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Prehistoric Fishing at Hane, Ua Huka, Marquesas Islands, French Polynesia

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ABSTRACT

Re-analysis of fish remains from the Hane Dune Site, Ua Huka, Marquesas Islands, yielded a Minimum Number of Individuals of 533 fish from 1246 identified bones. The catch of Hane fishermen was dominated by tuna. This dominance was strongest in the early phases and declined through time. Even so, tuna were still a significant part of the catch during the latest occupation. A similar pattern has been observed at other Marquesan sites. In this study, the distinctive ultimate vertebra and adjacent caudal vertebrae of tuna were identified as well as the standard cranial bones.

Keywords: PACIFIC, FRENCH POLYNESIA, MARQUESAS ISLANDS, PREHISTORY, ARCHAEOZOOLOGY, FAUNA, FISHING.

INTRODUCTION

For more than 30 years, Hane has been regarded as a key site in Polynesian prehistory. The results from Hane were of fundamental importance in refining the cultural sequence for the Marquesas first established by Suggs (1961) and exploring the position of these islands in the colonisation of Eastern Polynesia (Sinoto 1966, 1967, 1968, 1970, 1979).

The site was discovered by Sinoto and Kellum in 1963. Between May and August 1964 they excavated in two discrete areas (A and B) and dug a number of test pits. The excavations exposed extensive structural evidence in the form of stone pavements, postholes and hearth or oven features and recovered human burials and a wide range of artefacts and faunal remains from stratified contexts. Further excavations were carried out by Sinoto between September and December 1965. The results of the first season were described in some detail (Sinoto and Kellum 1965; Sinoto 1966). The second season has not been reported as fully, although it was noted that this season confirmed the results of the previous work and recovered some cultural material believed to be contemporary with burials found in Level IV of Area B (Sinoto 1968: 112). The central part of Area B provided a type sequence of six stratigraphic layers (designated Levels). Sinoto was able to correlate most stratigraphic units excavated with this central sequence, adding an earlier Level VII which was not represented in the centre of Area B. The various stratigraphic Levels were assigned to four chronological cultural Phases, to which other Marquesan sites and layers could also be related. However, a number of radiocarbon dates by several different laboratories presented a confusing picture of the absolute chronology of the Hane site.

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In the past 10 years there have been several attempts to reinterpret the Marquesan sequence in general and the chronology of Hane in particular, largely on the basis of the published data. Kirch (1986: 27) suggested that the Hane materials represent a long time span, possibly beginning in the second half of the first millennium BC, and incorporate a complex series of cultural changes. Anderson *et al.* (1994) have rejected Kirch's interpretation, arguing that the lower levels of the site represent a single, relatively brief occupational phase, beginning probably around the middle of the first millennium AD. Rolett (1989: 86–93) discussed the radiocarbon dates in some detail and concluded that they provide no basis for determining the precise age of the earliest deposits in Area B and support Sinoto's conclusion that the earliest part of the sequence is not represented in Area A.

In addition to its role in modelling the settlement history of Eastern Polynesia, Hane has been a key site in discussions of Marquesan subsistence. Kirch (1973) carried out an analysis by weight of the main components of midden from five excavation units at Hane, three other sites on Ua Huka and two test pits in Area A of the Ha'atuatua site on Nuku Hiva, all excavated by Sinoto. On the basis of this work he proposed a shift from a maritime focus associated with hunting and gathering techniques during Phase I to a terrestrially oriented economy associated with sedentary agricultural and animal husbandry techniques in Phases II to IV. He also attempted a preliminary identification of fish remains from Area B at Hane, reporting 51 bones identified to family, class or order from the upper layers (Levels I to III [Phase IV: late]) and 116 from the lower (Levels V to VI [Phases II and I: early]). He commented on a complete lack of Scombridae (tuna)[3] at Hane and suggested, on the basis of fishhooks from Nuku Hiva rather than fish remains, that trolling may have become less important from Phase II onwards.

Dye (1990) analysed all fish bone from Marquesan sites stored in the Bishop Museum. He reported 404 identifications from Hane, grouped into three assemblages: Area A all layers, Area B Levels V to VI (early) and Area B Levels I to IV (late). On the basis of this material and 247 identified bones from two other sites he argued that the early Marquesans were actively and productively exploiting a wide range of available marine environments, catching both free-ranging and pelagic fish and bottom-dwelling and inshore species. The later inhabitants were concentrating on inshore and bottom-dwelling fish. He identified only 16 bones of Scombridae from Hane; his category of free-ranging and pelagic included sharks and members of the Carangidae and Belonidae families. Dye also proposed a correlation between fishhook types and fish caught, and pointed out that the proposed shift in fishing could have meant greater rather than lower productivity. He found support for

[3]The systematic and common terminology relating to Scombridae is inconsistent and confusing. According to Nelson (1994: 427–28), the Scombridae family is divided into two sub-families, Gasterochismatinae and Scombrinae. The latter group includes five tribes of fishes — scombrini (mackerel), grammatorcynini, scomberomorini (spanish mackerel), sardini (bonito) and thunnini (tuna). Strictly speaking, therefore, the term tuna refers only to a small group of fishes within the Scombridae family. However, 'tuna' has come into common parlance to refer to various fishes in this family, distinguished from fish like wahoo (*Acanthocybium solandri*, scomberomorini tribe). 'Tuna' most commonly refers to the two groups of fishes which Nelson classifies separately as tuna and bonito. These two tribes (thunnini and sardini) have very similar cranial anatomy and it is difficult to distinguish their bones in archaeological assemblages. They are, however, readily distinguished from other tribes. The identifications in this paper named as Scombridae should be understood to refer to fishes in the tuna and bonito tribes. We also use the common name 'tuna' for this group.

Kirch's argument that pigs had become increasingly important in the Marquesas through time.

Sweeney *et al.* (1993) reassessed the subsistence evidence from Hane that had been presented by Kirch and Dye and reached quite different conclusions. They found no evidence of an economic shift apart from a dramatic decline in birds after Phase I, and no change in fish exploitation. Much of their paper focused on methodological aspects of faunal analysis and these were further considered by Dye (1996) in a response to their paper, which discussed issues such as assemblage definition, methodology of analysis, sample size, and the effects of spatial and functional variability.

Anderson *et al.* (1994: 49–50) have also reconsidered Kirch's data on subsistence at Hane. They were unable to find clear evidence for the shift from marine to terrestrial economy, although they recognised the rapid decline of easily obtained but vulnerable resources such as ground-nesting sea birds, turtles and large, easily collected shellfish. According to their analysis there is no evidence of increase in pigs, and fish remain constant through the site. They did not discuss the issue of change in fishing practice through time.

Both Sweeney *et al.* (1993: 234) and Dye (1996: 85) have called for new analyses of the Marquesan faunal assemblages. The present study of the fish remains from Hane is a contribution towards this end. Since it concerns only fish, it has little to contribute to the wider discussion of Marquesan subsistence. Its aim is to provide a better characterisation of the catch of Hane fishermen than has been possible previously, and place this in a broader context of pre-European fishing in the Marquesas and elsewhere.

LOCAL MARINE ENVIRONMENT

The Hane Dune Site is situated at the head of Hane Bay on the south coast of Ua Huka Island in the northern Marquesas (Fig. 1). The beach is sandy and suitable for canoe launching but the outer shores of the bay are rocky. Between Hane and the next valley to the east is a steep conical rocky islet, Motu Hane, separated from the mainland by a narrow channel (Fig. 2).

The Marquesas group is a small chain of volcanic islands, rising very steeply from the ocean bottom some 4000 m below the surface. Depths between individual islands are about 2000 m. However some islands, including Ua Huka, are surrounded by submarine shelves about 60 to 75 m below sea level, which extend in places up to 4 km offshore (Rousse *et al.* 1978: 13, 24–25). These shelves provide well known fishing grounds used today for offshore fishing with baited hook (Rolett 1989: 208).

Hane Bay is about 1 km long and less than 1 km wide at its mouth. It is relatively shallow, reaching a depth of 20 m towards the mouth. The surge is strong at the entrance to the bay but the interior, particularly on the west side, is more sheltered (Brousse *et al.* 1978: 40). There is no coral reef, although coral colonies are present everywhere in varying quantities. At the mouth of the bay, coral coverage reaches almost 50% on the west side of Motu Hane at depths between 10 and 15 m; elsewhere it is generally much sparser. Inside the bay, particularly on the more sheltered west side, the colonies are larger, some reaching 2 m in diameter. In the inner western part of the bay there is a prairie of *Halimeda* sp., a calcified alga. Sponges and sparse coral growth are also found here (Chevalier 1978: 259–60). The sand which forms the beach and the dune at the head of the bay is mainly derived from the *Halimeda* with the addition of some volcanic sand and coralline debris (Brousse *et al.* 1978: 40).

