

# Variability is in the Mesh-size of the Sorter: Harataonga Beach and Spatio-temporal Patterning in Northern Māori Fisheries

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## ABSTRACT

Prehistoric Māori fisheries have been characterized as specialized and focused on a few medium-sized, shallow water carnivorous taxa of high biomass. *Pagrus auratus* (snapper) in particular is an abundant component of many northern North Island archaeofish assemblages. However, few northern collections derive from well dated, stratified sites and past field recovery techniques were often less than ideal. Assemblages from Harataonga Beach, Aotea Island (Great Barrier) are useful in this respect, representing both early and late prehistory, and deriving from two field studies made 40 years apart. The recent study, using 2 mm screens, recovered 78,848 fish bones of which 5941 represented 15 bony fish families, sharks and rays. Snapper (*Pagrus auratus* or *Tamure*) dominates the early assemblage (69%) but is poorly represented in late prehistory (<20%). Jack mackerel, blue mackerel, and leatherjacket dominate the late prehistoric assemblages and suggest netting in offshore areas. Along with a few other northern localities, the Harataonga results illustrate how sampling and coarse sieves (>3.2 mm) can significantly bias assemblage composition, diversity and structure. The regional assessment also suggests that while early Māori fishing practices may have been specialised relative to those of tropical East Polynesia, over time they became more generalised.

*Keywords:* Māori fishing, marine resources, New Zealand prehistory, screen size, zooarchaeology, Great Barrier Island

## INTRODUCTION

With 15,000 km of coastline, New Zealand has a wealth of marine resources and a long-standing fishery that extends well into the prehistoric past. The archipelago's first settlers from central East Polynesia brought with them knowledge of a variety fishing strategies and diverse technologies including nets, traps, angling, spears and possibly weirs (Best 1986; Buck 1944; Paulin 2007). However, as many tropical species were not found in New Zealand waters, and traditional raw materials for fishing equipment often lacking, considerable adjustments had to be made. Understanding how Polynesian practices were adapted to the ecologically diverse seascapes of New Zealand is of relevance to prehistorians, indigenous Māori and contemporary fisheries managers. Of particular interest here are questions regarding spatio-temporal variation in the composition, structure and variety of Māori fishing activities, which ultimately give insights into local adaptations and human ecodynamics in the marine context.

Anderson (1997) offers a profile of traditional Māori

fisheries, drawing on a large number of zooarchaeological studies from across the country (see also Leach & Boocock 1993). His review suggests a specialized fishery relative to that of tropical Polynesia, emphasizing a limited number of taxa with exceptionally high biomass and seasonal patterns of aggregation. Key among these taxa was snapper (*Pagrus auratus*) in the north and barracouta (*Thyrsites atun*) in the south. A number of large assemblages from the east coast of the South Island provide solid evidence for the southern pattern (e.g., Leach & Boocock 1993; Anderson 1997; Nagaoka 2002; Smith 2004; Leach 2006). Northern assemblages are more limited but a recent study of assemblages from the Greater Hauraki and Otago-Catlins regions identifies possible regional and sub-regional variations (Smith 2013; Smith and James-Lee 2010).

Importantly, fishery composition and structure are routinely linked with variability in productivity, efficiency and resilience. Specialised economies focus on a small number of taxa and tend towards greater efficiency, but are more vulnerable to perturbations. At the other end of the continuum, generalised economies involve exploitation of a wide range of taxa in more even proportions. The losses of efficiency associated with generalised strategies are typically offset by enhanced resilience to perturbations or variation in prey, such as might arise from anthropo-

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genic or natural processes. In his holistic analysis of Māori diets, Smith (2004) suggests a working definition of specialised economies as those where one leading resource provides 75% or more to the diet, while generalised ones are defined as those where no resource contributes more than 50%. Differentiating between these two contrastive alternatives (and variation in the middle ground) requires large, well collected assemblages. Problematically, analytical decisions related to sampling and recovery procedures also can create patterning which may bias interpretations of past behaviours; in the case of the northern North Island assemblages this is a particular concern. Anderson (1997: 21) foreshadowed the potential impact of analytical improvements on substantive interpretations more than a decade ago, proposing that ‘upgrading the recovery and

identification procedures would have significant procedural consequences at all levels including excavation and recovery strategies.’

These ideas are considered here using archaeofaunal collections from Harataonga, Aotea (Great Barrier) Island (Figure 1), derived from excavations in 1962 and 1999–2000; the latter study was small in scale but utilized fine sieves for sediment processing. Additionally, assemblages synthesized by Anderson (1997) for the northern half of the North Island are re-visited, along with a small number of more recent archaeofish analyses where fine mesh screens were used and Smith’s (2013) recent Greater Hauraki study. The analysis suggests that early northern North Island fisheries may have been relatively specialized but over time they became more generalized. Additionally,

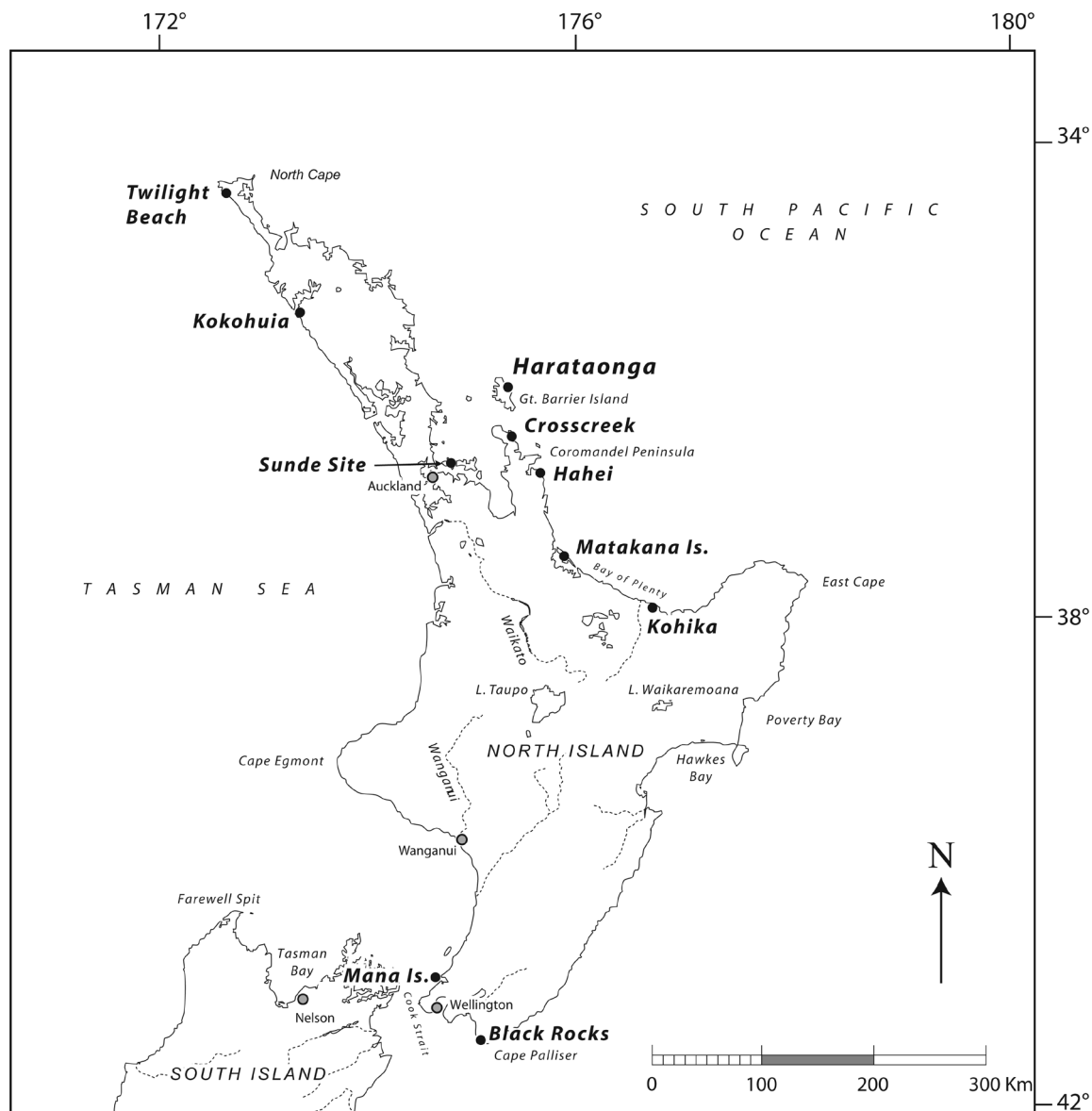


Figure 1. Location of main study site and other places discussed in text.

northern Māori fisheries were probably more geographically varied at all times than previously has been recognized (see also Smith 2013).

