

Small Screens, Small Fish and the Diversity of Pre-European Māori Fish Catches

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ABSTRACT

Recent analyses of archaeological fishbone assemblages from the upper North Island have identified taxa that have either not previously been recorded – pilchard (*Sardinops sagax*) and piper (*Hyporhamphus ihi*) – or that have only been rarely recorded – yellow-eyed mullet (*Aldrichetta forsteri*) and grey mullet (*Mugil cephalus*). We show that by sieving with small mesh screens and by identifying a wider range of elements than has conventionally been identified, these taxa become quite common in assemblages. We briefly consider the implications for both archaeological analysis and pre-European Māori fisheries.

Keywords: fish, richness, diversity, screen size

INTRODUCTION

New Zealand archaeological fishbone assemblages can be characterised as generally neither rich nor diverse; few taxa are identified and usually only one of these dominates the assemblage (Anderson 1997; Leach 2006; Smith 2013). Several explanations could account for this pattern: pre-European Māori fish catches may indeed have been species poor and highly concentrated; taphonomic factors may differentially destroy some taxa; or the choices of archaeologists regarding which sites to excavate and how to excavate them, sampling strategies, and analytical methods may bias the reported results. Given that netting was a common Māori fishing practice (Best 1977 [1929]), richness at least should be high, if not diversity. The most likely explanations for the observed character of fishbone assemblages are taphonomic bias, which is beyond the archaeologist's control, and methodological choice, which is not.

Campbell (2016a) has previously demonstrated how identifying an extended range of bones, including vertebrae, increases richness and diversity when compared to the conventional method long used in New Zealand that focuses on five paired mouth bones (Anderson 1973; Leach 1986; Leach 2006). Weisler *et al.* (1999) obtained a similar result using otoliths at Kakanui (J42/4), identifying 14 fish taxa new to New Zealand archaeology. Similar studies from across Oceania also show that identifying a wider range of elements is essential for accurately characterizing the taxonomic composition of fishbone assemblages (Bouffandeau

et al. 2018; Cannon *et al.* 2019; Lambrides and Weisler 2015; Ono and Clark 2012; Vogel 2005). While smaller bones are less likely to survive in archaeological contexts, they are also not caught in coarse screens, meaning taphonomy and the regular use of coarse screens have biased the northern New Zealand archaeological record in favour of snapper (tāmure, *Chrysophrys auratus*), which has large, robust bones (Allen 2014:34).

This paper attempts to broaden our understanding of pre-European Māori fisheries by examining patterns of richness and diversity in several recently analysed fishbone assemblages from consultant excavations in the upper North Island. Collecting with fine mesh screens (≤ 3.2 mm) and analysing an extended set of elements has resulted in the first archaeological records of two taxa – pilchard (mohimohi, *Sardinops sagax*) and piper (ihe, *Hyporhamphus ihi*) – and abundant remains of two rarely recorded taxa – grey mullet (hopuhopu, *Mugil cephalus*) and yellow-eyed mullet (aua, *Aldrichetta forsteri*) (Figure 1; for convenience, we refer to these fish as 'the four taxa'). It is likely these fish and other small-bodied species were present in other archaeological assemblages, but that they have been overlooked or underestimated due to a combination of recovery and analytic biases. More generally, these findings call previous archaeological interpretations of Māori fisheries into question and suggest current understandings of prey use and regional variability may not be accurate.

THE SITES

Fishbone assemblages containing one or more of the four taxa have recently been analysed following the extended method outlined by Campbell (2016a) from six sites in the upper North Island (Figure 2). At the Long Bay Restaurant

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Figure 1. Top, grey mullet (*Mugil cephalus*); middle, pilchard (*Sardinops sagax*); bottom, piper (*Hyporhamphus ihi*), not to scale. 1869–1875, Frank Edward Clarke. Museum of New Zealand Te Papa Tongarewa 1992-0035-2278/84, 1992-0035-2278/49, 1992-0035-2278/40.

site there were six clear phases of occupation, and these are treated as separate assemblages. At the Masonic Tavern, the pre-European Māori deposits were cut through by 19th century European occupations resulting in a complex stratigraphy, and this is treated as a single assemblage, as are all other sites discussed here.

Tauranga Bay

The Tauranga Bay site (P04/639) is located on the Whangaroa Harbour south head, Northland. Campbell excavated 4 m² in the eroding dune face in 2003. Midden was wet-sieved on site through a 2 mm screen (Campbell *et al.* in prep) and subsequently through nested 6.4 and 3.2 mm screens. The site dates to the early 14th century and probably represents a first-generation occupation. Fishbone was analysed initially by Campbell and reanalysed by Nims.

6 Ocean Beach Road

The midden at 6 Ocean Beach Road (Q07/751), near Bream Head, Whangarei Harbour, was excavated by CFG Heritage in 2017. It is one of a series of deposits recorded as a single site representing occupation from the early 15th century

to the early 19th century (Phillips and Druskovich 2009; Harris 2012; Campbell 2016a). Midden was sieved through a 3.2 mm screen. The 6 Ocean Beach Road midden dates to the mid-15th to mid-16th centuries (Campbell and Trilford 2019). Fishbone was analysed by Campbell.

The Long Bay Restaurant site

The Long Bay Restaurant site (R10/1374) was excavated by CFG Heritage on the foredune in the summer of 2015–16. An excavation of 13 × 12 m, largely within the footprint of the existing restaurant, revealed six cultural phases consisting largely of shell midden with some firescoops, each separated by clean, windblown dune sand. The site dates to the mid-late 15th century (Campbell *et al.* 2019a; Campbell *et al.* 2019b). Midden was primarily sieved through a 3.2 mm screen, but some was sieved through a 6.4 mm screen. Fishbone was analysed by Campbell and Nims.

Masonic Tavern

The Masonic Tavern sites (R11/2404, a pre-European Māori burial and midden; and R11/2517, 2518 and 2519, the tavern and other 19th century sites) located on beach dunes at

