

Prehistoric fishing strategies on the *makatea* island of Rurutu

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Abstract

Recent observations of fishing, the ethnohistoric literature, the archaeological fishing tool kit, marine environments adjacent to the site, and the fish bone assemblage were considered to understand fishing strategies on the *makatea* island of Rurutu, Austral Islands, French Polynesia. Excavations totalling 53.5 m² at the Peva dune site (ON1) were conducted in 2003. The sandy, calcareous deposits from Area 2 (33 m²) were dry sieved through 3.2 mm mesh and 5,011 fish bones weighing 2,229.7 g were retained for analysis. Two distinct cultural layers were identified. Archaic period layer D had 20 fish families inventoried from a total of 141 minimum numbers of individuals (MNI) and 1,081 numbers of identified specimens (NISP). Average bone weight was 0.42 g and median vertebra width between 5–6 mm (n=747). The Classic period layer A, associated with a *marae* complex, contained only seven fish families, a MNI of 24 and NISP of 403. Average bone weight was 0.63 g and median vertebra width between 10–11 mm (n=107). While a broad spectrum fish capture strategy is inferred for the Archaic, selective larger fish, including an order of magnitude increase in shark, were likely prestige items used in ritual offerings during the Classic period. Comparisons of the archaeological assemblages from five *makatea* islands show that in all but one case, sites are dominated by groupers, unlike many other Pacific island sites where parrotfish are most frequent. This, alone, might be the unique signature of *makatea* assemblages.

Introduction

Polynesian fishing strategies are generally similar across most tropical archipelagos with inshore reef fishing using seine nets a dominant strategy for capturing a broad range and size of taxa (Allen 2002; Kirch and Dye 1979; Leach and Davidson 1988; Nagaoka 1993; Weisler and Walter 2002:43). Analysis of prehistoric fishing must take into consideration the specific offshore conditions that influenced the strategies prehistoric fishers employed. Island type (including high volcanic, continental, *makatea* and atoll) as well as uplift and subsidence histories dictate local topographic conditions and the development and location of reefs. Young high volcanic islands (e.g. Hawai'i

Island) typically have fringing reefs, while older ones like Tahiti can have areas of barrier reef protecting a lagoon. Atolls typically include a central lagoon and characteristically have far more reef, measured along the ocean and lagoon margins, than islet (*motu*) circumference (Weisler 2001). For *makatea* islands, uplift plays a fundamental role in restricting the width of the reef platform. These narrow platforms typically have less distance to dissipate the intensity of wave action – especially along windward coasts. Local marine topographic conditions, dominant swell patterns and bottom type (live coral, loose rubble, sand, solid reef platform) also influence the type of fish that 'track' over these substrates. For example, when a seine net is positioned over different bottom types, goatfish are commonly gilled over sand, parrotfish near live coral and carnivorous fish, such as carangids, can be caught most anywhere.

In addition to the physical setting any analysis of prehistoric fishing benefits from ethnoarchaeological observations on current fishing practices (Dye 1983; Jones and Quinn 2009; Kirch and Dye 1979; Weisler 2001:107–108) as well as the wealth of detailed ethnographic observations, often recorded by indigenous people (for Hawai'i, see Kakā'ulelio 2006; Manu 2006; Titcomb 1972). From strictly archaeological perspectives, fish bone, artefacts to make fishing gear, the fishing tool kits (e.g. hooks, lures and sinkers) and non-portable constructions such as fish ponds and traps (Summers 1964) all provide the necessary basis for examining the temporal dimension of fishing.

In this paper a holistic approach is used for inferring prehistoric fishing strategies on the *makatea* island of Rurutu, Austral Islands. We use details of the offshore environments adjacent to the Archaic to Classic period site of Peva, briefly review ethnohistoric observations, describe the fishing zones and common fish caught, characterise the prehistoric fishing tool kit, then provide a detailed analysis of the fish bone and inferred fish size to understand prehistoric fishing strategies on this *makatea* island.

Environmental setting

The Australs lie on the periphery of central East Polynesia and define its southern boundary. They are more temperate than the Societies to the north and the southern Cooks to the

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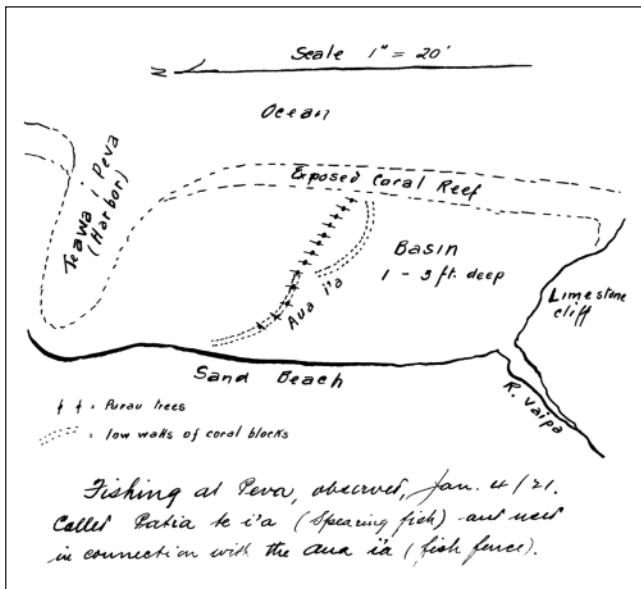


Fig 2. John Stokes' field sketch of the fishing trap method he observed at Peva. The original, drawn on a sheet of lined yellow paper, reads: 'Fishing at Peva, observed, Jan. 4/21. Called *Patia te i'a* (Spearing fish) and used in connection with the *Aua i'a* (fish fence)' (courtesy of the Bernice P. Bishop Museum Archives).

low walls with blocks of limestone, reaching six inches above the sea. These walls they called *aua i'a* (fish fences). The other six men waited on the beach, and proceeded to the southern end of the pond as the walls were nearing completion, and commenced spearing fish. The walls completely blocked the northern end of the pond except at three places where men with spears were posted. The intention, it was explained, was to wait until the tide receded, and to spear the fish as they attempted to pass through the openings. (Stokes n.d.)

Vérin (1969:47, Fig. 8) also commented upon the remains of this built-up section of coral, and marked its location on his map of Peva.

Environmental zones

As a *makatea* island, Rurutu is similar in many respects to Niue Island (Walter and Anderson 2002), Ma'uke and Mangaia in the southern Cooks (Kirch *et al.* 1995; Walter 1991), and Henderson Island, Pitcairn Group (Weisler 1995). However, Mangaia has substantial brackish and freshwater bodies where goby-like fish (Eleotridae) and eels (Anguillidae) could have been obtained (Butler 2001). Walter (1998:68-70) defined five ecological zones for Ma'uke, which are typical of *makatea* islands in general (Fig. 3).