## BACKGROUND

New Zealand is made up of two large islands and over 700 smaller islands and at 268,021 km<sup>2</sup> it greatly exceeds any other central Pacific archipelago in land area. The extensive coastline has a diversity of marine habitats, including numerous estuaries, harbours and beach settings of variable size, physiography, and complexity. Extending mainly in a north-south direction, and surrounded by complex systems of warm and cool currents, the marine fauna vary from sub-tropical to subantarctic, and include a few tropical elements which can vary in abundance with circulation and climate conditions (Ayling and Cox 1982:13). In both the North and South Islands, fish and shellfish were important dietary components throughout prehistory with evidence that they became more important as other fauna declined (Smith 2004).

Due to a long-standing zooarchaeological tradition, dating from the mid-19th century (Allen and Nagaoka 2006), and the sustained commitment of a few key analysts (i.e., Anderson 1986, 1989, 1997; Barber 2004; Leach 1986, 1997, 2006; Leach and Anderson 1979; Leach and Boocock 1993; Smith 1985, 2004, 2013), a large number of archaeofish and related faunal analyses are available for comparison. In the 1990s, Leach & Boocock (1993) produced a comprehensive database and review of New Zealand archaeofish assemblages, building on earlier more geographically restricted surveys of Anderson (1986), Nichol (1988), and others (detailed in Anderson 1997). They identified three broad regional patterns: a dominance of snapper (*Pagrus auratus*) in the northern North Island assemblages; a preference for barracouta (*Thyrstites atun*) in the southern South Island; and a catholic pattern of fishing in the central Cook Strait region with wrasses (Labridae), red cod (*Pseudophycis bachus*), and barracouta being important contributors. To some extent these regional patterns reflect natural abundances; snapper biomass, for example, is extremely high in northern New Zealand, with annual catches of 30,000 tonnes recorded in the past (Ayling and Cox 1982: 225).

The subsequent synthesis of Anderson (1997) drew on 55 mainland New Zealand sites with a total MNI of 13,702. His study confirmed these regional patterns and he concluded that Māori fisheries were fairly specialized and focused on a few moderate size carnivores (i.e., 1.5 kg or smaller) that are found in inshore waters of up to 60 m depth. Anderson also observed that several herbivorous and plankton-feeding fish were not well represented, despite their relatively high natural abundances. Comparing assemblages from before and after AD 1500, some temporal patterning was apparent (Table 1), including localised evidence for harvesting pressures on snapper (Anderson

Table 1. *Relative abundance patterns in 55 northern North Island fish assemblages before and after ca. AD 1500; the most common taxa highlighted in gray (data from Anderson 1997:20).*

Taxon	Early Period		Late Period	
	MNI <sup>1</sup>	%	MNI	%
Red Gurnard	7	0.1	20	4.3
Trevally	147	2.8	3	0.6
Jack Mackerel	127	2.4	–	–
Mackerels <sup>2</sup>	–	–	76	16.4
Kahawai	108	2.1	10	2.1
Snapper	4197	81.8	136	29.4
Tarakihi	21	0.4	9	1.9
Yellow-eyed Mullet	179	3.4	–	–
Wrasses	87	1.6	40	8.6
Barracouta	9	0.2	14	3.1
Leatherjacket	176	3.4	137	29.6
Other	70	1.3	17	3.6
<b>Totals</b>	<b>5128</b>	<b>99.5</b>	<b>462</b>	<b>99.6</b>

1. MNI = Minimum number of individuals.

2. Includes both jack mackerels (*Trachurus* spp.) and blue mackerels (*Scomber australasicus*).

1997; see also Anderson & McGlone 1992) and a greater reliance on leatherjacket in late prehistory. However, these trends were heavily influenced by a single site, Hahei on the Coromandel Peninsula. Problematically, there were few localities with both early and late components where ecological conditions could be held constant and temporal change fully assessed. Moreover, many of the reported assemblages were collected decades ago, often with inadequate concern for systematic bone recovery. In Leach's (2006) most recent treatise, he considered only one northern North Island collection suitable for detailed analysis, Kokohuia (see Figure 1). As Leach emphasizes, very few sites have sufficient time depth to permit comparative studies at a local scale. To this we might add that the number of well dated and well collected sites also is quite small. In this respect, the Harataonga, Aotea Island assemblages reported here, representing both early and late time periods, well dated and collected with fine mesh screens (2 mm), make a useful contribution to our understanding of prehistoric fisheries in northern New Zealand.

## HARATAONGA BEACH

Aotea or Great Barrier is the largest island of the Great Barrier group, a collection of 23 islands and islets located 80 km off the northeast coast of the North Island (Figure 1). At 285 km<sup>2</sup>, Aotea is the North Island's largest offshore land mass, separated from the Coromandel Peninsula by the 20 km wide Colville Channel (Armitage 2001). Several hundred prehistoric Māori sites have been identified on the island, many in coastal areas, including hamlets, forti-

fied sites, stone workshops, burials, and agricultural complexes (Sewall 2001).

Harataonga Beach stands out as one of two localities on Aotea with evidence for early Māori settlement. Lying on the more exposed northeast coast of Aotea, the bay is partially protected by Rakitu and other smaller offshore islets (Figure 2). The approximately 500 m long Harataonga shoreline is a stationary back-barrier system, bound at each end by rocky headlands (Nichol *et al.* 2007). The barrier dune extends nearly the length of the beach, and is ~100 m wide and up to 15 m high. The dune was the focus of human settlement from at least the 14th century AD (Jones 2002; Jones & Sutton *ms.*; Law 1972). At the western end of the beach the dune is breached by Harataonga Stream which drains a back-barrier wetland that is *ca.* 2 km long and extends inland for close to a kilometre (Horrocks *et al.* 2002a). Palynological and sedimentary studies suggest both the barrier dune and wetland were in place by *ca.* 3500 BP (Horrocks *et al.* 2002a; Nichol *et al.* 2007), well before the arrival of Polynesian colonists. A variety of marine micro-environments are found within and in close proximity to the bay, including the relatively protected sandy beach with its near-shore shallows, rocky headlands at either end, and more distantly, open ocean areas.

Excavations at Harataonga focused on two sites. Site T08/5 (modern metric site number; former imperial site number Site N30/5), a buried and probably short-term occupation dating to the 14th century, is located at the west end of the beach near the outflow of Harataonga Stream.

The second site also is a buried cultural deposit (formerly Site N30/4, now T08/4) found at the eastern end of the beach adjacent to a fortified hill or *pa* (formerly N30/3, now T08/3). Both sites were first excavated in 1962 under the direction of Roger Green (Law 1972), and revisited in 1999–2000 under the direction of Douglas Sutton (Jones & Sutton *ms.*). The latter study involved extensive coring of the dune system, palaeoenvironmental analyses (Horrocks *et al.* 2002a, 2002b; 2009; Nichol *et al.* 2007), and three-dimensionally controlled excavation of a limited number of test units. The materials recovered in 1999–2000 are reported here for the first time and complement published analyses of the site's avifauna (Allen and Holdaway 2010) and shellfish (Allen 2012).

The earlier 1962 study opened 7.5 m<sup>2</sup> at the early western site. At the late prehistoric eastern site 'Eight and a half 2 m squares were excavated' and faunal materials from 'six squares were sampled for faunal remains (Law 1972: 104–6), 24 m<sup>2</sup> or roughly 40% of the site (mistakenly reported as 12 m<sup>2</sup> in Allen 2012: 299, Allen and Holdaway 2010: 18). At both sites the sediments were screened, with 6.3 mm screens specifically indicated for the late site and presumably also used at the early site (Law 1972: 95, 104). The fish remains from the early site were analysed by Leach & Boock (1993), while those from the later site are reported in Law (1972). These findings are considered here in a comparative manner.

