New Taxonomic Records and Regional Trends for the Marquesan Prehistoric Marine Fishery, Eiao Island, Polynesia

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ABSTRACT

Eiao Island (39.2 km², 577 m elevation), situated at the northern extent of the Marquesas Archipelago, features rocky and steep coastlines with few sheltered embayments that allow easy access to the sea and marine resources. We report the first evidence of prehistoric fishing practices from Eiao Island based on three inland sites (possibly dating from the 14th to 17th centuries), and explore variation in fish exploitation. All previous archaeological fishing records from the archipelago are from coastal sites, with inland Eiao Island assemblages offering comparative data on site location and taxonomic composition. The Eiao Island fish bone assemblages are dominated by piscivorous taxa, specifically grouper (Serranidae). Few tuna, mackerel and bonito (Scombridae) remains were recovered from the Eiao Island assemblages, compared to reports from Ua Pou, Tahuata and Ua Huka. New family-level taxonomic records added for the archipelago include: bonefish (Albulidae), requiem sharks (Carcharhinidae), butterflyfish (Chaetodontidae), flagtail (Kuhliidae), damselfish (Pomacentridae) and rabbitfish (Siganidae). These results further contribute to our understanding of prehistoric Marquesan fishing practices and allow elucidation of subsistence in coastal versus inland settings, variability in taxonomic composition between islands of the archipelago, and importantly inform on human-environment interactions in East Polynesia.

Keywords: prehistoric marine subsistence, ichthyoarchaeology, Eiao Island, Marquesas Islands, Polynesia

INTRODUCTION

Archaeologists studying prehistoric fishing practices across the world have contributed time-series data that track species richness and abundance, which are critical to understanding long term human-environment interactions (e.g., Allen 2017; Barrett *et al.* 2011; Campbell & Butler 2010; Erlandson *et al.* 2009; Fitzpatrick & Donaldson 2007; Giovas *et al.* 2016; McKechnie *et al.* 2014; Ono & Intoh 2011; Reitz 2014; Rieth & Morrison 2017; Speller *et al.* 2012; Van Neer & Ervynck 2010; Weisler & Green 2013). During the last several decades there have been significant advances in prehistoric fishing studies in the Pacific, with increasing methodological rigor (excavation practices, recovery techniques and analysis), and through incorporating theoretical frameworks such as historical ecology and human behavioural ecology (Lambrides & Weisler 2016). These advancements have enhanced our understanding of marine resource sustainability, ecosystem resilience,

resource depression and foraging efficiency. In this paper we provide the first account of prehistoric fishing on Eiao Island, which furthers our understanding of East Polynesian marine fisheries through the analysis of assemblages from an isolated high volcanic island at the extreme north of the Marquesas Archipelago.

Insightful for the time, Suggs (1961:13) stated that the well-watered eastern and southern coasts of the Marquesas Islands were more favourable for habitation. Aswani and Allen (2009) noted a correlation between the location of early sites in the archipelago and coral reef cover (Conte & Molle 2014; Davidson *et al.* 1999; Rolett 1998; Sinoto 1970; Suggs 1961). Early insights into Marquesan fishing were derived from archaeological material culture studies; a transition from diverse fishhook kits to a predominance of small jabbing hooks in later prehistory was attributed to environmentally driven adaptation (Sinoto 1966, 1970; Sinoto & Kellum 1965; Skjølsvold 1972; Suggs 1961). However, utilising material culture studies and fish bone analyses from Ua Huka and Hiva Oa, Dye (1990) argued that the decline in the Marquesan fishing industry through prehistory, as demonstrated by a shift from offshore to inshore resource exploitation, a reduction in rotating hooks and bonito lures, and corresponding increase in mollusc and pig exploitation, could also be attributed to social factors,

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such as the rise of a class system and restricted access to certain resources (see also Davidson *et al.* 1999).

We analysed fish bone from three prehistoric sites from Eiao presenting the first archaeological fishing records from inland sites for the archipelago and situate these assemblages within the context of regional trends in prehistoric Marquesan fishing practices.

ENVIRONMENTAL AND ARCHAEOLOGICAL BACKGROUND

The Marquesan environment

Forming between 5.5 and 0.4 Ma, the eight main islands and several islets and seamounts of the Marquesas Archipelago trend south-east to north-west for 350 km in a roughly linear alignment (Figure 1). Although many
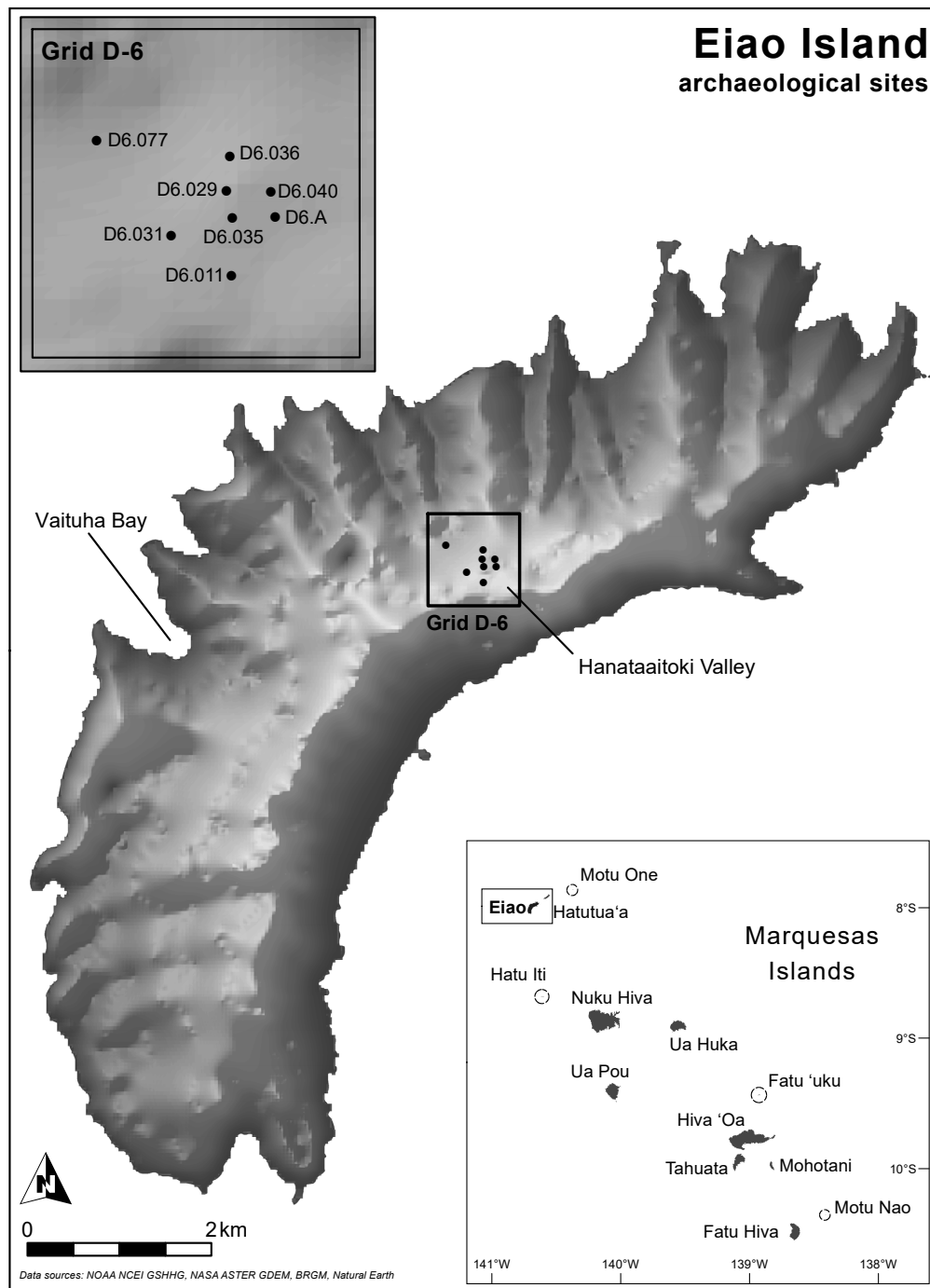

Figure 1. Map of Eiao Island with site locations, inset of the Marquesas.

island groups in the eastern Pacific are time-progressive archipelagos, a clear correlation between the timing of volcanism and distance to a presumed hotspot remains unclear for the Marquesas Islands (Crough & Jarrard 1981; McNutt *et al.* 1989). The largest and most fertile islands of the Marquesas are Nuku Hiva (339 km², 1224 m highest elevation) and Hiva Oa (320 km², 1213 m elevation) both of which have rugged and steep coastlines but, importantly, have a few deep embayments with sheltered reefs and adjacent coastal flats – favoured locales for early colonisation sites (Aswani & Allen 2009; Suggs 1961:13). Situated at the northern extent of the archipelago the 13 km long crescent-shaped Eiao Island (39.2 km², 577 m elevation) represents the remnant of a caldera wall of a larger volcano (25 km in diameter), which underwent catastrophic collapse (Liotard *et al.* 1986). The coastline is rocky and steep with only a few small sheltered embayments, mostly on the north and west coasts, where access to the sea is easier (Figure 2). Surface rocks are predominately alkali-rich basalts, which were commonly used to fashion adzes and flake tools; in fact, Eiao has one of the most extensive

stone adze quarry complexes in East Polynesia (Weisler *et al.* 2016a).