The *reef flat* is the intertidal and extreme upper subtidal portion of the reef (Myers 1991:6). The main difference between Ma'uke, Mangaia, Henderson and Rurutu is the depth of the reef flat. Walter (1998:70) noted that on Ma'uke this was always very shallow, perhaps less than 2 m. Peva's reef flat contains an important pass where the water

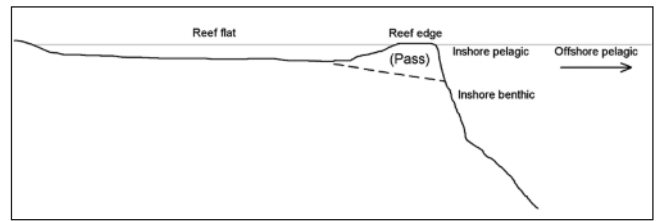


Fig 3. Ecological zones of a typical *makatea* island (adapted from Walter 1998:Fig. 6.2, used with permission).

becomes deeper at high tide, attaining depths of approximately 5 m or more near the reef edge. This area is sandy, with little coral. This zone is most commonly fished today, primarily with seine nets (Fig. 4). Species that frequent the area include surgeonfish, triggerfish (Balistidae), small carangids, porcupinefish, sea chubs, goatfish, parrotfish and puffers. Fishes from the reef edge and the inshore pelagic and benthic zones also enter the reef flat here at high tide. At low tide *Turbo* shellfish, crabs and sea cucumber are gathered.

The *reef edge* is the seaward extent of the reef flat including the surge channels. The reef flat is easily accessible on foot when it is exposed at low tide. Common species include surgeonfish, triggerfish, hawkfish, cornetfish, flagtails, goatfish, parrotfish and groupers. The reef edge provides access to inshore pelagic and benthic species as well as those that can be taken with a line while standing on the outer margin.

Inshore pelagic covers the coral shelf as it slopes downward. On Rurutu, the water attains a depth of 500 m approximately 2 km offshore. Inshore pelagic fishes include tunas, carangids, flyingfish, sharks and rays. This zone is

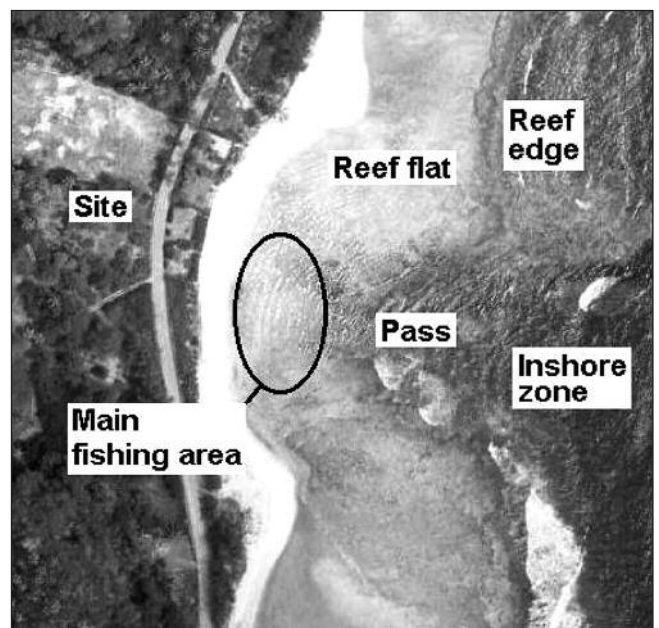


Fig 4. Peva's fringing reef at high tide, with areas labelled. Note the depth of the water around the pass indicated by darker water.

infrequently fished on Rurutu, because most families do not own a boat. This has almost exclusively become the domain of professional fishermen, who sell their catches for cash.

The *inshore benthic* zone is situated beneath the inshore pelagic zone. Fish caught here are primarily small carangids and groupers, as well as hawkfish, squirrelfish and soldierfish, snappers and parrotfish. While these species can be fished from a canoe using hand lines, they can also be caught on the reef flat.

The *offshore pelagic* zone is the most infrequently fished area on Rurutu. Tunas, which are usually caught by means of trolling, inhabit this zone. By all accounts, supported by the archaeological evidence in this study (see also Vérin 1969), trolling was probably never a major activity on Rurutu. Like the inshore pelagic zone, the offshore zone is also the domain of professional fishermen.

Previous archaeological research

Relatively little archaeological research has been done in the Australs and there are few early firsthand accounts of traditional life; consequently, the Australs remain a large blank in our knowledge of East Polynesian prehistory. Excavation has primarily been restricted to Classic period sites, namely Vitaria on Rurutu (Vérin 1969), the *marae* Te Rae Rae and the hilltop terrace of Hatuturi on Ra'ivavae (Skjølsvold 1965a, b); on Rapa – primarily fortifications (Ferdon 1965a, b; Kennett *et al.* 2003; Mulloy 1965; Smith 1965; Walczak 2003), rockshelters (Kennett *et al.* 2006) and vegetation reconstruction and documenting human impacts (Prebble 2006). Additional survey on Ra'ivavae (Edwards 1998, 2003) and Rimatara (Eddowes 2004) has contributed to our knowledge of Classic period sites and settlement patterns. These latter sites have yielded typical Classic period artefacts, and date to no earlier than the 17th century. Excavations at Archaic period sites have been more limited. Vérin's work at a rockshelter on Rurutu yielded some artefacts reminiscent of the Archaic, but the stratigraphy was complex and possibly mixed with a radiocarbon sample, likely contaminated, providing a date of 150 BP (Vérin 1969:146, Annexe I). More recent work on Tubuai (Eddowes 1998) has unearthed many diagnostic Archaic artefacts, but the research has not been reported in full. Consequently, while we have a sufficient database for the endpoint of Austral Island culture, we are missing the early sites that would allow us to construct a developmental sequence.

Rurutu was the first island in the Australs to receive archaeological attention, being surveyed first by the ethnographer F. A. Seabrook (1938). In the 1960's, Pierre Vérin excavated Vitaria, a late-period 'Classic' phase (c. 17th–18th century AD) settlement on the northwest coast of Rurutu, surveyed other portions of the island and excavated in the district of Vitaria (Vérin 1969). His work showed that Vitaria was a densely concentrated settlement, built and occupied by a population of ~1000 people. Vérin's research established a benchmark for a Classic period

Austral Island site, and provides an invaluable basis for comparison to the Peva assemblage.

Site description, stratigraphy and dating

Situated on the east coast of Rurutu just inland from one of the largest beaches on the island, the Peva Dune Site (ON1) is located near one of the few reef passes and adjacent to swampy land that was formerly in taro cultivation (Boltt 2008:Fig. 4.1 and 4.2). The environmental setting is similar to many Archaic period sites found throughout East Polynesia. Several streams drain through the swamp and out to sea retarding coral growth and thus forming the pass. The dune, where the Peva midden and *marae* are located, runs parallel to the coast for about .5 km.