The more recent investigation in 1999–2000 (hereafter 2000) tested these same two sites and maintained



Figure 2. Harataonga Beach and Rakita Island.



tight three-dimensional control, including excavation in 50 cm<sup>2</sup> quadrants and 2 cm spits or levels within strata (Jones & Sutton ms). Materials from the early site derive from a 2 × 2 m unit (TP1). Within this unit, the excavators identified three dune-building episodes, one containing a small amount of cultural materials. All three overlay a well defined cultural layer (identified here as Layer 3) with fire features, artefacts, and faunal remains (Jones pers. com., 2003). The sediments from Layer 3 were bulk collected and processed in the laboratory using 6.7, 3.2 and 2 mm screens. Based on a Bayesian analysis of 17 newly acquired wood charcoal (n=6) and shell (n=11) radiocarbon determinations, Jones & Sutton (ms; see also Jones 2002) placed the most likely age of the early Harataonga occupation between AD 1280 and 1410, a period which is relatively early in the New Zealand cultural sequence (Higham & Hogg 1997).

The 2000 investigation also tested the late prehistoric site at the opposing (eastern) end of the beach. Three units totalling 4.6 m<sup>2</sup> were opened along the seaward edge of the main beach ridge, exposing a single cultural layer of variable thickness (Jones & Sutton ms). TP4 (1 × 0.6 m) revealed a ~25 cm thick accumulation of shellfish and fish bone, with little sedimentary matrix or internal structure. The sediments were bulk sampled and processed in the lab with 6.7, 3.2 and 2 mm screens. One meter to the west, TP6 (1 × 2 m) exposed a ca. 45 cm thick cultural layer with a series of intercutting fire features (ovens and hearths) and an abundance of shell and bone; the sediments were coarse screened in the field to remove rocks, shells, and obvious bones and the residue bulk sampled and further processed in the lab with 6.7, 3.2 and 2 mm screens. TP11 (1 × 2 m) was located 10 m west of TP6 and 2.5 m inland from the beach ridge face; the sediments from here also were bulk sampled and processed in the lab. Jones (pers. comm., 2003) suggests the deposit represents a series of spatially discrete, short duration events. Bayesian analysis of 23 newly acquired radiocarbon determinations (10 on wood charcoal, 13 on shell) placed the occupation layer in the period AD 1650 to 1800 AD, while the artefact and faunal content suggests a pre-European age (Jones 2002).

## LAB METHODS

### Identification

Fish bone identifications were made using the University of Auckland, Department of Anthropology fish bone reference collection, which includes most of the economically important species of New Zealand, with multiple specimens for most taxa. The illustrated atlas of Leach (1997) and the zooarchaeological collections at Te Papa: The National Museum in Wellington also were utilized. A conservative approach was taken to identifications. For families with multiple species, identifications were usually only to genus. For example, the *Trachurus* specimens are

probably *T. novaezelandiae*, the more common northern species (Paul 1997), but *T. declivis* also could be represented as this species is sometimes present under certain climate conditions. For other species-rich groups, such as the wrasses, identifications were only to the level of family (see Leach and Anderson 1979: 4).

Five diagnostic mouth parts (Figure 3) were used for determinations (following Leach 1986, 1997). These paired cranial bones have the advantage of being relatively distinct for all families. The use of fine mesh sieves (2 mm) insured that even small mouth bones were collected. Other diagnostic bones, sometimes called 'special bones' (Leach 1997, 2006), also were recorded (Table 2). These are elements that may be well-represented and/or readily identifiable for a limited number of taxa, as for example unusual spines, scales, vertebrae, or pharyngeal plates. For example, the distinctive and durable dorsal spine of the family Monacanthidae is frequently preserved in archaeological sites, while those of many other families are fragile and/or non-descript. Monacanthidae dorsal spines are often recovered even when the diagnostic mouth elements of this taxon are lacking.

Problematically, special bones vary considerably in the degree to which they can be used to accurately assess taxonomic abundances. Some taxa are typically represented *only* by special bones (e.g., the largely cartilaginous sharks and rays), while others (e.g., porcupinefish, *Allomycterus* sp.) are simply more commonly represented by these distinctive elements. Some special bones are limited to one per individual and thus can be useful in determining the importance of a species (e.g., *M. scaber* dorsal spines, assuming a diagnostic proximal end of the spine is recorded), but others occur in varying and often large numbers on a single individual, as for example the distinctive scutes (modified scales) of the family Carangidae. These factors have figured into the choice of quantification measures used herein.

### Quantification

The recovered materials were quantified using three measures: 1) total number of identified specimens (NISP); 2) the NISP of the five paired diagnostic mouth bones (NISPjaw); and 3) minimum number of individuals (MNI). Grayson (1984) details the problems associated with NISP and MNI, suggesting the former is a less problematic estimator of taxonomic abundances (see also Lyman 2008). NISP also is preferred in the central Pacific (e.g., Allen 2002; Butler 1994; Walter 1998; Weisler 2001). Allen (1992) suggests using NISP of the jaw elements only (NISPjaw) as a way to equalise opportunities for representation across a wide array of taxa, while avoiding the MNI-associated problems of aggregation effects. In New Zealand, however, MNI has historically been the more commonly used quantitative measure (see Leach & Boocock 1993; Leach 2006) and reporting of all three measures maximizes comparisons.