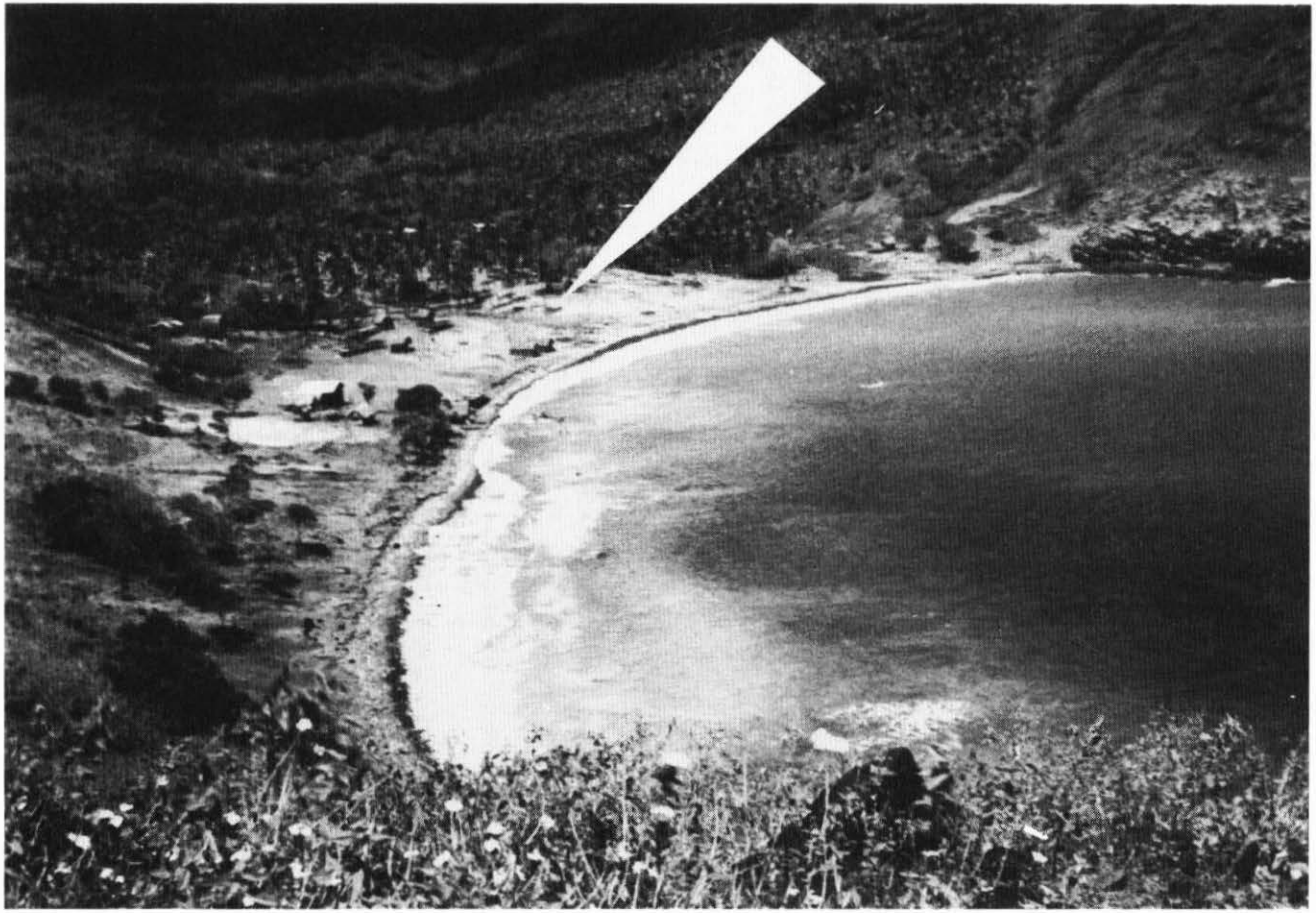

Figure 1: The location of the Hane Dune Site in Hane Bay, Ua Huka, Marquesas Islands (photo Y.H. Sinoto, Bishop Museum, 1963).

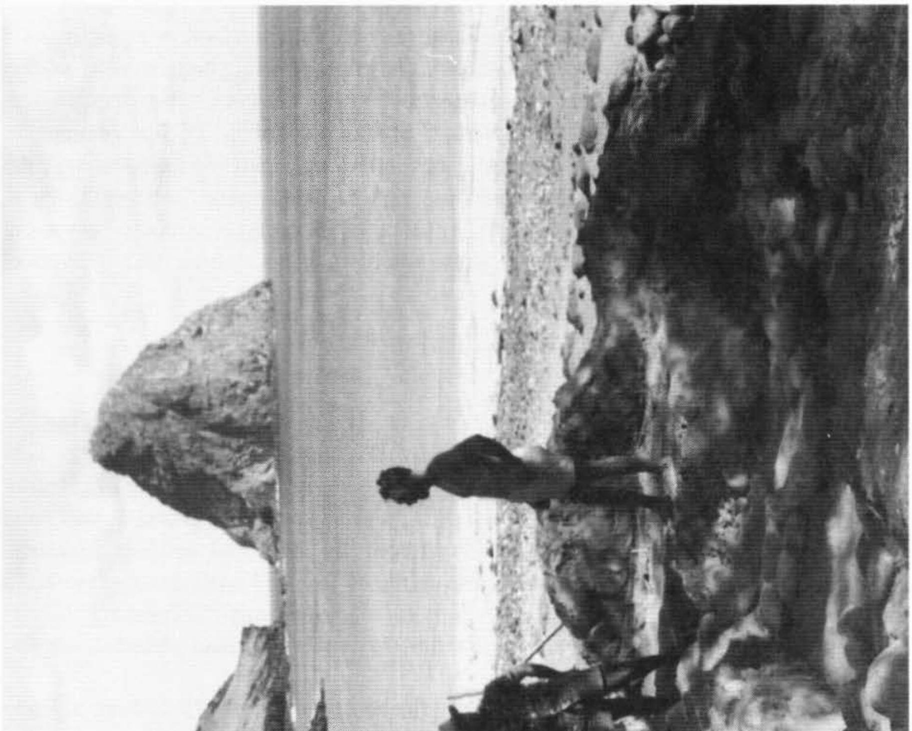

Figure 2: Motu Hane from the Hane Dune Site (photo Y.H. Sinoto, Bishop Museum, 1965).

It is evident that the Hane Dune site was well situated for the exploitation of the various fishing zones available in the Marquesas, having access to a sandy beach, a relatively sheltered bay, a rocky shore falling to deep water, the narrow, relatively deep rocky channel between Motu Hane and the shore, the deep underwater terrace, and the open sea.

Plessis and Maugé (1978: 233) describe the inshore environment of the Marquesas as a 'tropical reef' rather than a 'coral reef' environment. They note several characteristics of this environment. Isolated coral colonies are present everywhere but there are fewer species than in other parts of French Polynesia; the coverage of calcified algae is very extensive; although there is no lagoon, there are sheltered zones in the inner parts of bays; beyond the bays the coastline is very steep; beach deposits are very few and found only in the bays. However, the reef fishes are very similar to those of other parts of French Polynesia, although there are fewer species of some families, notably Chaetodontidae and Balistidae.

METHODS OF ANALYSIS

Fish remains recovered from the excavations at Hane were reanalysed in the Archaeozoology Laboratory of the Museum of New Zealand Te Papa Tongarewa. This material consisted of bones retained by the ¼ inch (6.35 mm) sieves used during excavation and hand picked from the sieves and bagged on site. It derives from both Area A and Area B (not including the peripheral test pits) and from both the 1964 and 1965 excavations. Identifiable bones were found in 100 discrete assemblages from 38 spatial units, mostly 2 metre squares. The numbers of identified bones by square are illustrated in Figure 3. As can be seen from this plan, most of the material is from clusters of adjacent squares near the centres of Areas A and B respectively.

The principal aim of the study was to characterise the nature of prehistoric fishing at Hane by establishing the relative abundance of different types of fish at the site. The method of analysis was that developed in New Zealand for the treatment of archaeological fish bone collections. This method was first developed in 1969 (Leach 1976) and has been progressively refined and used in the analysis of large numbers of archaeological collections from New Zealand and the Pacific. The use of this standard methodology enables reliable comparisons to be made across the large number of assemblages now in the data base. The majority of these assemblages were obtained using excavation methods not unlike those used at Hane. We are confident that any differences between the Hane assemblage and others we have analysed are unlikely to be due to the nature of the recovery techniques practised at Hane specifically.