Boltt, accompanied by Pierre Vérin, surveyed the Peva area in 2002 and re-located *marae* 'Uramoa, the largest structure in the valley. As Boltt detailed (2008:88), the *marae* is defined by a rectangular ground plan, containing a rectangular stone platform and uprights that is similar to other structures identified as *marae* in the Australs. The *marae* contained: human burials; a conch shell trumpet whose role in religious ceremonies in East Polynesia is well known (Buck 1944:269-270, 367; Ellis 1969:196-197; Henry 1928:156-157); and large quantities of *tapu* foods such as pig, turtle and shark. Residential house platforms of the Classic period are located at the backs of valleys, not on the coast.

The Peva Dune Site was excavated by Boltt and local assistants during May–August 2003. All deposits were dry screened through 3.2 mm (1/8") mesh. All artefacts recovered *in situ* were plotted on unit plans. Cultural features, such as earth ovens, were photographed and mapped, as were wall profiles. Full details of the excavation are presented in Boltt (2005, 2008). The excavations in the *marae* and immediately adjacent were designated Area 1 (20.5 m²), while Archaic period deposits were encountered in Area 2 (33 m²) (Fig. 5); each area had two distinct cultural layers. Area 2, where most effort was focused, yielded the richest deposits. The lower cultural layer, which dates from the late 13th to early 15th century AD, represents the Early Eastern Polynesian (EEP) or Archaic period. The upper cultural layer, associated with a *marae* complex, accumulated during the Late Eastern Polynesian (LEP) or Classic period (18th to early 19th century AD), which lasted until evangelization in 1823. The two cultural deposits are separated by a thick layer of sterile dune sand. The stratigraphy is described in detail in Boltt (2008:92-96). From one prehistoric period to the next, major changes took place in material culture and subsistence.

Seven charcoal samples from the EEP deposit (Layer D) at Peva were analysed by AMS radiocarbon (¹⁴C) and are reported in full in Boltt (2008:96-98). The results indicate an intensive period of occupation lasting from approximately the late 13th to early 15th century AD, which is consistent with EEP period deposits from other areas of Eastern Polynesia (Boltt 2008:Table 4.2), notably in the southern

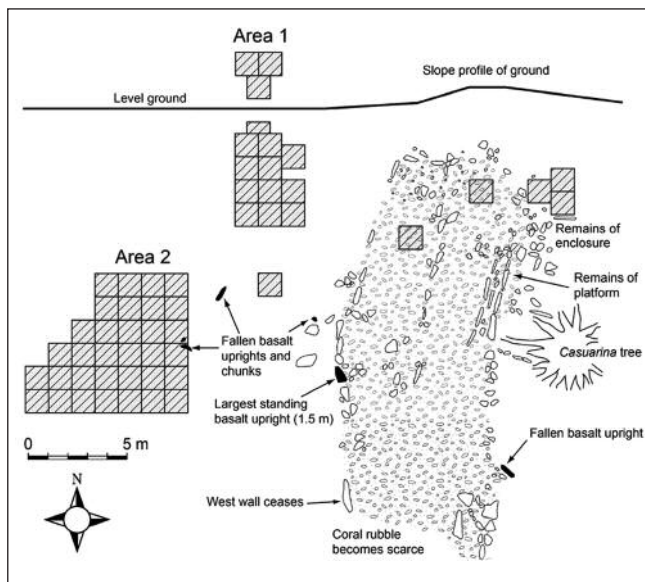


Fig 5. Map of excavations at the Peva Dune Site, Rurutu, Austral Islands.

Cook Islands such as the Anai'o site on Ma'uke (Walter 1998), Ureia and Moturakau sites on Aitutaki (Allen and Schubel 1990; Allen and Steadman 1990), Tangatatau rockshelter on Mangaia (Kirch *et al.* 1995), the Onemea site, Taravai Island, Mangareva (Kirch *et al.* 2010) and HEN-5, Henderson (Weisler 1995). Charcoal was not available for radiocarbon dating the LEP period (layers A and B), but the context of the *marae* and the associated midden and artefacts strongly suggests an 18th–19th century occupation.

The archaeological fishing tool kit

The small quantity of excavated fishing gear in various stages of manufacture comes from the Archaic deposit. All the Peva fishhooks are one-piece made of pearlshell (*Pinctada margaritifera*). Pearlshell does not appear to grow in Rurutu's waters. One-piece pearlshell fishhooks dominate Archaic assemblages throughout East Polynesia (Walter 1996:520), which display a much wider variety of forms than found in the Classic period. The only positively identifiable type from Peva is the acute recurved point (Boltt 2008:Fig. 7.1a, b), similar to examples found on Ma'uke (Walter 1998:Fig. 4.3), Aitutaki (Allen 1992:Pl. III) and Mangareva (Weisler and Green 2001:31.3f). Comparing the Peva examples to those of Classic period Vitaria (Vérin 1969:214-218), it is evident that the earlier notched head is as characteristic of Peva as the late knobbed head is of Vitaria and the Classic period.

Although *Turbo setosus* was recovered in large quantities from both the Archaic and Classic period deposits, it is all from midden and unworked. All Archaic period manufacturing debitage and unfinished hooks are made of pearlshell (Boltt 2008:Fig. 7.1d-s), in contrast to the worked *Turbo* shell from Vitaria (Vérin 1969). *Turbo* is found commonly on fringing reefs and rocky shorelines.

Compared to pearlshell, it is an inferior material for making fishhooks. The quantity of pearlshell, as opposed to *Turbo*, fishhooks, tends to decline over time in East Polynesian sites. This is especially evident in the southern Cooks, such as Mangaia (Kirch *et al.* 1995), Aitutaki (Allen and Steadman 1990; Allen 1996), and Mitiaro (Walter and Campbell 1996), and presumably reflects the dwindling ability of island populations to import pearlshell as long-distance voyaging declined after around 1450 AD (Weisler 2002). The Peva assemblage, though small, is typically Archaic in the sense that pearlshell was the only material used for fishhooks.

Fishhook manufacturing tools from Peva's Archaic period deposit are few, including one *Porites* file, one branch coral (*Acropora*) file and one sea urchin spine abrader (Boltt 2008:Fig. 7.1w, x, y). One stone anchor weight and a coral sinker were also found (Boltt 2008:Fig. 7.2). The lack of fishing gear is best explained by the prevalence of net fishing on Rurutu. This strategy is employed today, and is far more common than offshore angling and trolling. In fact, few families own a canoe on the island, and offshore pelagic fish such as tuna have to be purchased for cash from professional fisherman. Based on the fishbone assemblage, that contains overwhelmingly inshore species that are found within the fringing reef and are easily taken with seine nets, it is likely that this same strategy was employed in the Archaic period. The full array of Archaic East Polynesian fishhook types and bonito lures may well have been known to the early inhabitants of Rurutu, but were deliberately dropped from the kit. As net fishing is a far less risky method for catching large quantities of fish (e.g. Kirch and Dye 1979:61), it is unlikely that the proceeds of angling and trolling made significant contributions to the diet.

