

# Mangareva Fishing Strategies in Regional Context: an Analysis of Fish Bones from Five Sites Excavated in 1959

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## ABSTRACT

In 1959, Roger Green conducted pioneering excavations in Mangareva (or Gambier Islands), French Polynesia, at five rockshelters on three islands (Kamaka, Aukena and Mangareva) totalling ~86 m<sup>2</sup> (~99 m<sup>3</sup>). We report the analysis of 11,340 fish bones yielding 1738 number of identified specimens (NISP) and 421 minimal numbers of individual fish (MNI) dominated by inshore species including parrotfishes (Scaridae), groupers and rockcods (Serranidae), wrasses (Labridae) and surgeonfishes (Acanthuridae). Some 13 fish families (and Elasmobranchii or sharks and rays) were identified. Comparisons with 16 other Oceanic fish bone studies, which report an average of  $24 \pm 4$  families, suggests that larger excavated samples in Mangareva using fine sieving should document additional fish families. Specific comparisons with fish bone assemblages from Reao Atoll, Tuamotus and the *makatea* island of Henderson (Pitcairn Group) – all within ~500 km of Mangareva – demonstrates the unique composition of the Mangareva archaeo-fauna which is dominated by inshore fish families that could have been captured by a range of hook techniques and, secondarily, netting. The lower pharyngeals of parrotfish were measured to examine spatial (between sites) and temporal changes in fish size. A decrease in fish bone density in one rockshelter tentatively suggests that fishing diminished in later prehistory.

*Keywords:* Polynesia, Mangareva, marine subsistence, faunal analysis, fish bone

## INTRODUCTION

Fish bones are the most common subsistence remains in Pacific archaeological sites and for more than 30 years analytical studies and research questions have developed in lock-step towards addressing a range of progressively more sophisticated topics. From early archaeological excavations in Polynesia, fish bones were, if at all, merely listed in a table by weight and rarely discussed further (e.g., Emory and Sinoto 1961: Table 1). These days, entire articles have been written on using different mesh sieves and how this affects recovery of different elements and bone sizes (Gordon 1993; Nagaoka 2005; Weisler 1993). In the mid-1980s, Leach (1986) outlined a programmatic approach to identifying fish taxa using five paired head bones – all associated with the mouth – and ‘special’ bones that are unique to particular families. More recently there has been a concerted interest to expand the range of fish elements used for identifications where vertebrae (e.g., Ono & Intoh 2011), otoliths (Weisler 2002) and a broader array of paired

elements (Vogel 2005) have been useful for adding new identifications at the family to species level.

Early on Te Rangi Hiroa noted that ‘Fishing was the most varied and extensive food-procuring occupation of the Hawaiians’ (1957: 285) and this certainly holds true for Polynesia as a whole. While early interpretations based on tropical Pacific fish bone assemblages have been used mostly for reconstructing prehistoric diets and subsistence strategies (e.g., Kirch 1973, 1979; Leach & Intoh 1984; Leach *et al.* 1984), most recent studies have documented the affects of sustained predation (Allen 2002; Allen *et al.* 2001; Fitzpatrick & Kataoka 2005; McAlister 2002; Morrison & Addison 2009; Ono & Clark 2010; Weisler 2004) which seek explanations in changing technology and economies, and perhaps climate-related affects. Weisler *et al.* (2010) have suggested that a greater frequency of shark remains in one site was linked to an increasing emphasis on ritual practice. Despite the importance of fish bone analysis for developing a richer understanding of Polynesian prehistory, there have been relatively few studies for most tropical East Polynesian archipelagos (Hawai‘i is the notable exception). In this paper we present the analysis of fish bone assemblages from five archaeological sites in Mangareva (French Polynesia) excavated by Green in 1959 which nearly triple the number of bones identified to family from the main islands. It is noteworthy that Green collected faunal material from his excavations when it was

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Submitted 05.11.12, accepted 15.12.12

not a routine procedure in Polynesian archaeology at the time. We also explore the potential pitfalls with making analytical interpretations from faunal assemblages collected more than half a century ago.

### ENVIRONMENTAL SETTING

Located at the eastern limit of French Polynesia, Mangareva (or Gambier Islands; 23° S latitude, 135° W longitude) lies near the eastern end of the time-progressive Pitcairn-Mangareva lineament (Duncan & McDougall 1976) that trends 1700 km northwest to include the atoll archipelago of the Tuamotus. With a combined land area

of only 24.4 km<sup>2</sup>, Mangareva consists mainly of steep-sided, small volcanic islands within a lagoon some 25 km across which is enclosed on the northern margins by narrow sand islands that in the example of Tenoko, has been sufficiently stable to contain a prehistoric habitation site (Weisler 1996:75, Figure 1). Figure 1 illustrates the general depths of the lagoon showing the shallower areas located near islands. Mangareva, the name of the largest island (14 km<sup>2</sup>; highest peak is 441 m asl) contains more than 90 per cent of today's population centred at Rikitea village which is also the location of the administrative centre. The other volcanic islands in the archipelago make up less than half of the total land area and are typified by steep-sided



Figure 1. An abbreviated map of the Pacific (inset) showing the location of Mangareva in East Polynesia and the Mangareva archipelago with archaeological sites discussed in the text. Note the shallow water (0–15 m depth) associated with the islands and barrier reef. Map adapted from the Service Hydrographique et Océanographique de la Marine, France (#6461, Iles Gambier, 1:60 000, 1976) and *Atlas de la Polynésie Française*, ORSTOM, 1993, plate 16).

islands with narrow coastal flats that contain prehistoric middens or rockshelters, the latter situated at the base of steep slopes. The second largest island, Taravai (5.3 km<sup>2</sup>; maximum 250 m asl), is situated at the western limit of the group (Figure 1) and has three small bays along the west coast, one with an excavated prehistoric coastal midden at Onemea (Kirch *et al.* 2010); along the south shore and extending inland is a flat area with a large prehistoric village (Weisler 1996:74). The only relatively flat, expansive land at Akamaru (2.0 km<sup>2</sup>; 246 m asl) is located along the north and west shores – both areas containing prehistoric villages, as at Tokani which was mapped by Green (Green and Weisler 2000: Figure 2). At 1.5 km<sup>2</sup> Aukena consists of two peaks (the highest is 198 m asl) at opposite ends of the island that are connected by a narrow, steep ridge. Near the middle of the island the land narrows where a large rockshelter (GA-1, excavated by Green in 1959), is open at both sides at the base of ridge and backs on to level ground (Figure 1; Green and Weisler 2000: 28–30 and Figures 19–23). Agakaitai, (0.7 km<sup>2</sup>) is connected to Taravai by a reef platform. At 139 m elevation, a steep ridge runs north-south with rockshelters situated along the base of the west side. One of these rockshelters (probably AUG-1; Weisler 1996:66) was excavated recently (Kirch & Conte 2009:101; Kirch *et al.* 2004:104). Kamaka (0.5 km<sup>2</sup>) is surrounded by a high rocky coastline except the north shoreline that has a sandy beach with easy access to the offshore waters. The beach backs on to steep cliffs with basalt dykes that trap and channel subterranean water which issues as springs. Two rockshelters and a *marae* on Kamaka are described below.

#### ARCHAEOLOGICAL BACKGROUND

Mangareva has had relatively little archaeological research until recently. When considered in regional context with the nearest island group of Pitcairn located ~400 km east, there is substantial evidence that Mangareva was initially settled by at least cal AD 1000 (Green & Weisler 2002; Kirch *et al.* 2004:104, *et al.* 2010:73; Weisler 1995; Weisler & Green 2011). There is now a suite of 11th century radiocarbon age determinations from the Onemea site on Taravai (Kirch *et al.* 2010) and the archaic period site (HEN-5) on the north coast of Henderson Island, Pitcairn Group (Weisler 1995: Table 2, 1997: Figure 9.8, 1998a). This latter site is relevant since it lies east of Mangareva from where it was undoubtedly settled. The lowest layers of these earliest sites are typified by concentrations of bones of extinct and extirpated birds. Mangareva and the Pitcairn Group define the southeast Polynesian interaction sphere (Weisler 1997: Figure 9.9, Table 9.3) where vesicular volcanic oven stones, black-lipped pearl shell (*Pinctada margaritifera*) and a range of introduced plants and animals were transferred to Henderson and Pitcairn in exchange for – at least on archaeological evidence – fine-grained basalt from Pitcairn (Weisler *et al.* 2004: Table 7.5; Woodhead & Weisler 1997).