Precipitation throughout the archipelago is highly variable with frequent droughts, but windward (north and east) sides of islands receive more rainfall that is influenced by the Humboldt Current (also known as the Peru-Chile current system) which flows north along the Chilean coast, then towards the equator (Kämpf & Chapman 2016: Figure 5.3). El Niño ENSO events influence the periodicity of droughts, while La Niña episodes evidence colder waters and strengthened upwelling (Kämpf & Chapman 2016:169). This latter condition may be a contributing factor to the relatively high abundance of tuna in many Marquesan middens (see discussion below).

The Marquesas Islands is a unique region in terms of its marine and terrestrial biodiversity (Galzin *et al.* 2016). A recent biological survey of Marquesan shore fishes increased the known species from 415 to 495, with the number of endemic species increasing 2.1% (13.7% of all species) making the Marquesas the third highest for endemism after the isolated Hawaiian Islands and Easter
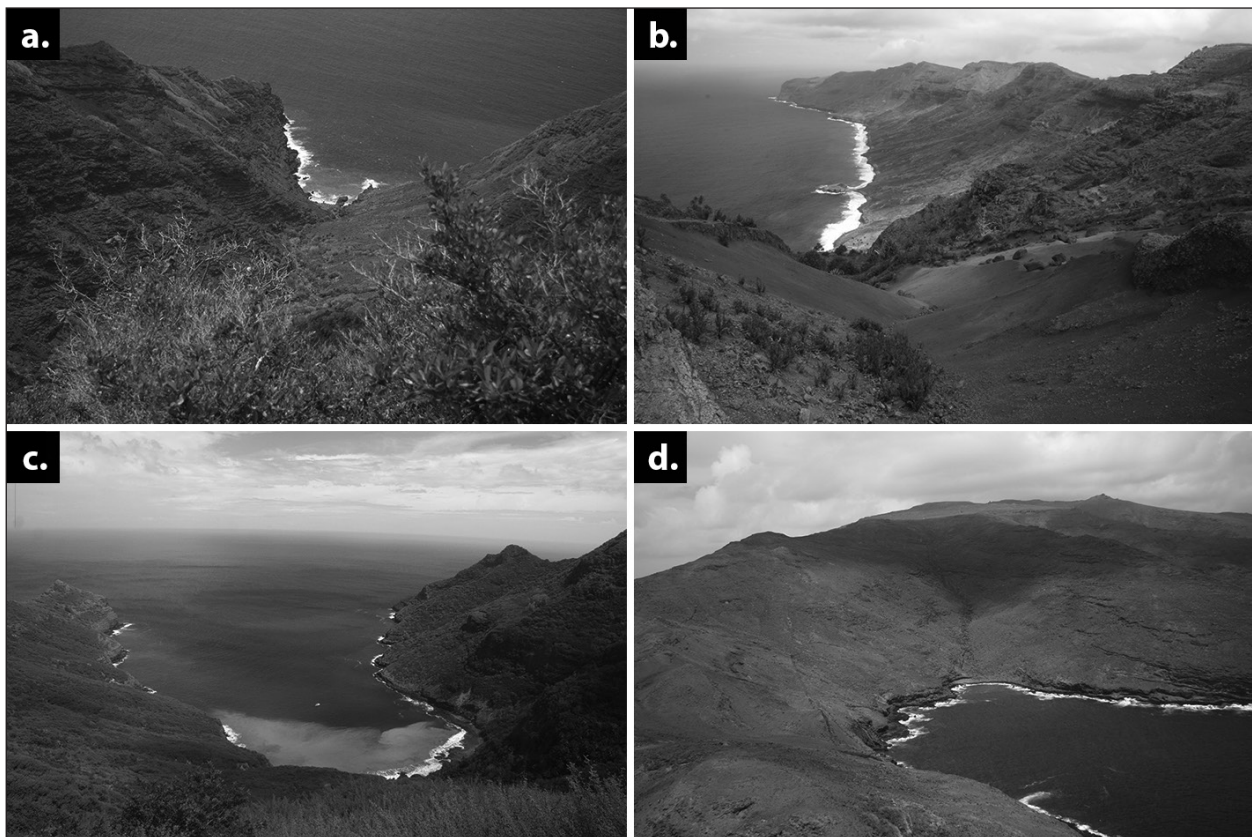

Figure 2. Representative photos of the Eiao coastline which is mostly rocky and steep. (a) Bay below Hanataaitoki Valley seen from about 400 m above sea level and nearly 2 km from the excavated habitation sites reported here; (b) The southeast coast from the top of the crest. A small islet (*motu*), of fossil eolian deposits, extends from the shore in the middle of the photo; (c) Vaituha Bay, west coast, taken from the slopes. Silt erodes into the bay after rains and muddy water can last for days to weeks contributing to ciguatera in fish; (d) One of the north coast bays seen from a helicopter. (All photos by M. Charleux.)

Island (Rapa Nui) in the extreme margins of Polynesia (Delrieu-Trottin *et al.* 2015). Sea surface temperatures are variable (26–30°C) in the Marquesas despite proximity to the equator (Randall & Earle 2000). Even though species richness is low across the archipelago, fish biomass is high, with communities dominated by piscivores and planktivores, unlike the more common carnivore and herbivore fish communities associated with the South Pacific (Planes *et al.* 2016). The strong upwelling of nutrient-rich waters in the region contributes to higher than average abundances of pelagic taxa; specifically, tuna longline catches are often double those recorded for other French Polynesian archipelagos (Taquet *et al.* 2016). Often associated with embayments, the few Marquesan coral reefs are relatively undeveloped when compared to other French Polynesian archipelagos (Planes *et al.* 2016). Diminished coral cover has been attributed to the upwelling of cold nutrient-enriched waters from the Humboldt Current (Suggs 1961:13), but this also increases primary productivity in the region. The upwelling of cold, low salinity and nutrient-rich waters from the Humboldt Current also has important implications for the marine fishery as colder water temperatures restrict coral formation and reef development (typical of the Marquesas), yet support a relatively high biomass of zooplankton and small pelagic fish (jack mackerel, anchovies and sardines) which attract tuna and larger carnivores (Martinez & Maamaatuaiahutapu 2004; Wolff *et al.* 2003).

Previous studies of Marquesan archaeological fish remains

When compared to other Pacific archaeological fish bone assemblages (e.g., Allen *et al.* 2001; Fitzpatrick *et al.* 2011; Ono & Clark 2012; Weisler & Green 2013; Weisler *et al.* 2016b), higher abundances of scombrids and other piscivorous taxa have been reported at Marquesan sites (Allen 2017: Figure 47.2). Ua Huka Island was a primary focus of the early Marquesan fishing literature, particularly the Hane Dune site (e.g., Davidson *et al.* 1999; Dye 1990; Kirch 1973; Sweeney *et al.* 1993), and the debate surrounding a shift from primarily marine to terrestrial resource exploitation through time.

Kirch (1973) analysed fish bone assemblages from Ua Huka recovered in the 1960s by Sinoto and Kellum and, while sample size was small (total bones identified = 183) and identification protocols have greatly improved since then, serranids and lutjanids were prominent within the assemblage. Although dentaries and premaxillae of these taxa are relatively easy to identify, a re-analysis using modern analytical techniques would undoubtedly increase species richness (see for example, Weisler *et al.* 2016b: Table 4). Additionally, Kirch's (1973:36–39) analysis of mollusc shell, bone remains (pig, bird, turtle and fish), urchin and crustaceans suggested a shift in focus from marine to terrestrial resources through time, which was argued to be more economically viable. More comprehensive analyses

of fish bone assemblages housed in the B.P. Bishop Museum were conducted by Dye (1990), including assemblages from the Hane Dune site, Hanatakua, and Hanapeteʻo Cave – the latter two sites located on Hiva Oa. The early layers of the Hane Dune and Hanatakua sites indicated that pelagic taxa were equally as abundant as inshore and bottom dwelling taxa, which suggests that a wide range of marine habitats were being exploited (Dye 1990:75). Yet, when compared to the late assemblages – from Hanapeteʻo Cave and the late layers of the Hane Dune site – a higher proportion of the identified fish bones represented inshore and bottom dwelling taxa. Dye (1990) broadly suggested that driven by social factors, a decline in offshore fishing occurred through time in the Marquesas, and an increased reliance on molluscs and pigs was reflected archaeologically. These trends were disputed by Sweeney *et al.* (1993) from a reanalysis of Dye's (1990) datasets (see also Anderson *et al.* 1994), which indicated that subsistence change did not occur, and that temporal trends outlined by Dye (1990) were a result of spatial and functional variability between sites (but see Dye 1996).