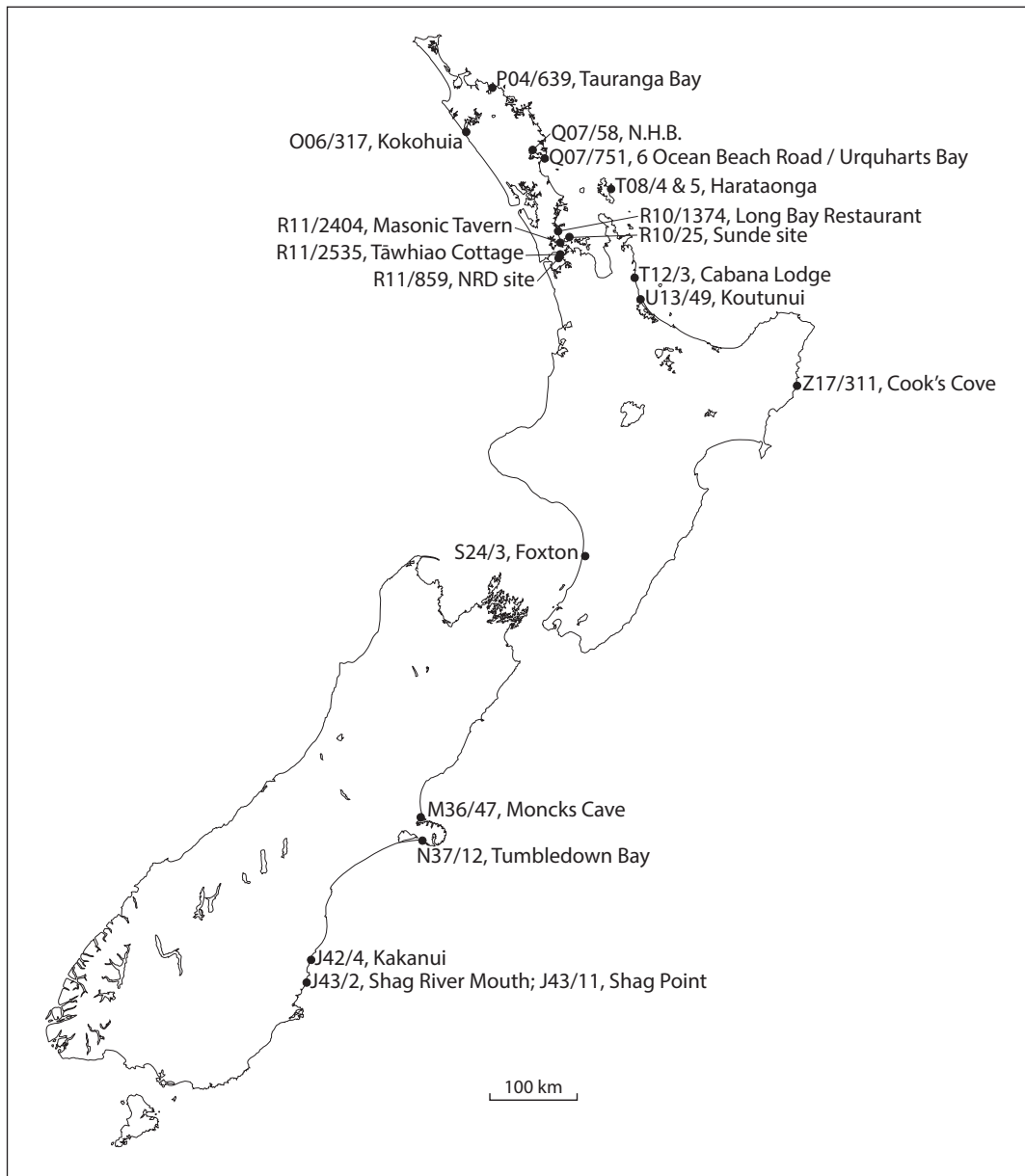


Figure 2. The sites from which the fish assemblages were obtained, and other sites mentioned in the text.

Torpedo Bay, Auckland were excavated in 2013 and 2015 by Geometria. Dates for the pre-European Māori deposits range from the 14th to mid-18th centuries. Faunal remains were primarily collected with 6.4 mm screens and hand-picked, though 3.2 mm screens were also used to sample deposits associated with human burials (Crown 2013, 2014). Fishbone was analysed by Nims.

Cabana Lodge

The Cabana Lodge site (T12/3) consists of multiple activity areas and middens on a beach dune at the mouth of Whangamata Harbour on the Coromandel Peninsula that was excavated in 2007 by Gumbley (2014). Midden was

sorted and analysed by James-Lee (2014) but screen size was not recorded – it is assumed a coarse screen was used for most of the analysis, though one 250 × 250 mm column was processed as a bulk sample. Nims subsequently sieved vertebrate remains from the bulk sample through nested 6.4, 3.2 and 2 mm screens and re-analysed the fishbone. This deposit dates to the mid-13th to mid-15th centuries (Gumbley 2014).

Koutunui

Pā U13/49 in Athenree, Western Bay of Plenty, was excavated by Phillips in 2017 to define the extent and nature of the pā defences. Nims analysed the fishbone from a mid-

den in the fill of the defensive ditch. Midden was sieved through nested 6.4 and 3.2 mm screens. The midden dates to the mid-15th to mid-16th centuries (Phillips 2017).

METHOD

Identifications were undertaken by the authors using comparative collections at the Anthropology Department, University of Auckland, and CFG Heritage. Each of the authors analyses a slightly different set of elements, with Nims identifying several elements that Campbell does not, and vice versa. Analysis in this paper essentially follows the method outlined in Campbell (2016a), but the set of identified elements is not consistent across all sites. Campbell counts broken elements that refit as a single bone, reported as a minimum number of elements (MNE), whereas Nims counts the number of identified specimens (NISF). These minor inconsistencies make no substantive difference to the taxonomic frequencies.

Minimum number of individuals (MNI) was calculated as the frequency of the most common element (and side for paired elements) for each taxon in an assemblage. Following the conventional methods of Anderson (1973) and Leach (1986), this measure does not account for variation in specimen size and only counts five paired mouth bones – dentary, articular, quadrate, maxilla, and premaxilla – and a limited suite of special bones – in this paper, the first dorsal spine of leatherjacket (kōkiri, *Meuschenia scaber*) and the pharyngeals of wrasse (Labridae).

Results are generally presented for the lowest level taxon identified only – if an identification was made to species level but other members of the family could only be identified to genus level or higher, then the higher level identifications are not tabulated to avoid counting the same taxon twice. The exceptions are: pigfish (pākurakura, *Bodianus vulpinus*), which is generally distinct from other commonly encountered Labridae; eagle ray (whai repo, *Myliobatis tenuicaudatus*) identified from its distinctive tooth plate; and stingray (whai, *Dasyatis* sp.) identified from tail spines.

Richness and diversity were also calculated for each assemblage. These terms from biodiversity statistics (Magurran 2004) are readily adopted by archaeologists to examine the structure of archaeofaunal assemblages. The simplest measure of richness is S, the number of taxa identified, often referred to as N-Taxa by archaeologists. A simple measure of diversity – the number and relative abundances of taxa – is the Berger-Parker index d (Magurran 2004:117), which measures the proportional abundance of the most abundant taxon in the assemblage, expressed as 1/d so that diversity increases as the proportion of most abundant taxon decreases. More sophisticated measures could have been calculated and the results compared between assemblages, but 11 assemblages is too small a sample for such meta-analyses and simple measures are appropriate in this context.

THE FOUR TAXA

The NISF's for all taxa from all assemblages are given in Table 1, with the four taxa highlighted.