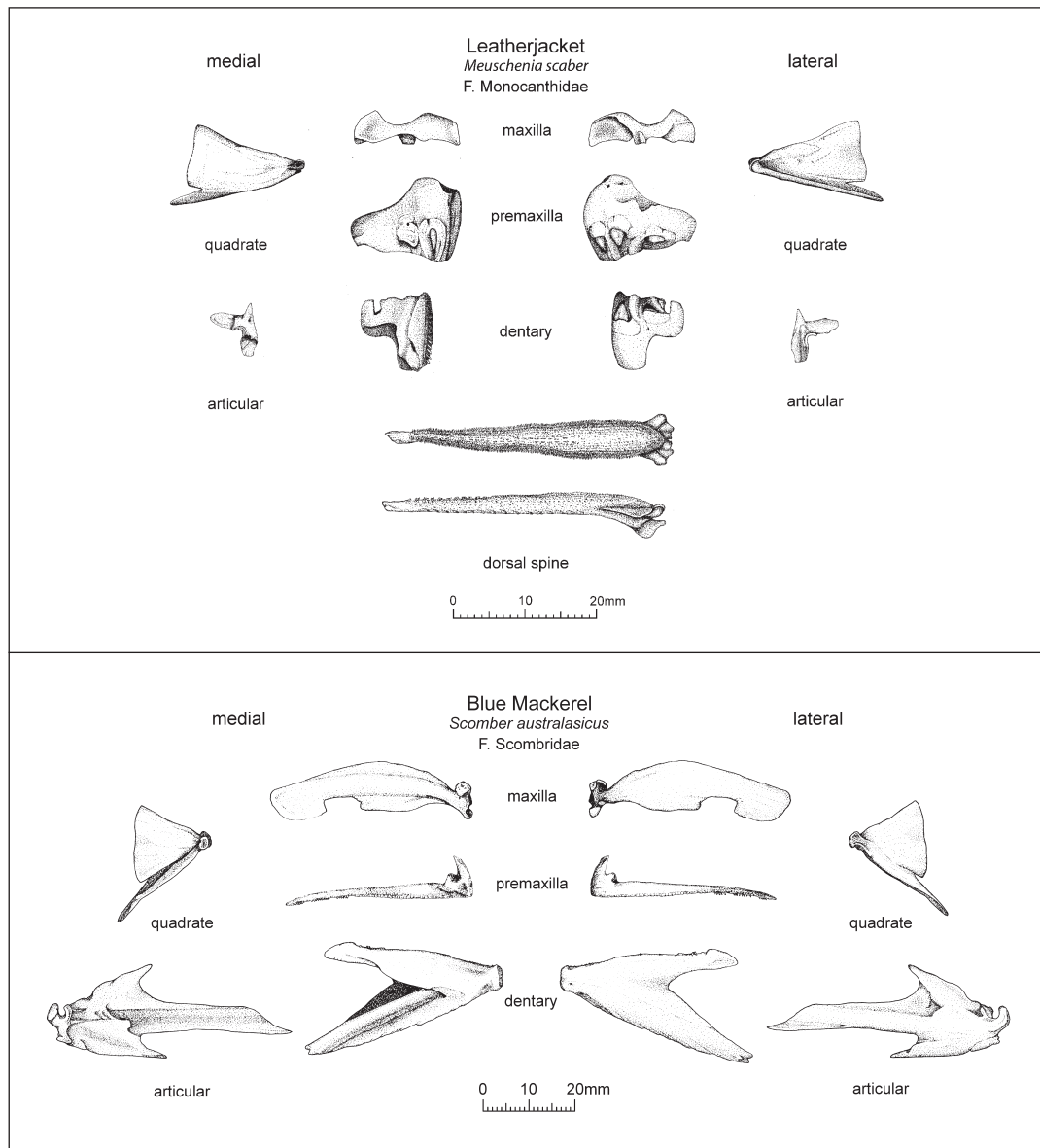


Figure 3. Examples of diagnostic mouth elements, showing two species not illustrated in the atlas of Leach (1997): *Meuschenia scaber* and *Scomber australasicus* (illustrations by Andrew McAlister).

As used in this study, NISP is simply a count of the total number of identified specimens for a given taxon, while NISP<sub>jaw</sub> is the number of identified diagnostic mouth bones, specifically the premaxilla, dentary, quadrate, articular, and maxilla. MNI was determined by counting the most common side of the most abundant element for each taxon; no adjustments were made for size differences that might indicate more than one individual. Specimens were aggregated by stratigraphic layer for each locality; MNI values are probably not grossly affected by aggregation given the dispersal of the units at the late site, and the single cultural layer under consideration at each locality. NISP of the five paired cranial elements (NISP<sub>jaw</sub>) was considered the most accurate measure of taxonomic abundances and

is the basis for the substantive interpretations which follow except where comparisons are made with older studies. The number of taxa is referred to here as richness (following Grayson), while evenness relates to the proportional contribution of taxa. Uneven assemblages are those dominated by one or a few taxa, while in even assemblages several taxa make moderate contributions.

## RESULTS OF RECENT HARATONGA STUDY

### Taxonomic Patterns

A total of 78,848 bony and cartilaginous fish specimens were recovered from the primary cultural layers of the

Table 2. Distinctive elements used in the Harataonga study.

Taxon	Element	No. per specimen
<b>Supra-family</b>		
Chondrichthyes (sharks & rays)	vertebra	+
Selachimorpha (sharks)	tooth	+
Rajiformes (rays)	mouth plate	2
Squaliformes (dogfish sharks)	dorsal spine	+
<b>Family</b>		
Arripidae (kahawai)	otolith	2
Carangidae (jacks & travellies)	otolith	2
<b>Carangidae</b>		
<i>Trachurus</i> spp. (jack mackerel)	scute	70–100 <sup>1</sup>
<b>Monacanthidae</b>		
<i>Meuschenia scaber</i> (leatherjacket)	dorsal spine	1
Labridae (wrasses)	pharyngeal plate, superior	2
	pharyngeal plate, inferior	1
<b>Species</b>		
<i>Pagrus auratus</i> (snapper)	frontal bone	1
	otolith	2

1. Source: Nichol (1988:175).

two sites. Information on their associated habitats, feeding preferences, average body size, spawning season, capture technologies and sociality are provided in Table 3. Despite the large amount of fish bone recovered, most of it was unidentifiable (Figure 4), especially in the 2 mm fraction. Nevertheless this fraction provided remains of several small taxa which were apparently of economic im-

portance, particularly the small scutes of *Trachurus* and fragile mouth parts of *Scomber*.

Altogether 5941 elements ( $MNI=262$ ) were identified to 15 bony fish families, 16 taxa, and at least two distinct taxa of the subclass Elasmobranchii (sharks and rays). Additionally, another two bony fish were distinguished but could not be identified, bringing the taxonomic richness

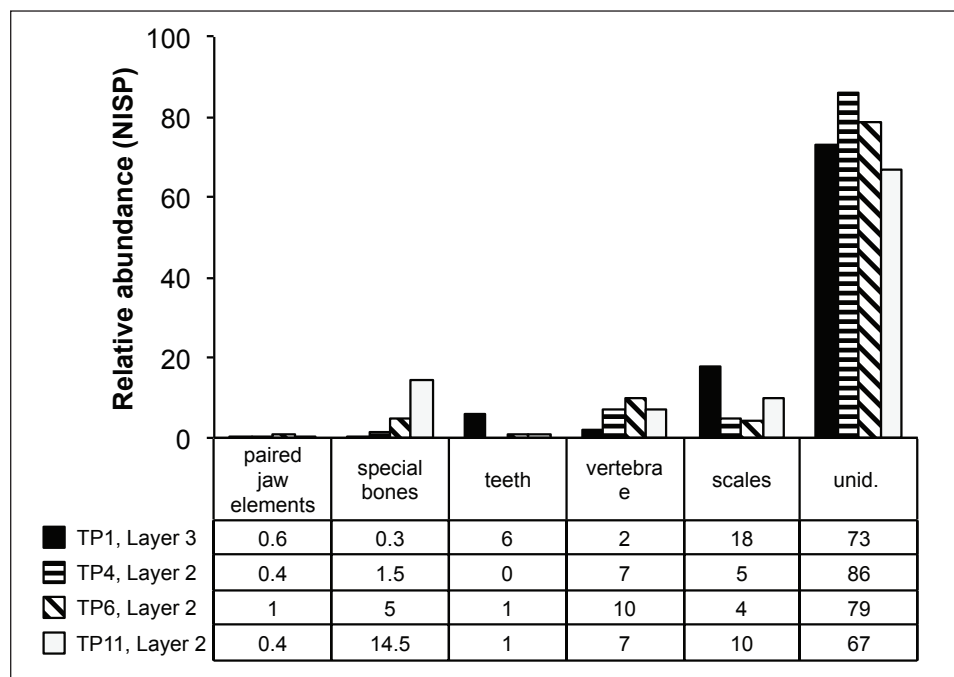


Figure 4. Body part representation by test unit.

Table 3. Characteristics of taxa most likely represented in the Harataonga Beach archaeofaunal assemblages.<sup>1</sup>