The method of analysis has been described in detail elsewhere (Leach 1976; Leach and Davidson 1977; Leach and Ward 1981; Leach *et al.* 1997a) and is therefore only briefly summarised here. For the purposes of the study an assemblage is defined as the contents of any single excavation unit. Thus, all bone from one excavation square and one excavation layer is regarded as an assemblage. Minimum Numbers of Individuals (MNI) are calculated with reference to these assemblage units. The MNI calculated from the assemblages are aggregated to arrive at MNI for various areal or chronological divisions within the site or for the entire site. It is important to understand that this process of aggregation does not affect *relative* abundance, which is the object of the analysis.

Each assemblage is sorted into identifiable and not identifiable bones and all material is rebagged and kept. Identifiable fragments are sorted anatomically and again rebagged. Taking each part of the anatomy in turn, bones are then sorted into species, genera or

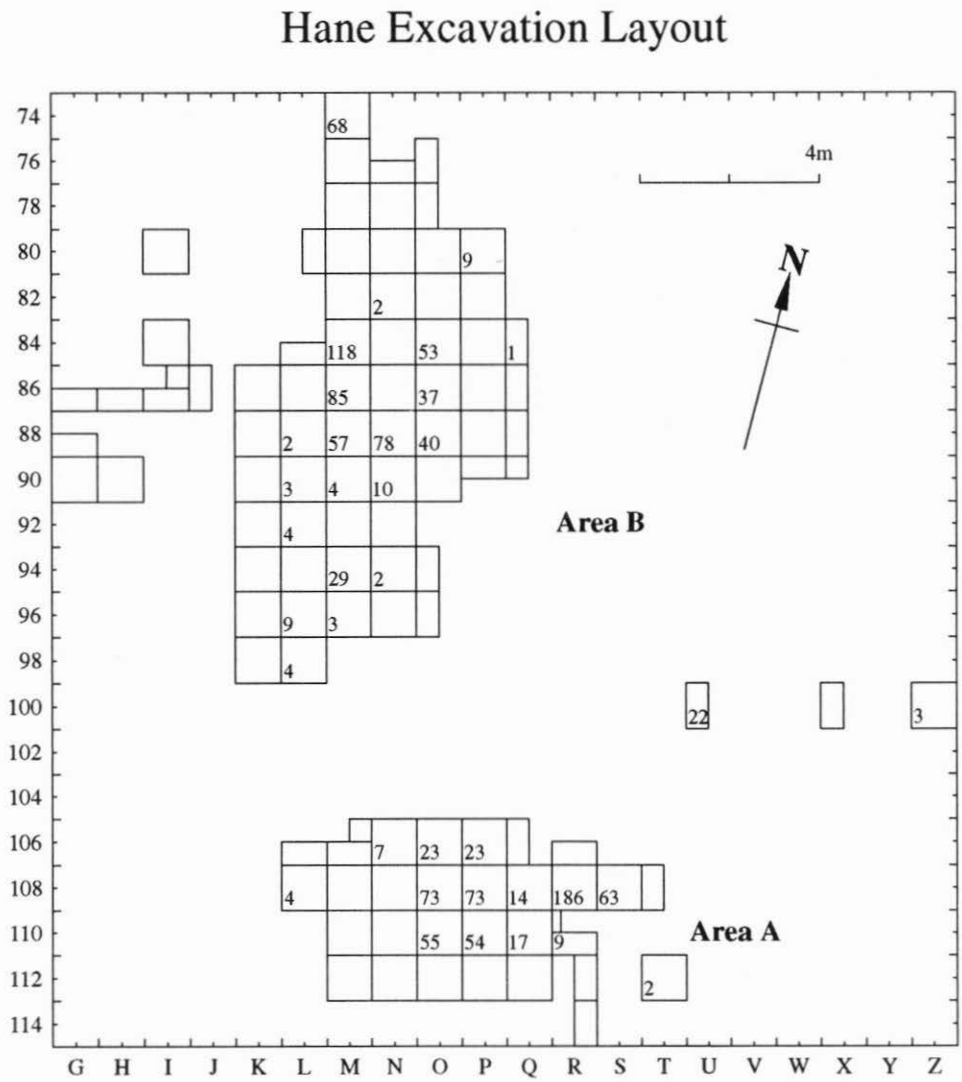

Figure 3: Plan of the excavations at Hane, showing the distribution of identified fish bones.

families and identified with reference to the comparative collection which contains mounted bones of over 300 Pacific species. Taxonomy largely follows Munro (1967). Identifications are made to the lowest taxonomic level possible. All information is entered into a computer data base specifically developed for fish bone studies in the Pacific.

In the Hane assemblages, some bones were found which could not confidently be matched in the comparative collection, even to family level. These were entered in the data base as Species A, Species B, etc. and appear in Tables 3, 5–7 as teleostomi. Possible identifications are discussed below.

The calculation of minimum numbers follows the general technique of Chaplin (1971) and is further discussed by Leach (1986). No attempt is made to increase MNI by taking into account any observed size mismatches.

The 1246 bones identified are listed according to anatomical parts in Table 1. More than half were 'special bones' such as ultimate vertebrae and dermal spines. Of the standard paired cranial bones approximately equal numbers were identified from one side of the body to the other.

The term 'ultimate vertebra', important in this study, needs some explanation. We have previously described this element incorrectly as the caudal peduncle (Leach *et al.* 1997b: 56, 60). In many fishes the ultimate vertebra consists of a centrum and neural spine to which are attached up to six flattened plates or hypurals. The whole structure is sometimes also called the urostyle or hypural plate. In fast swimming pelagic predators such as the various tuna species, marlin, swordfish and dolphin fish, the components of the ultimate vertebra are fused into a single bone which is strong, durable and very diagnostic.

TABLE 1
Identified fish bones from Hane according to anatomy

Anatomy	**Number of Bones**
Left Dentary	77
Right Dentary	73
Left Articular	49
Right Articular	34
Left Quadrate	40
Right Quadrate	44
Left Premaxilla	75
Right Premaxilla	71
Left Maxilla	13
Right Maxilla	23
Inferior Pharyngeal	10
Right Superior Pharyngeal	3
Left Superior Pharyngeal	1
Tooth/Dental Plate	103
Dorsal/Erectile Spine	8
Dermal Plate/Scale	3
Dermal Spine	52
Buckler	5
Scute	42
Ultimate Vertebra	103
Vertebra	417
Number of Bones	**1246**

TABLE 2
The number of assemblages from Hane
by Area and Phase

	Phase I	**Phase II**	**Phase III**	**Phase IV**	**Unassigned**	*Total*
Area A	13	19	1	3	8	44
Area B	18	11	1	13	13	56
Total	**31**	**30**	**2**	**16**	**21**	**100**

The individual assemblages were assigned by Sinoto, where possible, to his previously established Phases I to IV. Phases I and II are characterised as 'Early' and Phases III and IV as 'Late'. The number of assemblages in each phase in each area is shown in Table 2. Twenty-one assemblages were not able to be assigned to a phase and were excluded from the chronological analysis, although they are included in the calculation of total MNI for the site, and in the comparison of fish from Areas A and B.

THE NATURE OF THE FISH CATCH

Table 3 lists the fish families identified from Hane in decreasing order of abundance[4]. The dominant fish taken were tuna. These are pelagic fish which, ethnographically, were generally taken on the surface during schooling by Polynesian fishermen using trolling lures on short lines, although there are also some reports of the use of one-piece hooks near the surface (Davidson and Leach 1996: 189, 198). The dominance of tuna at Hane is in marked contrast to the previous studies of Hane fish remains. This is almost certainly because in our fish bone studies we routinely identify the diagnostic ultimate vertebra and adjacent caudal vertebrae of fast swimming pelagic predators, as discussed above. As can be seen from Table 4, the majority of the identified elements of tuna were these 'special bones' rather than parts of the cranial anatomy. The standard paired cranial bones of tuna are fragile and although fragments survive they are correspondingly more difficult to identify.

Only one of the Scombridae has been identified to species. This is an example of the dog tooth tuna, *Gymnosarda nuda* (also known as *G. unicolor*), a very large, normally solitary fish with distinctive large teeth. These fish are rarely found in archaeological sites, although Rolett (1989: 224) reports two identified cranial bones from Hanamiai in the southern Marquesas and notes that they are caught today by deep baited line fishing off-shore. The remaining fish could belong to one or more species of tuna or bonito. No examples of wahoo (*Acanthocybium solandri*, scomberomorini tribe) have been identified from Hane.

The next most abundant fish taken were members of the Epinephelidae family, a diverse group which includes many kinds of rock cod, grouper, coral trout, and so on. They tend to be bottom feeders and will readily take a baited hook.

[4]Error margins stated throughout this paper are 95% standard errors calculated by the method described by Snedecor and Cochran (1967: 210–11) and Leach and de Souza (1979: 32).