There are few records of yellow-eyed mullet in New Zealand archaeological sites (Table 2). At the Sunde site on Motutapu in the Hauraki Gulf (R10/25) Nichol (1988:238) identified 4031 NISF, 4027 from vertebrae. Interestingly, Allen (2014) did not record any yellow-eyed mullet at Harataonga Beach (To8/4 and To8/5) on the eastern, ocean side of Aotea/Great Barrier Island in the northern Hauraki Gulf, despite careful use of small screens. This pattern is consistent with the life histories of modern yellow-eyed mullet that prefer relatively calm, sheltered waters rather than high energy open coasts. They are a small schooling fish (max 360 mm) common in estuarine and coastal waters especially during warmer months (Paul 2000:113; Roberts *et al.* 2015:942). Their mouth bones are small and fine and the majority of yellow-eyed mullet bones identified from this study consist of vertebrae, which are clearly the most robust element. While small, these vertebrae are very distinctive, with the thoracic vertebrae having elaborate processes (neural spines and haemapophyses) and the caudal vertebrae having clearly rounded margins on the haemal canal posterior to the haemal spine (Figure 3).

Grey mullet are also uncommon in archaeological assemblages (Table 2). Grey mullet are larger than yellow-eyed mullet (max 600 mm) and school along coasts and in estuaries, spawning at sea in late summer, and are more common in the upper North Island (Paul 2000:112; Roberts *et al.* 2015:944). They also have small mouth bones and most specimens from this study are vertebrae.

Piper has been reported from DNA meta-barcoding of bulk midden samples from Cook's Cove (Z13/311, Walter *et al.* 2011; Seersholm *et al.* 2018) but has not been identified by standard zooarchaeological methods (Table 2). Piper is a small (max 400 mm), slim fish with an elongated lower jaw and small mouth. It commonly schools in shallow waters in sheltered bays and estuaries (Paul 2000:66; Roberts *et al.* 2015:967). The mouth bones are fine and fragile, and most identified elements were vertebrae.

Pilchard are a small fish (max 225 mm) usually found in dense schools in open waters, particularly in embayments such as the Hauraki Gulf (Paul 2000:40; Roberts *et al.* 2015:302). They have not previously been identified in New Zealand archaeological assemblages (Table 2). Although vertebrae were the most commonly identified element for pilchard, other bones were also common. Operculars, though small, are relatively dense and have highly distinctive radiating striae. The otic series refers to the prootic and pterotic bones of the neurocranium, which are difficult to distinguish from each other. In pilchards and other Clupeidae these elements have a robust, spherical shape that is diagnostic to family level (Figure 3). Pilchards are members of the order Clupeiformes (herrings), which are the most commonly caught fish by weight

Table 1. All identified fish taxa by NISP for each assemblage.

Taxon	Tauranga Bay	6 Ocean Beach Road	Long Bay Phase						Masonic Tavern	Cabana Lodge	Koutunui	NISP	Count
			1	4	5	7	10	12					
Barracouta (<i>Thyrsites atun</i>)	4		1	3		8			6		3	25	6
Blue cod (<i>Parapercis colias</i>)	20		5	4	4	1	4			1		39	7
Blue mackerel (<i>Scomber australasicus</i>)		1	2	31	9	3			3		7	56	7
Eagle ray (<i>Myliobatis tenuicaudatus</i>)				8		3			4			15	3
Eel (<i>Anguilla</i> sp.)	4											4	1
Flounder (<i>Rhombosolea</i> sp.)					5							5	1
Grey mullet (<i>Mugil cephalus</i>)	1			17	8				4			30	4
Hapuku (<i>Polyprion oxygeneios</i>)				2								2	1
John Dory (<i>Zeus faber</i>)			4			1			8			13	3
Kahawai (<i>Arripis trutta</i>)	27	1	64	151	301	12	10	10	47	7	13	643	11
Kingfish (<i>Seriola lalandi</i>)	1				3	4			2			10	4
Leatherjacket (<i>Meuschenia scaber</i>)	636									3		639	2
Mackerel (<i>Trachurus</i> sp.)	5	11	17	42	91	128	5	5	11	2	548	865	11
New Zealand sole (<i>Peltorhamphus novaezelandiae</i>)				2								2	1
Parore (<i>Girella tricuspidata</i>)	15		1		2	3			12			33	5
Pigfish (<i>Bodianus vulpinus</i>)	3											3	1
Pilchard (<i>Sardinops sagax</i>)	9		1	2	10	192		6				220	6
Pink maomao (<i>Caprodon longimanus</i>)	1		1	1	2	1						6	5
Piper (<i>Hyporhamphus ihi</i>)	4	29	7		20	3			4		1	68	7
Ray (<i>Dasyatis</i> sp.)			1						2			3	2
Red cod (<i>Pseudophycis bachus</i>)					1					1		2	2
Red gurnard (<i>Chelidonichthys kumu</i>)	2	5	908	1060	616	236	111	81	154	1	2	3176	11
Shark / ray (<i>Chondrichthyes</i>)	4	3		4	1	21	1	2	24	1		61	9
Snapper (<i>Chrysophrys auratus</i>)	1534	51	1626	2211	1507	525	310	389	5861	83		14097	10
Spotted stargazer (<i>Genyagnus monopterygius</i>)	1											1	1
Swep / blue maomao (<i>Scorpiis</i> sp.)	131			1	1					1		134	4
Tarakihi (<i>Nemadactylus macropterus</i>)	25	1							2	28		56	4
Trevally (<i>Pseudocaranx georgianus</i>)	9		5	52	4	2			14		1	87	7
Wrasse (<i>Labridae</i> sp.)	23		10	7	15	6	1		1			63	7
Yellow-eyed mullet (<i>Aldrichetta forsteri</i>)	161	11	366	589	314	129	129	137	1	12	4	1853	11
NISP	2620	113	3019	4187	2914	1278	571	630	6160	140	579	22211	
N-Taxa	22	9	16	18	19	18	8	7	18	11	8		
Berger-Parker 1/d	1.71	2.22	1.86	1.89	1.93	2.43	1.84	1.62	1.05	1.69	1.06		

in the world (FAO 2016:10). Figures published by the FAO show that between 2008 and 2014 herrings accounted for 20–26% of the global catch by weight, and in 1982 herrings accounted for two thirds of the catch by weight in some fisheries (Whitehead 1985:3). While this is unlikely to have been the case for pre-European Māori, Clupeiformes may have been considerably more important than the archaeological record suggests.