Geochemistry of adze material has documented extensive contacts with the Eiao source (Marquesas) and Ra'iatea, Society Islands (Weisler & Green 2001: Table 31.5; Weisler 1998b). From faunal materials recovered from Green's pioneering stratigraphic excavations in two rockshelters on Kamaka, the well-preserved contexts yielded bones of a suite of commensal animals. Chicken or Jungle Fowl (*Gallus gallus*), in GK-1 and -2, was introduced to the archipelago at least by cal AD 1200 to 1400. Dog (*Canis familiaris*) was recovered from layers dated to cal AD 1300 to 1600 in GK-1 and -2 and earliest layers at GK-2 contained pig (*Sus scrofa*) dated to cal AD 1025–1292 (Green & Weisler 2004). Pig was also recovered from later prehistoric contexts on Agakaitai and Taravai (Kirch *et al.* 2010:76). Some 381 bird bones from five islands are predominantly those of seabirds as well as two ground-doves (Columbidae) and the chicken (Steadman & Justice 1998; Worthy & Tennyson 2004).

Similar to the sequence with other East Polynesian archipelagos, early occupation sites are located at coastal middens in ideal environmental locations. In this regard, Mangareva should contain the earliest evidence for human colonisation of the archipelago (Green & Weisler 2000:32, 2002:232; Weisler 1996:80–81); indeed, Emory recorded the major chiefly complex at Rikitea (Figure 1; Emory 1939: Figure 7). The elaboration of monumental architecture comes later in the sequence for Mangareva perhaps by the 15th century on limited dating evidence (Kirch *et al.* 2004). Interestingly 69 charred and fragmented human bones found throughout the latest midden layers of the GK-1 rockshelter (cal AD 1600 to 1750) may be evidence of cannibalism as depicted in the oral traditions which characterised late prehistoric Mangarevan society as one of upheaval and much social unrest for competition of limited resources (Goldman 1970:151–53).

Emory mentioned several long fish weirs (*pa re'e*) constructed at the south shore of Mangareva at Ganoha, a stone enclosure at Atiaoha extending 25 feet (7.6 m) from shore may be a fish pond and a similar structure at Tokai Bay may have held turtles (Figure 1; 1939:17). The information thus far on prehistoric fishing and related subsistence practices comes from one site each on Taravai and Agakaitai with combined totals of 6668 fish bones of which 983 (14.7 per cent) were identified to one order, one subclass and 11 families – all but one bone (a tentative identification) representing inshore species. Excavations at the Onemea dune (site 190–12-TAR-6) produced 1095 fish bones of which 222 were identified to groupers (Serranidae), snappers (Lethrinidae), wrasses (Labridae), parrotfish (Scaridae), porcupinefish (Diodontidae) and triggerfish (Balistidae) as well as shark and ray vertebrae (Elasmobranchii) and mackerel shark (Lamniformes/Lamnidae) teeth (Howard & Kirch 2004). Further excavations increased the sample size by 3486 bones with 624 (17.9 per cent) identified to taxon (Kirch *et al.* 2010: Table 6) and added three additional families: surgeonfish

(Acanthuridae), squirrelfish (Holocentridae) and boxfish (Ostraciidae). A single square metre excavation at a rockshelter on Agakauitai (site 190-02-AGA-3) yielded 2087 fish bones of which 137 (6.6 per cent) were identified to 12 taxa (Kirch & Conte 2009: Table 6). Added to the inventory of families represented in these Mangarevan sites were moray eel (Muraenidae) and tentatively the pelagic wahoo (Scombridae). The latter family was reported as Acanthocybiidae (Howard and Kirch 2004: 118). Howard and Kirch (2004: 18) stated that their identifications presented thus far are preliminary and 'doubtless additional taxa will be recognized when the collection is analysed by a zooarchaeologist specializing in Pacific fishes.' Although we did not have the opportunity to reanalyse these assemblages, we present our identifications of 11,340 fish bones with 1738 identified to nearest taxon (13.3 per cent) from one site on Mangareva and Aukena, and three sites on Kamaka – all from Green's excavations in 1959.

### GREEN'S 1959 EXCAVATIONS

Detailed descriptions of the sites, stratigraphy and dating are presented in Green and Weisler (2000, 2002). Brief site information is presented here to place the fish bone assemblages in context.

#### Kamaka, GK-1

Above the beach and situated at the base of the cliffs at the east end of Sancho's Cove is the most substantial rockshelter on the island with ~80 m<sup>2</sup> of protected level space and the best preserved stratified deposits to a maximum depth of ~2 m (Figure 1; Green and Weisler 2000: 12–20). About 22 m<sup>2</sup> (~38 m<sup>3</sup>) were excavated revealing prepared sand floors, beachrock slab alignments, postholes, pits, ovens, and dense concentrations of bird bones (n = 92), 6596 fish bones and also 217 bones of rat, dog, pig, human, sea turtle, goat/sheep and other vertebrate elements too small to identify further (Green & Weisler 2004: Table 1; Steadman & Justice 1998: Table 2). A fire pit at the basal cultural deposit (layer J) yielded a conventional radiocarbon age determination of cal AD 1040–1110, 1115–1271 at two sigma (all calibrations using Calib v. 6.0; Stuiver and Reimer 1993). Portable artefacts included mostly those made of pearl shell (whole and broken fishhooks, harpoon, coconut grater and picks or drills), a basalt adze, flakes and coral files.

#### Kamaka, GK-2

At the western end of the cliff base, near the promontory that divides the two beaches on the north coast, is a large overhang shelter. Green observed an eroded bank exposing cultural deposits in 1959; Weisler mapped this exposed section in 1991 noting a cultural deposit to a depth of ~120 cm. Some 12 m<sup>2</sup> (~20 m<sup>3</sup>) were excavated by Green in ar-

bitrary spits as the stratified deposits were poorly defined probably due to considerable post-depositional disturbance from prehistoric site use (excavating pits and ovens) and high surf. The deepest cultural layer was ~2 m below surface in the two seaward units with a basal date of cal AD 1026–1262 at two sigma (Beta-109019; Green & Weisler 2000: Table 2). Portable artefacts included those of pearl shell: worked pieces, fishhook tabs, whole and fragmentary fishhooks and coconut graters as well as a stone pounder and basalt flakes. Of the 82 bird bones identified from the site (Steadman & Justice 1998: Table 2), 75.6 per cent were from the lowest cultural layer and, although included almost exclusively bones of seabirds, one bone from a ground dove (*Gallicolumba*) was identified. The presence of relatively high concentrations of bird bones in basal cultural deposits is a hallmark of early settlement; in this case for Kamaka specifically, but these are not the earliest cultural deposits in the archipelago. Some 4483 fish bones from GK-2 were analysed here.

#### Kamaka, GK-3

Situated at the top of the beach, 20–75 cm of wind-blown sand covered a midden deposit, below which was a ~6 m long stone pavement or *marae* that was built atop a charcoal-stained cultural layer. Some 12 m<sup>2</sup> (at least 6 m<sup>3</sup>) were excavated to sterile subsoil revealing three human burials, few artefacts, 14 bones of seabirds and 1662 fish bones. A radiocarbon age determination from charcoal directly under the pavement produced a 'modern' date (Green & Weisler 2000: Table 2); however, there were no historic artefacts associated with the structure which is more likely late prehistoric in age.