Fish assemblages from the Hane Dune site were most recently analysed by Fraser (1998:81–92) and Davidson *et al.* (1999). Scombrid remains accounted for ~26% of total MNI, but a high proportion of the assemblage could have been captured with trolling lures as well as by angling. Increased abundance of scombrids compared to previous analyses of the site (Dye 1990; Kirch 1973) was due to the inclusion of more elements for identification, such as vertebrae (Fraser 1998:87). Overall, the limited evidence for the exploitation of inshore taxa could be explained by the absence of extensive reef flats and lagoon waters, leading to the exploitation of the more productive reef edge. A decline in scombrids was reported over time, with a corresponding increase in inshore resource exploitation (Davidson *et al.* 1999). These trends have been attributed to cultural factors, but as the timing of this decline is not accurately known, these trends cannot be further evaluated. In the last several years, Conte and Molle (2014) have re-excavated the Hane Dune site to establish a more precise chronological sequence. Settlement was reported from ~950 cal BP to ~400 cal BP, but as the new excavations were only conducted in Area B (Conte & Molle 2014), and given that fish bone from both Area A and B was analysed by Davidson *et al.* (1999: Table 5), these new dates are difficult to correlate with the original excavations and the observed trends in scombrid abundance.

Similar declines in pelagic taxa/scombrids have been noted elsewhere in the Marquesas Islands. At Te Anapua, Ua Pou, Scombridae was the top ranked taxon by MNI and accounted for 25% of the total assemblage, which was also dominated by piscivorous taxa. A decline in scombrids and corresponding increase in serranids and holocentrids was reported through time, but no obvious alterations in capture methods were identified (Fraser 1998:92–101; Leach *et al.* 1997). Additionally, the dating of the site is

problematic, as an anomalously early date of ~2100 ± 95 BP was reported for basal deposits (calibrated dates were not provided). However, the latter date of 770 ± 50 BP (Ottino 1992) is more consistent with archipelago-wide settlement models (Allen & McAlister 2013). Finally, at Hanamiai on Tahuata Island, excavations by Rolett (1998) reported site occupation from ~925 cal BP. Declines in exploitation of pelagic and offshore deep-sea fish species (e.g., scombrids, large/medium bodied serranids and lutjanids, etc.) and corresponding increases in fish remains represented by inshore dwelling species were noted through time (see also Dye 1990), so too were increases in fish taxa commonly captured by spearing, netting and poisoning. While sample size is small (total bones identified = 497), the assemblage was dominated by piscivorous taxa, similar to other Marquesan sites.

The multidisciplinary project established in 2003 by Allen and colleagues focused on Anaho Bay, Nuku Hiva to assess long term human-environment interactions. Subsequent excavation and analysis has also been completed at the Hakaea Beach site and Hatiheu Valley (Allen 2004; Allen & Addison 2002; Allen & McAlister 2010, 2013; Allen *et al.* 2005; Aswani & Allen 2009). Archaeological fish bone assemblages from Anaho Bay are dominated by scarids, lutjanids, serranids and carangids (Allen 2004; Aswani & Allen 2009). However, Anaho Bay has a well-developed coral reef, which likely accounts for the higher occurrence of scarid remains compared to other Marquesan sites.

The temporal changes in fishing practices noted by earlier researchers, particularly declines in offshore fishing and the exploitation of scombrids, cannot be addressed using the Eiao fish bone assemblages as, based on the limited dating using unidentified wood charcoal, it is possible that many of the cultural deposits are contemporaneous (see below). However, these assemblages are the first archaeological fish bone reported from Eiao and contribute the initial account of fish exploitation inferred from inland sites in the Marquesas, thus enhancing a review of archipelago-wide trends in prehistoric fishing subsistence practices.

Eiao Island archaeology, the study sites and radiocarbon dating

Compared to some of the other islands of the Marquesas, archaeological research on Eiao has been limited to surface surveys, mostly restricted to residential architecture and to the major adze quarry complex. Linton (1925:106–107) completed the first archaeological survey of Eiao recording several house platforms and adze workshops noting that broken adzes, rejects, and 'chips' were located all along the plateau and the southern end of the island. Suggs (1961) visited the island briefly and collected a few basalt flakes (geochemically analysed by Weisler 1998: Table 1), while Candelot (1980) focused primarily on the surface

architecture. Interested mostly in the adze quarry complex, Rolett (2001) recorded a stone-working area on the north of the island. In 1987, 2010, 2011 and 2013 Charleux surveyed the island and noted that habitation and adze working sites were predominantly numerous in the north half of the island, along the plateau. The highest site density appeared to be in the Hanataaitoki Valley with habitation, basalt extraction and reduction areas noted (Weisler *et al.* 2016a: Figure 1). Adze material and geological samples collected from Eiao by Charleux have been geochemically analysed (Charleux *et al.* 2014; Weisler *et al.* 2016a) and artefacts from Eiao have been recovered elsewhere within the archipelago (e.g., Allen & McAlister 2013; McAlister 2011; Rolett 1998) and throughout East Polynesia (Di Piazza and Pearthree 2001; McAlister *et al.* 2013; Weisler 2008: Figure 52.2, *et al.* 2016a, c) attesting to its importance. The dated contexts with Eiao stone artefacts document use of Eiao Island by the 13th to 14th centuries (Rolett 1998; Weisler 1998).

During five field seasons between 1987 to 2013, Charleux identified what is likely the densest concentration of residential and fine-grain basalt quarry features on Eiao situated between ~400–550 m elevation along the plateau at Hanataaitoki Valley, within grid square D6 (Figure 1). Sites were recorded using the World Geodetic System (WGS) 1984 where 07M indicates the Pacific region. Several large pavements (*paepae*), one up to 72 m long, and five *hiamoe* or house sites were situated near stone extraction and working areas. All residential sites are a combination of *hiamoe* and/or *paepae*. The plateau has fine-grain basalt resources which were undoubtedly the main attraction to this inland part of the island; however, access to the coast is challenging. The west coast is accessed along the difficult lower valley route and down short waterfall cliffs (2–2.5 km total distance). The south-east coast is slightly closer to the plateau habitations, but it is necessary to traverse the crest and then down the wall of the caldera and its 200–300 m cliffs. The least challenging route is to Vaituha Bay, a three to four hour walk, descending ~500 m in elevation. At initial settlement, the plateau was probably covered by an open canopy forest, while today *hau* (*Hibiscus tiliaceus*) often covers archaeological sites with only a few candlenut trees (*Aleurites moluccana*) and two coconut palms seen; Linton (1925:106) also noticed rosewood (*mi'o*, *Thespesia populnea*) in the early 1920s. Other residential site complexes and site types have been identified across Eiao Island (Candelot 1980), and while Hanataaitoki Valley has been the focus of excavation given the important basalt resources in the area, continued excavation of the island, particularly coastal sites, will provide datasets useful for further considering island-wide trends.

Charleux excavated nine features/sites, with excavation totalling 69 m² (11.4 m³). We focus on three sites that produced 97 per cent of the total fish remains identified.

Site MEI.D6.011.B.C1 and 2
(X: 07M0535337; Y: 9117006; Z: 443 m)

A small, relatively well preserved *hiamoe* situated on the western eroded slope of the Hanataaitoki Valley (Figure 3a), the structure consists of a stone enclosure, 2 by 6 m, oriented roughly north-south, with half the length paved. The eastern face of this enclosed sleeping area has two courses of stones to compensate the slope. Excavation unit C1 revealed a small fireplace, a post hole and some fauna – the fish bone, numbering less than 10 bones, was not available for analysis. This unit was expanded 0.5 m to the south and designated unit C2, which revealed numerous fish bones and scales, mollusc shells, a few stone tool fragments, and two post holes – all to a maximum depth of ~70 cm below surface (Figure 3b).

Site MEI.D6.011.E.C1
(X: 07M0535355; Y: 9116987; Z: 474 m)

Located on the deforested red clayey eroded slopes of upper Hanataaitoki Valley, this site remnant consisted of four stones forming a right angle (Figure 3c). It originally

was not selected for excavation but the discovery of two octopus lure sinkers and some rat bones eroding from intact cultural deposits suggested that excavation might be worthwhile. Excavation unit C1 (Figure 3d), to 45 cm below surface, revealed abundant wood charcoal, a large number of fish and rat bones, mollusc shells, and dog bones (jaw fragments and teeth) – the first and only dog bones recovered from Eiao (Charleux in prep. a). Two octopus lure sinkers and 13 unfinished or broken stone adze preforms were also collected during the excavation.