All four taxa school near- or inshore and have small mouths. They could not have been caught on large pre-

European Māori hooks but would have been readily netted. Māori nets could be made with a fine mesh and any of the four taxa could have been deliberately targeted. They may also represent bycatch when larger fish are targeted, or intentional catch from fisheries that target schools of small prey fish in order to also catch larger fish preying on them (Monks 1987). Best (1977 [1929]:12) repeats a story told by Gilbert Mair of the use of a seine net more than 1 mile in length: ‘... some 37,000 fish were tallied, not including many small fry ...’ These small fry would have

Table 2. *Pre-European Māori sites where the four taxa have been recorded in New Zealand. The list is not necessarily exhaustive. S = identified by the standard set of 5 mouth bones; E = identified from an extended set of elements; D = identified by DNA meta-barcoding (Seersholm et al. 2018); O = identified from otoliths.*

	Grey mullet	Pilchard	Piper	Yellow-eyed mullet
Tauranga Bay, P04/639 (Campbell <i>et al.</i> in prep)	E	E	E	E
Kokohuia, O06/317 (Leach <i>et al.</i> 1997)	S			
Urquharts Bay, Q07/751 (Harris 2012; Campbell 2016a)	E			
6 Ocean Beach Road, Q07/751 (Campbell and Trilford 2019)			E	E
The N.H.B. site, Q07/58 (Nichol 1988)	E			E
The Sunde site, R10/25 (Nichol 1988)	E			E
Long Bay Restaurant, R10/1374 (Campbell <i>et al.</i> 2019a; Campbell <i>et al.</i> 2019b)	E	E	E	E
The Masonic Tavern, R11/404 (Crown 2013, 2014)	E		E	E
The NRD site, R11/859 (Campbell 2011)	S			
Tāwhiao Cottage, R11/2535 (Campbell 2016b)	E			
Cabana Lodge, T12/3 (Gumbley 2014; James-Lee 2014)				E
Koutunui, U14/39 (Phillips 2017)			E	E
Cooks Cove, Z13/311 (Walter <i>et al.</i> 2011)			D	
Foxton, S24/3 (Davidson <i>et al.</i> 2000)				S
Moncks Cave, Redcliffs, M36/47 (Trotter 1975)				D
Tumbledown Bay, N37/12 (Mason and Wilkes 1963)				D
Kakanui, J42/4 (Weisler <i>et al.</i> 1999)				O
Shag Point, J43/11 (Weisler 2000)				D
Shag River Mouth, J43/2 (Anderson and Smith 1996)				S

Sites are ordered roughly north to south and the distribution of the four taxa generally reflects their current distribution: grey mullet are more common in northern New Zealand, pilchard are common except on the south east coast, while piper and yellow-eyed mullet are common throughout the country (Paul 2000).

included fish like pilchards and piper, and numerous other small inshore taxa that have not (yet) been identified in New Zealand archaeological assemblages.

SCREEN SIZE

The fishbone assemblages were sieved through a variety of screen sizes, ranging from 6.4 mm down to approximately 1 mm sieves that were used to sample grave fill at the Long Bay Restaurant site. Nims re-sieved Tauranga Bay, Masonic Tavern and Cabana Lodge assemblages through nested 6.4 and 3.2 mm screens, Long Bay was sieved through a mix of screens and 6 Ocean Beach Road through 3.2 mm only. This inconsistency and lack of direct comparability introduces a certain amount of noise into any analysis of screen size data, nonetheless the pattern remains clear. Table 3 shows the proportions of the four taxa that were retrieved in these two screen sizes. All piper bone and almost all pilchard and yellow-eyed mullet were caught in the smaller screen size. For grey mullet, the largest of the four taxa, and three common large taxa the 6.4 mm screen caught a significant proportion of the bones.

The importance of screen size and recovery effects has been briefly acknowledged in past syntheses of both marine resources (Leach 2006: 4; Smith 2013: 3) and birds

in New Zealand (Worthy 1997:132), but the possibility of systematic biases has been ignored. Smaller screens catch smaller and more fragmented bone specimens (Payne 1972; Gordon 1993; Shaffer and Sanchez 1994; Nagaoka 1994, 2005; Zohar and Belmaker 2005). For large snapper, which have large, robust bones, screen size is unlikely to make any substantial difference, but for smaller taxa with smaller or more fragile bones screen size makes the difference between being recorded in often high numbers and not being recorded at all. Additionally, smaller bones are less likely to survive in archaeological contexts so a combination of differential bone destruction through taphonomic processes and screen size bias the archaeological record in favour of large taxa. Similar results were also apparent at the Harataonga Beach sites, where the number of taxa and the relative abundance of snapper were substantially different in adjacent excavation units that were sampled with different screen sizes (Allen 2014). This is not to deny the importance of snapper; snapper are the most common species in every assemblage considered here (typical of upper North Island sites on harbours and embayments) except Koutunui where mackerel dominates (typical of Bay of Plenty sites), and they would have provided much more food per individual than any single piper or pilchard. However, smaller species such as these may have been much