#### Aukena, GA-1

Te Ana Pu is a large rockshelter at the base of a narrow ridge that runs the length of Aukena. The shelter, open at both ends, has a level floor of ~115 m<sup>2</sup>. Excavations totaling ~27 m<sup>2</sup> (roughly 25 m<sup>3</sup>) produced traditional artefacts including pearlshell fishhooks and manufacturing debris, coral files, shell scrapers, octopus lure sinkers and a basalt adze and chisel to a depth of 1 m. Two dates for the main cultural layers were obtained; for layer C, one conventional radiocarbon age determination calibrated at two sigma to cal AD 1283–1519 (97.4 per cent) and from layer B, a U-series date of a seemingly fresh collected *Acropora* coral finger used as a file dated recently to cal AD 1454 ± 4 (see Weisler *et al.* 2006 for analytical procedures). Fauna included 26 sea bird bones and 257 fish bones.

#### Mangareva, GM-1

Located near Taku village at the northwest end of Mangareva island, and several hundred metres from the shoreline, this overhang shelter, although about 46 m long, had



a ~15 m long and 3–3.5 m wide space that was suitable for habitation (Green & Weisler 2000:30). About 13 m<sup>2</sup> (~10 m<sup>3</sup>) were excavated through a primarily fine black homogeneous silt containing oven stones, pebbles, charcoal, some marine shell as well as one chicken bone in layer B and 39 fish bones. The site had not been dated but historic artefacts were only found in the top 5 cm.

## SUMMARY

About 86 m<sup>2</sup> were excavated at five sites totalling ~99 m<sup>3</sup>. From eight radiocarbon age determinations from three of the sites, and a single U-series date on a fresh-collected *Acropora* sp. coral finger used as a file or abraded, a sequence was defined from about cal AD 1200 to the 1840s. Green and Weisler (2004:34) estimated that about 200 to 400 years of the sequence had yet to be established. Recent excavations at the Onemea site on Taravai have extended the Mangarevan sequence to at least AD 1000. Fishing gear is well represented at the Kamaka rockshelters, while the two sites on Mangareva and Aukena produced minimal portable artefacts.

## EXCAVATION METHODS

Reporting explicit field procedures is essential for placing limits on the kinds of interpretations that realistically can be made from assemblages excavated more than half a century ago. In terms of sieving procedures, most Pacific archaeologists would take it for granted that at least samples from cultural layers would be passed through 3 mm screens to recover small bones and artefacts. Yet, in 1934 when Kenneth Emory excavated a rockshelter on Agakauitai, no screens were used (1939:28–29). And, what defines an artefact whose importance shifts with the coming decades? Who would have thought that many of the coral files discarded by Green during his pioneering excavations in 1959 would be valuable specimens for high-precision U-series dating some 50 years later? Consequently, we report here the field procedures for establishing site excavation grids and recording stratigraphy which, perhaps not so surprisingly given Green's background in geology and attention to detail, are certainly current in many respects with today's best practice. As screening procedures have changed over the years (not simply a move towards smaller screen mesh sizes, but deciding what to save), we discuss these in detail in order to lay a foundation for interpreting the fish bone assemblages.

A compass and tape were used to establish an excavation grid of two metre squares with intervening baulks of one metre. Those squares selected for excavation were dug in a series of layers or levels until deposits without further evidence for human occupation were reached. Either during or after the completion of each layer or level, a plan was made of any structural features exposed. When no further cultural deposits were encountered, this fact

was tested by a small but deep test trench into underlying deposits. Next, stratigraphic sections for each of the walls were drawn. After adjacent squares were completed intervening baulks were excavated only if the stratigraphic connections between one square and the next appeared unclear.

Where stratified deposits were encountered excavation proceeded by definable layers; otherwise arbitrary levels were employed, in which case those levels were matched to stratigraphic units, whenever possible. In most of the excavations, however, it was neither possible nor feasible to excavate each individual lens or discontinuous bed entirely on its own. Instead, a system of 'layers' was devised to overcome the problems posed by a multitude of localized lenses and circumscribed beds, none of which were easy to define during actual excavation operations. This system was based on the assumption that, in general, the major events at a site will be recorded in fairly extensive beds that are also capable of definition during excavation. It is also likely that these beds would serve as markers, easily traced and identified from one square to the next as excavation in each proceeded simultaneously.

Marker-beds were used to define the top of each stratigraphic unit during excavation. This has the merit of keeping the debris of one occupation clearly separated from that below, and it was easier to trace the upper surfaces of such beds. Pits, ovens, and other features intruding into the layers below, were fully excavated with the layer to which they belonged. Each of these stratigraphic units was called a 'cultural layer' and was designated in alphabetical order by a set of capital letters as each was excavated.

Sediment was screened through either 1/4 inch (6.4 mm) or 1/8 inch (3.2 mm) sieves, although it was not recorded which sieves were used to screen individual spits. Judging from the concentration of small rat bones in unit A-I at GK-1, we can assume that 1/8 inch sieves were used to screen those deposits and, using a similar criterion, possibly sediment from Z-II from that site as well. While we acknowledge that different mesh sizes can contribute to the differential recovery of fish bones (e.g., Nagaoka 1994), the use of small-mesh sieves (< 4 mm) generally results in the retention of bones from small-sized fish such as cardinalfishes (Apongidae), damselfishes and clownfishes (Pomacentridae) and bigeyes (Priacanthidae) (see Gordon 1993: Table 3). Since fish otoliths, normally retained in 3.2 mm sieves (Weisler 1993), were not recognised during the excavations, their omission may mean the loss of taxa with small elements and/or bones of low density that do not generally preserve such as, for example, flying fish (Exocoetidae) and bone fish (Albulidae). The abundance of large pearl shell fishhooks throughout some of the deposits suggests that sizeable carnivorous fish, from the families including groupers (Serranidae), wrasses (Labridae) and snappers (Lethrinidae), were important targeted species.

## ANALYTICAL METHODS

All the fauna were first sorted by Weisler into major groups: fish, bird, rat and other vertebrates (e.g., sea turtle, human, artiodactyl, non-specific mammal). The fish were identified by Weisler using extensive reference collections at the University of Otago (Walter *et al.* 1996) which for the parrotfish (Scaridae) included 13 species in the genera: *Bolbometopon*, *Calotomus*, *Cetoscarus*, *Hipposcarus* and *Scarus* encompassing more than the known scarid genera from Mangareva (Fourmanoir *et al.* 1974:556). Excellent scarid bone illustrations were also used in Bellwood (1994) to make identifications. The bird bones were sent to David Steadman who has reported on them (Steadman & Justice 1998). Rat bones were identified at the University of Otago by comparison with reference specimens. mtDNA was extracted from a sample of these which demonstrate membership to the main East Polynesian haplogroup (Matisso-Smith & Robins 2004). The other bones were sent to Dr Alan C. Ziegler for identification and have been reported in Green and Weisler (2004).

Some 13,384 bones were inventoried, 84.7 per cent of which were fish and 13.3 per cent of these were identified to the family or genus level. No quantitative taphonomic observations were made of individual elements aside from noting burning evidence on fish bones which averaged from 9.4 per cent for GK-1, 2.7 per cent for GK-2 and <1 per cent for GK-3, while GA-1 and GM-1 had no burnt fish bones; however, in general, all bones were well preserved and many were whole.

A total of 11,340 fish bones were recovered from five sites with 97.5 per cent coming from the three sites on Kamaka. Per cent identified fish bones for the five assemblages ranged from 12.5 to 25.6 with a combined average of 13.3. This latter figure is reasonably typical of other Pacific assemblages processed with 6.4 mm sieves identified by Weisler for sites from Hawai'i, the Pitcairn Group, and the Marshall Islands – using a range of elements – that were identified to family level or lower using extensive comparative collections.