Site MEI.D6.036.G
(X: 07M0535357; Y: 9117324; Z: 431 m)

This large *paepae*, >72 m long and 15 m wide (1080 m²), was built to reduce the natural slope from ~25 to 15–16 degrees. The downslope face consists of one to three courses of basalt boulders up to 1.5 m high, while the surface of the *paepae* is almost completely paved. (Figure 4a). The *paepae* contains at least five structures (*hiamoe*) and basalt flakes are associated with all the features. Unit G was situated in an area free of pavement, about 3 m from the *paepae* facing. Excavation to sterile subsoil at 1.08 m below surface
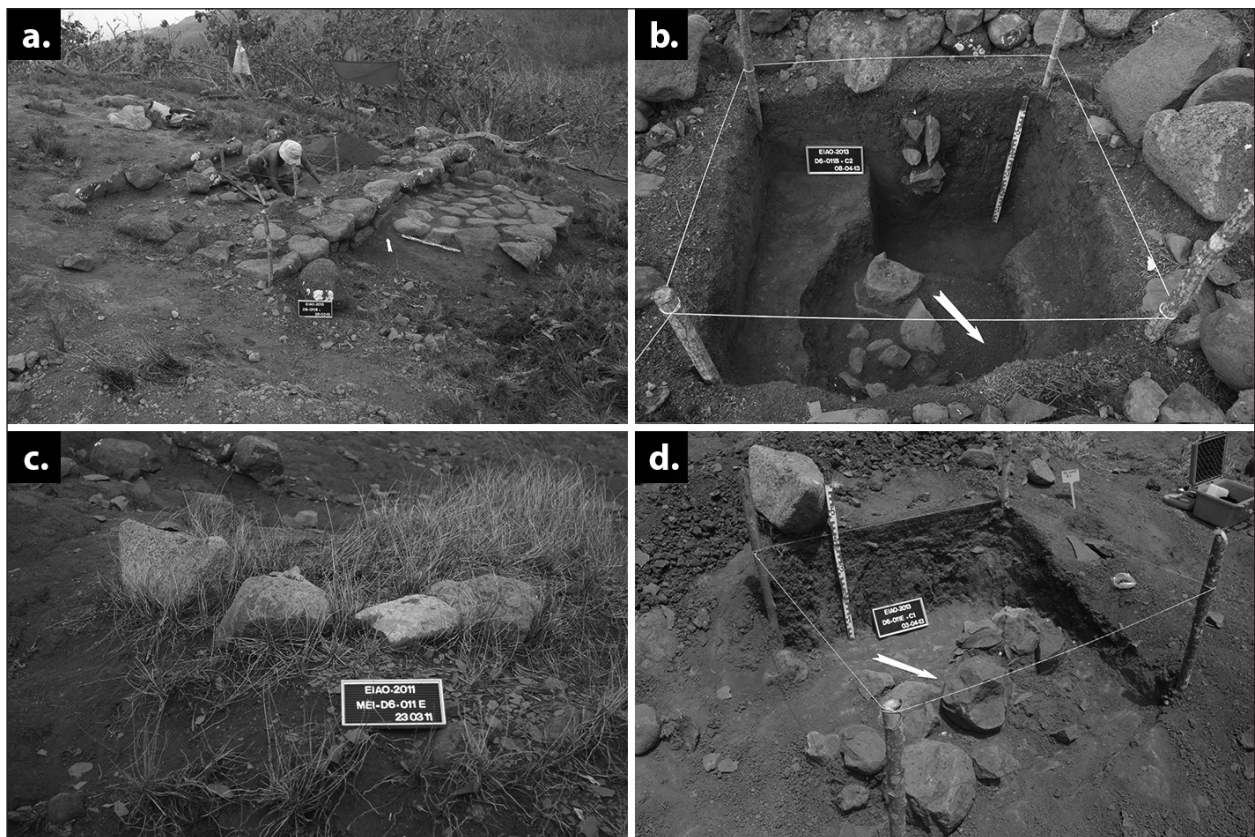
Figure 3. One of the three sites that contributed most fish bone to this study. (a) *Hiamoe* site MEI.D6.011.B, view north, during excavation of unit C1; (b) South profile of unit C2 at site MEI.D6.011 showing stone-filled post mould in profile and circular pit feature; (c) Site MEI.D6.011.E, consisting of stone alignments and associated basalt flakes, before excavation in 2011; (d) South profile of unit C1 at site MEI.D6.011.E. (All photos by M. Charleux.)
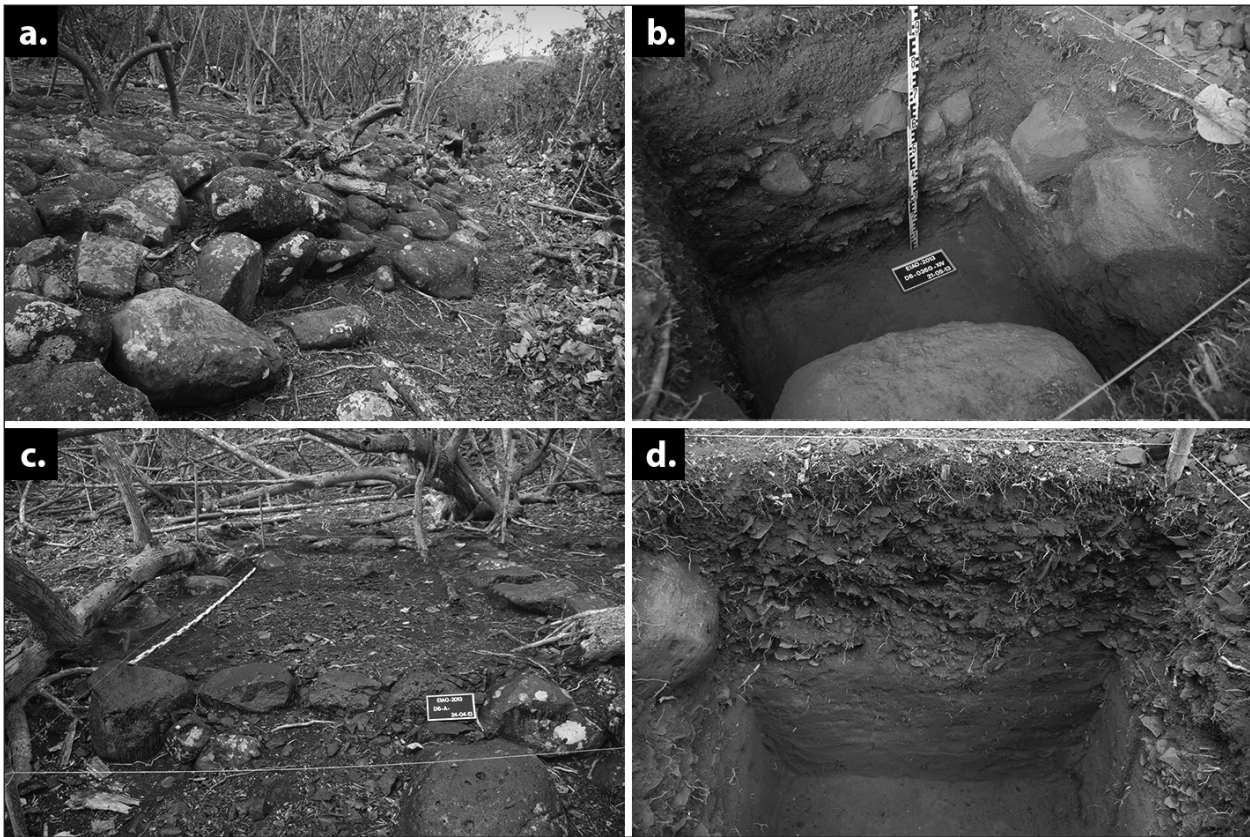
Figure 4. Two additional sites that contributed most fish bone to this study. (a) Stone-filled terrace (*paepae*) site MEI.D6.036 looking northeast; (b) Stratigraphy of the MEI.D6.036.G excavation unit showing dense lithic material, combustion features with concentrated ash, and level XIV sterile subsoil exposed ~1 m below surface; (c) Site MEI.D6.A associated with dense concentrations of basalt flakes and adze blanks; (d) Stratigraphy at site MEI.D6.A, unit C1 showing ~0.5m thick layer of basalt flakes atop sterile subsoil. (All photos by M. Charleux.)

revealed combustion features and mostly basalt flakes and adze blanks (Figure 4b). Aside from fish remains, bones included those of birds, pigs and rats. Other midden constituents and specifically rat bones and sea mammal bones will be reported elsewhere (Charleux in prep. a).