Order/Family <sup>2</sup>	Genus & species	Common Name	Māori Name <sup>3</sup>	Habitat	Diet	Mean Size	Spawning Season	Capture Method	Sociability
<b>CLASS CHONDRICTHYES</b>									
Order: Squaliformes	not known	spiny dogfish		mainly deep waters; bottom oriented	carnivorous	varied	varied	nets, lines	varied
Order: Rajiformes	not known	rays and skates		mainly deep waters; bottom oriented	carnivorous	varied	varied	nets, lines	varied
<b>CLASS OSTEICHTHYES</b>									
Muraenidae	<i>Gymnothorax</i> sp.	Moray eel	various	rough ground	carnivorous	50–100 cm	not known	hooks, traps	solitary
Serranidae	<i>Caprodon longimanus</i>	Pink Maomao	Maataa	open water	herbivorous	30–40 cm	not known	hooks, nets	school
Carangidae	<i>Trachurus</i> sp.	Jack Mackerel	Haature	bottom, pelagic	carnivorous	30–40 cm	summer	nets, hooks	school
Carangidae	<i>Pseudocarnax dentex</i>	Trevally	Araara	varied	carnivorous	30–50 cm	early summer	hooks, nets	school
Aripiidae	<i>Aripiis trutta</i>	Kahawai	Kahawai	pelagic	carnivorous	up to 60 cm	late summer	trolling, hooks, nets	school
Sparidae	<i>Pagrus auratus</i>	Snapper	Tamure	shallow bays, estuaries, harbours	carnivorous	30–50 cm	spring, early summer	hooks, nets	varied
Mullidae	<i>Upeneichthys lineatus</i>	Red Mullet	Ahuruhuru	sheltered bays & harbours	omnivorous	30–40 cm	late summer–autumn	nets	school
Kyphosidae	<i>Scorpiis</i> sp.	Blue Maomao or sweep	various	close to islands and rock reefs	carnivorous	20–30 cm	not known	hooks, nets, spear	school
Cheilodactylidae	<i>Nemadactylus macropterus</i>	Tarakihi	Tarakihi	bottom–dwelling, rock reefs	carnivorous	30–40 cm	late summer	hooks, nets	school
Latrididae	<i>Latris lineata</i>	Trumpeter	Kohikohi	rocky, deeper rock reefs	carnivorous	50–80 cm	not known	hooks, nets	not known
Labridae	not known	Wrasse	undetermined	rocky areas, varied depths	carnivorous	10–30 cm	not known	hooks	rel. solitary
Odacidae	<i>Odax pullus</i>	Butterfish	Mararii	shallows of rocky coasts with kelp	herbivorous	30–75 cm	spring–summer	nets, spear	school
Pinguipedidae	<i>Parapercis colias</i>	Blue Cod	Raawaru	shallow to deep waters, near rock reefs	carnivorous	30–40 cm	spring, early summer	hooks	varied
Gempylidae	<i>Thyrsites atun</i>	Barracouta	Mangaa	varied	carnivorous	60–90 cm	late winter–autumn	trolling	school
Pinguipedidae	<i>Parapercis colias</i>	Blue Cod	Raawaru	shallow to deep waters, near rock reefs	carnivorous	30–40 cm	spring, early summer	hooks	varied
Scombridae	<i>Scomber australasicus</i>	Blue Mackerel	Tawatawa	pelagic	carnivorous	35–45 cm	summer	nets, hooks	school
Monacanthidae	<i>Meuschenia scaber</i>	Leatherjacket	Kookiri	rocky, weedy areas	carnivorous	20–30 cm	winter–spring	nets, traps, hooks	solitary
Diodontidae	<i>Allomycterus jaculiferus</i>	Porcupinefish	Nohu	varied depths	carnivorous	30–40 cm	not known	spear, net	solitary

1. Information from Paul (1997, 2000) unless otherwise noted

2. In systematic order

3. Information from Paulin et al. (1989: 267)



of the overall assemblage to 20 (Tables 4 and 5). Six taxa are significant contributors (5% or more) (Figure 5): snapper (*Pagrus auratus*), leatherjacket (*Meuschenia scaber*), jack mackerel (*Trachurus* sp.), blue mackerel (*Scomber australasicus*), wrasses (Labridae) and porcupinefish (*Allo-*

*mycterus jaculiferus* sp.). All are common along the north-east coast of the North Island, and in the Hauraki Gulf in particular (Ayling and Cox 1982).

Of these, snapper is one of the largest and most abundant species (Ayling and Cox 1982). It dominates the early

Table 4. Fish taxa identified from the 2000 excavations.

Taxon	TP1			TP4			TP6			TP11		
	NISP	NISPjaw	MNI	NISP	NISPjaw	MNI	NISP	NISPjaw	MNI	NISP	NISPjaw	MNI
Chondrichthyes	–	–	–	2	–	1	8	–	1	4	–	1
Rajiformes	–	–	–	–	–	–	2	–	1	–	–	–
Squaliformes	–	–	–	–	–	–	1	–	1	1	–	1
Muraenidae												
<i>Gymnothorax</i> sp.	–	–	–	–	–	–	1	1	1	–	–	–
Serranidae												
<i>Caprodon longimanus</i>	–	–	–	–	–	–	1	1	1	1	1	1
Carangidae												
<i>Trachurus</i> sp. <sup>2</sup>	10	8	3	59	5	3	1545	134	20	3656	57	36
Undet., poss. <i>Pseudocaranx</i> sp.	–	–	–	–	–	–	11	11	3	4	3	1
Arripidae												
<i>Arripis trutta</i>	–	–	–	–	–	–	2	1	1	–	–	–
Sparidae												
<i>Pagrus auratus</i>	65	43	10	7	3	2	46	21	11	9	7	3
Mullidae												
<i>Upeneichthys</i> sp.	–	–	–	–	–	–	1	1	1	–	–	–
Kyphosidae <i>Scorpius</i> sp.	–	–	–	–	–	–	–	–	–	2	2	1
Cheilodactylidae	1	1	1	–	–	–	2	2	1	1	1	1
Latrididae												
cf. <i>Latris</i> sp.	2	2	1	–	–	–	4	4	1	–	–	–
Labridae	2	1	1	10	1	2	53	14	20	8	3	3
Pinguipedidae												
<i>Paraperca colias</i>	2	2	1	–	–	–	7	7	4	1	1	1
Gempylidae												
<i>Thysites atun</i>	–	–	–	–	–	–	1	1	1	–	–	–
Scombridae												
<i>Scomber australasicus</i>	–	–	–	–	–	–	20	20	7	11	11	2
Monacanthidae												
<i>Meuschenia scaber</i> <sup>1</sup>	13	5	4	39	9	6	260	59	78	65	5	22
Diodontidae												
<i>Allomycterus jaculiferus</i>	–	–	–	1	1	1	–	–	–	–	–	–
<b>TOTAL</b>	<b>95</b>	<b>62</b>	<b>21</b>	<b>118</b>	<b>19</b>	<b>15</b>	<b>1965</b>	<b>277</b>	<b>153</b>	<b>3763</b>	<b>91</b>	<b>73</b>

1. Only spine bases were used in MNI counts.

2. Jack mackerel scutes estimated at 100 per individual (see Table 1)

Table 5. Comparison of assemblage richness values and sample size ( $r_s=1.0$ ;  $p<.001$ ).

Provenience	No. of taxa	Rank order no. of taxa	Sample size	Rank order sample size
TPI, Layer 3 (early)	7	3	13,972	3
TP4 (late)	6	4	6,276	4
TP11, Layer 2 (late)	11–12	2	25,304	2
TP6, Layer 2 (late)	16	1	33,296	1
<b>Total fish bone</b>			<b>78,848</b>	

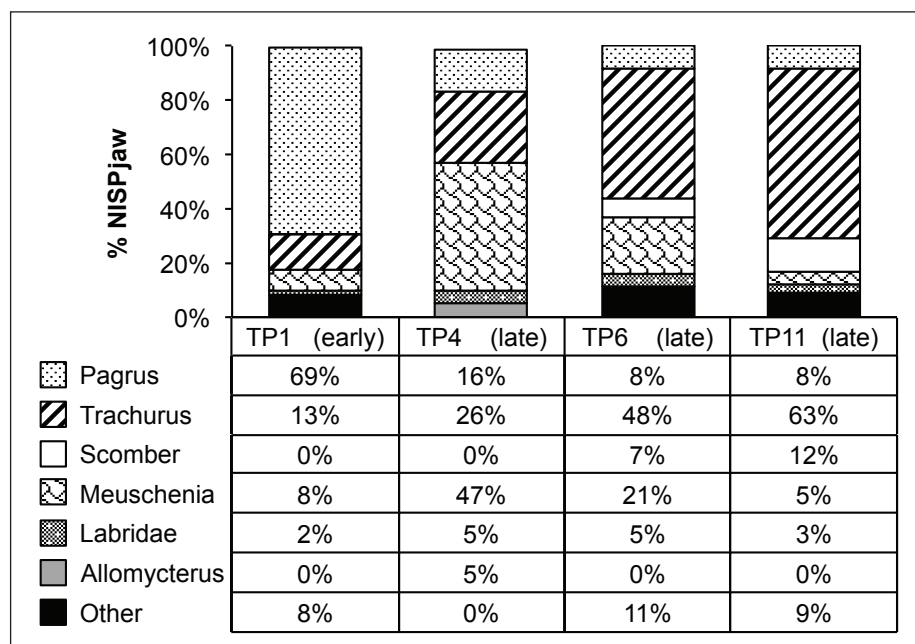


Figure 5. Distribution of most common taxa across the four test units.

occupation assemblage with 69% NISPjaw. Other large fish include the pelagic kahawai (*Arripis trutta*), deep water trumpeter (*Latris* sp.), and barracouta (*Thyrsites atun*); all are found in low numbers but are more prominent in the late occupation. Snapper, while also abundant in late contexts, is less well represented at this point in time (only 8 to 16%). Fish richness values in the late test units suggest an increase in diet breadth, but given the perfect correlation between sample size and richness, such inferences problematic (Table 5) (Grayson 1984).