The five paired mouth parts (premaxilla, maxilla, dentary, articular, and quadrate) are typically used for identifications (Leach 1986) because these elements – with numerous distinctive landmarks – are often characteristic of families or genera. Butler (1994) demonstrated the correspondence between fish mouth morphology, dietary preference (e.g., carnivorous, herbivores) and capture techniques. Table 1 presents the fish elements used for identification to family in our study. Note that there is a nearly identical number of premaxillaries ( $n=386$ ) and dentaries ( $n=381$ ) and a similar amount of quadrates ( $n=143$ ) to articulars ( $n=133$ ). The greater number of premaxillaries and dentaries reflects the more robust nature of these elements and, consequently, greater chance of preserving landmarks used for identification. Conversely articulars, and especially quadrates, are less dense and have

relatively larger areas of flat bone that often erode. Along with the five paired mouth parts, 'special' bones, such as the dorsal spines of acanthurids and balistids, scutes of carangids, and grinding mills of scarids and labrids are highly distinctive elements used routinely for family-level identifications. In some cases, other paired bones were used for identifications: cleithra, palatine, epiphyal and preopercular.

Once elements were identified to taxon, the provenance, element and side were recorded on the FileMaker Pro database programme. The number of identified specimens (NISP) was calculated for each taxon. Although this procedure has the drawback of specimen interdependence (i.e. one element can fracture into several pieces, each counted individually, inflating the overall total for the taxon), it is strongly correlated to the minimum number of individuals (MNI) quantification measure (Grayson 1984) in many, but not all cases. Consequently, MNI values are reported for the Mangarevan assemblages we analysed. (We did not consider size differences in calculating MNI for a given taxon.) Furthermore, we agree with Allen (2003:318) that NISP and MNI values should be reported to facilitate comparisons between assemblages in the literature. However, either measure often yields similar values for rank-order abundance at the family level.

## RESULTS

Table 2 presents the NISP, MNI and rank-order abundance of identified fish taxa from the Mangarevan sites. Predicably, parrotfish (Scaridae) account for the largest taxon with 39.8 per cent of the 1738 identified bones. Scarids usually dominate fish bone assemblages from sites on volcanic islands and atolls, but rank below serranids for raised limestone or *makatea* islands such as Ma'u'ke (Walter 1998:65), Rurutu and Henderson Island (Weisler *et al.* 2010: Table 4). This seems correlated to the local marine environment of *makatea* islands with their typically narrow, high-energy inshore environment devoid of much live coral. Consequently, scarids – herbivore/omnivore fish that are closely associated with coral reefs (Bellwood 1994:3) – are relatively few in number. Noticeably absent from the scarid inventory are members of the genus *Bolbometopon* which are known from as far east as Samoa (Muñoz *et al.* 2012), but archaeological records may potentially extend its biogeographic distribution. Reaching standard lengths of up to 1500 mm and 75 kg (Gladstone 1986), this largest of scarids typically frequents the outer lagoon and seaward reefs from depths of 1 to 30 m (Myers 1991:193); in relatively unfished areas it can be found resting in less than two feet of water where it is particularly prone to spearing (Johannes 1981:53) and it frequently sleeps in large groups making it highly vulnerable to human predation. It is the only scarid species identified by Palauan fisherman to have declined in response to fishing pressure (Johannes 1981:82). Its absence from the Mangareva inventory may

Table 1. Fish elements used for identification.

Element	Taxon														Total
	Acanthuridae	Balistidae	Belonidae	Carangidae	Diodontidae	Elasmobranchii	Holocentridae	Labridae	Lethrinidae	Lutjanidae	Mullidae	Muraenidae	Scaridae	Serranidae	
articular							2	17	18	3			39	54	133
caudal peduncle spine	7														7
cleithra							2								2
dentary	3	13	3	3	1		7	54	29	6	1	8	110	138	381
dentary/premaxilla								6	1				9	3	19
dermal spine					2										2
dorsal spine	100	5		2	5		2								114
first or second dorsal spine	3														3
first ventral spine	2														2
horn	2														2
hypural	1	2													3
inferior pharyngeal cluster								53					84		137
maxilla				2			2	24	18	2	1		47	51	147
molar-form tooth									7						7
operculum							3								3
palatine										2				7	9
4th epibranchial													36		36
premaxillary	3	5	2	3				90	29	5	1	1	176	68	386
preopercular							1								1
pterygiophore				1											1
quadrate	1	6		1	1			8	19		1	1	44	61	143
scute				2											2
superior pharyngeal cluster								21					147		170
tooth		2													2
ventral spine		1					1								2
vertebra						23									23
vomer												1			1
<b>Total</b>	<b>122</b>	<b>34</b>	<b>5</b>	<b>14</b>	<b>9</b>	<b>23</b>	<b>20</b>	<b>273</b>	<b>121</b>	<b>18</b>	<b>4</b>	<b>11</b>	<b>692</b>	<b>382</b>	<b>1738</b>

indicate locale extirpation of these species in the first few centuries after human colonisation. Also absent from the Mangareva assemblage are members of the parrotfish genus *Calotomus* which has not been recorded from live sightings (Fourmanoir *et al.* 1974:556), but is probably present in small numbers since it is known from archaeological contexts on Henderson Island and biological surveys around Pitcairn (Randall 1999:23), about 400 km to the east, as well as in archaeological sites on Reao, Tuamotus, 530 km north-north-west (Figure 1).

Scarids are most frequently captured by nets and spears in the inshore waters, although one species, *Scarus harid*, is easy to catch with baited hooks on Losop Atoll

(Severance 1986:37; see also Kahā'ulelio 2006:209 for Hawai'i) and, less commonly, they can be jagged by hooks (Walter 1991:48). All taxa listed in Table 2 can be caught in nets with the exception of marine eels such as Muraenidae. However, serranids, labrids, lethrinids, lutjanids and belonids are routinely caught with hooks and account for 45 per cent of all identified fish bones. We acknowledge that J. Allen (1986) has made a convincing case that lethrinids, serranids (Epinephelidae) and lutjanids can be taken routinely by net (see also Akimichi 1978:315). In Mangareva, members of the serranids, labrids, lethrinids and lutjanids could be caught by bottom fishing in the lagoon near live coral or along the outer reef slope. Belonids usually take

Table 2. Identified fish bones from Green's 1959 Mangareva excavations.

Taxon	GA-1		GK-1		GK-2		GK-3		GM-1		Total		per cent		Rank Order		Ubiquity
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	
Acanthuridae	3	1	80	62	31	16	9	2	2	1	125	82	7.2	19.5	3	3	5
Balistidae	4	2	10	6	2	2	18	5			34	15	2.0	3.6	6	6	4
Belonidae			2	1	3	1					5	2	0.3	0.5	12	12	3
Carangidae			4	1	5	4	7	3	1	1	17	9	1.0	2.1	8	8	4
Diodontidae	2	2	4	4	2	2			1	1	9	9	0.5	2.1	8	8	4
Elasmobranchii					4	3	19	1			23	4	1.3	1.0	11	11	2
Holocentridae	2	2	14	8	3	2	1	1			20	13	1.2	3.1	7	7	4
Labridae			170	34	76	19	27	7			273	60	15.7	14.3	4	4	3
Lethrinidae			44	18	35	7	43	12			122	37	7.0	8.8	5	5	3
Lutjanidae			10	6	8	2					18	8	1.0	1.9	9	9	2
Mullidae			3	2	1	1					4	3	0.2	0.7	12	12	2
Muraenidae	1	1	4	2	5	3	1	1			11	7	0.6	1.7	10	10	4
Scaridae	23	6	290	33	243	28	133	19	3	2	692	88	39.8	20.9	1	1	5
Serranidae	6	3	192	41	146	29	38	9	3	2	385	84	22.2	20.0	2	2	5
<b>Total identified</b>	<b>41</b>	<b>17</b>	<b>827</b>	<b>218</b>	<b>564</b>	<b>119</b>	<b>296</b>	<b>60</b>	<b>10</b>	<b>7</b>	<b>1738</b>	<b>421</b>	<b>100.0</b>	<b>100.0</b>			
<b>Total unidentified</b>	<b>175</b>		<b>4942</b>		<b>3355</b>		<b>1070</b>		<b>19</b>		<b>9561</b>						
<b>Total bones</b>	<b>257</b>		<b>5769</b>		<b>3919</b>		<b>1366</b>		<b>29</b>		<b>11340</b>						
<b>% identified</b>	<b>16.0</b>		<b>14.3</b>		<b>14.4</b>		<b>21.7</b>		<b>34.5</b>								

a moving lure inside or outside the lagoon, while Weisler has caught serranids bottom fishing off the outer-reef slope of Henderson Island with unbaited, single-piece, rotating pearl shell hooks fashioned after archaeological specimens. Whether baited or not, the single piece pearl shell fishhooks from the Mangareva sites would have been ideal for catching these carnivorous species. Inclusion of the balistids, holocentrids, carangids, muraenids, and mullids (totalling an additional 11.2 per cent) would raise the inventory of fish that *could* be taken by hooks to 56.2 per cent. While the common technique for taking balistids may be by net or poison in Tonga (Kirch & Dye 1979), Weisler has caught balistids by baited hook which has also been recorded for Hawai'i (Hosaka 1944) and recently for Sabah (Ono 2010:288).