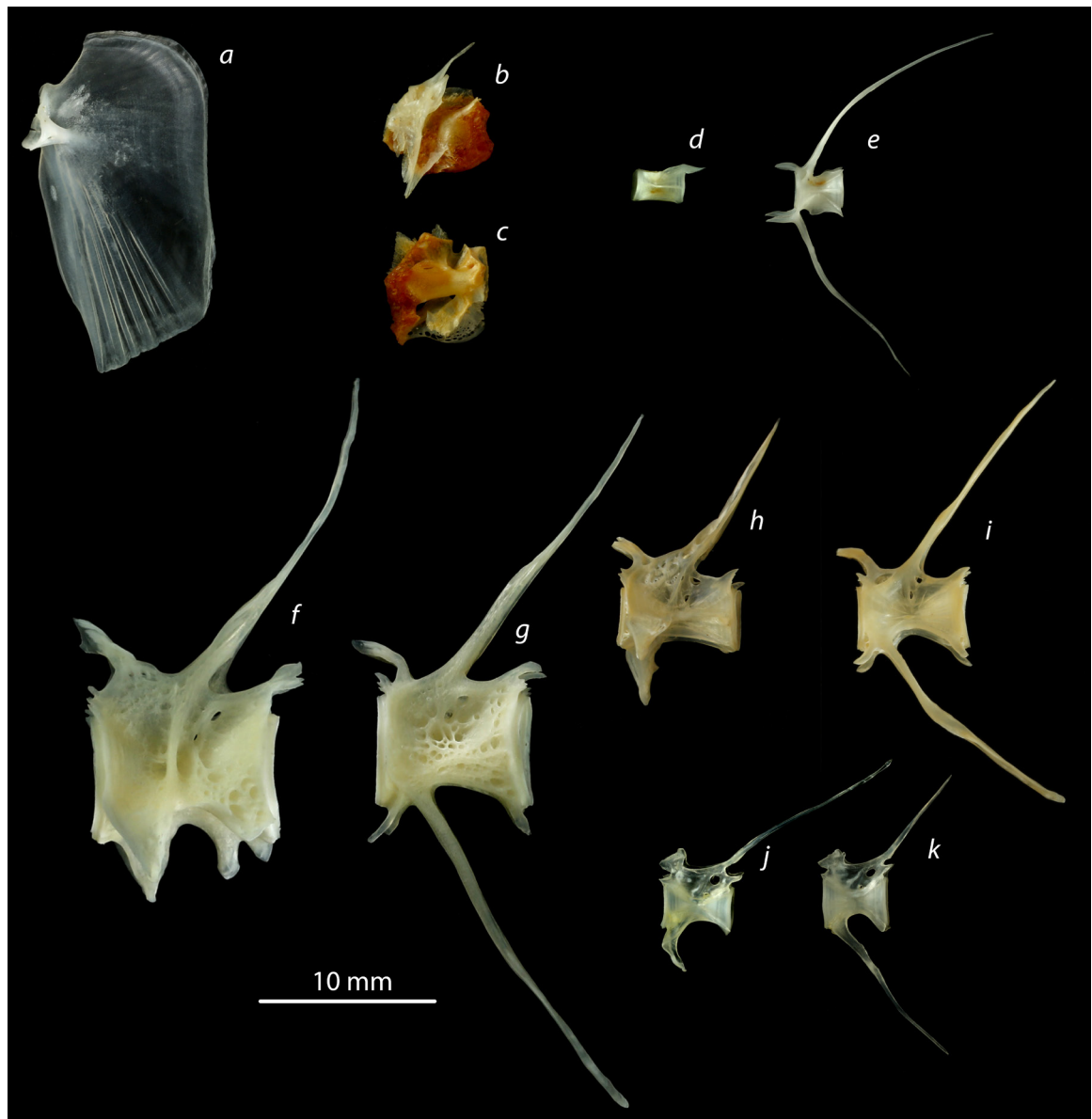


Figure 3. a, pilchard opercular, showing the distinctive striae; b, pilchard prootic; c, pilchard pterotic; d, pilchard thoracic vertebra; e, pilchard caudal vertebra; f, grey mullet thoracic vertebra; g, grey mullet caudal vertebra; h, yellow-eyed mullet thoracic vertebra; i, yellow-eyed mullet caudal vertebra; j, piper thoracic vertebra; k, piper caudal vertebra.

Table 3. Percentages of bone retrieved from 6.4 mm and 3.2 mm or smaller screens for the four taxa compared to three common large taxa.

	6.4 mm	≤3.2 mm
Grey mullet (<i>Mugil cephalus</i>)	43.33	56.67
Kahawai (<i>Arripis trutta</i>)	14.31	85.69
Pilchard (<i>Sardinops sagax</i>)	0.91	99.09
Piper (<i>Hyporhamphus ihi</i>)		100
Red Gurnard (<i>Chelidonichthys kumu</i>)	15.72	84.28
Snapper (<i>Chrysophrys auratus</i>)	46.38	53.62
Yellow-eyed mullet (<i>Aldrichetta forsteri</i>)	1.79	98.21

more important in pre-European Māori economies than previous archaeological research has suggested.

IDENTIFIED ELEMENTS

Identifying the four taxa depends on both the use of fine screens to collect them in the first place, and on the use of a suitable set of elements for analysis. Each of these species has a small mouth with fine mouth bones, and few mouth parts were found in any assemblage despite the use of fine screens (Table 4). Instead, the majority of elements identified were vertebrae, which represent as much as 95% of the yellow-eyed mullet NISP (Table 4).

Table 4. Elements identified for each taxon, all sites combined, ordered by NISP.

	Caudal vertebra	Premaxilla	Dentary	Thoracic vertebra	Quadrate	Maxilla	Articular	Otolith	Palatine	Hyomandibular	Cleithrum	Posttemporal	Parasphenoid	Atlas	Supracleithrum	Opercular	Scapula	Ceratohyal	Dorsal spine	Preopercular	Epihyal	Vomer	Lachrymal	Vertebra	Urostyle	Otic series	Tooth plate	Inferior pharyngeal	Superior pharyngeal	Barb	NISP	N-Elements	
Snapper (<i>Chrysophrys auratus</i>)	1832	2247	1749	525	1041	922	920	864	821	587	342	378	213	204	255	189	294	231		235	103	46			4	95					14097	23	
Red gurnard (<i>Chelidonichthys kumu</i>)	1403	89	68	382	106	74	41	3	72	78	129	82	100	44	87	57	17	73		35	26	57	131	1	21						3176	24	
Yellow-eyed mullet (<i>Aldrichetta forsteri</i>)	1195	1	3	537	2	1	3			28	11	5	3	33	15	8	1			2	2	5									1853	17	
Mackerel (<i>Trachurus</i> sp.)	258	35	49	75	28	38	34	47	16	47	55	19	32	20	18	34	3	24		3	24	6									865	21	
Kahawai (<i>Atripis trutta</i>)	233	31	29	75	18	19	15	18	14	16	8	7	27	30	3	3	15	8		2	10	26	36							643	22		
Leatherjacket (<i>Mesobius scaber</i>)	173		4	48	8		4			48	26		8	16	1				290			13									639	12	
Pilchard (<i>Sardinops sagax</i>)	72		3	2	5	1	12			11	7	10			27	4			4	8	8		22			28					220	15	
Sweep / blue maomao (<i>Scorpius</i> sp.)	31	1		22	5	4		10		7	1	15	18	15	1							4									134	13	
Trevally (<i>Pseudocaranx georgianus</i>)	36	8	3	7	5	5			4		1	3	5	2	1	1	4				2										87	15	
Piper (<i>Hyporhamphus ihi</i>)	12		3	46							2				4					1											68	6	
Wrasse (<i>Labridae</i> sp.)	14	7	2	6	7	2	2			1			1	2																	63	12	
Shark / ray (Chondrichthyes)																								61							61	1	
Blue mackerel (<i>Scomber australasicus</i>)	22	6	3	11	2	3				3	1		1		1						2					1					56	12	
Tarakihi (<i>Memadactylus macropterus</i>)	1	5	4		14	1	5			6	1	8	2	2	5						2										56	13	
Blue cod (<i>Parapercis colias</i>)	5	1		1	5	5	1			1	1	7	4	2	3						1										39	15	
Parore (<i>Girella tricuspidata</i>)	6			14	2	1	1			1	2	1	2	2	2																33	11	
Grey mullet (<i>Mugil cephalus</i>)	20			5			1					1	1		1					1											30	7	
Barracouta (<i>Thyrsites atun</i>)	3	5	4	2	1	5	2						1		2																25	9	
Eagle ray (<i>Myliobatis tenuicaudatus</i>)																											15					15	1
John Dory (<i>Zeus faber</i>)	4	3	3	2	1																											13	5
Kingfish (<i>Seriola lalandi</i>)	5		1			1							1								2											10	5
Pink maomao (<i>Caprodon longimanus</i>)			1	2			1										2															6	4
Flounder (<i>Rhombosolea</i> sp.)	2			3																												5	2
Eel (<i>Anguilla</i> sp.)			2																													4	2
Pigfish (<i>Bodianus vulpinus</i>)			1	1								1																				3	3
Ray (<i>Dasyatis</i> sp.)																													3			3	1
Hapuku (<i>Polyprion oxygenoides</i>)	2																															2	1
New Zealand sole (<i>Peltorhamphus novaezelandiae</i>)				2																												2	1
Red cod (<i>Pseudophycis bachus</i>)			1																													2	2
Spotted stargazer (<i>Gerygagnus monopterygius</i>)	1																															1	1
NISP	5330	2441	1932	1767	1250	1082	1043	942	928	834	587	537	419	370	366	346	344	342	290	287	173	164	131	124	117	28	15	12	7	3	22211	30	
N-Taxa	22	15	18	20	16	15	15	5	6	13	14	13	16	11	6	16	8	7	1	8	6	11	1	5	3	1	1	1	1	1	30		

Time and money are major constraints on faunal analyses, and it may not always be desirable or feasible to identify every element of every taxon. Nims *et al.* (2019) have argued it is even unnecessary to do so when adding new elements does not result in new taxa being identified. However, the four taxa would not have been identified at all, or only in very small numbers, if a limited range of elements was identified (Leach 1986; Campbell 2016a).