Fish faunal analysis methods

All bone from the Peva Dune Site was retained, but only the abundant bone from Area 2 is reported here because the EEP deposit of Area 1 consisted almost entirely of mussel shell and few bones. Because the deposits were located in a calcareous sand dune, preservation of bone and shell was excellent. The EEP deposit in Area 2 was far richer in invertebrate remains as well as bone. The prehistoric bird bones were identified by Steadman (Steadman and Boltt 2010) and flying fox bones reported by Weisler *et al.* (2006). The fish bones were sent to Weisler and Findlater for identification using comparative collections held by Weisler (2001:Appendix 3) and those at the University of Otago (Walter *et al.* 1996). The bones from a unique provenance were first counted and weighed. Then the bones were sorted by element, before identification to family, genus or species. This process resulted in a group of 'unidentified fish', which were unable to be identified further, but in some cases the element was identified. More than 30 different elements including articulated combinations were identified such as commonly used paired cranial bones (dentary, articular,

quadrate, maxilla and premaxilla), and other useful, but not as often used, paired elements including, for example, cleithrum, opercular, post-temporal, hyomandibular and palatine. These latter elements can be useful for identifying species that are less commonly noted in fish bone assemblages (Vogel 2005). Typical 'special bones' were also used for identification such as dermal spines of porcupinefish, anal spines of soldierfish, scutes of carangids, caudal tangs of surgeonfishes, and vertebrae of sharks and rays (see also Findlater [2004] for further details on methods). No otoliths were found in the assemblage (see Weisler 1993).

There have been numerous discussions regarding quantification of faunal material from archaeological and palaeontological sites (e.g. Grayson 1984; Lyman 2008:21-82; Reitz and Wing 2008), the strengths and weaknesses of various measures of abundance (Grayson 1979) and differential recovery of bones due to screen sizes (Nagaoka 1994, 2005). All these issues affect the outcome of the quantification and interpretation of archaeofaunal assemblages. For the quantification of the Peva fish remains we used the number of identified specimens per taxon (NISP) and the minimum number of individuals per taxon (MNI). Although MNI values for any series of taxa can be predicted by NISP counts (Grayson 1979:223), we present results in both measures to facilitate comparisons between Pacific assemblages. Findlater (2004:Tables 3 and 4) lists all taxon identifications, the elements used and side. NISP counts can be viewed as a maximum possible MNI for a given taxon. NISP and MNI provide complementary measures for interpreting an assemblage. While NISP often inflates the actual number of specimens identified to taxon due to fragmentation of individual bones during their depositional history and archaeological recovery, MNI suffers from the affects of aggregation. For example, the smaller the aggregation unit (such as spit or unit) the larger total number of MNI. Consequently, here we used the entire Archaic deposit of Area 2, Layer D, as the unit of aggregation. This, in fact, results in a minimum number for total MNI as it is likely that there are separate depositional events that resulted in the formation of Layer D across the 33 m² area of excavation.

All elements used for identification of fish bones to family (and Elasmobranchii) are listed in Table 1. This indicates, in part, why certain taxa, when quantified by NISP, have a greater abundance. For example, Scaridae (parrotfish) and Labridae (wrasses) have upper and lower pharyngeal clusters, which are specialised and robust elements used for grinding that tend to preserve well. The scarids also have a 4th epibranchial that is easily identified. The porcupinefish (Diodontidae) has more than 200 dense dermal spines that inflate simple counts for this taxon. Scutes, unique to the jacks (Carangidae), are the second most common element used here for identifying this taxon. A single fish can have more than 20 of these elements. Vertebrae, used to identify sharks and rays (Elasmobranchii), can average >100 per individual animal. These 'special bones' can also more accurately reflect taxonomic

abundance. Anal spines, only one of which occur per individual squirrel and soldierfishes (Holocentridae), was the most common element used to identify this family – even more abundant than the routinely used dentary. Comparison of Table 1 demonstrates that dentaries were used to identify 17 of the 24 taxa reported and is the most common paired element in the assemblage.

Results

Layer D, Phase I, Archaic Period

Some 4,461 bones (89% of the entire assemblage) weighing 1,876.5 (mean = 0.42g) were recovered from Layer D. Twenty fish families were inventoried (Table 2). Whether quantified by MNI or NISP, the four most common fish families were parrotfish, groupers, surgeonfish and porcupinefish and accounted for 83% of total layer NISP and 72% of total layer MNI. Porcupinefish numbers using NISP are greatly inflated where 223 of the 245 NISP for this taxon are dermal spines that could have been from one fish. Eleven families (50%) each contributed less than 1% MNI to this assemblage. Genus-level identifications were possible for some of the surgeonfish, squirrelfish, wrasses, emperors, goatfish, parrotfish and tunas.

Layer A, Phase II, Classic Period

A total of 560 bones (11% of the entire assemblage) weighing 353.2g (mean = 0.63g) were recovered from Layer A deposits. Bones from only seven families were identified (Table 2). The three most common families included sharks and rays, parrotfish and porcupinefish, which made up 96% of NISP and 71% of MNI. Jacks were the fourth most common family using NISP and groupers for MNI. Three families (43%) had less than 1% MNI. The lower family inventory relative to Layer D is unlikely reflecting sample size as there is an order of magnitude increase in Elasmobranchii and clear differences in combined bony and cartilaginous fish size.

Discussion

Marine environments exploited and fishing strategies

The importance of Rurutu's fringing reef as a resource cannot be overstated. The waters of Peva in particular are favoured by modern fishermen on Rurutu; fishermen come from other valleys to fish in Peva's waters where net fishing is especially predominant. Today, few fishing boats venture beyond the reef edge.