Despite the common occurrence of pearl shell fishhooks in the GK-1 assemblage on Kamaka, net fishing is a more predictable and less risky method of capture that consistently results in greater quantities of fish (Allen 1992; Ono 2010: Table 3) and is a common capture technique for many Pacific island societies, as at Tokelau (Ono & Addison 2009:8), Aitutaki, Cook Islands (Allen 1992) and throughout the Marshall Islands (e.g., Weisler 2001). Spearing may not have been widely practiced since only nine bones of diodontid were identified. Numerous dermal spines of this taxon are so routinely found in archaeological contexts that they are often eliminated from abundance measures since they can distort results (Nagaoka 1993:193; see also Dye 1996:83). Their low numbers in the Kamaka sites may suggest that spearing (Hiroa 1957:288) or capturing while reef foraging (Ono 2010:288) were not important strategies because of the: (1) abundance of natu-

ral pearl shell stocks to make hooks and the overall importance of angling; (2) nature of the Kamaka coastline which, aside from the north coast beach, was rocky and difficult to access; and (3) very limited foraging areas exposed at low tide (Figure 1). In contrast, Harry (1953:176) reported that spearing provided the largest volume of fish at Raroia Atoll (Tuamotus), although this atoll has more accessible shallow water shorelines than Mangareva. We recognise that members in the families: Holocentridae, Labridae, Lethrinidae, Lutjanidae, Mullidae and Serranidae (to name a few) can be taken by poisoning (Dye 1983:256), but the easily accessible waters off the north beach of Kamaka are relatively deep (Figure 1) and not ideal for using fish poisons.

Even in well fished areas, one or a few fish of a given species can be caught outside their 'common' habitat be it in the inshore waters, deep lagoon or oceanside reef slope. For example, scombrids, when found in archaeological contexts, are usually assumed to be evidence for pelagic fishing (O'Connor *et al.* 2011; Ono and Intoh 2011; Leach & Davidson 1988). However, within the atoll setting or coastal lagoons, numerous scombrids can be caught in shallow water by herding with coconut frond sweeps or seine nets (Finsch 1893; Pulsford 1975; Severance 1986:40) a practice Weisler recorded on Ebon Atoll, Marshall Islands (2001). We agree with Ono (2010:291) that '...it is hard to reconstruct the exact method of capture for each fish family or species simply from the identification of excavated fish bones'. Consequently, the diversity and abundance of the fish families listed in Table 2 are the result of a variety of capture techniques using hooks, nets, spears and, perhaps, poison. Because of the ready availability of dense pearl



shell stocks in the Mangareva lagoon and pearl shell fishing gear, especially in GK-1, angling probably played a significant role in the capture techniques where about half of all fish may have been taken by hooks. Consequently, the artefact assemblages associated with the fish bones is an important source for inferring fish capturing techniques (Weisler *et al.* 2010).

### Fish size

We agree with Masse (1986:112; see also Rolett 1998:136, 142) that determining fish size – especially of the labrids, lethrins, lutjanids, serranids and carangids – is instrumental in getting a more precise understanding of where fish may have been caught and subsequent capture strategies as inferred from archaeological bones. For example, it is more likely that the smaller members of the carnivorous fishes will be caught inshore, while larger individuals will be routinely caught along outer reef slopes and in deeper areas of the lagoon if coral is present. However, this probably holds true for later occupation periods since large groupers, especially, have been seen by Weisler in shallow waters (<1 m deep) close to shore on Henderson Island, or moving through *hoa* on Temoe Atoll (40 km east of Mangareva) where they have been speared while standing on dry land. Additionally, on Henderson, large carangids and reef sharks (Carcharhinidae) have been observed by Weisler partially sticking out of shallow water as they hunt for prey. Both Henderson and Temoe have been uninhabited for a few hundred years and the inshore fishery probably approximates what initial colonists experienced. Consequently, large individuals of labrids, lethrins, lutjanids, serranids, carangids and sharks may have been captured almost anywhere when fisheries were pristine.

Declines in fish size (or large bodied taxa) can be a response to shifting human foraging strategies where smaller low-return prey was targeted with greater frequency in later prehistory as large-bodied prey become increasingly scarce (Allen 2003; Butler 2001). The issue is rather complex as sea surface temperatures (e.g., Thresher *et al.* 2007), a change in fishing technology (Leach & Davidson 2001:156) and archaeological bone collection procedures (Allen 2003; Butler 2001) can all effect the reconstructed population structure of targeted fish populations. Large fish can also be absent or decline from the archaeological record due to avoidance of large bodied taxa that are ciguatoxic – a type of food poisoning caused by eating large carnivorous species in the families of groupers, snappers, wrasses, triggerfish, barracuda, eels and some surgeonfishes (Desse-Berset & Desse 2008).

There have been a number of studies with the goal of reconstructing live weight or length of fish from archaeological bones (see Weisler *et al.* 2010:139–40 for a recent review) using commonly-recovered paired head bones such as dentaries, premaxillaries and articulars (Leach & Boocock 1994; Leach *et al.* 1997). Regression formulae have

been specifically developed for selected balistid (triggerfish) elements (Zohar *et al.* 1997), lower pharyngeals of scarids (Flemming 1986) and the final vertebra or hypural of tuna or Scombridae (Frasier 2001). Vertebrae widths, which are well-known to have a strong correlation to reconstructed fish size (Casteel 1967), have been used to examine changing fish size over time (Rolett 1998: Figure 6.2; Weisler *et al.* 2010: Figure 6). This, however, may not be a good indication of temporal changes in fish size unless the same species diversity and richness is present in each analytical assemblage. Butler (2001) and Allen *et al.* (2001) have used the relative size and overall frequency of fish within particular families to examine changes in the percentages of large-bodied to small-bodied fish through time.

Scarid lower pharyngeals tend to preserve well in archaeological deposits and the width is a robust measure correlated to live fish weight and size (Flemming 1986) which has been used to determine human foraging pressure on parrotfish (e.g., Weisler 2004). We measured the width of 62 lower pharyngeals from four Mangarevan sites to see whether there was a change in parrotfish size over time or between sites. We used all measureable pharyngeals identified to family, but note that more than one species might be represented, which potentially could mask size changes within a particular taxon. We report an overall mean width of  $12.08 \pm 3.11$  mm (range = 5.56 to 19.80). The individual values for each site are: GA-1 ( $n = 2$ , mean = 14.30 mm); GK-1 ( $n = 21$ , mean  $11.29 \pm 2.16$  mm); GK-2 ( $n = 29$ , mean  $12.55 \pm 3.61$  mm) and GK-3 ( $n = 11$ , mean  $12.04 \pm 2.42$  mm). There is no meaningful difference in the width of scarid pharyngeals between sites with sample sizes >10. GK-1 was the only site that had an analytically useful distribution of scarid pharyngeals across most strata. We divided the stratigraphy into a lower zone (layers F–J) and an upper zone consisting of layers B, C and E (no scarid pharyngeals were in layers A and D). The average size between zones was nearly identical: lower zone  $11.36 \pm 2.75$  mm ( $n = 10$ ) and upper zone  $11.23 \pm 1.59$  mm ( $n = 11$ ) suggesting that, for at least the parrotfish, there was no change in the average size during the occupation of the Kamaka rockshelter.

