and pipi were common.

One of the best studied of the later sites is Rangitane (15 in Figure 3) – the level-topped, 100-metre-high summit

Table 3 continued.
of archaeological material; Age means simply an age determination. Under Markers, Cd is Cellana denticulata; MI is Mayor Island obsidian; and TB is Tahanga basalt. Tick indicates presence of the taxon; blank indicates the taxon not reported as being present; numerals give the number of species. For Row 4a, additional excavation of Layer 5 revealed fishbone, and 3 soft-sediment and 3 rocky-shore bivalve species; see NAR (1998). For Row 9, entry remains incompletely resolved.

						Fish		Shellfish				
	Moa	Marine Mammal	Bird	Kuri	Kiore	Reef spp.	Non-reef spp.	Cockle	Pipi	Soft-sed. spp.	Rocky spp.	Reference
1	√	√	√	√	√	3	1	√	√	7	12	a) Site Record Form Q05/682; b) DOC (1981)
2a	√	√ (?)		√		1		√	√	3	5	Best (2003)
2b												Best (2003)
3a												*(a) NAR (1997); (b) Anderson (1991); (c) Peters (1975)*
3b												(a) NAR (1997); (b) Anderson (1991); (c) Peters (1975)
4a	√	√	√			1			√	3	4	NAR (1997)
4b												NAR (1997)
5						√ (?)	√ (?)		√	2	3	Prince (2013a)
6						2		√	√	4	4	Best (2003)
7						3	3	√	√	9	7	(a) Judge & Bickler (2013); (b) McCoy & Ladefoged (2012)
8												NAR (2012a)
9												Bickler & Clough (2006)
10								√		3 (c)	3 (c)	(a) Judge & Bickler (2013); (b) Middleton 2008); (c) Site Record Form P05/853
11a												*NAR (1997)*
11b												NAR (1997)
12						√ (?)	√ (?)	√	√	3	0	Prince (2013b)
13						√ (?)		√	√	3	5	Best (2003)
14												*Harlow(2009)*
15								√		*2*	*2*	*Phillips (2005)*
16												*NZ Radiocarbon Database*
17												Judge & Bickler (2013)
18												*Judge & Bickler (2013)*
19												*Best (2003)*
20								√		*1*	*1*	*Judge & Bickler (2013)*
21												Judge & Bickler (2013)
22						*√ (?)*	*√ (?)*	√	√	*4*	*0*	*Prince (2013b)*
23												*Bickler & Clough (2006)*
24a												*NAR (2011a)*
24b												*NAR (2011a)*
25								√		*3 (d)*	*2 (d)*	*(a) Best (2003); Middleton (2008); Judge & Bickler (2013); Site Record Form P05/854*
26												*Judge & Bickler (2013)*
27a												Judge & Bickler (2013)
27b												Judge & Bickler (2013)
28								√	*√*	*2*	*0*	*NAR (2012b)*

near Kerikeri. Great volumes of shellfish were lugged up to the safety of this hill whole (along with firewood, and probably hangi stones too), rather than being processed on the shore below. Shell samples dated to between 1623 and 1765 AD (Phillips 2005).

> …Rangitane was part of a larger system, involving the cultivation of kumara and other crops nearby, the harvesting of shellfish from the Kerikeri Inlet and collection of stones and firewood for cooking. Other activities may also have taken place on the terraces, and the residents may also have had a fortified pa site close at hand (Phillips 2005: 29).

Two dated sites are of the Historical Period (after 1800), both located in the central west Bay of Islands (27, 28); the one analysed in detail contained only estuarine shellfish. Both are near Te Haumi, which remains to this day one of the most productive cockle beaches in the entire Bay of Islands. Early in the Historical Period, several hundred Māori lived between Te Haumi and Whangae in the lower Kawakawa River, harvesting shellfish, flatfish