Based on the Peva fishbone assemblage, the reef zone was always the area more frequently exploited. Groupers are the most common taxon in the Peva assemblage when the special bones of parrotfish are removed from quantification measures; groupers can be caught by seine net, angling off the reef edge, or by diving and spearing. Parrotfish,

Taxon	4th epibranchial	anal spine	articular	cleithrum	dentary	dentary/premaxilla	dentary/premaxilla plates	dermal spines	dorsal spine and pterygophore	dorsal spines	epiphyal	hyomandibular	hypural	interior pharyngeal cluster	maxilla	opercular	palatine	paraspineoid	post-temporal	preopercular	pterygophores	quadrate	scute	superior pharyngeal cluster	tang	tooth	ventral spine	vertebrae	vomere	Number of elements
Acanthuridae			26					16	11	1	1				1					3	86	1		8					9	
Balistidae	1						1	3							1										2				5	
Belontiidae			1												1														2	
Carangidae		4	4				1								4					8	6	3	7						8	
Carcharhinidae		5	4												3							1							1	
Cirrhidae			11	5	3	265									8					8	1	1							4	
Diodontidae																						1							6	
Elasmobranchii																											342		1	
Exocoetidae			1																										1	
Fistulariidae					1																								1	
Holocentridae	12	4	5												2					1	7	1							7	
Kuhliidae			1																										1	
Kyphosidae		1	1												1					1									4	
Labridae		1	1										13	3	3					2		4	12						7	
Lethrinidae			1												3					3					3				4	
Lutjanidae		1	2																									1	3	
Mullidae	15	9	2																										2	
Scaridae			53	28											47	10	4			66	1	6	75						13	
Scombridae			1							3										1									3	
Serranidae		24	12	54	4						2	6			16	4			3	48	8	25						7	15	
Syngnathiformes		1	1																										2	
Tetraodontidae			1																										3	
Total	15	13	50	39	144	37	3	265	18	14	2	8	3	60	43	5	6	3	4	141	19	42	7	87	8	4	2	342	8	1484

Table 1. Fish bone elements used for identification to family and Elasmobranchii.

Taxon	Common Name	Layer A		Layer D		Total		% Family	
		NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
Acanthuridae	Surgeonfishes	0	0	144	18	144	18	10	11
Acanthuridae <i>Naso</i> sp.	Unicornfish	0	0	5	1	5	1	<1	<1
Acanthuridae (not <i>Naso</i> sp.)		0	0	4	1	4	1	<1	<1
Balistidae	Triggerfishes	0	0	8	1	8	1	<1	<1
Belonidae	Needlefishes	0	0	2	1	2	1	<1	<1
Carangidae	Jacks	9	1	26	3	35	4	2	1
Carangidae cf. <i>Caranx</i> sp.		2	1	0	0	2	1	<1	<1
Carcharhinidae	Requiem Sharks	0	0	1	1	1	1	<1	<1
Cirrhitidae	Hawkfishes	0	0	13	5	13	5	<1	3
Diodontidae	Porcupinefishes	48	2	245	10	293	12	5	7
Elasmobranchii	Sharks & Rays	307	6	35	1	342	7	23	4
Exocoetidae	Flyingfishes	0	0	1	1	1	1	<1	<1
Fistulariidae	Cornetfishes	0	0	1	1	1	1	<1	<1
Holocentridae	Squirrelfishes & Soldierfishes	1	1	30	3	31	4	2	2
Holocentridae cf. <i>Adioryx</i> sp.		0	0	1	1	1	1	<1	<1
Kuhliidae	Flagtails	0	0	1	1	1	1	<1	<1
Kyphosidae	Sea Chubs	0	0	4	1	4	1	<1	<1
Labridae or Corinae		0	0	4	1	4	1	<1	<1
Labridae	Wrasses	0	0	31	6	31	6	2	4
Labridae <i>Anampses</i> sp.		0	0	1	1	1	1	<1	<1
Labridae cf. <i>Bodianus</i> sp.		0	0	1	1	1	1	<1	<1
Lethrinidae <i>Monotaxis</i> sp.	Emperors	0	0	10	2	10	2	<1	1
Lutjanidae	Snappers	1	1	2	1	3	2	<1	1
Mullidae <i>Parupeneus</i> sp.	Goatfishes	0	0	3	1	3	1	<1	<1
Scaridae	Parrotfishes	28	7	262	38	290	45	19	27
Scaridae cf. <i>Chlorurus</i> sp.		1	1	4	1	5	2	<1	1
Scaridae <i>Calotomus</i> sp.		0	0	19	4	19	4	<1	2
Scaridae cf. <i>Hipposcarus/Scarus</i> sp.		1	1	0	0	1	1	<1	<1
Scaridae cf. <i>Scarus</i> sp.		0	0	1	1	1	1	<1	<1
Scombridae cf. <i>Gymnosarda</i> sp.	Dog-Toothed Tuna	1	1	1	1	2	2	<1	1
Scombridae <i>Katsuwonus</i> sp.	Bonito	0	0	2	2	2	2	<1	1
Scombridae <i>Thunnus</i> sp.	Tuna	0	0	1	1	1	1	<1	<1
Serranidae	Groupers	4	2	213	28	217	30	15	18
Syngnathiformes (not Fistulariidae)	Pipefishes	0	0	2	1	2	1	<1	<1
Tetraodontidae	Puffers	0	0	3	1	3	1	<1	<1
Total Identified		403	24	1081	141	1484	165		
Total bones		560		4461		5021			
Percent identified		72		24		19			

Table 2. NISP and MNI values for the Peva Dune Site, Rurutu, Austral Islands.

representing ~25% of the total assemblage, were probably taken with nets and spearing as were surgeonfish. Porcupinefish are commonly speared throughout Polynesia today. Other species, which represent small percentages of both periods, could have all been caught in the inshore zone with nets, spears, or other opportunistic methods (Table 3).

On Rurutu, true offshore, deep-water fishing may have been largely restricted to the pursuit of the benthic Oil fish (*Ruvettus*) and the Bermuda Cat fish or Rabbit fish (*Promethichthys prometheus*), none of which has been identified in the Peva assemblage. The large *pi'i* hook, made from *Casuarina* wood, was used for this sort of fishing (examples are illustrated in Vérin [1969: Fig. 90] and Aitken [1930:Plate V]). Seabrook (1938:97) wrote that the *Promethichthys prometheus* 'are obtainable on dark nights all the year round, and are therefore nearly as important in Rurutu as the flying fish. 'Au'a (Rurutuan name) are taken from certain familiar pockets (*rua* 'au'a), outside of the

reef; the best of these holes are two hundred fathoms deep.' Local informants told Bollt that these deep-sea pockets were not in the waters off Peva. Stokes (n.d.:2) noted that *Ruvettus* were caught at depths of 900 [~275 m] to 1000 feet [~305 m], and that the flesh was said to be 'very oily and having a purgative effect, but being delicious eating'.

Flyingfish (Exocoetidae, *Rur. marara*) probably constituted a much larger portion of the Polynesian diet than is represented archaeologically in Tikopia (Kirch and Yen 1982:291-292), the Marquesas (Rolett 1998:141) and the Cook Islands (Walter 1998:68) as well as the Marshall Islands of eastern Micronesia (Weisler 2001:109) and this is probably also true for Rurutu. Seabrook wrote that pursuit of the flyingfish 'seems to have been practised in Rurutu from time immemorial ... [as] Rurutu specializes in this particular type of fishing ... [and] ordinarily a boat catches from fifty to a hundred' (1938:95-96).