RICHNESS AND DIVERSITY

To explore how identification methods affect richness and diversity, N-Taxa and Berger-Parker 1/d were calculated for the conventional set of elements tabulated as MNI (Table 5), and for the extended set of elements by NISP (Table 1). In every case, richness is higher for the extended element set than the conventional set, in other words, the method employed here identifies more taxa in every assemblage. In most cases 1/d is also higher, indicating that the dominant taxon is proportionally less dominant and that other taxa account for a higher proportion of NISP.

This paper began with the claim that New Zealand

fishbone assemblages are generally neither rich nor diverse. These are relative terms – the 15 taxa identified by conventional methods at Tauranga Bay indicate relatively high richness, but the 22 taxa identified in the same assemblage with an extended element set would be considered exceptionally rich, by New Zealand standards. Diversity is still not very high – the most diverse assemblage is Long Bay Phase 7, where 1/d is 2.43, indicating that the dominant taxon, snapper, still accounts for 41% of NISP. In most cases 1/d is less than 2, so the dominant taxon accounts for >50% of NISP. Even so, this method results in an increase in measures of richness and diversity and provides a more accurate picture of the pre-European Māori fish catch.

DISCUSSION AND CONCLUSION

This paper has shown that use of fine screens and analysis of a broad range of skeletal elements produces new taxonomic fish identifications, and changes assemblage richness and diversity. While subsistence and food production are often invoked as causal factors in explanations for settlement and culture change in New Zealand, these tend

Table 5. All identified fish taxa by conventional MNI for each assemblage.

Taxon	Tauranga Bay	6 Ocean Beach Road	Long Bay Restaurant (Phase)						Masonic Tavern	Cabana Lodge	Koutunui
			1	4	5	7	10	12			
Barracouta (<i>Thyrsites atun</i>)	1		1	1		2			1		1
Blue cod (<i>Paraperis colias</i>)	3			1	2			1		1	
Blue mackerel (<i>Scomber australasicus</i>)		1	1	3	1	1					1
Eel (<i>Anguilla</i> sp.)	2										
Grey mullet (<i>Mugil cephalus</i>)				1							
John Dory (<i>Zeus faber</i>)			1						3		
Kahawai (<i>Arripis trutta</i>)	2		2	7	6	1		1	5	2	1
Kingfish (<i>Seriola lalandi</i>)									1		
Leatherjacket (<i>Meuschenia scaber</i>)	290									1	
Mackerel (<i>Trachurus</i> sp.)	1		1	2	3	6	1		1		20
Parore (<i>Girella tricuspidata</i>)	1		1						1		
Pigfish (<i>Bodianus vulpinus</i>)	1										
Pilchard (<i>Sardinops sagax</i>)						6					
Pink maomao (<i>Caprodon longimanus</i>)	1				1						
Piper (<i>Hyporhamphus ihi</i>)					2						
Red cod (<i>Pseudophycis bachus</i>)					1					1	
Red gurnard (<i>Chelidonichthys kumu</i>)		1	16	18	18	5	2	4	6	1	
Snapper (<i>Chrysophrys auratus</i>)	134	4	74	149	76	30	23	15	680	8	
Swep / blue maomao (<i>Scorpiis</i> sp.)	4										
Tarakihi (<i>Nemadactylus macropterus</i>)	1	1							1	2	
Trevally (<i>Pseudocaranx georgianus</i>)	2		1	2	1				2		1
Wrasse (<i>Labridae</i> sp.)	3		1	3	1	2	1		1		
Yellow-eyed mullet (<i>Aldrichetta forsteri</i>)	3				1			1			
MNI	449	7	99	187	113	53	28	21	702	16	24
N-Taxa	15	4	10	10	12	8	5	4	11	7	5
Berger-Parker 1/d	1.55	1.75	1.34	1.26	1.49	1.77	1.22	1.4	1.03	2	1.2

to focus on a decline in terrestrial and marine megafauna and an increased emphasis on horticulture (Davidson 1984; Smith 2002; Anderson 2016). Our research calls into question whether the marine component of pre-European Māori diets is also implicated in these changes.

We have shown that methodological and analytical methods, both in the field and in the lab, have biased our interpretations of pre-European Māori diet and our understanding of pre-European Māori fisheries. Fisheries were not as specialised as has been previously understood and a wider range of fish, such as pipers, pilchards, and mullets, were regularly caught and presumably eaten. This may also be the case for other clupeids like sprats (*kūpae*, *Sprattus antipodum*) and anchovies (korowhāwhā, *Engraulis australis*) which, while they have not been identified

in New Zealand archaeological assemblages, have Māori names, indicating that Māori were familiar with them. It is likely that additional small fish are ‘missing’ as well because they are vulnerable to taphonomic processes and because archaeologists have relied on large screens and the selection of only five mouth bones for analysis. Archaeological interpretations are only as good as the data they are based on, and there is always scope to improve archaeological processes of recovery and data collection to provide more robust models.

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Table 6. Fish taxa identified at our six sites or mentioned in the text. Sources for Māori names: primarily Roberts et al. (2015), with additional names from Moorfield (2011) and MPI (2018).