Materials from the three late units provide insights into spatial variability as well. Rank order differences are apparent even for the most common taxa. Jack mackerel dominates TP6 and TP11 (Rank 1), followed by leatherjacket in the case of TP6 and blue mackerel in TP11. In the small TP4 sample, leatherjacket dominates, followed by jack mackerel. Notably snapper is not a top contributor in any of the three late period units. Differences between these units point to the importance of obtaining spatially dispersed samples to gain a representative picture of fish catch and consumption patterns.

### Fishing Technologies

Consistent with the New Zealand wide patterns identified by Anderson (1997), nearly all of the recovered species are carnivores. As Butler (1994) suggests, fish diet has a strong relation to capture methods, relationships also generally (but not entirely) borne out by ethnographic accounts of traditional fishing technologies. Snappers and wrasses could have been caught with baited hooks on lines (see Best 1986:49), while the piscivorous *Kahawai* are com-

monly taken by trolling. Snapper also can be taken with nets when they move into shallow waters for breeding, typically in summer months (Paul 2000). Although leatherjackets might take a hook, their mouths are so small that trapping or netting were probably more efficient means of capture (Law 1972:98; Witter 1969). The jack mackerels, in contrast, were most likely obtained with nets, and blue mackerel may have been an inadvertent by-catch as they often school with the former (Paul 2000:125). Comparison of the early versus late assemblages suggests a shift in fishing technologies, from an early focus on angling to the greater use of nets and possibly traps and spears in late prehistory.

The only fishing tool recovered in 2000 was a large modified spine (Figure 6) from the late site (To8/4), probably from a spiny dogfish (F. Leach, pers. comm., 2001). Notched along its proximal end, presumably for attachment to a shank, it would have made for a quite large hook (example in Paulin 2007, Figure 19). Law (1972) recovered 13 finished and five unfinished fishhook fragments from the early site (To8/5), along with hook manufacturing debris and drill points. One of the fishhooks was made from 'ivory' and the remainder rendered in moa bone. A single moa bone lure shank and shell point from the early site indicates use of trolling technologies.

### Habitat Use

Patterning also is apparent in the fish habitat data (Table 6, Figure 7). The early site is dominated by taxa that inhabit sheltered bays not unlike the immediate local area, while later in time fish from other habitats are more



Figure 6. Modified spine recovered from TP11, probably a two-piece fishhook point (photo by Tim Mackrell).

Table 6. *Distribution of fish taxa across habitats (as per Table 3)*<sup>1</sup>

HABITAT	TP1 Layer 3	TP4 Layer 2	TP6 Layer 2	TP11 Layer 2
<b>Sheltered bays, harbours, estuaries</b>				
<i>Pagrus auratus</i>	43	3	21	7
<i>Upeneichthys</i> sp.	0	0	1	0
	43	3	22	7
<b>Rocky areas &amp; reefs</b>				
<i>Gymnothorax</i> sp.	0	0	1	0
Labridae	1	1	14	3
cf. <i>Latris</i> sp.	2	0	4	0
Cheilodactylidae	1	0	2	1
<i>Parapercis colias</i>	2	0	7	1
<i>Meuschenia scaber</i>	5	9	59	5
Kyphosidae	0	0	0	2
	11	10	87	12
<b>Pelagic waters</b>				
<i>Arripis trutta</i>	0	0	1	0
<i>Caprodon longimanus</i>	0	0	1	1
<i>Scomber australasicus</i>	0	0	20	11
<i>Trachurus</i> sp.	8	5	134	57
	8	5	156	69
<b>Varied</b>				
<i>Allomycterus jaculiferus</i>	0	1	0	0
<i>Thysites atun</i>	0	0	1	0
Unidentified carangid	0	0	11	3
	0	1	12	3
<b>TOTAL</b>	<b>62</b>	<b>19</b>	<b>277</b>	<b>91</b>

1. Frequency based on NISPjaw.

abundant. The fairly even representation of rocky habitat taxa in all four units suggests that fishing took place from the headlands on either side of the bay in both early and late periods. The most marked change is the increase in pelagic species which are well represented in the late occupation units, along with a few remains of shark and ray. As a whole, the fish remains suggest that the late pre-historic Māori groups who occupied Harataonga Beach made greater use of the offshore zone and used a wider array of fishing technologies relative to those of the 14th century AD.

These changes could have been driven by a variety of processes, singly or in combination. Intensive harvesting pressures can lead to reduced prey abundances or 'resource depression' (e.g., Allen 2012; Broughton 1999; Nagaoka 2002). This situation could arise as a result of increased visitation, development of a more permanent local population, and/or increased reliance on fishing as other protein resources (such as native birds) (see Allen & Holdaway 2010) were reduced. The late deposit could also reflect visitation by groups with differing fishing priorities. Prey abundances might decline as a result of natural causes as well, as for example altered recruitment due to variation in sea surface temperatures (e.g., Greig *et al.* 1988) or hydrological changes such as shifts in ocean circulation patterns (Ward & Roberts 1986).

## DISCUSSION

### Comparisons with Prior Harataonga Analyses

The two Harataonga excavations (1962, 2000), carried out at the same two sites (one early, one late), allow for con-

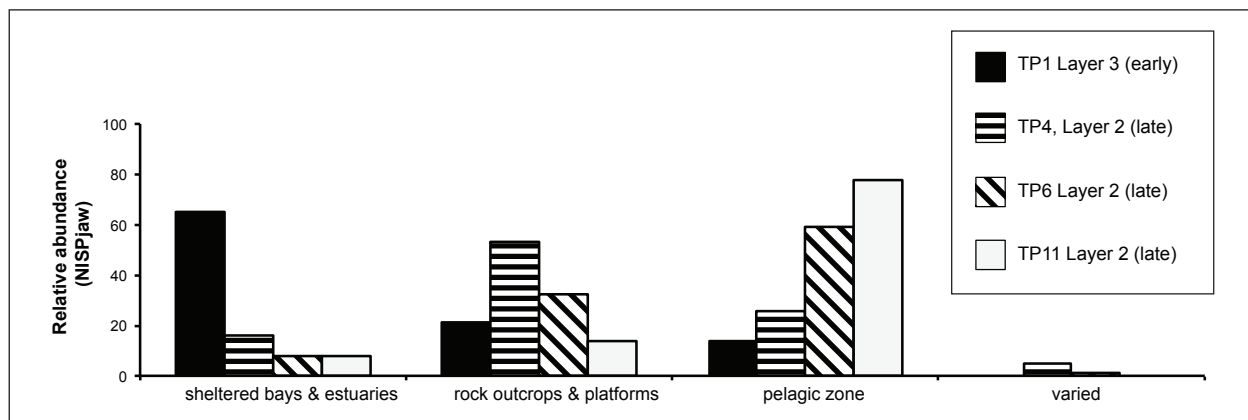


Figure 7. Representation of marine habitats by test unit.

sideration of the impact of different processing strategies on bone recovery at a single locality at two points in the prehistoric Māori sequence (Table 7). The 1962 Harataonga field study opened 31.5 m<sup>2</sup> and recovered an NISP of 574 fish, or ~18 identifiable bones/m<sup>2</sup>. In 2000, only 8.6 m<sup>2</sup> was excavated but 78,848 fish bones were recovered. Of these 5941 were identifiable. If the 5066 jack mackerel scutes are excluded, an NISP of 877 remain and roughly 102 identifiable bones/m<sup>2</sup> were recovered. It is possible that the 1962 excavations were undertaken in an area where fish bone was less dense. However, it seems more likely that the dramatic gains in bone recovery are largely attributable to the use of fine mesh sieves, along with sorting under controlled laboratory conditions (e.g., good lighting, a stable environment, and access to stereo microscopes). Most surprising is the number of identifiable bones recovered from the 2 mm sample of the year 2000 study, in some units comprising 77% of the assemblage. Additionally, the variety of taxa recovered in 2000 was nearly twice that of 1962, with six new identifications, and two or more distinctive but unidentified taxa, despite the small excavation area. The new taxa include blue mackerel (*Scomber australasicus*), Cheilodactylidae (probably *Nemadactylus* or *Tarakihi*), pink maomao (*Caprondon longimanus*), moray eel (*Gymnothorax* sp.), probable red mullet (*Upeneichthys* sp.) and blue maomao or sweep (*Scorpius* sp.). Use of fine screens also resulted in better representation of taxa with small mouth parts, such as leatherjacket (*Meuschenia scaber*), jack mackerel (*Trachurus* spp.), and red mullet (*Upeneichthys* sp.), affecting rank order relations and relative abundances. *Trachurus*, for example, was not recovered in 1962 at the early site, but in the 2000 assemblages it contributed around 13% in the early period and by late pre-history had become an assemblage dominant (up to 63%).