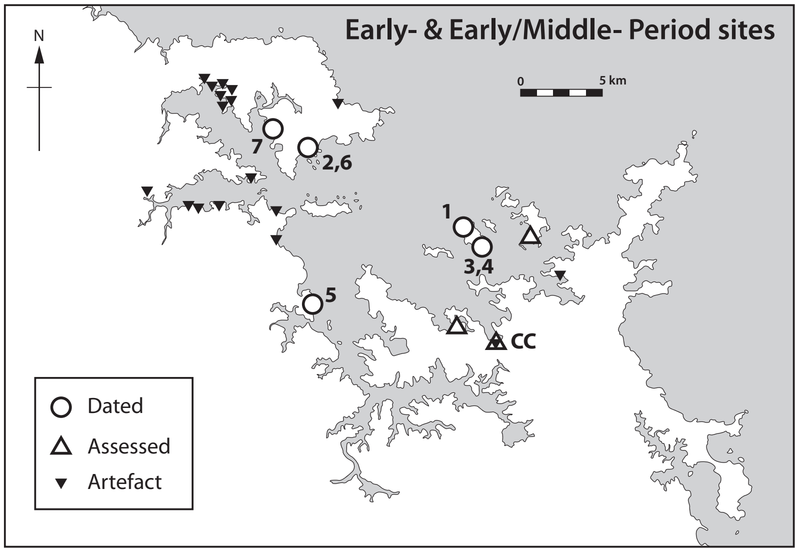

Figure 2. Early sites, dated (○, Early- and Early/Middle-Period, the associated digits referring to Table 3), or containing distinctive items such as moa bone (△), or where ancient stone artefacts have been found (▾, identified by Ian Smith, University of Otago, and housed in the Booth Family Collection, Te Kōngahu Museum of Waitangi). Note that we cannot be sure the artefacts had not been taken to their find-spot by later peoples, although the find hot-spot in Te Puna Inlet is strongly suggestive of early occupation. CC is Clendon Cove where moa bone, as well as a cache of buried Tahanga basalt toki, have been found (Best 1996; NAR 2011b)

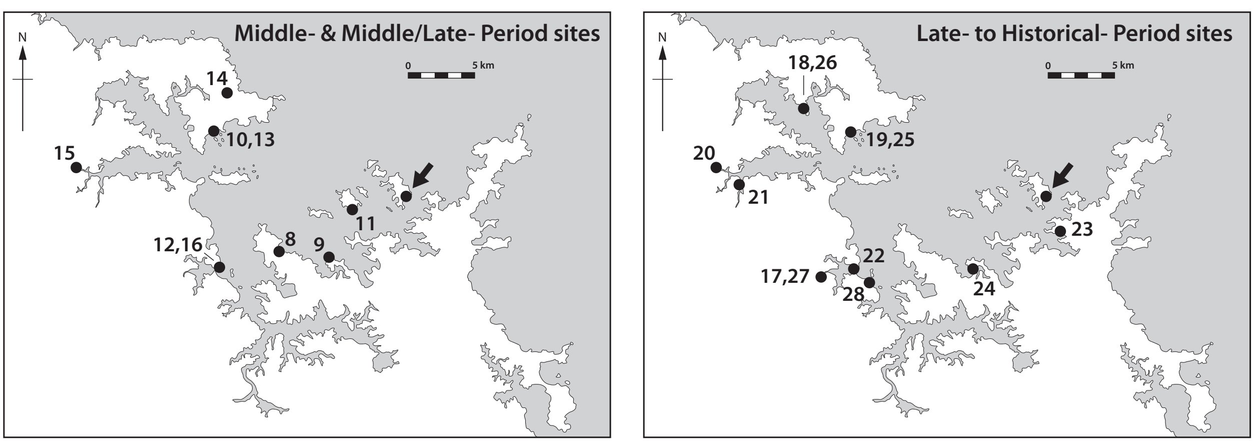

Figure 3. Dated middle to late sites, the associated digits referring to Table 3. The arrowed site is Urupukapuka Bay with altogether six radiocarbon datings (summarised in McCoy *et al*. n.d.).

and other harbour resources, leading to a '…packed archaeological landscape' with an average seven recorded sites per square kilometre (Crown 2012: 13).

DISCUSSION

Early sites

Bay of Islands' dated middens suggest that, during the first five centuries of human presence, there was change over time in the foods sought and consumed. And although there are far fewer dated sites, the pattern of change appears similar to that for the Hauraki Gulf (Smith 2013): marine mammal, seabirds and the Cook Strait limpet (with moa) were present only in early Bay of Islands sites (as were Tahanga basalt and most of the Mayor Island obsidian); fish and shellfish variety narrowed over time, with growing focus on soft-shore estuarine shellfish. And, there is the suggestion that colonisation started out being focussed on and near the outer islands, extending further and further westward over time, into the Bay.

It appears that Early Period human populations of the Bay of Islands were small and occupations impermanent. Therefore harvesting could have had only minimal impact – localised and none with potential to endure – on productive (highly fecund, fast-growing and early-maturing) fishes, or on those widespread and abundant. But for fishes with low productivity (few offspring, slow-growing, late-maturing and long-lived) and which lived their lives in one place, it could have been different. The one fish which could conceivably have been locally extirpated is the highly territorial and slow-growing hapuku (*Polyprion oxygeneios*). Once common in shallow waters, fishing pressure continues to this day to banish them to deeper and deeper places.

The only shellfish similarly affected by Early Period harvesting was the Cook Strait limpet, a species whose preferred waters are cool and well to the south (Cook 2010: 321–22). Unlike most other shellfish, which produce millions of gametes each year, the Cook Strait limpet, with its modest numbers of eggs, is thought to be restricted in dispersal potential. Further, it may not even breed in northern waters, recruitment to its outposts in the north resulting instead from intermittent delivery of larvae from the south. Middens show this large (up to 75 mm long), intertidal, mainly open-coast limpet must have been present in reasonable numbers along the east Northland coast pre-1450 AD and then become extinct (or – and much less likely because other open-reef species continued to be harvested – no longer sought as food). That climatic change could have led to the extirpation of this species from northeastern waters seems unlikely, because the early part of the last millennium, beginning in 1150 and at least 150 years before Polynesians first settled the northeast of the North Island, was actually warmer (and presumably less suitable) than the middle centuries (Anderson *et al.* 2014: 121). It is very likely, therefore, that populations of the Cook Strait limpet that had established themselves in the northeast over the millennia were quite quickly harvested to local extinction by the early settlers.