TABLE 3
The relative abundance of fish families at Hane
all assemblages combined
(mean percent and standard error refer to MNI only)

Family Name	**NISP**	**MNI**	**Percent**		
Scombridae	537	137	25.70	±	3.8
Epinephelidae	158	84	15.76	±	3.2
Carangidae	145	67	12.57	±	2.9
Teleostomi	47	39	7.32	±	2.3
Lutjanidae	51	38	7.13	±	2.3
Elasmobranchii	113	36	6.75	±	2.2
Lethrinidae	34	26	4.88	±	1.9
Scaridae	18	16	3.00	±	1.5
Coridae/Labridae	16	15	2.81	±	1.5
Holocentridae	16	14	2.63	±	1.5
Diodontidae	52	11	2.06	±	1.3
Acanthuridae	8	7	1.31	±	1.1
Belonidae	8	7	1.31	±	1.1
Kyphosidae	9	7	1.31	±	1.1
Balistidae	5	5	0.94	±	0.9
Mullidae	5	4	0.75	±	0.8
Sphyraenidae	4	4	0.75	±	0.8
Myliobatiformes	4	4	0.75	±	0.8
Aphareidae	4	3	0.56	±	0.7
Ostraciidae	3	3	0.56	±	0.7
Nemipteridae	2	2	0.38	±	0.6
Anguillidae	2	1	0.19	±	0.5
Aulostomidae	2	1	0.19	±	0.5
Muraenidae	2	1	0.19	±	0.5
Leptocephalidae	1	1	0.19	±	0.5
Total	**1246**	**533**	**100**		

The third most important family, Carangidae or trevallies, are free-ranging fish also normally taken by trolling. Although most of the Hane examples have only been identified to family, four examples of *Caranx ignobilis*, six of *Selar boops* and one rainbow runner (*Elegatis bipinnulatus*) were distinguished.

Examples of teleostomi which could not be matched in the comparative collection are unusually numerous at Hane. A number of them have been provisionally identified as belonging to the family Khulidae; however the identification is uncertain because the archaeological bones appear to belong to fish that are significantly larger than normal for this family.

The Hane fish catch is remarkable for the high proportion of fish that were probably caught on trolling lures (almost 40% if the Belonidae are included with the Scombridae and Carangidae), and for the high proportion of Scombridae in particular. These features are most unusual in our experience of Pacific island fish bone assemblages. However, we have studied a few comparable assemblages from the eastern Pacific, notably Anapua in the southern Marquesas (Leach *et al.* 1997b) and Fa'ahia in the Society Islands (Leach *et al.*

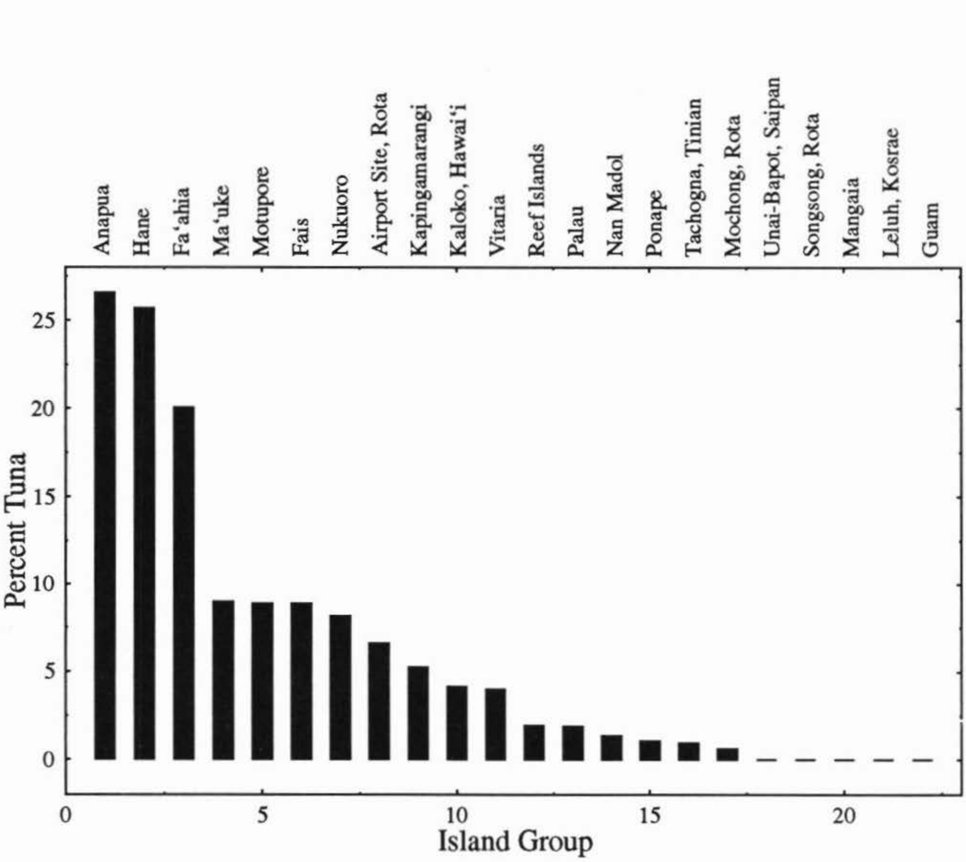

Figure 4: The proportions of tuna in a number of Pacific island archaeological sites.

1984) (Figure 4). The Hane fish catch also contains a relatively high proportion (more than 30%) of fish that were probably caught by angling with a demersal baited hook: Epinephelidae, Lutjanidae, Lethrinidae, Mullidae, Coridae/Labridae, Nemipteridae, and possibly Holocentridae and Balistidae. Rolett (1989: 211–12, 228) describes modern techniques for taking fish of the last two families with baited hooks, but the hooks used are small steel hooks.

The fishhooks in an archaeological site are not usually a good indication of the fish catch as revealed by fish bones (Leach and Davidson 1988; Davidson and Leach 1996). At Hane, the large fishhook assemblage consists mostly of one-piece bait hooks and does not adequately reflect the dominance of fish most likely to have been caught by trolling. This may be because trolling lures are particularly likely to be lost during fishing. There is little doubt, however, that the majority of fish (about three quarters) caught by the Hane fishermen were taken on lines in one way or another. Other fishing methods such as netting, trapping and foraging were relatively insignificant. The emphasis on line fishing is perhaps not surprising in view of the rugged Marquesan coastline and paucity of coral reef development.

TABLE 4
Number of identified elements (NIE) of tuna

Anatomy	**NIE**
Left Dentary	10
Right Dentary	10
Left Articular	2
Left Premaxilla	6
Right Premaxilla	1
Ultimate Vertebra	103
Vertebra	404
Total	**536**

Another important feature of the Hane catch is the low proportion of Scaridae, one of the most important fish families in many Pacific island assemblages (Fleming 1986). There does not seem to be any evidence that Scaridae are less abundant in the Marquesas than they are in many other island groups. Indeed, Plessis and Maugé (1978: 233) point out that although Scaridae are often said to be coral eaters they are also attracted to calcified algae and in this respect are particularly well served in the Marquesas. The low proportion of Scaridae in the Hane catch may therefore be due to cultural preferences for other species and for line fishing rather than netting.

The Hane results are similar to the results of fish bone studies from two other Marquesan sites, Hanamiai (Rolett 1989) and Anapua (Leach *et al.* 1997b). The Anapua and Hane results are directly comparable, since identical methods of analysis were used for both assemblages. The relative abundances of fish families in these two sites are shown in Figure 5. The proportions of Scombridae are almost identical and those of Epinephelidae are not dissimilar. The only statistically significant differences at the 95% confidence level are the relatively higher proportions of Holocentridae and Balistidae at Anapua and of Carangidae and unidentified teleostomi at Hane. The Hanamiai analysis (Rolett 1989: 224) was not directly comparable but the dominance of tuna there is unmistakable. Rolett identified 87 Scombridae dentaries and premaxillas (including two identified as similar to *Gymnosarda unicolor*) from a total number of identified specimens of 495 (which included spines, vertebrae and teeth of species which have numbers of each of these elements to an individual). Other important families at Hanamiai, although less so than tuna, were Belonidae, Lutjanidae, Sphyraenidae, Serranidae (equivalent to our Epinephelidae) and Carangidae.

A clear indication is emerging from these Marquesan sites of a distinctive pattern of fishing behaviour which involved a major emphasis on successful trolling for tuna and other pelagic species and considerable use of demersal baited hooks, probably both inshore and offshore. Within this general pattern, variations occur in the individual sites which may reflect particular aspects of the marine environment close to the site, or the incorporation in the site of fish remains resulting from particular, targeted fishing practices. At Anapua, for example, the numbers of Holocentridae and Balistidae might indicate fishing methods similar to present day practices described by Rolett (1989: 211–12, 228).