Fishing for flyingfish would have provided the

Taxon	Common Name	General Habitat					Capture Techniques 1-9
		Reef Flat	Reef Edge	Inshore Pelagic	Inshore Benthic	Offshore Pelagic	
Acanthuridae	Surgeonfishes	x	x				3,4,7,8
Acanthuridae <i>Naso</i> sp.	Unicornfish	x	x				3,4,7,8
Balistidae	Triggerfishes	x	x				7,8
Belonidae	Needlefishes						7,8
Carangidae	Jacks		x	x	x		2,3,4,7,8
Carangidae cf. <i>Caranx</i> sp.			x	x	x		2,3,4,7,8
Carcharhinidae	Requiem Sharks						7,8
Cirrhitidae	Hawkfishes		x		x		2,8
Diodontidae	Porcupinefishes	x	x				5,8
Elasmobranchii	Sharks & Rays			x			2,7,8
Exocoetidae	Flyingfishes			x			9
Fistulariidae	Cornetfishes						7,8
Holocentridae	Squirrelfishes and Soldierfishes				x		4,8
Holocentridae cf. <i>Adioryx</i> sp.					x		4
Kuhliidae	Flagtails		x				3,7,8
Kyphosidae	Sea Chubs	x					3,7,8
Labridae	Wrasses						3,4,7,8
Labridae <i>Anampses</i> sp.							3,4,7,8
Labridae cf. <i>Bodianus</i> sp.							3,4,7,8
Lethrinidae <i>Monotaxis</i> sp.	Emperors						4
Lutjanidae	Snappers				x		2
Mullidae <i>Parupeneus</i> sp.	Goatfishes	x	x				3,5,7,8
Scaridae	Parrotfishes	x	x		x		3,4,7,8
Scombridae cf. <i>Gymnosarda</i> sp.	Dog-Toothed Tuna			x			2
Scombridae <i>Katsuwonus</i> sp.	Bonito			x		x	trolling
Scombridae <i>Thunnus</i> sp.	Tuna			x		x	trolling
Serranidae	Groupers		x		x		2,4,8
Syngnathiformes (not Fistulariidae)	Pipefishes						7,8
Tetraodontidae	Puffers	x					7,8

See text for description of fish capture techniques.

Table 3. Habitat and common capture technique represented by the Peva Dune Site fish bone.

occasional opportunity to capture predatory pelagic fish. Seabrook (1938:96) wrote, 'Tunny (*varu*), prey on the flying-fish and are caught during the same season by trolling in the evening dusk and at dawn. The related albacore ('*a'a'i*), is rarely caught in Rurutu; bonitas (*au'opu*), stay too far from the shore for a people who will not use sails. And the *varu* itself may not have been caught formerly since the trolling hook is said to be a modern invention in Rurutu.' Vérin (1969:215) speculated that the luring technique was abandoned because of the rarity and distance of the schools of bonito in the waters of the Australs, and not simply because of the local shortage of pearlshell on Rurutu. As no bonito trolling lures were recovered in either the Archaic or the Classic deposits of Peva, and none were found by Vérin, this observation seems reasonable.

Other types of pelagic fish, such as jacks, could be taken by line fishing, primarily during the day. Jacks (Carangidae) accounted for ~3% of the entire Peva assemblage. Seabrook provided an account of the pursuit of the Black Jack fish (*Caranx lugubris*), a carangid that inhabits inshore waters.

The *ru'i* is the most important of the jacks that are obtained and Rurutuans usually regard the mature version of this fish as the first prize of the sea (Seabrook 1938:99). These fish, which can also be caught in nets, are represented

in both periods in small percentages, and based upon the relative size of the bones, were diminutive varieties that were probably caught in the inshore zone. The lack of sailing technology apparent to Seabrook was probably the result of Rurutu's inhabitants realising that fishing was far more productive and less risky if one did not venture far beyond the fringing reef. Nearly all fish species in the Peva assemblage could be taken within the reef zone, even the pelagic fishes that ventured close to shore to feed upon the smaller reef fishes (Leach *et al.* 1984:191). Opportunistic capture inshore may account for their small numbers in the assemblage.

Overall, the early residents of Peva recognized the reef zone as a primary resource, and did not emphasize offshore fishing. This is precisely the situation today. This interpretation agrees with the artefact assemblage, which contains few fishhooks, none of which are ideal for catching pelagic species. No rotating hooks were found, which are often used to catch bottom feeders in the benthic zone. Similarly, no trolling lure shanks or points were found, which are typically used to capture offshore pelagic species. The fishhooks are all small jabbing hooks, which would probably have been used with a rod and line to fish from the reef edge. As Walter (1998:71) wrote concerning Anai'o,

‘This type of fishing is likely to account for most of the Serranids in the assemblage.’ It is probable that netting, which is the predominant method today on Rurutu, was also so at the beginning of the cultural sequence. Only one stone sinker was recovered from Peva Phase I (Bollt 2008:Fig. 7.2). No net sinkers were recovered either at Peva, or at Anai’o (Walter 1998:71). This is in accord with the fact that Ma’uke’s reef flat is generally too shallow to be productive with respect to this method (1998:70). In the case of Peva, with an assemblage dominated by inshore species that are currently taken most often by net, it is likely that the absence of net sinkers does not mean that net fishing was unimportant. Net sinkers are rare artefacts in any archaeological site.

Analysis of fishbone sizes

Casteel’s landmark volume (1976) demonstrated the correlation between fish weight, size, and age through bone measurements. Subsequently, Leach and colleagues conducted a number of New Zealand based studies that estimated live fish size from archaeological bones of wrasses (Leach *et al.* 1997), snapper (Leach and Boocock 1994) and other taxa. Desse and Desse-Berset (1996a) have produced similar studies with groupers and Flemming (1986) with parrotfish (Scaridae). These studies rely on multiple measurements of mostly cranial elements rendered from whole fish to derive algorithms for estimating size and weight of live fish from archaeological bones. Butler (2001:97) measured the archaeological dentaries of groupers (Serranidae) and freshwater eels (*Anguilla*) from the Tangatatau rockshelter, Mangaia, Cook Islands to determine any size changes in these elements over time. The width of parrotfish lower pharyngeals were measured from five late prehistoric habitation sites on Temoe Atoll, Mangareva to estimate changes in live fish weight (Weisler 2004:81). All these studies relied on accurate measurements of bones. Rolett (1998:135, Fig. 6.1) separated the bones of jacks, groupers, snappers, tunas and barracuda (Sphyraenidae) from the Hanamiai site, Marquesas, into small, medium and large groups according to the size of the dentary and/or premaxillary. No measurements were taken, however, and bones were assigned to groups based on relative size within the assemblage. Although the lack of measurements limits inter-site comparisons, the method is fast. This procedure is useful for analyzing the bones from the Peva assemblage as placing dentaries and premaxillaries from jacks, groupers, snappers and tuna into relative size groups permits insights into marine zones exploited by the prehistoric Peva inhabitants. This is because fish that belong to the same family, and are grouped accordingly in the faunal analysis, can inhabit different marine environments. Fish of the same species, but of different sizes (e.g. juvenile vs. adult) can also frequent different coastal zones. Based on ethnographic observations and 30 years of fishing in the tropics by Weisler, larger specimens tend to be caught along the reef slope and offshore zones, small fish inshore and medium-sized individuals in either. This has implications for prehistoric capture methods.