Site MEI.D6.A.C1/C2
(X: 07M0535458; Y: 9117153; Z: 430 m, estimation)

This site is located in the upper part of Hanataaitoki Valley, a flat zone with dense trees, roots, and fallen branches, where runoff leaves a deposit of fine red clay. This zone is in the middle of thousands of square meters covered with medium to large flakes, worked basalt cores, broken stone tools, hammerstones, preforms of different types and a polishing stone. Some other *paepae* have been noted in the area but have not been studied to date. However, the area was densely occupied. The excavated structure is a typical *hiamoe* (Figure 4c). The first square metre unit C1 was excavated inside the unpaved area and revealed two pits with a thick accumulation of flakes (Figure 4d). The excavation was terminated at 1.03 m below surface, in a

yellow-reddish brown silty-clay deposit. Wood charcoal, fish, bird and rat bones were encountered as well as mollusc shells and pieces of coral. An ovoid hammerstone and an adze preform were also collected. A second square metre (unit C2), separated by 0.20 m baulk, was excavated revealing a pit with three water-rounded basalt boulders probably used to support a wooden post situated in the middle of the sleeping zone. Wood charcoal (including *Pandanu*s sp.), fish and bird bones were identified.

Five other sites will not be discussed in detail here as they produced a combined total of only 29 fish bones. Sites D6.029.F2 and D6.031.C2/C5 are basalt flake accumulations; D6.035.C2/C4 and D6.040.C2/D2 house sites (*hiamoe*) and D6.077.D a fireplace.

Radiocarbon dating

Four accelerator mass spectrometer (AMS) dates were obtained from combustion features near the basal cultural deposits of all excavated features/sites that contained substantial amounts of fish bone (Charleux in prep. b). Samples were selected by Charleux and submitted to the Cen-

tre de Datation par le Radiocarbone (Lyon, France) and the Radiocarbon Dating Laboratory, University of Waikato, New Zealand. Unfortunately, the wood charcoal was not identified in order to select appropriate short-lived species for dating, so some or all of the dates may be older than the actual target date (Dean 1978: 228). Since coconut, candlenut (*Aleurites moluccana*) and rosewood (*Thespesia populnea*) grow on the plateau where the study sites are located and these taxa are considered 'long-lived' (>75 years; Allen and Hubert 2014: Table 1), their use as fuel would add significant years to the dates. Additionally, only the basal deposits were dated from cultural layers that were 45 to ~100 cm thick, so we don't know the duration of occupation of each site. Consequently, it is possible that some cultural deposits are contemporaneous across the sites. The AMS dates are presented in Table 1. Both labs note that the δ^{13}C was measured on prepared graphite using the AMS spectrometer. The radiocarbon dates were therefore corrected for isotopic fractionation. The AMS-measured δ^{13}C value can differ from the δ^{13}C of the original material and it was therefore not reported. Conventional ages were calibrated using Calib 7.1 (Stuiver *et al.* 2017). There is a spread of 300 years between the median dates of the three sites (AD 1350 to 1654) and, for reasons above, we did not examine changes in the fish bone assemblages over time and consider all assemblages possibly dating to between the 14th and 17th centuries.

METHODS

Field and laboratory methods

Excavated bone was recovered using 1.6 mm mesh screens and all sediments were dry screened. All the bone was shipped to The University of Queensland Pacific Archaeology Laboratory where the fish was separated for taxonomic identification and all other bone returned. Unfortunately, during transport to The University of Queensland, additional bone fragmentation occurred, which was evident from the fresh bone surfaces. NISP (of identified fish bone) and total bone counts (including identified and unidentified fish bone) may have been affected by this post-

excavation fragmentation, although attempts were made to exclude fresh breaks from these counts. Rather than using a preselected range of elements for identification to lowest taxonomic level, all fish bone elements were attempted for identification to ensure that element selection would not impact richness and evenness (see Lambrides & Weisler 2015a: 57; Weisler 2001, for a description of the comparative collection). Genus and species taxonomic identifications were cautiously assigned, as despite lower fish biodiversity than other regions of the tropical Pacific, endemism is high across the Marquesas Islands and our fish reference collection lacked these unique, endemic taxa (Delrieu-Trottin *et al.* 2015; Randall & Earle 2000). Taxonomic abundance was quantified using NISP and MNI values. Fish bone assemblages were aggregated by site prior to MNI calculations for examining assemblage differences between sites, but not within sites as there were few dated contexts in which to chart changing richness and evenness of taxa over time. Consequently, we can document prehistoric fishing adaptations on Eiao – possibly dating from the 14th to 17th centuries – and provide comments on the taxonomic composition represented by inland sites.

Regarding issues of quantification using NISP and/or MNI, we argue that for any given taxon there is a need to consider not only the number of identifiable elements, but the relationship between the number of elements that can be identified and the number of each element in an individual specimen – this varies across taxa. For example, Diodontidae (Porcupinefish) possess ~200–300 dermal spines that often preserve well and are easy to identify to family. Consequently, it can be overrepresented relative to other taxa (e.g., Sweeney *et al.* 1993; Weisler *et al.* 2016b), especially if NISP is the only measure of quantification. MNI can be problematic due to issues of aggregation (e.g., Grayson 1984), but given that MNI was calculated at the site level for the Eiao assemblages (i.e., all layers from each site were aggregated prior to MNI calculation), this is not an issue in this study. MNI calculations, as used in this study, are considered a conservative estimate of relative taxonomic abundance. As measures of quantification NISP and MNI have well-known limitations, the use of either measure will need to be justified on a case-by-case

Table 1. *Accelerator mass spectrometer (AMS) results for Eiao Island habitation sites.*

Provenance	Lab ID	Material	Conventional ^{14}C age ± 1σ (BP)	δ^{13}C (‰)	cal AD (2σ range)	Median	% Probability
D6.011.B.C1/level VI/60cmbs	Lyon-11428	Unid. wood	645 ± 30	NR	AD1282–1327; 1342–1395	1351	44.2; 55.8
D6.011.E.C1/level VI/42cmbs	Lyon-11419	Unid. wood	650 ± 30	NR	AD1280–1325; 1343–1394	1350	45.6; 54.4
D6.036.G/level XIII/86-92cmbs	Lyon-11423	Unid. wood	250 ± 30	NR	AD1522–1575; 1626–1679 AD1764–1800; 1939–1950	1654	15.3; 59.6; 21.9; 3.3
D6.A.C1/level VI/65cmbs	Wk-40390	Unid. wood	356 ± 20	NR	AD1458–1525; 1556–1632	1539	50.1; 49.9

Provenance: D6 is the Eiao Island 1 km square grid designation, 011 is the site number, E is the feature number, and C1 is the excavation square.
Lab ID: Lyon is the Centre de datation par le Radiocarbone (Lyon, France) and Wk is the Radiocarbon Dating Laboratory, University of Waikato, New Zealand
Both labs do not report (NR) δ^{13}C for AMS dates (see text for discussion)
Conventional ages calibrated using CALIB 7.1 (Stuiver *et al.* 2017)

basis, rather than advocating a universal approach, which implies that a single method is appropriate for all assemblages and research questions (Lambrides & Weisler 2016).

Statistical analyses

Fish remains from eight archaeological sites in the Hanataaitoki Valley were analysed, but only three of these sites (D6.011.B.C2 and D6.011.E.C1 represent two architectural features at one site, D6.A.C1/C2 and D6.036.G) provided sufficient sample size to determine inter-site assemblage differences and to infer potential variation in fishing practices; the other sites, which yielded a total NISP of 28, will only be briefly considered. These sites are located ~2–2.5 km inland and access to the ocean is difficult due to the topography of Eiao. The total excavated area was 16 m² – considering only sites that contained fish bone remains and discussed in the previous section – yet fish bone was sparsely distributed resulting in a concentration index of 485 bones per m³ (Table 2) for all sites.

All statistical analyses were completed using NISP and MNI values. Here we use five measures of taxonomic heterogeneity: NTAXA, Shannon-Weiner index of diversity (H') and Shannon's evenness (E), Fisher's α, Simpson's index of diversity (1-D) to test for differences in taxonomic richness, diversity and evenness within and between sites. All measures of taxonomic heterogeneity were calculated using mutually exclusive taxa (or non-overlapping taxa), specifically all NISP and MNI values were collapsed into mutually exclusive categories to prevent inflation of NTAXA or to artificially increase differences between sites. Mean trophic level (MTL) was estimated to detect alterations in the feeding guilds represented by captured taxa. All statistical analyses were completed using Past, version 3.11 (Hammer *et al.* 2001).