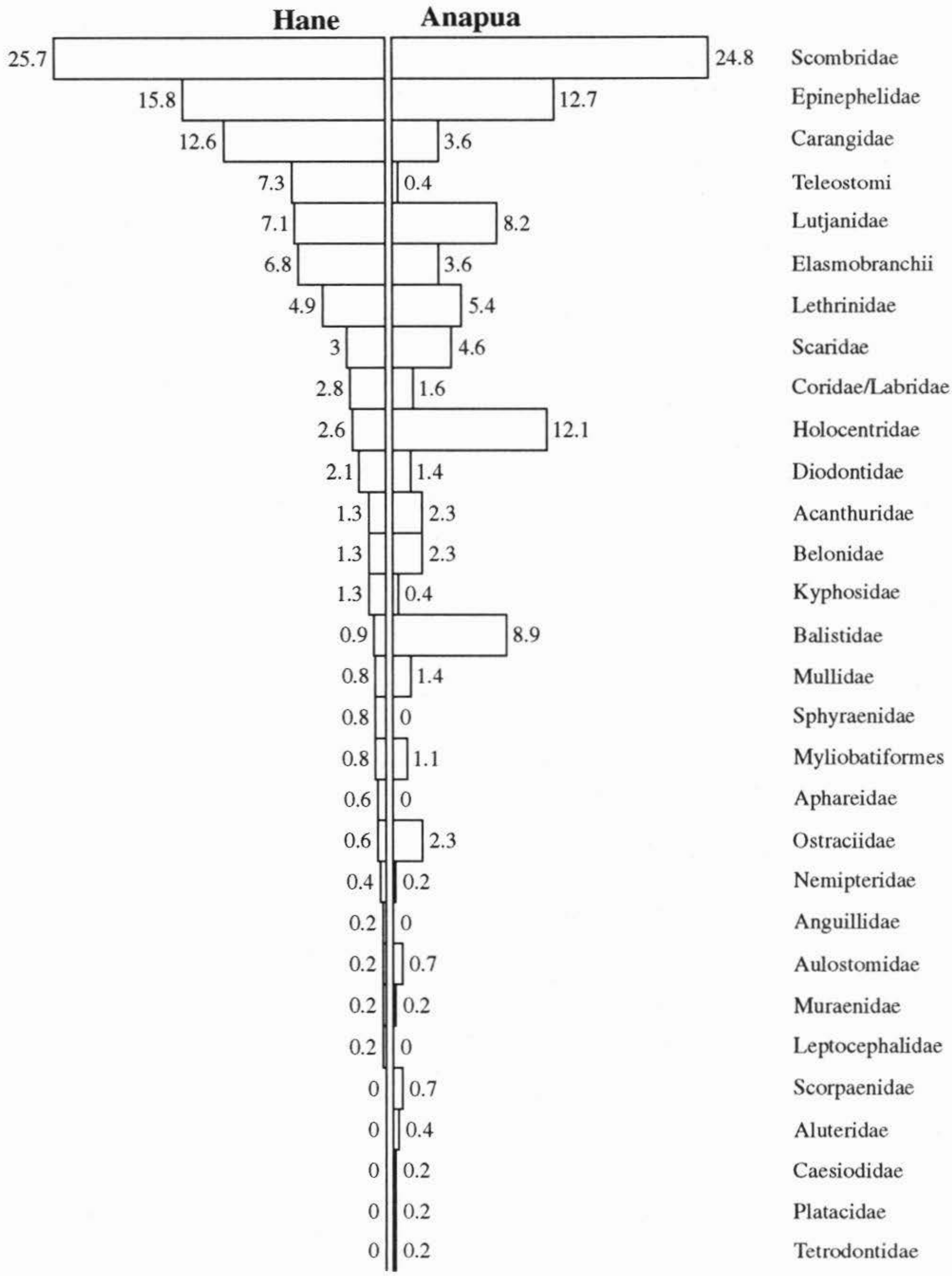

Figure 5: The relative abundance (percentage of MNI) of fish families at Hane and Anapua, Marquesas Islands. The total MNI were 533 at Hane and 440 at Anapua.

CHANGES IN FISH CATCH OVER TIME

The point cannot be overemphasised that large samples are required before statistically significant changes can be identified. Tempting though it may be to identify trends or changes from tables of percentages, these often do not stand up to statistical tests. As we demonstrate below, it is only at a high level of aggregation that statistically significant changes can be identified at Hane, and these are fewer than might be expected from simple inspection of the data tables.

Table 5 shows the relative abundance of fish families according to both Area and Phase. Although some interesting possibilities are suggested by these data, the samples are in most cases too small and the error margins too large for any apparent trends to be statistically significant. Features worth noting are the high proportion of Scombridae in Area A Phase II (comparable to the figure of 33.67 ± 6.82 in the early Level II at Anapua (Leach *et al.* 1997b: 55)) and the high proportion of Epinephelidae and relatively large number of families overall in Area B Phase IV.

When Areas A and B are combined (Table 6) the assemblage from Phase III is still far too small for meaningful comparisons. This Phase III material is from deposits excavated during the second season and correlated with the sterile Level IV deposit of the first season. At this level of analysis the figures for Phases I and II are remarkably similar, whereas Phase IV seems to show some differences. However, statistical significance is still elusive.

Table 7 and Figure 6 compare 'Early' (Phases I and II) and 'Late' (Phases III and IV) assemblages from Areas A and B combined. Figure 6 appears to show a clear decline in Scombridae and Carangidae and a corresponding rise in Epinephelidae, signalling a decline in trolling and a probable increase in baited line fishing. Figure 7, however, graphically presents the statistical significance of the apparent differences in Figure 6. A difference between the early and late assemblages in Figure 6 is only significant at the 95% confidence level when the absolute difference exceeds the error margin (Fig. 7). The only statistically significant differences are the decline in Scombridae, the increase in Diodontidae and the disappearance of Kyphosidae. Of course, statistical significance is not everything.

A drop from six Kyphosidae to none may have no cultural significance at all. On the other hand, it is important that the apparent decline in tuna fishing through time in the Marquesas, which has been the subject of considerable discussion, is statistically significant at Hane. At the same time, it must be pointed out that in the wider Pacific context, the proportion of tuna in the late period contexts at Hane is still unusually high.

Similar changes in fishing behaviour have been suggested for both Anapua and Hanamiai. At Anapua there appeared to be a decline in tuna fishing and an increase in grouper fishing through time (Leach *et al.* 1997b: 54, 63). Rolett (1989: 239) has argued that the most marked change at Hanamiai was a decline in pelagic fishing but that there was also a decline in off-shore deep sea fishing and an increase in in-shore fishing. These similar results from three different sites on three different islands are strongly suggestive of a general trend throughout the Marquesas, but this must be placed in perspective. At both Anapua and Hane tuna fishing was still an important part of the overall fishing strategy in the late period—far more so than it appears to have been in many other Pacific islands at any period. The evidence from Hane, such as it is, does not seem to support Dye's (1990) argument, based on historical sources, that by early European times, the Marquesan fishing industry was in serious decline. Tuna was still an important component of the catch of Hane fishermen in the late period and they were also catching a wider range of fish species than formerly. Kellum-Ottino (1971: 24) suggested several possible explanations for some of the

TABLE 5
Relative abundance of fish families at Hane according to Area and Phase
(percent of MNI and 95% standard error)
Columns 1–4 = Area A Phases 1–4 (MNIs = 87, 110, 4, 5)
Columns 5–8 = Area B Phases 1–4 (MNIs = 109, 45, 6, 70)