### Tracking fishing decline and species composition through time

The amount of fish bone per volume has been used to track the frequency of deposition as a proxy for the importance of fishing through time (Allen 2003: Figure 2). This is a useful measure but requires accurate volume estimates for each analytical zone. The longest stratigraphic sequences are for rockshelters GK-1 and -2 on Kamaka. Both depositional sequences contain numerous intercutting pits (Green and Weisler 2000: Figure 9) making volume estimates from profiles quite problematic. We simply do not have the necessary information to accurately esti-

mate bone density for these sites. Figure 2 approximates the trend in fish bone counts per layer at GK-1. Layer A is historic and aside from the spike at layer B, there is a downward trend in layers E, D and C. This is similar to diminishing fish bone frequencies per volume noted especially for Aitutaki (Allen 1992), Rotuma (Allen *et al.* 2001), Tikopia (Kirch & Yen 1982) and Hanamiai, Marquesas (Rolett 1998). However, some sites have shown the reverse trend with a marked increase in bone deposition over time (Ono & Clark 2010: Tables 4 and 5). Clearly, trends in bone deposition per volume merits regional study as one measure to chart the importance of fishing over time which may be linked to other, terrestrial based, subsistence practices (e.g., Allen & Craig 2009). Table 3 lists the NISP and MNI of identified fish bones from the GK-1 rockshelter. If we assign the prehistoric layers into a lower zone (layers F–J) and an upper zone (layers B–E) there is 68.5 per cent of all fish bone in the lower zone and 63.4 per cent of all NISP. This frequency distribution may be related to fishing intensity, but without accurate volumes for the analytical groups, it is not possible to say with more confidence.

The presence of fish families represented in each layer of GK-1 was tallied as a ubiquity measure (Table 3). The top-ranked taxa include Acanthuridae, Labridae, Lethrinidae, Scaridae and Serranidae which are present throughout almost all layers. Only Mullidae is found in the lower layers and Belonidae in the upper layers; however, both families total only seven NISP. Of interest here is the change in rank-order abundance for NISP and MNI. The top ranked families for NISP are Scaridae, Serranidae, Labridae and Acanthuridae, while the top ranked families

by MNI are Acanthuridae, Serranidae, Labridae and Scariidae. It is necessary, then, to report both sets of values for a fish bone assemblage especially if the ratio of serranids to scarids is used to infer the dominant capture techniques only by MNI (Leach & Davidson 1988; Leach *et al.* 1984).

## DISCUSSION AND CONCLUSIONS

### How representative is the Mangareva fish bone?

In order to better understand the significance of the Mangareva fish bone collected in 1959, we address: 1) recovery bias and 2) comparisons with other assemblages in Oceania, in general, and southeast Polynesia, in particular.

### Identification and recovery bias

A general examination of fish elements reveals a range of shapes, sizes and densities of bone elements that bias identifications. The upper and lower pharyngeal grinding elements of scarids have enamel dentition that preserves well and is one reason why this family dominates nearly all fish bone assemblages from the tropical Pacific. Conversely, flying fish and rabbitfish (Siganidae) have small fragile mouth parts and are rarely recovered from archaeological contexts (Masse 1989: 682–704; but see Weisler 1993) although today they are netted in large quantities as in the Marshall Islands where, in the case of flying fish, they are the primary species eaten over many weeks when seasonally abundant (Weisler 2001). Likewise ethno-archaeological observations in Sabah recorded siganids as the

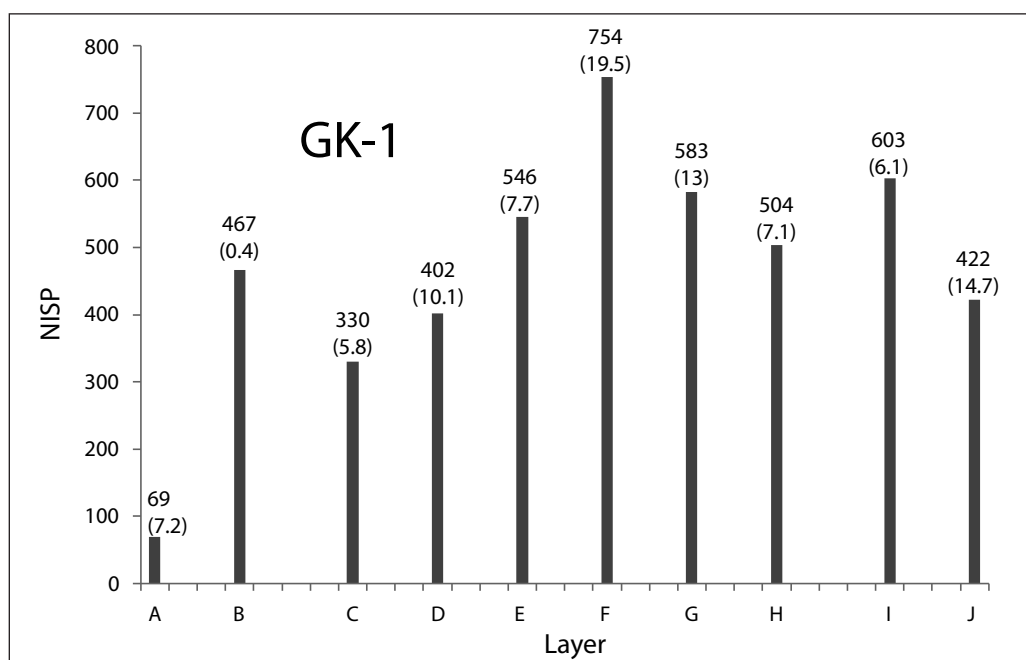


Figure 2. The distribution of fish bones and per cent burnt bones (in brackets) for stratigraphic layers of rockshelter GK-1, Kamaka Island.

Table 3. Stratigraphic distribution of identified fish bones from rockshelter GK-1, Kamaka Island, Mangareva.

Taxon	Layer												Total		Ubiquity	Rank Order													
	A		B		B-C		C		D		D-E		E			F		G		H		I		J					
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI			
Acanthuridae	1	1	4	4			3	3	13	13			22	11	14	12	15	12	5	5	3	1			9	80	62	4	1
Ballistidae			1	1				1	1										1	1	2	1	3	2	5	8	6	8	7
Belonidae			1	1	1	1																			2	2	2	11	10
Carangidae											1	1											3	1	2	4	2	9	10
Diodontidae								1	1						1	1						2	2		3	4	4	9	8
Holocentridae							1	1					3	1	6	2	1	1	1	1	1	1	1	1	7	14	8	6	6
Labridae	2	2	6	3			6	1	6	2			21	4	15	4	15	3	33	5	43	6	22	7	10	169	37	3	3
Lethrinidae	2	1	9	4	1	1	6	2	8	2	1	1	2	1		4	1	2	1	4	1	5	5	11	44	20	5	5	
Lutjanidae			1	1			1	1				2	1	5	2				1	1				5	10	6	7	7	
Mullidae																1	1	1	2	1				2	3	2	10	10	
Muraenidae												1	1	2	1	1									3	4	3	9	9
Scaridae	2	1	20	3	4	2	15	3	11	1	1	1	60	5	51	4	27	4	26	4	52	5	21	3	12	290	36	1	4
Serranidae	1	1	7	2	4	2	9	1	3	1	1	1	39	5	35	8	15	5	22	4	38	5	18	9	12	192	44	2	2
<b>Total identified</b>	<b>8</b>	<b>6</b>	<b>49</b>	<b>19</b>	<b>10</b>	<b>6</b>	<b>41</b>	<b>12</b>	<b>43</b>	<b>21</b>	<b>5</b>	<b>5</b>	<b>151</b>	<b>29</b>	<b>128</b>	<b>34</b>	<b>78</b>	<b>27</b>	<b>93</b>	<b>23</b>	<b>145</b>	<b>22</b>	<b>73</b>	<b>28</b>		<b>824</b>	<b>232</b>		
<b>Total bones</b>	<b>69</b>		<b>467</b>		<b>105</b>		<b>330</b>		<b>402</b>				<b>546</b>		<b>754</b>		<b>583</b>		<b>504</b>		<b>758</b>		<b>422</b>			<b>4940</b>			
<b>% identified</b>	<b>11.6</b>		<b>10.5</b>				<b>12.4</b>		<b>10.7</b>				<b>27.7</b>		<b>17.0</b>		<b>13.4</b>		<b>18.5</b>		<b>19.1</b>		<b>17.3</b>						

second most common species caught by net fishing (Ono 2010:271) and today rabbitfish are quite popular in Palau (Johannes 1981:11).