These findings are consistent with the global literature on the effects of screen size on bone recovery (e.g., Thomas 1969; Steadman 1989; Zohar and Belmaker 2003) and more specifically with Pacific archaeofish studies (Allen 2003; Butler 1988; Gordon 1993; Nagaoka 1994). Use of

fine mesh sieves typically increases the amount of bone recovered, providing larger samples for study. Larger samples often translate into enhanced richness values and in particular recovery of elements from small species.

#### Other Northern North Island Assemblages and Effects of Screen Size

The 2000 Harataonga results are even more striking when placed in regional context. With 20 taxa, the recent Harataonga assemblages are remarkably varied, exceeding the richness values of all 55 of the northern North Island assemblages reported by Anderson (1997), including the very large Houhora (Mount Camel) assemblage with an MNI of 2425 and 18 taxa (Nichol 1988). Given that most of the assemblages reported by Anderson were identified by experienced analysts using large reference collections (e.g., Leach & Boocock 1993; Nichol 1988), it is doubtful that there are problems with the quality of the taxonomic determinations. The foregoing comparisons suggest sample and screen sizes are more likely contributing factors (see also Grayson 1984; Nagaoka 1994). Northern North Island sites in Anderson's (1997) Table 3 with small samples (less than 100 MNI) typically had low richness values (1 to 7 taxa), samples with 100–500 specimens slightly higher richness values (11–14), and those with more than 200 MNI contained up to 18 taxa. Large samples appear to be associated with use of fine mesh. Those processed with fine mesh sieves all had MNI values of 100 or more, including Kohika, Hahei, two Sunde collections, Twilight Beach, and Matakana (Table 8). Results from a more recent North Island analysis, where fine mesh screens were used, corroborates this association. At Kokohuia (Figure 1), a stratified site with two occupation layers dating between the late 15th and early 16th centuries AD, the deposit was largely sieved through 4 mm screens (Leach *et al.* 1997:102), resulting in an MNI of 835, with 23 taxa from 21 families.

Screen size also may affect assemblage structure or the proportional contribution of taxa, with fine mesh

Table 7. Fish fauna recovered from the 1962 versus 1999–2000 excavations.

Taxa	Early		Late	
	1962 (6.3mm) % MNI (n) <sup>1</sup>	2000 (2mm) % MNI (n)	1962 (6.3mm) % NISP (n) <sup>1</sup>	2000 (2mm) <sup>2</sup> % NISP (n)
<i>Pagrus auratus</i>	65 (43)	48(10)	36 (83)	8 (62)
<i>Meuschenia scaber</i>	12 (8)	19 (4)	40 (92)	47 (364)
<i>Trachurus</i> sp.	–	14 (3)	<1 (2)	25 (196) <sup>3</sup>
Labridae	9 (6)	5 (1)	1 (4?)	9 (71)
<i>Latris</i> sp.	3 (2)	5 (1)	–	<1 (4)
<i>Odax pullus</i>	–	–	4 (9?)	–
<i>Scomber australasicus</i>	–	–	–	4 (31)
<i>Parapercis colias</i>	3 (2)	5 (1)	–	1 (8)
<i>Polyprion oxygeneios</i>	3 (2)	–	–	–
Carangidae, undetermined	2 (1)	–	2 (5?)	2 (15)
Chondrichthyes (undetermined)	1.5 (1)	–	–	2 (14)
Chondrichthyes (sharks)	–	–	11 (26)	<1 (2)
Chondrichthyes (rays)	–	–	–	<1 (2)
Cheilodactylidae	–	5 (1)	–	<1 (3)
<i>Arripis trutta</i>	–	–	3 (8)	<1 (2)
<i>Thyrsites atun</i>	–	–	<1 (2)	<1 (1)
<i>Allomycterus jaculiferus</i>	1.5 (1)	–	–	<1 (1)
<i>Caprodon longimanus</i>	–	–	–	<1 (2)
<i>Scorpius</i> sp.	–	–	–	<1 (2)
<i>Gymnothorax</i> sp.	–	–	–	<1 (1)
<i>Upeneichthys</i> sp.	–	–	–	<1 (1)
Area excavated	7.5 m <sup>2</sup>	4 m <sup>2</sup>	24 m <sup>2</sup>	4.6 m <sup>2</sup>
No. of recovered fish bones	Not known	13,972	Not known	64,876
Minimum number of individuals (MNI)	66	21	Not known	241
Number of Identified specimens (NISP)	343	95	231	5846 (782) <sup>5</sup>
N. of taxa <sup>4</sup>	9	7	9	18

1. 1962 early site MNI values from Leach and Boocock (1993, Table 26); late site NISP values from Law (1972) (MNI not provided).
2. Combined NISP values from TP4, TP6 and TP11.
3. Excludes 5064 scutes.
4. 'Undetermined Chondrichthyes' not included in NTAXA counts if sharks and rays distinguished.
5. Value in parentheses excludes Carangidae scutes.

Table 8. Impact of fine screening on MNI and richness values.

Site	Sieve size (mm)	MNI <sup>1</sup>	No. Taxa <sup>1</sup>	Original reference
Hahei N44/215	2 mm	202	12	Nichol 1986
Harataonga	2 mm	262	20	This paper
Kohika	4 mm	184	14	Nichol 1988
Kokohuia	4 mm	835	23	Leach <i>et al.</i> 1997
Matakana	2 mm	122	11	Leach <i>et al.</i> 1994; Marshall 1994
Sunde, Oyster Lens	2 mm	584	12	Nichol 1988
Sunde, Softshore Midden	2 mm	401	12	Nichol 1988
Twilight Beach	0.5 mm	635	12	Taylor 1984

1. These values from Anderson 1997, Table 3.



sometimes resulting in more even assemblages. Gordon (1993) dramatically illustrates this point, using results from two excavations at the Hawaiian site of Nualolo Kai, one carried out in the 1960s and a second more recent study. The 1962 excavation used ¼ inch (6.4 mm) sieves which resulted in low taxonomic richness and a quite uneven assemblage structure. The more recent excavation, in contrast, using 1/8 inch (3.2 mm) sieves produced a far greater number of taxa and a much more even assemblage structure. The impacts are not inconsequential, as richness and evenness are often used as measures of dietary structure, subsistence strategies and socio-economic resilience (e.g., Allen 1992: 13–27; Jones 2003; Parsons 1983). Low evenness values point to specialised economies, while a wide range of taxa in comparatively even proportions characterise generalised strategies.

The northern New Zealand assemblages analysed by Anderson, like the older Hawaiian example, are in large part quite uneven as well. Snapper (*Pagrus auratus*) dominates, contributing 81% on average (Table 1). Leach (2006: 164) using a larger series of sites suggests snapper on average comprises 74% of the available northern North Island samples. Along with low richness values, this uneven structure suggests a specialised fishery, consistent with Anderson's (1997) observations and Smith's (2004) quantitative definition (see above). At Harataonga, in contrast, snapper comprises a more modest proportion of the early assemblage, 69%, and only 8 to 16% of the late site assemblages. This suggests a shift from a moderately specialised fishery early in time to a more generalised one in late prehistory.