Family	1	2	3	4	5	6	7	8
Scombridae	26.4 ± 10.0	32.7 ± 9.3	50.0 ± 76.8	40.0 ± 63.6	24.8 ± 8.6	17.8 ± 12.6	16.7 ± 44.3	12.9 ± 8.7
Epinephelidae	9.2 ± 6.7	14.5 ± 7.1	- - -	- - -	18.3 ± 7.8	15.6 ± 12.0	16.7 ± 44.3	22.9 ± 10.7
Carangidae	17.2 ± 8.6	11.8 ± 6.5	- - -	20.0 ± 53.8	11.9 ± 6.6	17.8 ± 12.6	16.7 ± 44.3	7.1 ± 6.8
Teleostomi	16.1 ± 8.4	7.3 ± 5.4	25.0 ± 68.2	- - -	4.6 ± 4.4	6.7 ± 8.6	- - -	5.7 ± 6.2
Elasmobranchii	6.9 ± 6.0	10.9 ± 6.3	- - -	- - -	8.3 ± 5.7	2.2 ± 5.5	- - -	7.1 ± 6.8
Lutjanidae	6.9 ± 6.0	7.3 ± 5.4	- - -	- - -	5.5 ± 4.8	11.1 ± 10.5	- - -	5.7 ± 6.2
Lethrinidae	4.6 ± 5.0	4.5 ± 4.4	- - -	20.0 ± 53.8	5.5 ± 4.8	6.7 ± 8.6	- - -	5.7 ± 6.2
Coridae/Labridae	2.3 ± 3.8	0.9 ± 2.2	- - -	- - -	7.3 ± 5.4	2.2 ± 5.5	16.7 ± 44.3	1.4 ± 3.5
Scaridae	1.1 ± 2.8	2.7 ± 3.5	- - -	20.0 ± 53.8	1.8 ± 3.0	4.4 ± 7.3	- - -	4.3 ± 5.5
Holocentridae	1.1 ± 2.8	- - -	25.0 ± 68.2	- - -	2.8 ± 3.6	4.4 ± 7.3	- - -	4.3 ± 5.5
Diodontidae	- - -	- - -	- - -	- - -	0.9 ± 2.3	2.2 ± 5.5	16.7 ± 44.3	7.1 ± 6.8
Belonidae	1.1 ± 2.8	- - -	- - -	- - -	4.6 ± 4.4	- - -	- - -	1.4 ± 3.5
Kyphosidae	4.6 ± 5.0	- - -	- - -	- - -	0.9 ± 2.3	2.2 ± 5.5	- - -	- - -
Acanthuridae	1.1 ± 2.8	- - -	- - -	- - -	- - -	2.2 ± 5.5	- - -	4.3 ± 5.5
Myliobatiformes	- - -	3.6 ± 4.0	- - -	- - -	- - -	- - -	- - -	- - -
Aphareidae	1.1 ± 2.8	1.8 ± 3.0	- - -	- - -	- - -	- - -	- - -	- - -
Balistidae	- - -	0.9 ± 2.2	- - -	- - -	- - -	2.2 ± 5.5	- - -	1.4 ± 3.5
Ostraciidae	- - -	- - -	- - -	- - -	- - -	2.2 ± 5.5	- - -	2.9 ± 4.7
Sphyraenidae	- - -	0.9 ± 2.2	- - -	- - -	1.8 ± 3.0	- - -	- - -	- - -
Mullidae	- - -	- - -	- - -	- - -	0.9 ± 2.3	- - -	- - -	1.4 ± 3.5
Anguillidae	- - -	- - -	- - -	- - -	- - -	- - -	- - -	1.4 ± 3.5
Aulostomidae	- - -	- - -	- - -	- - -	- - -	- - -	- - -	1.4 ± 3.5
Nemipteridae	- - -	- - -	- - -	- - -	- - -	- - -	- - -	1.4 ± 3.5
Muraenidae	- - -	- - -	- - -	- - -	- - -	- - -	16.7 ± 44.3	- - -
Totals	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

TABLE 6
Relative abundance of fish families at Hane according to Phase

	MNI by Phase					**% of MNI by Phase ± SE**			
Family Name	**1**	**2**	**3**	**4**	**Totals**	1	2	3	4
Scombridae	50	44	3	11	108	25.5 ± 6.4	28.4 ± 7.4	30.0 ± 36.9	14.7 ± 8.8
Epinephelidae	28	23	1	16	68	14.3 ± 5.2	14.8 ± 5.9	10.0 ± 25.9	21.3 ± 10.1
Carangidae	28	21	1	6	56	14.3 ± 5.2	13.5 ± 5.7	10.0 ± 25.9	8.0 ± 6.9
Teleostomi	19	11	1	4	35	9.7 ± 4.4	7.1 ± 4.4	10.0 ± 25.9	5.3 ± 5.8
Elasmobranchii	15	13	-	5	33	7.7 ± 4.0	8.4 ± 4.7	- - -	6.7 ± 6.4
Lutjanidae	12	13	-	4	29	6.1 ± 3.6	8.4 ± 4.7	- - -	5.3 ± 5.8
Lethrinidae	10	8	-	5	23	5.1 ± 3.3	5.2 ± 3.8	- - -	6.7 ± 6.4
Coridae/Labridae	10	2	1	1	14	5.1 ± 3.3	1.3 ± 2.1	10.0 ± 25.9	1.3 ± 3.3
Scaridae	3	5	-	4	12	1.5 ± 2.0	3.2 ± 3.1	- - -	5.3 ± 5.8
Holocentridae	4	2	1	3	10	2.0 ± 2.2	1.3 ± 2.1	10.0 ± 25.9	4.0 ± 5.2
Diodontidae	1	1	1	5	8	0.5 ± 1.3	0.6 ± 1.6	10.0 ± 25.9	6.7 ± 6.4
Belonidae	6	-	-	1	7	3.1 ± 2.7	- - -	- - -	1.3 ± 3.3
Kyphosidae	5	1	-	-	6	2.6 ± 2.5	0.6 ± 1.6	- - -	- - -
Acanthuridae	1	1	-	3	5	0.5 ± 1.3	0.6 ± 1.6	- - -	4.0 ± 5.2
Myliobatiformes	-	4	-	-	4	- - -	2.6 ± 2.8	- - -	- - -
Aphareidae	1	2	-	-	3	0.5 ± 1.3	1.3 ± 2.1	- - -	- - -
Balistidae	-	2	-	1	3	- - -	1.3 ± 2.1	- - -	1.3 ± 3.3
Ostraciidae	-	1	-	2	3	- - -	0.6 ± 1.6	- - -	2.7 ± 4.4
Sphyraenidae	2	1	-	-	3	1.0 ± 1.7	0.6 ± 1.6	- - -	- - -
Mullidae	1	-	-	1	2	0.5 ± 1.3	- - -	- - -	1.3 ± 3.3
Anguillidae	-	-	-	1	1	- - -	- - -	- - -	1.3 ± 3.3
Aulostomidae	-	-	-	1	1	- - -	- - -	- - -	1.3 ± 3.3
Nemipteridae	-	-	-	1	1	- - -	- - -	- - -	1.3 ± 3.3
Muraenidae	-	-	1	-	1	- - -	- - -	10.0 ± 25.9	- - -
Total	**196**	**155**	**10**	**75**	**436**	**100**	**100**	**100**	**100**

early European comments about the poverty of fishing in the Marquesas, including the number of prohibitions associated with fishing and the fact that the prestige fish caught were the exclusive property of chiefs.

TABLE 7
Relative abundance of fish families
in the Early and Late Periods at Hane (% ± SE)

	Early		Late	
Family Name	**MNI**	**Percent**	**MNI**	**Percent**
Scombridae	94	26.8 ± 4.8	14	16.5 ± 8.6
Epinephelidae	51	14.5 ± 3.8	17	20.0 ± 9.2
Carangidae	49	14.0 ± 3.8	7	8.2 ± 6.5
Teleostomi	30	8.5 ± 3.1	5	5.9 ± 5.7
Elasmobranchii	28	8.0 ± 3.0	5	5.9 ± 5.7
Lutjanidae	25	7.1 ± 2.8	4	4.7 ± 5.1
Lethrinidae	18	5.1 ± 2.5	5	5.9 ± 5.7
Coridae/Labridae	12	3.4 ± 2.0	2	2.4 ± 3.9
Scaridae	8	2.3 ± 1.7	4	4.7 ± 5.1
Holocentridae	6	1.7 ± 1.5	4	4.7 ± 5.1
Diodontidae	2	0.6 ± 0.9	6	7.1 ± 6.1
Belonidae	6	1.7 ± 1.5	1	1.2 ± 2.9
Kyphosidae	6	1.7 ± 1.5	-	- - -
Acanthuridae	2	0.6 ± 0.9	3	3.5 ± 4.6
Myliobatiformes	4	1.1 ± 1.3	-	- - -
Aphareidae	3	0.9 ± 1.1	-	- - -
Balistidae	2	0.6 ± 0.9	1	1.2 ± 2.9
Ostraciidae	1	0.3 ± 0.7	2	2.4 ± 3.9
Sphyraenidae	3	0.9 ± 1.1	-	- - -
Mullidae	1	0.3 ± 0.7	1	1.2 ± 2.9
Anguillidae	-	- - -	1	1.2 ± 2.9
Aulostomidae	-	- - -	1	1.2 ± 2.9
Nemipteridae	-	- - -	1	1.2 ± 2.9
Muraenidae	-	- - -	1	1.2 ± 2.9
Total	**351**	**100**	**85**	**100**

Several factors could have affected tuna fishing in the Marquesas over time. The implicit reason, in previous discussions of Marquesan fishing, seems to be primarily cultural: the idea of a shift away from off-shore towards inshore fishing, perhaps related to increasing social tension, a decline in inter-island travel and a growing tendency to stick closer to home. The data from Hane and Anapua, however, show that Marquesan fishermen were still catching tuna in significant numbers in late prehistory. Since tuna are pelagic species, it is unlikely that human predation was having a detectable effect on their abundance in the waters around the Marquesas. It is possible, however, that changing patterns of weather and currents were affecting their abundance, and that Marquesan fishermen of the late period devoted just as much effort to tuna fishing as their predecessors had, but with diminishing success.