There are only 13 families (in addition to Elasmobranchii) inventoried from 1738 bones from five sites which, in comparison to other Polynesian assemblages, seems somewhat low. Comparisons between the number of fish families identified from 6.4 mm in contrast to 3.2 mm sieves generally documents that small bodied taxa such as Apogonidae, Pomacentridae, Priacanthidae, Aulostomidae and Belonidae will not be retained in the 6.4 mm sieves (Gordon 1993: Table 3) and that Acanthuridae has a low chance of recovery if 3.2 mm sieves are not used (Nagaoka 2005: Table 3). Interestingly, Acanthuridae is the highest ranked taxon in the Mangarevan assemblages by MNI, yet ranked fourth by NISP, along with Lethrinidae which has one of the highest recovery rates when 6.4 mm screens were used in experimental tests (Nagaoka 2005: Table 3). Additionally, Mullidae and Belonidae are families composed of generally small individuals that have a lower chance of retention in 6.4 mm sieves (Gordon 1993; Nagaoka 2005), yet bones of these families were identified in the Mangarevan assemblages. However, we have little doubt that systematic fine sieving with 3.2 mm and smaller will identify more taxa than we have presented here.

Recovery bias also pertains to over-representation of certain taxa in archaeological assemblages. In this regard, Scaridae is a prominent example as bones from this family are the most common identified fish elements in Pacific archaeological sites, excluding makatea islands (Weisler et al. 2010: Table 4). However, ethno-archaeological studies and personal observations tell a very different story. In their list of most frequently captured fish in Niuaotupapu, Tonga, Kirch and Dye report scarids far below acanthurids, mullids and pomacentrids (1979: Table 5) and Ono attributes Scaridae to only 4.4% of all fish recorded from 101 fishing sorties in Sabath (2010:Table 6). Observations in early 2012 on Ebon Atoll, Marshall Islands documented that parrotfish were never the top species captured during more than a dozen sorties. With the exception of makatea islands, these figures clearly mirror 30 years of participant observations across the Pacific by Weisler in all kinds of islands. Even modern fisheries research relegates Scaridae below the most frequently captured species (Wright & Richards 1985). The bias in scarid representation in archaeological assemblages is clearly due to its robust chewing and grinding elements which are heavily buttressed with enamel that not only preserves well, but makes elements easy to identify to family and oftentimes genus (e.g., Weisler 2001: Table 7.4). We do acknowledge that scarids can be an important part of modern indigenous fisheries and can be common reef components. The importance of scarids in prehistoric fisheries across island types and through time requires more thorough assessment.

### Comparisons with other Pacific assemblages

To place the Mangarevan fish bone assemblages in the broader Pacific context, we reviewed 16 analyses from across the Pacific (from East Timor to Henderson Island, Pitcairn Group) that reported identified fish bones from archaeological sites. We selected studies from all island classes: continental (Butler 1994; O'Connor *et al.* 2011), high volcanic (Allen *et al.* 2001; Gordon 1993; Leach *et al.* 1984; Rolett 1998), *makatea* or limestone islands (Butler 2001; Fitzpatrick & Kataoka 2005; Masse 1986; Ono & Clark 2010; Weisler, unpublished), almost atolls (Allen 2002) and atolls with and without passes (Ono & Intoh 2011; Weisler 2001, 2004, unpublished). We only selected studies that used: modern field techniques, extensive fish reference collections and a wider range of elements for identification than simply the five-paired head bones and some 'special' elements. The number of identified bones per study ranged from 497 to 5196 NISP, 373 to 1564 MNI or had >10,000 total fish bones. The average number of families identified per study was  $24 \pm 4$  and ranged from 17 to 30. Of the 59 taxa reported for all studies (56 families plus Elasmobranchii, Chondrichtheys and marine eel), the top 10 taxa (30.5 per cent) were widely distributed regardless of geography, while 29 taxa were identified in only three of the studies. Figure 3 illustrates the ubiquity of fish families identified in these archaeological studies. The ubiquity measure is used here to record the relative presence of particular fish families across selected Pacific assemblages. The number of families identified from archaeological assemblages showed no decline in diversity from west to east as is true of the natural distributions. For example, the largest number of families identified in any assemblage was in the Cook Islands (Allen 2002), east of sites in East Timor (O'Connor *et al.* 2011), Palau (Fitzpatrick & Kataoka 2005; Masse 1986; Ono & Clark 2010) and Rotuma (Allen *et al.* 2001) that have a higher diversity of fish families in their surrounding waters. Acanthuridae, Carangidae, Diodontidae, Labridae and Lutjanidae are reported in all 16 studies, whereas only Acanthuridae, Scaridae and Serranidae are represented at all the Mangarevan sites. The 13 families represented at our sites is well below the average of the studies inventoried here and reflects fishing strategies, collection methods and probably other factors as well. It is instructive, then, to compare assemblages from islands immediately west and east of Mangareva. Any identification bias is ruled out since all the bones were identified by Weisler.

### Comparisons with Southeast Polynesian assemblages

When viewed within the context of southeast Polynesia the Mangareva archaeological fish fauna stands out. This is, in part, because immediately to the west is the southeast extension of the atoll archipelago of the Tuamotus, where