NTAXA allows an assessment of taxonomic richness for each site assemblage. We acknowledge that our study sites possibly date to between the 14th and 17th centuries,

but separating the assemblages by site provided a means to examine inter-site variability. The relative representation of fish taxa was determined using Shannon-Weiner index of diversity (H') and Shannon's evenness (E). Higher H' values indicate greater species diversity and richness. Assemblages dominated by a single taxon are indicated by E values close to 0, compared to those that are rich and even and are closer to 1 (Lyman 2008). Fisher's α was calculated to provide an assessment of diversity that is independent of sample size, unlike NTAXA and Shannon's indices (Faith 2013; Hayek & Buzas 2010). Simpson's index of diversity (1-D) was used to assess dominance; values range between 0 and 1, and low values suggest an assemblage dominated by a single taxon (Magurran 2004). As demonstrated by Faith & Du (2017), assemblage richness can also influence measures of evenness; Simpson's index was found to be the most useful given that it is insensitive to changes in richness and sample size, efficient at detecting minor changes in evenness (even for assemblages with small sample size), but its discriminatory power is reduced when assemblages are move even. Finally, MTL for each site was estimated using MNI in accordance with the formula utilised by Reitz (2004:70). Trophic level data were obtained from FishBase (Froese & Pauly 2016). For higher level taxonomic identifications (i.e., family and genus), trophic levels were calculated based on the modern geographic range of genera and species according to checklists of Marquesan fish species (Delrieu-Trottin *et al.* 2015; Froese & Pauly 2016; Randall & Earle 2000). Archaeologists have widely used this index to provide local, time-series records of trophic level change through time (e.g., Carder & Crock 2012; Erlandson *et al.* 2009; Morrison & Addison 2009; Quitmyer & Reitz 2006; Wake *et al.* 2013). Here we use MTL only to assess the feeding guilds that have been targeted prehistorically.

RESULTS

Table 3 provides the quantification of fish remains from all sites in this analysis. A total of 5440 fish bones, weighing 756.0 g were recovered from sites D6.011.B.C2 (n = 1272), D6.011.E.C1 (n = 1813), D6.A.C1/C2 (n = 1029) and D6.036.G (n = 1326). Across all sites, 1021 (NISP) specimens were identified to taxon, comprising 157 (MNI) individuals. Overall, ~19% of all fish bones were identified to family, genus or species even though the assemblage was highly fragmented. Of the 1021 fish bones identified to taxon less than two per cent had evidence of root etching (i.e., etching or channels left on bone by root action; see also Lyman 1994), or digestive processes. All reported cases were vertebrae and characterised as deformed after Butler and Schroeder (1998:960). Approximately 16% (NISP = 164) of the total identified assemblage was burnt, however, all but three bones were recovered from site D6.036.G, where ~12% of fish bone was reported as burnt. Table 4 provides a summary of the elements that were identified to taxon

Table 2. *Concentration indices (CI) for each site mentioned in text.*

Site	Total fish bone counts	Excavated volume (m³)	CI (bones/m³)
D6.011.B.C2	1272	1.8	707
D6.011.E.C1	1813	0.8	2266
D6.A.C1/C2	1029	1.8	572
D6.036.G	1326	0.9	1473
D6.029.F2	27	0.3	90
D6.031.C2/C5	9	1.4	6
D6.035.C2/C4	11	1.9	6
D6.040.C2/D2	20	1.5	13
D6.077.D	22	1	22
All sites	**5529**	**11.4**	**485**

Table 3. *Quantification of fish remains from sites D6.011.B.C2, D6.011.E.C1, D6.A.C1/C2 and D6.036.G.*

Taxon	Feeding Behaviour	D6.011.B.C2		D6.011.E.C1		D6.A.C1/C2		D6.036.G		Total	
		NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
Actinopterygii (unid. fish to element)	N/A	55		14		10		20		99	
Elasmobranchii	P							1	1	1	1
Selachii	P	4	1	1	1	11	2	21	1	37	5
Carcharhinidae											
Carcharhinus cf. *amblyrhynchos*	P							2	1	2	1
Acanthuridae	H	13	3	3	1	2	1	20	4	38	9
Acanthurus spp.	H	3	1					6	1	9	2
Ctenochaetus spp.	H	1	1	1	1			1	1	3	3
Naso spp.	H	1	1	2	1	1	1			4	3
Albulidae	O/BC							2	1	2	1
Balistidae	O/BC	5	1	2	1			5	1	12	3
Carangidae	P	1	1							1	1
Carangoides orthogrammus	P					1	1			1	1
Elagatis bipinnulata	P							4	1	4	1
Chaetodontidae	O/BC							1	1	1	1
Cirrhitidae	O/BC	25	3	5	1	12	2	8	1	50	7
Diodontidae											
Diodon cf. *hystrix*	O/BC							5	1	5	1
Holocentridae	O/BC					1	1	2	1	3	2
Myripristis spp.	O/BC	8	1	6	2	1	1	1	1	16	5
Sargocentron spp.	O/BC	1	1			1	1			2	2
Kuhliidae											
Kuhlia cf. *petiti*	O/BC	1	1			1	1			2	2
Kyphosidae											
Kyphosus sp.	H			1	1					1	1
Labridae	O/BC	2	1	1	1	1	1	5	1	9	4
Lethrinidae	O/BC	3	2	12	2	15	2	2	1	32	7
Lethrinus spp.	O/BC	14	1	31	3	20	3	5	2	70	9
Monotaxis grandoculis	O/BC	1	1							1	1
Lutjanidae	P	1	1	1	1	3	1	12	1	17	4
Lutjanus spp.	P	5	1	1	1	10	2	21	3	37	7
Mullidae	O/BC			1	1	1	1			2	2
Mulloidichthys sp.	O/BC			2	1					2	1
Parupeneus sp.	O/BC			1	1					1	1
Muraenidae	P	2	1					5	1	7	2
Polynemidae	O/BC	9	2					8	1	17	3
Pomacentridae	O/BC	5	2			4	1	5	2	14	5
Scaridae	H	2	1	22	2	6	1	11	5	41	9
Calotomus cf. *carolinus*	H	1	1					1	1	2	2
Scarus spp.	H	4	1	9	2	2	1	4	1	19	5
Scombridae	P	1	1	23	3	2	1	1	1	27	6
Katsuwonus pelamis	P			42	2	9	2			51	4
Serranidae	P	167	8	64	7	96	8	148	7	475	30
Siganidae											
Siganus cf. *argenteus*	H	1	1	1	1			1	1	3	3
Total Identified (excl. unidentified fish to element)		281	40	232	37	200	35	308	45	1021	157
Total bones		1272		1813		1029		1326			
Total weight (g)		164.0		180.0		168.3		243.7			
% identified		22.1		12.8		19.4		23.2			

Feeding Behaviour: H, herbivores; P, piscivores; O, omnivores; BC, benthic carnivores

Table 4. *Fish bone elements identified from sites D6.011.B.C2, D6.011.E.C1, D6.A.C1/C2 and D6.036.G.*

Element	Elasmobranchii	Selachii	Carcharhinidae	Acanthuridae	Albulidae	Balistidae	Carangidae	Chaetodontidae	Cirrhitidae	Diodontidae	Holocentridae	Kuhliidae	Kyphosidae	Labridae	Lethrinidae	Lutjanidae	Mullidae	Muraenidae	Polynemidae	Pomacentridae	Scaridae	Scombridae	Serranidae	Siganidae	Total
antepenultimate vert.									2										1			1	7		11
articular									2		3				5	4			1		3	2	17		37
atlas				1	1										1							1	11		15
basypterygium				1	1						1				3						3		6		15
caudal vert.				19		2	6		5		2	1		1	21	7		4	6	5	13	56	78	2	228
caudal tang				1																					1
ceratohyal									3						1								10		14
cleithrum				3		1			2						1	1							12		20
coracoid									3																3
dentary											4			1	4	7		2				1	31		50
dermal spine										5															5
ectopterygoid																1							17		18
epibranchial																					2				2
epihyal															1								6		7
first anal spine				7																					7
first dorsal spine				6																					6
frontal									1																1
hyomandibular				2		1			2						1	1					2		6		15
interopercle																							6		6
lower pharyngeal grinding plate														3							6				9
maxilla									2						4	3		1	1				21		32
opercle				3					3		1				3	3	1				6	3	9		32
palatine									4						8					4	3		7		26
parasphenoid																							2		2
penultimate vert.																			1				3		4
posttemporal									1						1	1							8		11
precaudal vert.				4	2			1	5		1	1		1	14	4	1	3	2	2	4	3	39		87
premaxilla									1				1		8	6	2				3		28		49
preopercle				2							4				2	2					1		21		32
proatlas vert.						2									1					1	2		8		14
quadrate						1			2						7	2					2	1	27		42
scale						1																			1
scapula				1		2			1		1				3	2			1		1	1	7		20
subopercle									2														6		8
supracleithrum				1					3		1				1	1					2		22		31
thoracic vert.				3					6		3		2		9	7				3	1	7	51		92
tooth (lower jaw)		1																							1
tooth (upper jaw)			2																						2
ultimate vert.															1	1	1				1	2	1	1	8
unknown vert. type	1	36																							37
upper pharyngeal grinding plate														1							7				8
urohyal															3	1							4		8
vomer																							4		4
Number of elements	1	2	1	14	1	9	1	1	19	1	10	2	1	6	23	18	4	2	8	6	18	11	30	2	**1021**

Table 5. *Measures of taxonomic heterogeneity:* NTAXA, *Shannon-Weiner index of diversity* (H') *and Shannon's evenness (E), Simpson's index of diversity (1-D) and Fisher's α.*

Index	D6.011.B.C2		D6.011.E.C1		D6.A.C1/C2		D6.036.G		All Sites	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
NTAXA	18	18	14	14	14	14	19	19	22	22
1-*D*	0.63	0.90	0.79	0.89	0.72	0.89	0.74	0.91	0.75	0.91
H'	1.64	2.60	1.81	2.41	1.76	2.41	1.96	2.63	2.01	2.67
E	0.57	0.90	0.69	0.91	0.67	0.91	0.66	0.89	0.65	0.87
Fisher's α	4.29	12.59	3.28	8.20	3.43	8.65	4.48	12.4	3.96	7.00

for all sites. New family-level taxonomic records for the archipelago added by this study include: Albulidae, Carcharhinidae, Chaetodontidae, Kuhliidae, Pomacentridae and Siganidae.