No large jacks are represented in the Peva assemblage. Today, larger specimens are normally targeted specifically when fishermen venture into the deeper offshore waters. Similarly, only two specimens of grouper were classified as large, 60 elements were medium, and 44 small. The small individuals were likely caught inshore, and the medium ones either inshore or along the reef slope. The medium groupers might have been caught in the inshore zone when they swam in to feed during the evening, (Leach *et al.* 1984:191). The few snapper bones present in the Peva assemblage are small, suggesting that they were caught in the inshore zone as well. Tunas may either have been caught offshore, or else when they came inshore to feed on the smaller fishes there.

Another useful measurement for estimating the average fish size in layers A and D is the width of the fish vertebrae (Casteel 1976; Desse and Desse-Berset 1996b). This gives an overall estimate of the size ranges of the fish caught. Figure 6 illustrates the sizes of vertebrae from phases I and II. It can be seen immediately that the trend is very different from that of Hanamiai (Rolett 1998:Fig 6.2). In the Archaic phase I assemblage of Hanamiai, there is a much wider range of sizes represented, including many more large specimens. In the Classic period Phase IV assemblage of Hanamiai, there is a high concentration of smaller vertebrae and few larger specimens. Peva, on the other hand, exhibits an almost opposite trend. It is in the Archaic phase I assemblage that most of the smaller vertebrae are found, with the majority between only 3–4 mm in diameter, and the

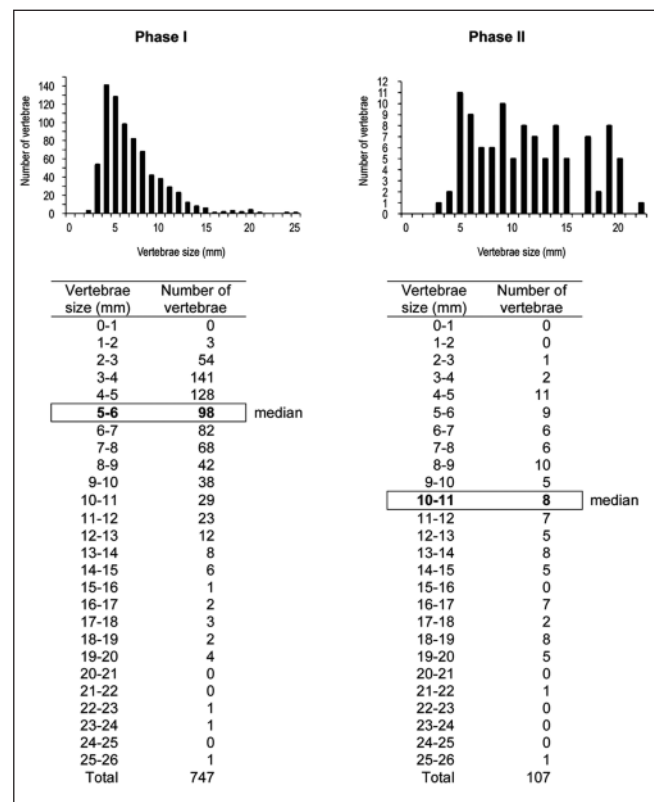


Fig 6. Fish vertebrae width from layers A (n=747, median between 5-6 mm) and D (n=107, median between 10-11 mm).

median in the 5–6 mm size class. This is additional evidence for a focus on inshore fishing. In the Classic period phase II assemblage, there is a more even distribution of sizes represented, although the sample size is much smaller, but still statistically robust. The median for this population is in the 10–11mm size class – nearly twice the width of the Archaic period specimens. It is possible that during the Classic period larger fish were being selected, specifically for the feasting that took place upon the *marae*. However, the larger vertebrae in Layer A might be due to an increase in sharks and rays, reflecting the larger average body size of these taxa than bony fishes. Fishes were still caught in the inshore zones, but a conscious effort was made to bring only the more impressive examples to the feasts. This interpretation is supported by the greater size of *Turbo* opercula in the Classic period than in the Archaic period layer (Boltt 2008:130).

Intra-site comparisons

There are clear differences in species richness, individual fish size and quantity of bones between the Peva dune site Archaic layer D and Classic layer A. Twenty fish families are represented by the fish bones in the oldest deposits, while only seven in the Classic period layer. This signals a shift from broad spectrum fish capture at colonisation and early settlement of Peva, to a focused and selective use of larger fish and presumably sharks (Elasmobranchii) incorporated into ritual activity associated with the *marae* 'Uramoa complex. The larger fish size in later deposits is borne out by the greater average weight of individual bones (0.42 g in the Archaic vs. 0.63 g in the Classic) and median size of vertebrae (5–6 mm in the Archaic vs. 10–11 mm in the Classic). The larger fish and shark in the Classic deposits implies selection of prestige specimens specifically for ritual presentation. The fauna associated with the Classic layer and *marae* complex suggests that the emphasis was on special feasting foods such as pig and turtle (Boltt 2008:Tables 5.1 and 5.2), in addition to selected fish, especially shark. Although it is difficult to precisely quantify individual shark numbers from vertebrae and teeth (there can be >100 vertebrae per shark), there is almost an order of magnitude shift in Elasmobranchii vertebrae from the Archaic (n=35) to the Classic period (n=307). Shark (Elasmobranchii) was clearly more common in later deposits. It is possible that shark was significant in terms of the religious nature of the site, because it was a *tapu* food in the Societies (Oliver 1974:275), and most likely in the Australs as well. Morrison (1935:67) noted that on Tubuai dolphin (Odontoceti) were forbidden to women and remains of this taxon were only found in the Classic layer (Boltt 2008:Table 5.2). Differences between the two layers can also be seen in the density (concentration index) of fish bone numbers from 675.9 in the Archaic to 141.4 in the Classic period (Boltt 2008:Table 5.1).

Is there a makatea adaptation?

In reference to the other types of Polynesian islands (oceanic, continental and atolls), the *makatea* islands are

rare. Their unique uplift history created narrow reefs and no lagoons, with only the occasional pass that permits boat (canoe) access to the reef edge slope, benthic and pelagic zones. There is limited coral development on the reef platform and wave surge can be strong, restricting fishing activity. Parrotfish, so common across Pacific island assemblages, are not the dominant taxon from *makatea* fish bone assemblages. This is due, in part, to environmental conditions – there is simply less coral that parrotfish depend on for grazing and it is tricky to place a seine net on the reef platform when the wave surge is strong or the waters are shallow. This may be precisely why Rurutuans developed the fish capture technique illustrated and described by Stokes where low stone walls were built on the reef platform to channel and concentrate fish for spearing (Fig. 2).