Common name	Family	Taxon	Māori name
Anchovy*	Engraulidae	<i>Engraulis australis</i>	Kokowhāwhā
Barracouta	Gempylidae	<i>Thyrsites atun</i>	Mangā, Māka
Blue cod	Pinguipedidae	<i>Parapercis colias</i>	Kopukopu, pākirikiri, pātutuki, rāwaru
Blue mackerel	Scombridae	<i>Scomber australasicus</i>	Tawatawa, tewetewe
Eagle ray	Myliobatidae	<i>Myliobatis tenuicaudatus</i>	Whai repo
Eel	Anguillidae	<i>Anguilla</i> sp.	Tuna
Flounder	Rhombolsoleidae	<i>Rhombosolea</i> sp.	Pātiki
Grey mullet	Mugilidae	<i>Mugil cephalus</i>	Hopuhopu, kanae
Hapuku	Polyprionidae	<i>Polyprion oxygeneios</i>	Hāpuku, hāpuka, whāapuku
John Dory	Zeidae	<i>Zeus faber</i>	Kuparu, pukeru
Kahawai	Arripidae	<i>Arripis trutta</i>	Kahawai, hāpukupuku, kōhere, kopapa + many others
Kingfish	Carangidae	<i>Seriola lalandi</i>	Haku, makumaku, warehenga
Leatherjacket	Monacanthidae	<i>Meuschenia scaber</i>	Kōkiri, hiriri
Mackerel	Carangidae	<i>Trachurus</i> sp.	Haature, hauture
New Zealand sole	Rhombosoleidae	<i>Peltorhamphus novaezelandiae</i>	Horihero, pātiki rore, kutuhori, pakeke + many others
Parore	Girellidae	<i>Girella tricuspidata</i>	Parore, Ngāhoehoe, parakoka
Pigfish	Labridae	<i>Bodianus vulpinus</i>	Pākurakura
Pilchard	Clupeidae	<i>Sardinops sagax</i>	Mohimohi
Pink maomao	Serranidae	<i>Caprodon longimanus</i>	Mātā
Piper	Hemiramphidae	<i>Hyporhamphus ihi</i>	Hangenge, ihe, karehā, takeke, wariwari
Ray	Dasyatidae	<i>Dasyatis</i> sp.	Whai
Red cod	Moridae	<i>Pseudophycis bachus</i>	Hoka
Red gurnard	Triglidae	<i>Chelidonichthys kumu</i>	Kumukumu
Shark / ray		Chondrichthyes	Mango / whai
Snapper	Sparidae	<i>Chrysophrys auratus</i>	Tāmure, karati
Spotted stargazer	Uranoscopidae	<i>Genyagnus monopterygius</i>	Kourepoua, moamoa, ngu
Sprat*	Clupeidae	<i>Sprattus antipodum</i>	kupa, marakuha
Swep / blue maomao	Scorpididae	<i>Scorpis</i> sp.	Hui, maomao, kiwa, paihau
Tarakihi	Cheilodactylidae	<i>Nemadactylus macropterus</i>	Tarakihi
Trevally	Carangidae	<i>Pseudocaranx georgianus</i>	Araara
Wrasse	Labridae	<i>Labridae</i> sp.	Pūwaiwhakaruā, tāngahangaha, pau
Yellow-eyed mullet	Mugilidae	<i>Aldrichetta forsteri</i>	Aua

* not identified at sites discussed in this paper

References

- Allen, M.S. 2014. Variability is in the mesh-size of the sorter: Harataonga Beach and spatio-temporal patterning in northern Māori Fisheries. *Journal of Pacific Archaeology*, 5 (1): 21–38.
- Anderson, A.J. 1973. Archaeology and behaviour: prehistoric subsistence behaviour at Black Rocks Peninsula, Palliser Bay. MA Thesis, University of Otago.
- Anderson, A.J. 1997. Uniformity and regional variation in marine fish catches from prehistoric New Zealand. *Asian Perspectives*, 36 (1): 1–26.
- Anderson, A.J. 2016. The making of the Māori Middle Ages. *Journal of New Zealand Studies*, NS23: 2–18.
- Anderson, A.J. and I.W.G. Smith 1996. Fish remains. In A.J. Anderson, B. Allingham and I.W.G. Smith (eds) *Shag River Mouth: The Archaeology of an Early Southern Maori Village*. Research Papers in Archaeology and Natural History, 27: 237–244. ANH Publications, Canberra.
- Best, E. 1977 [1929]. *Fishing Methods and Devices of the Maori*. E.C. Keating, Government Printer, Wellington.
- Bouffandeau, L., P. Béarez, S. Bedford, F. Valentin, M. Spriggs and É. Nolet 2018. Fishing at Arapus-Mangaasi, Efate, Vanuatu (2800–2200 BP): new methodological approaches and results. *Journal of Archaeological Science Reports*, 18: 356–369.
- Campbell, M. 2011. The NRD site: I the archaeology. Unpublished CFG Heritage report to the New Zealand Historic Places Trust and Auckland International Airport Ltd.
- Campbell, M. 2016a. Body part representation and the extended analysis of New Zealand fishbone. *Archaeology in Oceania*, 51: 18–30.
- Campbell, M. 2016b. The Tawhiao Cottage and the archaeology of race and ethnicity. *Journal of Pacific Archaeology*, 7 (2): 43–58.
- Campbell, M., J. Craig, L. Furey, S. Hawkins, A. McAlister, R. Nims, M. Turner and R. Wallace in prep. The Tauranga Bay site, P04/639. Unpublished report to Heritage New Zealand Pouhere Taonga, The Karangahape Marae Trust, and The Green Foundation for Polynesian Research.
- Campbell, M., B. Hudson, J. Craig, A. Cruickshank, L. Furey, K. Greig, A. McAlister, B. Marshall, F. Petchey, T. Russell, D. Trilford and R. Wallace 2019a. The Long Bay Restaurant site, R10/1374: Volume 1, the archaeology (HNZPTA authorities 2015/19 and 2016/81). Unpublished CFG Heritage report to Heritage New Zealand Pouhere Taonga and Auckland Council.
- Campbell, M., B. Hudson, J. Craig, A. Cruickshank, L. Furey, K. Greig, A. McAlister, B. Marshall, R. Nims, F. Petchey, T. Russell, D. Trilford and R. Wallace 2019b. The Long Bay Restaurant site (R10/1374), Auckland, New Zealand, and the archaeology of the mid-15th century in the upper North Island. *Journal of Pacific Archaeology* 10 (2): 1–24.
- Campbell, M. and D. Trilford 2019. Archaeological investigations at Q07/751, 6 Ocean Beach Road, Urquharts Bay (HNZPTA authority 2017/599). Unpublished CFG Heritage Ltd report to Heritage New Zealand Pouhere Taonga and Lou and Karen Kiss.
- Cannon, A., R. Wildenstein, D.Y. Cannon and D.V. Burley 2019. Consistency and Variation in the Focus, Intensity and Archaeological Histories of Lapita and post-Lapita Fisheries in Ha'apai, Kingdom of Tonga. *Journal of Island and Coastal Archaeology*, 14: 515–540.
- Crown, A. 2013. Interim Report for archaeological authority 2011-486, Stage One (excavation of sites R11/2404, 2517, 2518 and 2519) of The Masonic Tavern Redevelopment, King Edward Parade, Devonport. Unpublished Gemetria report to Redback Develop Ltd.
- Crown, A. 2014. Interim report for archaeological authority 2011-486, Stage Two (excavation of site R11/2517) of the Masonic Tavern redevelopment, King Edward Parade, Devonport. Unpublished Geometria report to Redback Develop Ltd.
- Davidson, J.M. 1984. *The Prehistory of New Zealand*. Longman Paul, Auckland.
- Davidson, J.M., B.F. Leach, K. Greig and P. Leach 2000. Pre-European Māori fishing at Foxton, Manawatu, New Zealand. *New Zealand Journal of Archaeology*, 22: 75–90.
- FAO 2016. *Fishery and Aquaculture Statistics 2014*. FAO Yearbook. Food and Agriculture Organisation of the United Nations, Rome.
- Gordon, E.A. 1993. Screen size and differential faunal recovery: a Hawaiian example. *Journal of Field Archaeology*, 20 (4): 453–460.
- Gumbley, W. 2014. The Cabana site (T12/3), Whangamata: results of the 2007 investigation. Unpublished report to Heritage New Zealand.
- Harris, J. 2012. Archaeological investigation at Q07/751, 4 Ocean Beach Road, Urquharts Bay. Unpublished CFG Heritage report to the New Zealand Historic Places Trust and Don Grimwood and Anni Veart-Smith.
- James-Lee, T. 2014. Prehistoric Maori subsistence: evaluating two regions in north-eastern New Zealand. PhD thesis, University of Otago.
- Lambrides, A.B.J. and M.I. Weisler 2015. Assessing protocols for identifying Pacific Island archaeological fish remains: the contribution of vertebrae. *International Journal of Osteoarchaeology*, 25: 838–848.
- Leach, B.F. 1986. A method for the analysis of Pacific Island fishbone assemblages and an associated database management system. *Journal of Archaeological Science*, 13: 147–159.
- Leach, B.F. 2006. *Fishing in pre-European New Zealand*. New Zealand Journal of Archaeology Special Publication. New Zealand Archaeological Association, Wellington.
- Leach, B.F., J.M. Davidson and L.M. Horwood 1997. Prehistoric Māori fishermen at Kokohuia, Hokianga Harbour, Northland, New Zealand. *Man and Culture in Oceania*, 13: 99–116.
- Magurran, A.E. 2004. *Measuring Biological Diversity*. Blackwell, Malden, MA.
- Mason, G.M. and O. Wilkes 1963. Tumbledown Bay – a Banks Peninsula moa-hunter site S94/30. *New Zealand Archaeological Association Newsletter*, 16 (2): 98–100.
- Monks, G.G. 1987. Prey as bait: the Deep Bay example. *Canadian Journal of Archaeology*, 11: 119–142.
- Moorfield, J. 2011. *Te Aka: Māori-English, English-Māori Diction-*