For each site, moderate to high evenness was reported, minor differences in richness between sites was noted, but no indication of taxonomic dominance (Table 5). Measures of taxonomic heterogeneity as determined by NISP and MNI track similar trends. The lower counts of dominance reported using MNI counts likely relate to the increased number of taxa represented by a single individual, which is particularly demonstrated by the Fisher's α values (significantly higher values reported for MNI).

Fish feeding behaviour data indicates that per cent MNI contribution and per cent NISP contribution track similar trends – in terms of the relative contribution of herbivores, piscivores, and omnivores/benthic carnivores – between sites, which broadly indicates a dominance of piscivorous taxa (Figure 5a and b). This trend is more pronounced when NISP values are considered, but this is likely driven by differences in sample size between the two quantification measures. More specifically, MTL values for each site were as follows: D6.011.B.C2 (MTL = 3.34), D6.011.E.C1 (MTL = 3.48), D6.A.C1/C2 (MTL = 3.68) and D6.036.G (MTL = 3.29). Spearman's rho (rs) indicates that sample size is not correlated with MTL (rs = −1.00, *p* = 0.08). Very few herbivorous taxa were identified from D6.A.C1/C2, relative to piscivorous taxa (e.g., scombrids and serranids). D6.036.G reported the highest relative abundance of herbivorous taxa (e.g., acanthurids and scarids). However, piscivorous taxa (e.g., serranids, lutjanids, carangids and scombrids) were the highest contributor to total MNI and NISP for all sites.

The other sites (D6.029.F2, D6.031.C2/C5, D6.035.C2/C4, D6.040.C2/D2 and D6.077.D) that yielded fish bone had small sample sizes (total NISP = 28) and taxonomic distribution was not considered to be distinct from D6.011.B.C2, D6.011.E.C1, D6.A.C1/C2 and D6.036.G, with the exception of a few unique taxa: *Selar crumenophthalmus* (D6.029.F2), *Caranx* sp. (D6.031.C2/C5) and *Carcharhinus* cf. *melanopterus* (D6.035.C2/C4).
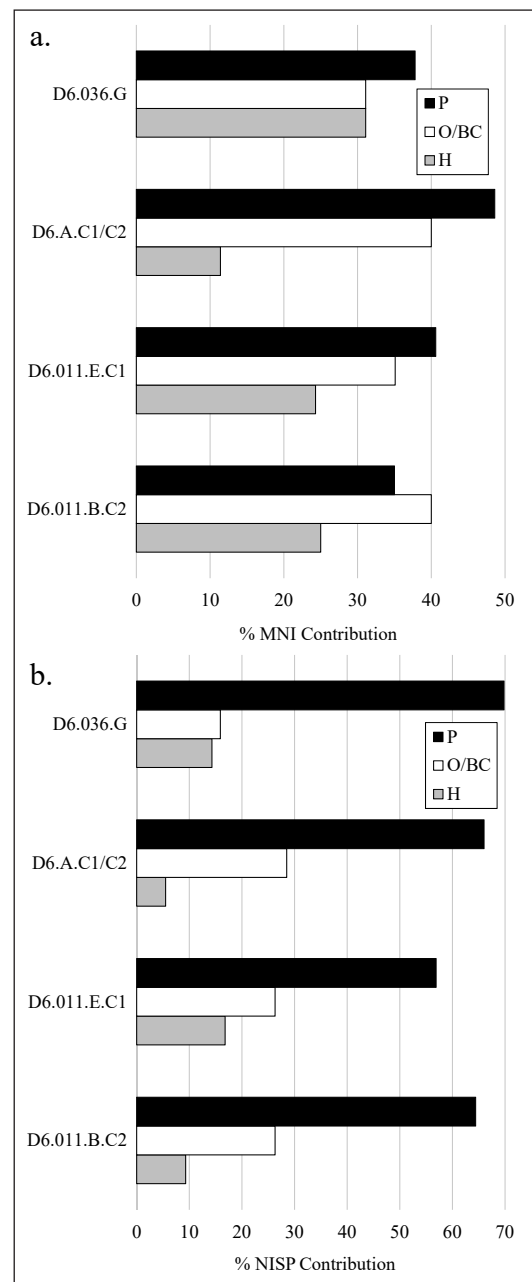

Figure 5. Fish feeding behaviour by site as calculated by (a) per cent MNI contribution, and (b) per cent NISP contribution.

DISCUSSION AND CONCLUSIONS

Fishing on Eiao Island

The four architectural features from three sites investigated here (D6.011.B.C2, D6.011.E.C1, D6.A.C1/C2 and D6.036.G) are situated several kilometres inland from the coast within the Hanataaitoki Valley and are all residential sites comprised of a combination of *hiamoe* and/or *paepae*. The faunal assemblages from these sites represent prehistoric fishing adaptations – possibly dating to between the 14th and 17th centuries – from the only inland habitations now known from the Marquesas Islands. Serranids are consistently the highest rank family for each site. The archaeological fish bone assemblage is dominated by piscivorous taxa, which is likely a reflection of local marine habitat distribution, limited area of inshore reefs, and the fish capture strategies, suggesting a reliance on angling and the use of canoes to exploit offshore resources (e.g., Aswani & Allen 2009; Davidson *et al.* 1999; Leach *et al.* 1997).

Across the archipelago a relationship between fish density and diversity has been noted, hence, areas with more taxonomic diversity are associated with higher abundances, but individual island size and the north-south configuration of the archipelago does not seem to influence biomass (Planes *et al.* 2016: 272–275). At the island level, there is variation in the distribution of species as it relates to the location of suitable habitat proclivities, but taxonomic composition is similar across the archipelago (Delrieu-Trottin *et al.* 2015; Planes *et al.* 2016). Comparisons between the Eiao archaeological data and recent modern marine surveys, indicate that archaeological taxonomic composition largely tracks local species distributions and species availability; for instance, the high abundance of piscivore communities associated with the archipelago and Eiao today are reflected archaeologically (Planes *et al.* 2016). Furthermore, archaeological taxonomic composition reflects the distribution of local marine habitats, with evidence for the exploitation of a wide range of zones from inshore to more seaward zones. Reef associated species and those that live over a combination of reef, sand and rubble bottoms are present archaeologically, such as acanthurids, carangids, chaetodontids, cirrhitids, diodontids, labrids, kyphosids, lethrinids, lutjanids, pomacentrids, scarids, serranids and siganids (Randall 2003), as well as taxa associated with bays and sheltered areas: holocentrids, labrids, mullids and serranids. Lutjanids and *Naso* sp. (unicornfish) are also associated with steep drop-offs (Mundy 2005; Myers 1999), characteristic of the Marquesan inshore waters. In terms of offshore resource exploitation, *Carangoides orthogrammus* (island trevally) are pelagic and most commonly associated with the oceanic rather than neritic zone (Mundy 2005; Randall 2003), and based on modern capture observations are commonly associated with trolling (Meyer *et al.* 2001). However, because Marquesan inshore environments are characterised by deep

waters, the identification of this taxon is not necessarily indicative of offshore exploitation, as line fishing from the shore could account for its presence archaeologically. Indeed, one of the Marquesan field crew caught a ~1 m long Giant Trevally (*Caranx ignobilis*) from casting a hand line from the shoreline rocks. In contrast, *Katsuwonus pelamis* (skipjack tuna) is an oceanic taxon most often associated with offshore waters, and its archaeological identification may indicate offshore trolling (Lehodey 2001). Regardless, while octopus lure sinkers were recovered during excavation, no fishhooks or associated fishing gear were recovered, indicating there is no direct artefactual evidence for a reliance on angling, with the exception of taxonomic composition (e.g., *Katsuwonus pelamis, Elagatis bipinnulata,* serranids, lutjanids, etc.). However, given the deep inshore waters, access to marine resources would have either required a canoe or fishing from the shore using a line. It seems unlikely that all of the fish reported archaeologically were captured by angling from the shore, given the broad range of habitats that were likely exploited and the diverse range of fish species captured.