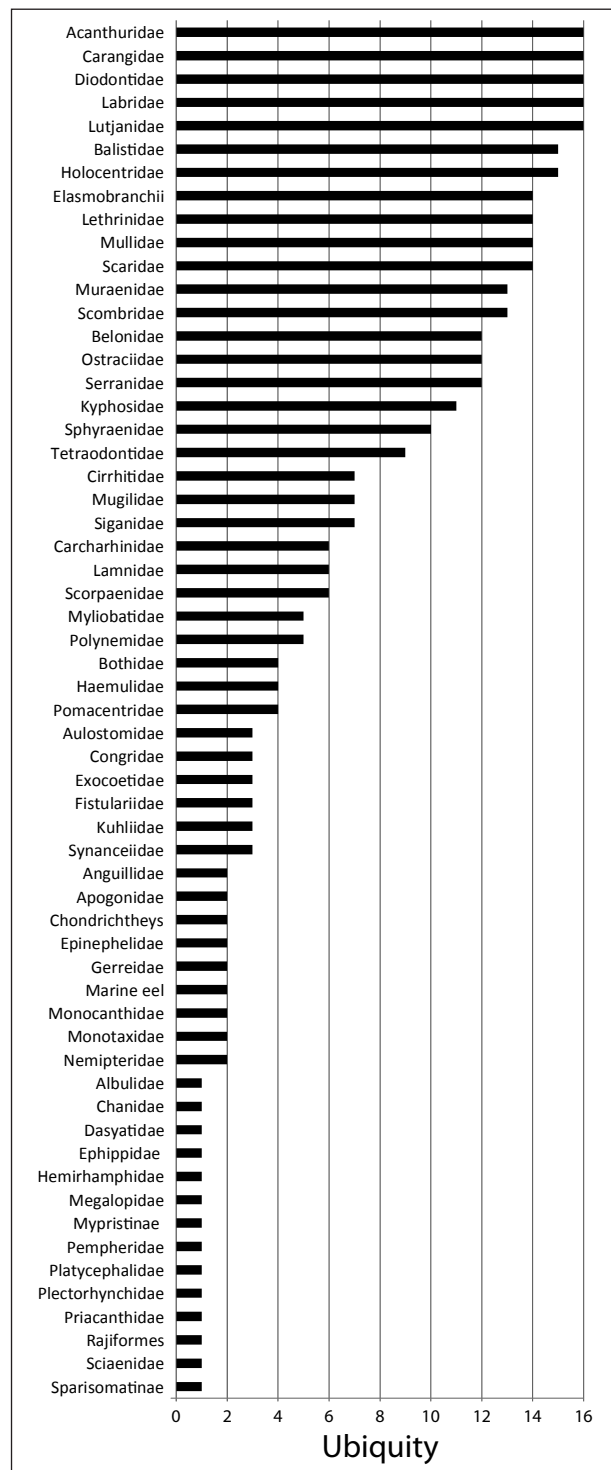


Figure 3. The ubiquity of fish families identified from 16 recent studies of archaeological fish bones from across the Pacific. Eleven families are commonly found in 14 of the 16 studies, whereas most taxa are represented by one or two occurrences. References include: Allen 2002; Allen *et al.* 2001; Butler 1994, 2001; Fitzpatrick and Kataoka 2005; Gordon 1993; Leach *et al.* 1984; Masse 1986; O'Connor *et al.* 2011; Ono and Clark 2010; Ono and Intoh 2011; Rolett 1998; Weisler 2001, 2004, unpublished.



Reao Atoll is situated. Some 400 km to the east is Henderson (Pitcairn Group) and, as a *makatea* island, has a unique fish bone assemblage. Reao Atoll, the high volcanic islands of Mangareva and the *makatea* (raised limestone) Henderson Island are all part of the same marine biogeographic province with similar fish diversity (Stoddart 1992: Figure 16). The top five ranked taxa for these islands are listed in Table 4. These taxa represent 79 to ~88 per cent of all NISP in these assemblages and are consistent with the Pacific as a whole where only a few taxa of a typical assemblage account for the vast majority of NISP. The obvious assemblage contrast is between Reao with 47.5 per cent scarids and Henderson with <1 per cent. Parrotfish are the dominant taxon at most atolls; see also Weisler (2001) for

Utrök Atoll, Marshall Islands and Temoe Atoll (Weisler 2004) just east of Mangareva. The highest ranked taxon at *makatea* islands is typically the groupers or Serranidae (Weisler *et al.* 2010: Table 5) which is probably the result of narrow reef platforms devoid of much live coral and high energy shorelines that restrict net fishing. By NISP, they account for 41.7 per cent at Henderson, 20.8 per cent at Mangareva and only 4 per cent at Reao.

We can use the data in Table 4 to infer capture strategies by adding per cent taxon values of fish species that are typically caught by angling. In this group we include here: Balistidae, Carangidae, Cirrhitidae, Fistularidae, Holocentridae, Labridae, Lethrinidae, Lutjanidae and Serranidae, although we recognise that small individuals of any of

Table 4. Rank order abundance of identified fish bone (NISP) from Reao Atoll, Mangareva and Henderson Island.

Taxon	Reao Atoll		Mangareva		Henderson Island	
	% Taxon	Rank Order	% Taxon	Rank Order	% Taxon	Rank Order
Acanthuridae	1.9		4.9	5	21.2	2
Anguilliformes (Order)	<1.0					
Balistidae	<1.0		2.3		2.5	
Belonidae			<1.0		<1.0	
Bothidae	<1.0					
Carangidae	1.4		<1.0		13.6	3
Carcharhinidae	<1.0				<1.0	
Chondrichthyes (Order)	<1.0				<1.0	
Cirrhitidae	<1.0				3.7	5
Congridae	<1.0					
Diodontidae	10.4	3	<1.0		2.2	
Elasmobranchii	1.7		6.4	4	<1.0	
Fistularidae	2.5					
Holocentridae	3.8		1.1		<1.0	
Kuhliidae	<1.0				1.7	
Kyphosidae	<1.0				<1.0	
Labridae	6.5	4	11.5	3	6.5	4
Lamniformes			<1.0			
Lethrinidae	<1.0		4.8		<1.0	
Lutjanidae	1.6		<1.0		<1.0	
Mullidae	<1.0		<1.0		1.2	
Muraenidae	2.5		<1.0			
Ostraciidae	2.2		<1.0			
Pempheridae					<1.0	
Polynemidae	<1.0					
Scaridae	47.5	1	43.9	1	<1.0	
Scombridae	<1.0		<1.0		<1.0	
Serranidae	4.0	5	20.8	2	41.7	1
Syngnathiformes (Order)	<1.0					
Tetraodontidae	10.9	2				
<b>Total identified</b>	<b>4481</b>		<b>2720</b>		<b>1725</b>	
<b>Total unidentified</b>	<b>15786</b>		<b>9561</b>		<b>30466</b>	
<b>Total bones</b>	<b>20267</b>		<b>11340</b>		<b>33194</b>	

Reao Atoll and Henderson Island sources: Weisler unpublished.

Mangareva sources: Kirch *et al.* (2010: Table 6); Howard & Kirch (2004: Tables 5.11 and 5.12) and this report. 1003 dermal spines removed from Henderson Diodontidae NISP.

these families can be caught inshore with nets. The results are striking: ~20 per cent of the Reao Atoll fish were captured by angling, ~40 per cent at Mangareva and 68 per cent at Henderson. These results suggest that the top ranked taxa for atolls and *makatea* islands should be predictable; whereas Mangareva seems to lie between these two extremes.

We can also examine the Henderson fauna to gain further insights into Mangareva assemblage composition. Most telling are the 20 families identified from just over 30,000 total fish bones from site HEN-5 at the species-depauperate Henderson Island. Because Henderson lies to the east of Mangareva, biogeographical distributions dictate that whatever non-endemic taxa are found there would likely be present in Mangareva. Noticeable exceptions to the archaeological fauna of Mangareva include members from the families: Bothidae, Cirrhitidae, Kuhlidae, Kyphosidae, Monacanthidae, Pempheridae and Pomacentridae. We believe that larger excavated samples, systematically processed using both 6.4 and 3.2 mm sieves, will increase the known diversity of the Mangarevan archaeological fish fauna.

## CONCLUDING THOUGHTS

Given more than a half century of advances in Pacific archaeology, there is little doubt that field and lab methods have gotten more sophisticated and new questions are routinely asked. We have analysed fish bone assemblages collected from five sites more than 50 years ago and made interpretations relevant to contemporary archaeological practice. We have described the field collection procedures in detail to provide a solid basis for comparing species representation with assemblages with southeast Polynesia. Regional comparisons with fish bone assemblages from an atoll and *makatea* island point to the unique set of fish families at Mangareva whose members are dominated by fish that could have been captured by a range of hook and line techniques, although fish size is important when interpreting capture techniques. Further work should consider additional excavations on Mangareva to increase the sample size from the largest island in the archipelago. Additionally, excavations at Tenoko (Weisler 1996:75), the only known midden situated along the barrier reef (Figure 1), should provide a fuller understanding of the range of fishing strategies undertaken from this island setting – and thus enhance the picture of prehistoric fishing and marine subsistence in the archipelago.

## Acknowledgements

We gratefully acknowledge Paul Beelitz, Belinda Kaye and Sharon Loetz who organised the Mangareva archaeological collections and made them accessible to Weisler in 1997. Permission to borrow the collections was made possible by David H. Thomas and members of the research committee,

American Museum of Natural History. The University of Otago humanities research committee supported Weisler's travel to New York to visit the museum, as well as some of the analytical studies. Figures were prepared by Les O'Neill (University of Otago) and Matthew Harris (University of Queensland). The comments of two anonymous reviewers are appreciated.

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