Also in the Early Period, the mainland-New Zealand lineage of sea lion in the Bay of Islands was almost certainly hunted to extinction – as it was in other parts of Northland. Fur seals were extirpated from Northland through overharvesting, but dolphins were apparently too difficult to capture (and perhaps too numerous) to be overharvested. The demise of the sea lion and fur seal in the north, apparently unrelated to climate change (Smith 1989), is an example of how even low levels of artisanal fishing can critically impact stocks of species that have low productivity (Pinnegar & Engelhard 2008). And the kiore Māori brought with them led to the early extinction, or at least extirpation from the mainland, of many seabird species (Holdaway *et al.* 2001).

Later sites

By 1650 AD human populations had burgeoned and become more permanent, with fishing in the north more firmly focused around cockles and snapper (Smith 2013). Māori potentially now had capacity to overfish stocks, but did they?

For the Bay of Islands the picture painted by James Cook in 1769, and the French soon after, is one of bounteous fish and shellfish resources despite almost 500 years of continuous occupation (Salmond 1991: 220). As Leach (2006: 231) observes '…catching fish for food presented no real problem for Māori… [and] signifies that a ready supply of protein for their diet was simply there for the taking without too much difficulty', almost all being caught inshore (within 100 metres of the shore and within 50 metres depth).

For shellfish, the numerous cockle-dominated middens along sheltered inner Bay of Islands shores are consistent with significant late pre-Contact and early Historical-Period harvesting pressure. Even on the islands, cockles that had been imported were present in high proportions and high densities well into the Historical Period (McCoy *et al.* n.d.). The extent of the great cockle middens of the Kerikeri and Waikino – of sufficient size to be later quarried for their shell – was arguably evidence of something more than mere artisanal harvesting of shellfish in at least parts of the Bay of Islands during the Late Period and perhaps into the Historical Period, but it seems there was no lasting ecological legacy (c.f., the failure of some of the cockle beaches near Auckland to recover after closure in recent times (Kelly *et al.* 2014: 86)). This is probably because, for at least the easily accessible and highly sought species, there was 'ownership' and active stock management that prevented abundance and mean-size from plummeting. For example, in Kerikeri Inlet:

> The cockle beds belonged strictly to certain tribes. Their extent and ownership were marked by poles, sometimes with old flax mats hung upon them. Violation could bring retribution (or be used as an excuse for such) when, as was the case in 1819, Hongi's slaves gathered cockles from a bed in the Kerikeri Inlet, tapu to his enemy Te Morenga and his tribe. Twenty of Hongi's war canoes were subsequently burnt at Kerikeri and a fight took place inland near Taiamai (Easdale 1991: 22).

Indeed, Atholl Anderson concluded there was no indisputable archaeological evidence for the extinction of shellfish or of widespread, sustained depression in the mean size of any species anywhere in New Zealand – even though there were, in places, reductions in the average size of rocky shore shellfish, in accord with localised depletion, and evidence of foraging down the food web (Anderson 2008: 37).

The story for finfish seems similar. For snapper, the most highly sought species in the north, independent estimates are that each adult person consumed 37 (Smith 2011: 29) or 46 fish (Leach 2006: 208) annually, giving an annual harvest of this species in Northland at the period of first European Contact on the order of 2000 t. This is a substantial harvest, given that the current total snapper catches for Northland are close to 3000 t when commercial, recreational and estimated illegal components are summed across the applicable parts of Quota Management Areas SNA 1 and SNA 8. Even with their giant seines, Māori did not fish snapper stocks down to anywhere near the concerningly low-levels of today (Plenary 2016). Indeed, it appears that, in the face of significant and sustained Māori fishing, average snapper size in Northland actually *increased* over time (Leach 2006: 9).

CONCLUSIONS

It seems 500 years of pre-Contact Māori harvesting pressure (and a local population of perhaps as many as 10,000 in 1750) left no lasting legacy on Bay of Islands' fish and shellfish resources – with the probable exception of the fishing-out of local populations of the Cook Strait limpet, and possibly initiating the extirpation of hapuku from shallow waters. As it turned out, the later, indirect effects of poor forestry and farming practice, in particular, had much greater long-term effects on the fish and shellfish of the Bay of Islands than Māori ever had, soon to be compounded by the intense commercial and recreational fishing of the mid- to late-1900s. But, almost certainly, overharvesting in the Bay of Islands contributed to the extinction of sea lions in the Early Period, and to the extirpation of breeding colonies of the New Zealand fur seal from Northland by 1500. Furthermore, the kiore rats the early canoes transported to this country, together with human harvesting, resulted in seabird extinctions and extirpations.

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