Regional trends in Marquesan fishing

Different methodologies have been used to analyse Pacific fish bone assemblages, which has hindered syntheses, so we used 'ubiquity' to measure the occurrence of individual taxa across all assemblages to facilitate regional comparisons (Table 6; see, for example Weisler and Green 2013: Figure 3). Ubiquity measures the presence or absence of a taxon and for the Marquesan assemblages we calculated the ubiquity of 31 fish families and one subclass (Elasmobranchii) identified for all previous studies. Table 7 provides the rank-order of the four most frequently identified fish families calculated by NISP and/or MNI as reported in the Marquesan fishing literature. Diodontidae was excluded as individual fish have more than 200 dermal spines that preserve well and are readily identified to family, which can inflate NISP values relative to other families. The findings from Eiao Island are consistent with other published Marquesan fish bone assemblages. There is a dominance of piscivores taxa (e.g., serranids and lutjanids), as described by Aswani and Allen (2009), which likely relates to the lack of coral reef habitat more commonly associated with the tropical Pacific, and higher abundances of scarids, acanthurids, holocentrids and labrids (Weisler & Green 2013: Figure 3). Lutjanidae, Scaridae and Serranidae are the most ubiquitous families identified for the archipelago, but these families are easily identified due to highly diagnostic cranial elements. Elasmobranchii, Acanthuridae, Balistidae, Diodontidae, Holocentridae and Labridae were identified in all but one early study by Kirch (1973). It is apparent that while fish species richness across the archipelago is far lower than regions in the western Pacific Ocean (Froese & Pauly 2016), the archaeological assemblages are still rich, which is likely a reflection of the high biomass for each

Table 6. *Fish taxa grouped by family identified from Marquesan archaeological sites.*

Taxon	this study	Kirch (1973)	Dye (1990)[1]	Dye (1990)[2]	Dye (1990)[3]	Leach *et al.* (1997)	Rolett (1998)	Davidson *et al.* (1999)	Ubiquity %
Lutjanidae	×	×	×	×	×	×	×	×	100.0
Scaridae	×	×	×	×	×	×	×	×	100.0
Serranidae	×	×	×	×	×	×	×	×	100.0
Elasmobranchii	×	×	×	×		×	×	×	87.5
Acanthuridae	×		×	×	×	×	×	×	87.5
Balistidae	×		×	×	×	×	×	×	87.5
Diodontidae	×		×	×	×	×	×	×	87.5
Holocentridae	×		×	×	×	×	×	×	87.5
Labridae	×	×	×		×	×	×	×	87.5
Carangidae	×		×		×	×	×	×	75.0
Lethrinidae	×		×		×	×	×	×	75.0
Mullidae	×		×		×	×	×	×	75.0
Scombridae	×		×		×	×	×	×	75.0
Muraenidae	×		×		×	×		×	62.5
Belonidae			×		×	×		×	50.0
Kyphosidae	×		×			×		×	50.0
Ostraciidae			×			×		×	37.5
Tetraodontidae					×	×	×		37.5
Aulostomidae						×		×	25.0
Cirrhitidae	×		×						25.0
Polynemidae	×		×						25.0
Nemipteridae						×		×	25.0
Sphyraenidae							×	×	25.0
Carcharhinidae*	×								12.5
Albulidae*	×								12.5
Anguillidae								×	12.5
Chaetodontidae*	×								12.5
Exocoetidae							×		12.5
Kuhliidae*	×								12.5
Pomacentridae*	×								12.5
Scorpaenidae						×			12.5
Siganidae*	×								12.5
Total # families	**23**	**5**	**19**	**8**	**15**	**21**	**16**	**21**	
Total bones ID	**1021**	**183**	**404**	**24**	**223**	**1430**	**497**	**1246**	

*First archaeological record of these families in the archipelago
Kirch (1973) Hane Dune site (MUH1) and Manihina Valley (MUH2), Ua Huka
Dye (1990)[1] Hane Dune site (MUH1), Ua Huka
Dye (1990)[2] Hanatakua site (MH-10), Hiva Oa
Dye (1990)[3] Hanapeteʻo Cave site, Hiva Oa
Leach *et al.* (1997) Te Anapua, Ua Pou
Rolett (1998) Hanamiai, Tahuata
Davidson *et al.* (1999) Hane Dune site (MUH1), Ua Huka

species (Planes *et al.* 2016). Serranids and scombrids are the most highly ranked families across most Marquesan fish bone assemblages. The high abundance of pelagic taxa, especially tuna, has been attributed to the strong upwelling of nutrient-rich waters in the region (Taquet *et al.* 2016).

Given these suitable conditions, and the limited variation in taxonomic composition along the north-south gradient of the archipelago, the variation in scombrid abundance across Marquesan sites is of particular interest. Only a few tuna, specifically skipjack, were identified from

Table 7. *Highest ranked fish families by reported* NISP *and/or* MNI *from Marquesan archaeological sites. Elasmobranchii and Diodontidae were excluded when* MNI *was not reported due to inflation of relative abundance when using* NISP *values.*

Taxon	this study NISP	this study MNI	Kirch (1973) NISP	Dye (1990)[1] NISP	Dye (1990)[2] NISP	Dye (1990)[3] NISP	Leach et al. (1997) MNI	Rolett (1998) NISP	Davidson et al. (1999) NISP	Davidson et al. (1999) MNI	Burt (1999) NISP
Acanthuridae		2		3	2			2			
Balistidae					2		4				
Belonidae								3			
Carangidae				2					3	3	4
Holocentridae					2	3	3				
Labridae			3				4				
Lethrinidae	2	2									
Lutjanidae		3	2		2				4	4	2
Polynemidae				4							
Scaridae	4	4	4		1	2					1
Sphyraenidae								4			
Scombridae	3			4			1	1	1	1	
Serranidae	1	1	1	1	2	1	2		2	2	2
% contribution of top 4 taxa	70.3	58.0	61.2	46.5	29.2	43.0	58.4	42.7	71.5	61.2	NR
# of all ID fish bones	1021		183	404	24	223	1430	497	1246		105

NR=not reported
Kirch (1973) Hane Dune site (MUH1) and Manihina Valley (MUH2), Ua Huka
Dye (1990)[1] Hane Dune site (MUH1), Ua Huka
Dye (1990)[2] Hanatakua site (MH-10), Hiva Oa
Dye (1990)[3] Hanapete'o Cave site, Hiva Oa
Leach et al. (1997) Te Anapua, Ua Pou
Rolett (1998) Hanamiai, Tahuata
Davidson et al. (1999) Hane Dune site (MUH1), Ua Huka
Burt (1999) in Aswani and Allen (2009) Anaho Bay, Nuku Hiva Island

all analysed Eiao sites, and in terms of family level identifications (total MNI = 6), MNI is considerably lower than scombrid counts reported from other Marquesan sites. At both the Hane Dune site (Ua Huka) and Te Anapua (Ua Pou) scombrid remains accounted for ~25% of total MNI (Davidson *et al.* 1999; Fraser 1998; Leach *et al.* 1997). This variation may be explained by site function and possibly proximity to the shore (Hane is a major coastal village and Te Anapua a rockshelter difficult to access except by the sea), whereas the architectural sites on Eiao are situated several kilometres inland from the ocean. Coastal sites on Eiao will need to be investigated before this variation in scombrid abundance can be fully assessed.

All cranial and postcranial elements were considered for taxonomic identification when analysing the Eiao Island assemblages, and a comprehensive reference collection, with the exception of Marquesan endemics, was used to facilitate identifications. New family-level taxonomic records for the region added by this study and based on the literature assessed in Tables 6 and 7, include: Albulidae, Carcharhinidae, Chaetodontidae, Kuhliidae, Pomacentridae and Siganidae. Bonefish (Albulidae) are widely distributed across the Pacific, but are not well represented in Polynesian fish bone assemblages (Allen 2014), with remains recovered from only a few sites (e.g., Allen 2002;

Allen 2017; Weisler 1993, 2002). It is likely this disconnect between bonefish availability and archaeological presence relates to identification bias. Weisler (1993, 2002) used otoliths to identify Bonefish and here identifications were made using vertebrae, elements that are not routinely used for identifying Pacific fish.

The major contributions of this study have been the identification of new taxonomic records for the region as well as perspectives on Marquesan fishing practices related to inland sites, as all other archaeological fishing records from the archipelago are from coastal locales. However, there is a need to increase sample size and target coastal sites on Eiao for excavation to allow comparison with the inland sites reported here. The lower levels of all archaeological features were dated with unidentified wood charcoal and there is a spread of 300 years between the median dates of the three sites (AD1350 to 1654). Since the uppermost and latest cultural deposits were not dated, there is the potential for overlap in occupation across all sites, hence, temporal changes in fishing was not considered. We have demonstrated that using a comprehensive fish bone reference collection and considering all elements for taxonomic identification can add new identifications to the archipelago-wide inventory and therefore improve our understanding of prehistoric fishing. Our study has

documented overall agreement between the Eiao Island archaeological fish bone assemblages and the unique nature of the nearshore marine environment that is rich in piscivorous species, thus adding another chapter to the variability of prehistoric fishing in the Marquesas Islands and its place within East Polynesia.

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