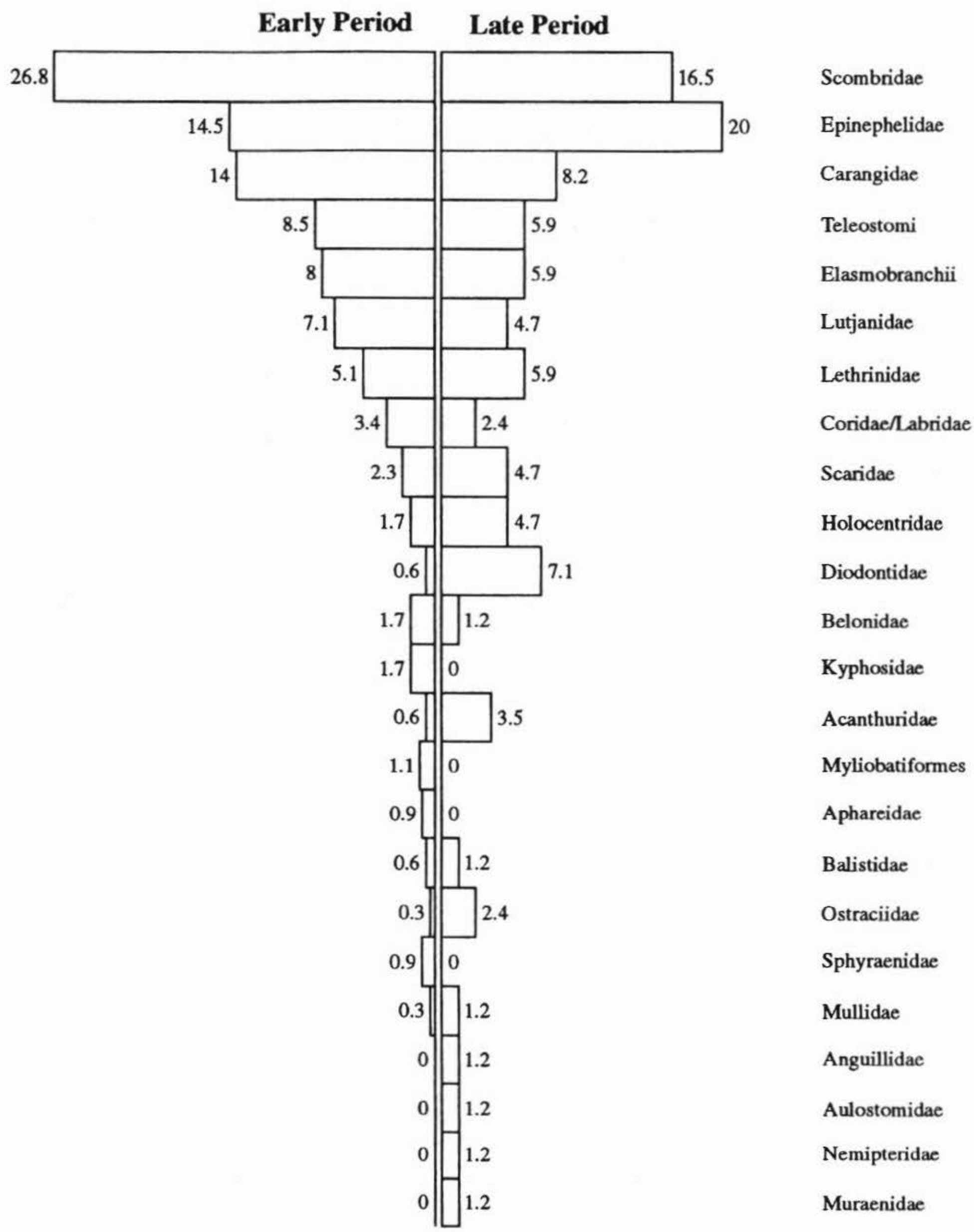

Figure 6: The relative abundance (percentage of MNI) of fish families in the Early and Late periods at Hane. For MNI see Table 7.

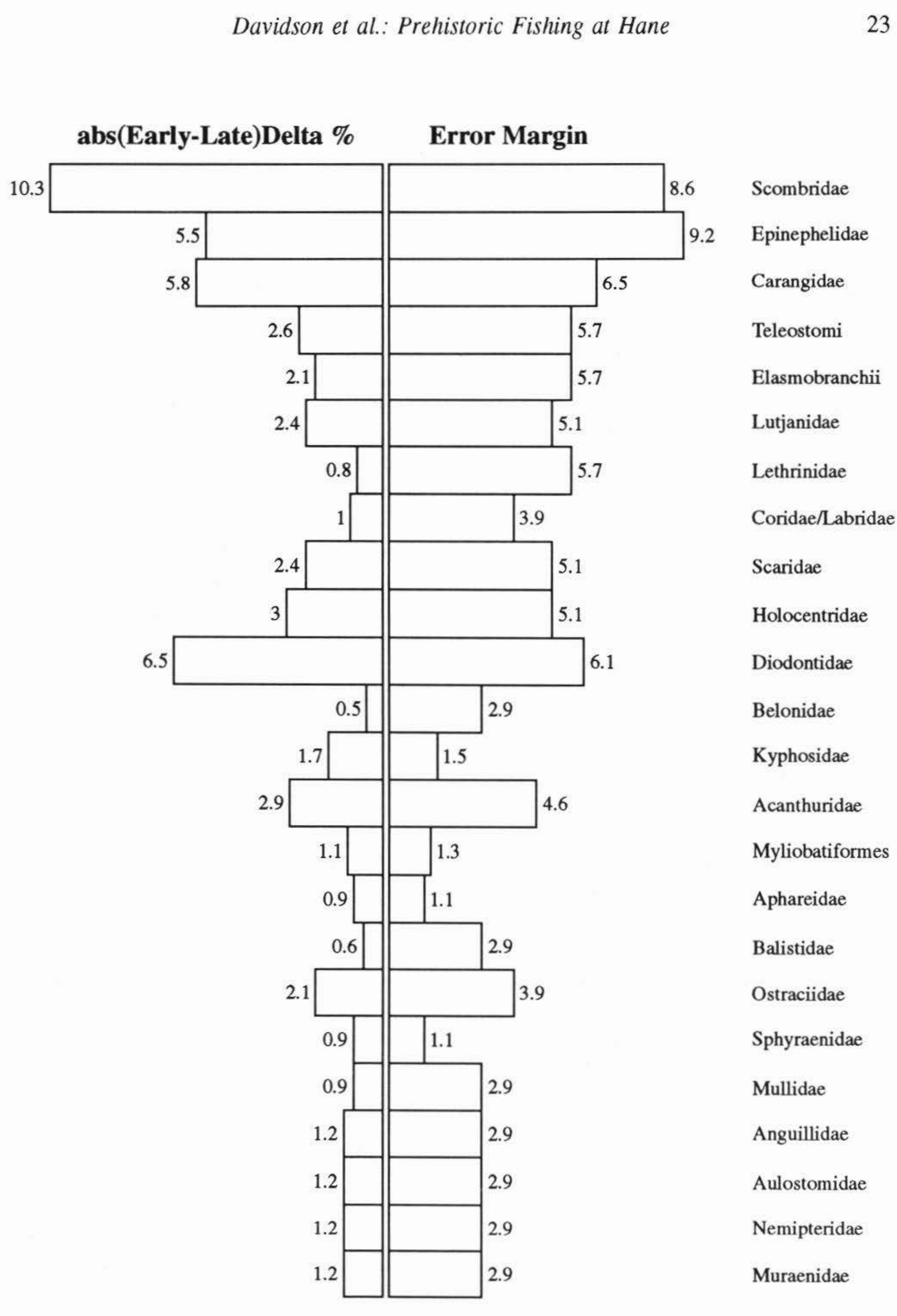

Figure 7: The size of the absolute differences in relative abundance of fish families in the Early and Late periods at Hane compared with the size of the error margins. A difference is statistically sigificant at the 95% confidence level only when the size of the absolute difference exceeds the size of the error margin, as in the case of Scombridae.

COMPARISON BETWEEN AREAS A AND B

There is no direct stratigraphic connection between Areas A and B and correlations were based on artefact content (Sinoto 1966: 292, 296). Most of the deposits in Area A are thought to belong to the Early Period (Phases I and II). Figure 8 compares the catches from the two areas (all layers combined). This highlights the dominance of tuna in Area A and the contribution that Area A is making to the total 'Early Period' catch in this study. The figures for each Phase in Area A can be seen in Table 5, although it is obvious that no reliance can be placed on the small assemblages assigned to Phases III and IV.