Parrotfish are a favoured catch where available in Polynesia. They are primarily grazing herbivorous fish that feed on coral algae (Randall 2007:356), will rarely take a hook, and they are only occasionally snagged; they are most frequently caught by spear or seine net (see also Kirch and Dye 1979:Table 9). On the *makatea* island of Ma'uke (Cook Islands) parrotfish are relatively insignificant compared to groupers (Serranidae), the most prevalent taxon. Walter (1998:72) states that 'the reef flat is too shallow for many parrotfish to be caught in nets, and the outer reef face, where Scarids are active, is relatively inaccessible'. In archaeological assemblages from the *makatea* island of Mangaia (Butler 2001; Kirch *et al.* 1995) parrotfish are scarce.

Table 4 presents the rank-order abundance of the top six fish families from Archaic period assemblages from five *makatea* islands. NISP was used here as it was the common quantification measure across all assemblages. Elasmobranchii (shark and rays), Scombridae (tunas and mackerels) and Muraenidae (moray eels) were removed from consideration as their numbers were inflated due to the use of vertebrae for quantification. For the Peva assemblage, 'special bones' were removed from the counts of parrotfish to make more equal comparisons to other families. Groupers are the top-ranked taxon across four assemblages, while parrotfish rank second at Peva and Paluki, sixth at Anai'o and not within the top six families from Henderson and Mangaia.

We agree with Walter that 'the importance of taking local factors into account when analyzing fishbone assemblages and the inadvisability of applying general models of diet and exploitation behaviour' (1998:72). This is abundantly clear when considering the unusual dominance of fresh and brackish water species (gudgeons and eels) represented at the Tangatatau rockshelter, Mangaia. Although fresh to brackish water swamps are found on Rurutu, there are only small bodies of fresh water in sinkholes associated with caves on Niue (Walter and Anderson 2002:11) and there is no standing fresh water on Henderson (Weisler 1995). We add to this the importance of considering the artefact assemblage that is associated with the fish bone fauna. For example, on Henderson Island, black-lipped pearlshell (*Pinctada margaritifera*) was imported to the island for

Taxon	Common Name	Peva Rurutu	Anai'ō Ma'u'uke	Paluki Niue	HEN-5 Henderson	MAN-44 Mangaia	Capture Techniques
Acanthuridae	Surgeonfishes	3	4	3	2	3	net
Anguillidae	Freshwater eels					6	hook
Balistidae	Triggerfishes				4		hook/net
Carangidae	Jacks	6	5	6	3		hook/net
Cirrhitidae	Hawkfishes				6	2	hook
Eleotridae	Sleepers					1	hook/net
Holocentridae	Squirrelfishes	5	3				hook
Labridae	Wrasses	4	2			4	hook
Lethrinidae	Emperors		5	4			hook
Lutjanidae	Snappers			5			hook
Mullidae	Goatfishes				5		hook/net
Scaridae	Parrotfishes	2	6	2			net
Serranidae	Groupers	1	1	1	1	5	hook
Total ID		780	339	406	1,557	628	
Total bones		5,021	1,816	3,239	14,751	not reported	

Table 4. Rank-order abundance of fish families from *makatea* islands, based on NISP. Layer D, Peva, Rurutu (this report); Layers 2 and 4, Ana'io (Walter 1998:66); Paluki 2 (Walter and Anderson 2002:100); Test Pit 12, HEN-5, Henderson Island, Pitcairn Group (Weisler, unpublished data); and MAN-44 (Butler 2001:91).

much of its culture-historical sequence and fishhooks were relatively common in the Archaic and later deposits (Weisler 1997). This contributed to an emphasis on angling which is borne out by the dominance of fish families that are commonly caught by this method. In this context it is interesting that, by bone count and by rank-order abundance, angling should have been common at the Peva site. However, there are few fishhooks and pearlshell manufacturing detritus (Boltt 2008:143-147). It is likely, then, that prehistoric fishers not only took advantage of the specific reef conditions adjacent to the Peva site, but adapted capture strategies to the unique circumstances. The deep water pass at Peva was the optimal zone for using seine nets to capture fish on out-going tides (Fig. 4). Weisler has participated in just such strategies in Hawai'i where seine nets are placed across narrow passes when fish are inshore and retreating to deeper zones on the receding tide. This is an effective strategy and results in the capture of a wide range of taxa – species that are more commonly associated with the reef slope such as sharks, larger jacks and groupers that come closer inshore to feed on smaller prey. The capture strategy illustrated by Stokes (Fig. 2), using low stone walls on the reef platform to channel and concentrate fish for spearing, is clearly an adaptation to the specific marine conditions and topography at Peva. Both seine netting across passes and spearing fish as Seabrook (1938) describes, would likely have resulted in the diversity and relative abundance represented by the Peva assemblage in the Archaic period.

When interpreting any archaeological fish bone assemblage one must be mindful of site taphonomic conditions that differentially preserve fish bone, and the influence of bone density on element survivorship. Importantly, 'fishing is a socially complex behavior' (Weisler and Walter 2002:56) and the occupants of the Peva dune site understood the intimate details of their marine world – the specific topography that presented constraints or opportunities

depending on the time of day, strength of the tide, moon phase and season. Fishers originating from other types of islands would have adapted their knowledge and skills not only to a *makatea* island, but to optimize capture outcomes specifically to the conditions of the Peva coast. So are there specific *makatea* adaptations? There is probably no capture strategies only used on *makatea* islands, but the archaeological assemblages recovered from these unique islands, in almost all cases, are dominated by groupers, unlike most other islands throughout the Pacific where parrotfish are usually most frequent. This, alone, might be the unique signature of most *makatea* assemblages.

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This paper is an outgrowth of a conversation Weisler had with Barry Rolett nearly ten years ago when he mentioned that Robert Boltt was working in the Austral Islands and needed someone to analyse the fish bone from an Archaic site he was excavating for his PhD research. I thank Barry for bringing me together with Rob and starting this project on its way. I was at the University of Otago at the time and had been working with then undergraduate student Amy Findlater teaching her how to identify fish bones from archaeological sites in Hawai'i. Amy was keen to take on an honours project, the results of which are incorporated into this article. The cost for some lab work was supported by a University of Otago research grant to Weisler and some figure preparations were supported by the Office of the Pro-Vice Chancellor for Research, University of Queensland. We appreciate that the Bernice P. Bishop Museum Archives allowed us to reproduce a sketch made by John Stokes in 1921. We thank two anonymous reviewers for their helpful comments. Rob Boltt passed away unexpectedly in early 2010 so could not contribute to the final version of this paper that was started years before. I trust he would have

been satisfied with the final outcome of our second collaboration and I am sure he would have liked to thank again the numerous people that are listed in the published version of his PhD thesis (2008:ix-x).

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