- ary. Pearson, Auckland.
- MPI (Ministry for Primary Industries Manatū Ahu Matua) 2018. Approved fish names list. <https://www.mpi.govt.nz/news-and-resources/resources/registers-and-lists/approved-fish-names/>.
- Nagaoka, L. 1994. Differential recovery of Pacific Island fish remains: evidence from the Moturakau Rockshelter, Aitutaki, Cook Islands. *Asian Perspectives*, 33 (1):1–17.
- Nagaoka, L. 2005. Differential recovery of Pacific Island fish remains. *Journal of Archaeological Science*, 32: 941–955.
- Nichol, R. 1988. Tipping the feather against a scale: archaeozoology from the tail of the fish. PhD Thesis, University of Auckland.
- Nims, R., D. Filimoehala, M. Allen and V. Butler 2019. Less is more, vol 2: element selection as sampling strategy. Paper presented at the 20th Fish Remains Working Group Meeting, Portland, Oregon.
- Ono, R. and G. Clark 2012. A 2500-year record of marine resource use on Ulong Island, Republic of Palau. *International Journal of Osteoarchaeology*, 22: 637–654.
- Paul, L. 2000. *New Zealand Fishes: Identification, Natural History and Fisheries*. Reed, Auckland.
- Payne, S. 1972. Partial recovery and sample bias: the results of some sieving experiments. In E.S. Higgs (ed.) *Papers in Economic Prehistory*, 49–64. Cambridge University Press, Cambridge.
- Phillips, C. 2017. Archaeological investigation, Pa U13/49, 56 Koutunui Road, Athenree: HNZ authority 2016/1187: final report. Unpublished report.
- Phillips, C. and B. Druskovich 2009. Archaeological investigation, midden Q07/571, 2567 Whangarei Heads Road, Urquharts Bay: Historic Places Authority 2007/25. Unpublished report.
- Roberts, C.D., A.L. Stewart and C.D. Struthers (eds) 2015. *The Fishes of New Zealand*. Te Papa Press, Wellington.
- Seersholm, F.V., T.L. Cole, A. Greal, N.J. Rawlence, K. Greig, Michael Knappe, M. Stat, A.J. Hansen, L.J. Easton, L. Shepherd, A.J.D. Tennyson, R.P. Scofield, R. Walter and M. Bunce 2018. Subsistence practices, past biodiversity, and anthropogenic impacts revealed by New Zealand-wide ancient DNA survey. *Proceedings of the National Academy of Science*, 115 (30):7771–7776.
- Shaffer, B.S. and J.L.J. Sanchez 1994. Comparison of 1/8" - and 1/4" - mesh recovery of controlled samples of small-to-medium-sized mammals. *American Antiquity*, 59 (3): 525–530.
- Smith, I.W.G. 2002. Retreat and resilience: fur seals and human settlement in New Zealand. In G.G. Monks (ed.) *The Exploitation and Cultural Importance of Sea Mammals. Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham, August 2002*, 6–18. Oxbow Books, Oxford.
- Smith, I.W.G. 2013. Pre-European Maori exploitation of marine resources in two New Zealand case study areas: species range and temporal change. *Journal of the Royal Society of New Zealand*, 43 (1):1–37.
- Trotter, M.M. 1975. Archaeological investigations at Redcliffs, Canterbury, New Zealand. *Records of the Canterbury Museum*, 9 (3):198–220.
- Vogel, Y. 2005. Ika. MA thesis, University of Otago.
- Walter, R., C. Jacomb and E. Brooks 2011. Excavations at Cook's Cove, Tolaga Bay, New Zealand. *Journal of Pacific Archaeology*, 2 (1):1–27.
- Weisler, M.I. 2000. Excavations at Shag Point J43/11 North Otago: a summary report. *Archaeology in New Zealand*, 43 (3): 220–229.
- Weisler, M.I., C. Lalas and P. Rivett 1999. New fish records from an Archaic midden, South Island. *Archaeology in New Zealand*, 42 (1):37–43.
- Whitehead, P.J.P. 1985. *Clupeoid Fishes of the World (Suborder Clupeoidei): An Annotated and Illustrated Catalogue of the Herrings, Sardines, Pilchards, Sprats, Shads, Anchovies and Wolf-herrings: Part 1 – Chirocentridae, Clupeidae and Pristigasteridae*. FAO Species Catalogue, 7. Food and Agriculture Organisation of the United Nations, Rome.
- Worthy, T. 1997. What was on the menu? Avian extinctions in New Zealand. *New Zealand Journal of Archaeology*, 19:125–160.
- Zohar, I. and M. Belmaker 2005. Size does matter: methodological comments on sieve size and species richness in fishbone assemblages. *Journal of Archaeological Science*, 32 (4): 635–641.