At the early stratified site of Hahei, where 2 mm sieves were used, snapper again is less well represented. Leatherjacket dominates the earliest stratum, contributing between 62 and 73% (Nichol 1986); good recovery of this species is probably directly attributable to the use of 2 mm screens. At Kokohuia snapper was the most abundant taxon in both occupation layers, but comprised only 53 to 48% (Leach *et al.* 1997). At the 17th century site of Kohika, jack mackerel was the most abundant taxon (63%), while at Matakana, another late site, jack and blue mackerel together comprised 62% of the assemblage. All of these assemblages were processed with fine sieves. However, there are ecological conditions which probably favoured the dominant species in each case as well. Nichol (1986) suggests leatherjacket may have been naturally abundant around the rocky headlands of Hahei (see also Smith 2013: 30). Kohika is adjacent to the estuaries of two rivers, a habitat frequented not only by jack mackerel, but also trevally, kahawai, and stargazer (Nichol 1988: 167). The Matakana samples derive from the harbour side of the island (Leach *et al.* 1994; Marshall 1994), where jack mackerel would be anticipated. Two other sites, however, Twilight Beach and the Sunde Site, show that fine sieves do not always result in more varied assemblages. In both cases snapper was clearly the targeted prey, comprising 93% of the Twilight

Beach assemblage and 67% of the Sunde site collections (Anderson 1997, Table 3 and Nichol 1988: 75). The key point of these comparisons is that fine mesh sieves were crucial to recovery of small body parts of taxa like jack mackerel and leatherjacket, which otherwise may not have been recovered, or their contribution seriously under-estimated. The assemblages of Hahei, Kohika, Matakana and late Harataonga show that the importance (or availability) of snapper changes over time. They also highlight that mesh size has a critical role to play in documenting and understanding spatial and temporal variability in Māori fishing practices.

### Implications for Reconstruction of Māori Fishing Practices

The foregoing indicates that the dominance of snapper in at least some North Island sites is probably the result of screen size biases. Snapper also is well represented because of their robust head bones which favour both preservation and recovery, even when screens are not used. Nevertheless, snapper was clearly an important prey species for northern North Island Māori and the Harataonga results, along with those where screen size biases can be discounted, suggest an interesting temporal trend. Snapper proportions are quite high in some early (pre-1500 AD) sites such as Twilight Beach (93%), Sunde site (67%), early Kokohuia (53%) and early Harataonga (69%). In late sites, however, other taxa tend to dominate with snapper contributing no more than 16% at Harataonga, and lesser amounts at Matakana (<1%), Hahei (10%), and Kohika (8%).

Broadly speaking, the Harataonga results are consistent with Smith's (2013; Smith and James-Lee 2010) assessment of spatio-temporal patterns in the Greater Hauraki region. Fifty-six assemblages with MNI values in excess of 10 from five time periods were examined, recovered by varied collection procedures. Although snapper is well represented, occurring in 75% of the sites, its ubiquity declines over time. Smith (2013) also found that snapper was one of only three taxa that contributed more than 50% to the MNI total, the other two being leatherjacket and kahawai. Although kahawai was not abundant at Harataonga, both snapper and leatherjacket were important. Finally, Smith noted an emphasis on mackerels in his middle/late prehistoric period (AD 1550 to 1750) (Smith 2013: 30), which is generally consistent with the Harataonga evidence. A late prehistory period (AD 1750) decline may relate to the small number of late Coromandel sites, especially ones near rocky shore environments (Smith 2013: 30).

With respect to snapper trends, Anderson and McGlone (1992) suggest harvesting pressures might have played a role; Leach (2006) in contrast, argues climate change is more likely. Problematically, especially for the northern North Island, there are few well dated assemblages from stratified sites where geography and local conditions can be held constant. Relevant to human impacts,

reduced availability could arise from changes in the prey population structure or alternatively prey behaviours (e.g., avoidance of predators). The prey choice model predicts reductions in prey abundance will lead to reduced foraging efficiency and shifts to lower ranked taxa, along with a broadening of diet breadth (i.e., increases in both richness and evenness) as foragers attempt to deal with the loss of high return resources (Allen 2002; Broughton 1999; Butler 2001; Nagaoka 2002). At Harataonga, as well as other sites, snapper declines are often accompanied by use of a greater number of other fish, suggesting a widening of diet breadth. However, in the present case, sample size correlations preclude any behavioural inferences (see Grayson 1984). In a few places, like Hahei and Cross Creek, decreases in fish size are suggested (respectively, Nichol 1986; Leach and Davidson 2000), consistent with expectations of the prey choice model. But given that increases over time also are reported, namely at Foxton and Rotokura (Leach 2006: 294), it is not entirely clear what these trends represent.

Leach (2006: 214–19, 294–5) discusses several other factors that could affect prey abundance and availability, including the season of capture, changes in technology or fishing locality, cultural preferences or changes in background climate. The latter may be the most relevant, as temperature affects snapper reproduction, growth rates and size. Warmer La Niña conditions, for example, are typically associated with weaker westerly winds, lead to more abundant plankton food sources and have a positive effect on snapper growth rates in both juveniles and adults (Dunn *et al.* 2009; Francis 1994). Recent research suggests that during the Little Ice Age (~AD 1450–1850), lower temperatures ( $-0.56^{\circ}\text{C}$ ,  $\pm 0.29^{\circ}\text{C}$ ), increased precipitation, and enhanced southwesterly flows prevailed (Lorrey *et al.* 2013). These are the kinds of conditions which might have adversely affected snapper abundances and size relative to earlier times, particularly in the Hauraki Gulf area (compare with Dunn *et al.* 2009).

## CONCLUSIONS

The Harataonga analyses contribute to our understanding of prehistoric Māori fisheries in several ways. The earlier reports of Law (1972) and Leach and Boocock (1993) have been extended with new species records and a more fine-grained quantitative assessment of the archaeofish record from this Hauraki Gulf locality. The 1999–2000 results speak to Māori familiarity with a large number of fish species, from varied marine habitats, and the possibility of varied fishing technologies being used over a 600 to 700 year period. In particular there are indications of a shift from an early reliance primarily on angling to a later emphasis on nets and other technologies, along with exploitation of offshore habitats where *Trachurus*, *Scomber*, sharks and rays are located. Methodologically, the findings point to the improvements in data quality afforded by the

use of fine mesh sieves, especially more accurate information on taxonomic abundances and richness. Comparisons with other older assemblages from northern New Zealand suggest that past field processing strategies may have led to over-simplified views of prehistoric Māori fishing practices, and exaggerated the importance of snapper in particular. Consideration of a small set of northern North Island assemblages where fine mesh sieves were employed point to spatio-temporal variation in response to: 1) local habitat conditions and associated prey, and 2) changing conditions over time, such as climate change, anthropogenic impacts, or both. The Harataonga results in combination with other sites in the region suggest that while early Māori fishing practices were perhaps initially specialised relative to those of tropical East Polynesia, over time they became more generalised and regionally varied.

Finally, with respect to more pragmatic aspects of archaeofaunal recovery, comparison of the 1962 and 2000 Harataonga assemblages illustrates how even small samples can provide important new information when subjected to fine screening. Fine sieving of a sample of excavation units, or systematic sub-sampling of small areas of all units, is likely to be profitable; such samples can provide a means of assessing the biases associated with coarse-screened sediments from the same locality. The collection and archiving of bulk samples for later study also can be beneficial, especially in bone rich sites which are in danger of being lost to development or coastal erosion. Taylor (1984) implemented both procedures (bulk sampling and fine screening) thirty years ago at Twilight Beach, and analysts have returned to his collections with new research questions on several occasions (e.g., Clark 1997; Nichol 1988; Leach *et al.* 1997; Nagaoka *et al.* 2008). As one reviewer for this paper emphasized, the archaeological record is a non-renewable resource and materials which fall through the screen are lost forever. Archaeofaunal data is increasingly used by non-archaeologists for purposes as diverse as indigenous resource claims (Leach 1989), fisheries management (Dalzell 1998; Pitcher 2001; Smith 2013:1) and wildlife conservation (examples in Nagaoka and Allen 2009). The implementation of stringent recovery practices is not only important for archaeological interpretive purposes, but also of value to the diverse communities which are using archaeological data to help solve contemporary problems.

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