It could be suggested that the high proportion of tuna in Area A, particularly in the deposits assigned to Phase II, reflects the presence of high status people with preferential access to tuna. However, we currently have no way of discerning the degree of stratification of Marquesan society at this early period, or of identifying preferential access to tuna among some segments of society. Arguments along these lines must be purely speculative.

On the other hand, given the fairly strong evidence from three sites on three different islands in the Marquesas for a decline in tuna through time, it is certainly interesting to observe that the proportion of tuna is high throughout Area A. Since Hane is one of these sites, there is obvious potential for circular argument here. Even so, it seems reasonable to suggest that Sinoto's assignment of most of the deposits in Area A to Phases I and II, made on other archaeological grounds, is supported by this analysis of the fish remains.

DISCUSSION AND CONCLUSIONS

This re-study of the Hane fish remains has resulted in a much greater number of identifications than the earlier studies by Kirch and Dye and has reversed the previous view that tuna fishing was not an important aspect of the behaviour of Hane fishermen. The Hane fish catch is now shown to be comparable to those from Anapua and Hanamiai in the southern Marquesas. This apparent emphasis on successful tuna fishing in the Marquesas is unusual in our experience and elsewhere is matched only at the early site of Fa'ahia on Huahine in the Society Islands. However, it may be significant that the majority of tuna bones identified at Hane were ultimate vertebrae and other caudal vertebrae, not cranial bones. Re-examination of other assemblages, for example that from Hanapete'o, might reveal a higher proportion of tuna than previously thought.

Comparison of assemblages assigned by Sinoto to his four Phases highlighted the difficulty of identifying any changes through time using small samples. It was only when the assemblages were aggregated into an Early Period (Phases I and II) and a Late Period (Phases III and IV) that any changes could be shown to be statistically significant. The principal change at Hane was a decline in tuna fishing. A similar change has been suggested at both Anapua and Hanamiai. However, this decline must be seen in its correct perspective. Even in the Late Period, tuna were far more important at Hane than at most other Pacific island sites in our experience.

Overall, the analysis of the Hane fish bones suggests a very heavy emphasis on line fishing, both trolling and baited hook fishing, and more limited use of other techniques. This is in keeping with the marine environment in the Marquesas with its restricted coral development, lack of lagoons and few sheltered bays. Most fishing was probably carried out

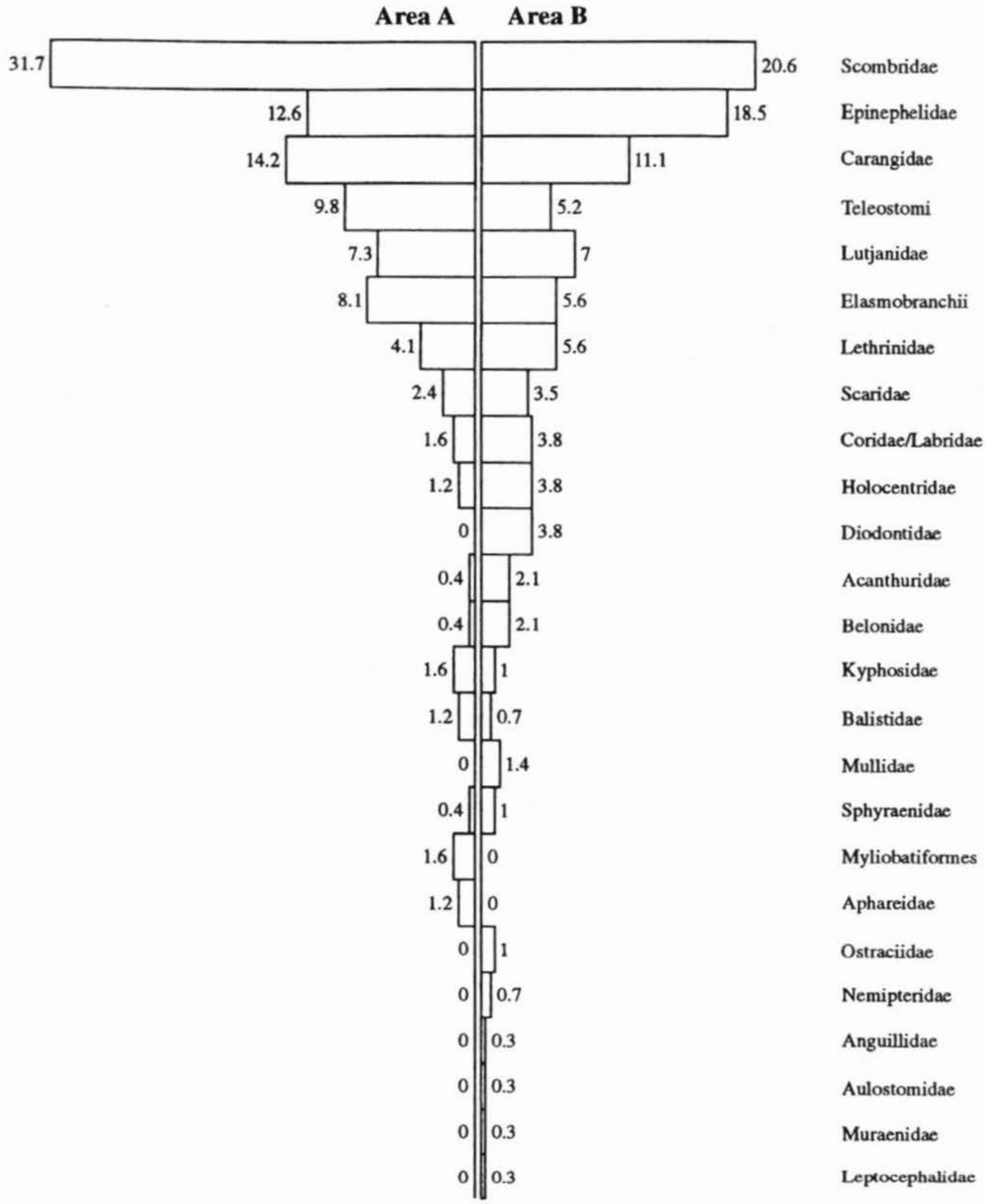

Figure 8: The relative abundance (percent of MNI) of fish families in Areas A and B at Hane, all Phases combined. Total MNI are 246 in Area A and 287 in Area B.

from canoes or from the rocky shore. Kellum-Ottino (1971: 19, 24) noted that fishing was a dangerous pursuit in the Marquesas, particularly between October and April when winds are variable and can be violent. In our view, the Hane fishermen at all periods responded to the challenge of their difficult environment by successfully undertaking the kind of fishing that many Pacific fishermen talk endlessly about but relatively few achieve.

This study has also highlighted the fact that a great deal has been written about Marquesan subsistence on the basis of very little data. We have shown how difficult it is to substantiate apparent chronological change using small samples. It is to be hoped that in future, rigorous studies of sufficiently large samples will provide a sounder basis for discussion.

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REFERENCES

Anderson, A., Leach, H., Smith, I. and Walter, R. 1994. Reconsideration of the Marquesan sequence in East Polynesian prehistory with particular reference to Hane (MUH1). *Archaeology in Oceania* 29: 29–52.

Brousse, R., Chevalier, J.-P., Denizot, M. and Salvat, B. 1978. Étude géomorphologique des Iles Marquises. *Cahiers du Pacifique* 21: 9–74.

Chaplin, R.E. 1971. *The study of animal bones from archaeological sites*. Seminar Press, London.

Chevalier, J.-P. 1978. Les coraux des Iles Marquises. *Cahiers du Pacifique* 21: 243–83.

Davidson, J. and Leach, F. 1996. Fishing on Nukuoro Atoll. Ethnographic and archaeological viewpoints. *In* M. Julien, M. Orliac and C. Orliac (eds), *Mémoire de Pierre, Mémoire d'Homme. Tradition et Archéologie en Océanie. Hommage à José Garanger*, pp. 183–202. Publications de la Sorbonne, Paris.

Dye, T.S. 1990. The causes and consequences of a decline in the prehistoric Marquesan fishing industry. *In* D.E. Yen and J.D.J. Mummery (eds), *Pacific Production Systems: Approaches to economic prehistory*, pp. 70–84. Department of Prehistory, Research School of Pacific Studies, The Australian National University, Canberra.

Dye, T.S. 1996. Assemblage definition, analytical methods, and sources of variability in the interpretation of Marquesan subsistence change. *Asian Perspectives* 35(1): 73–88.

Fleming, M.A. 1986. The Scaridae family in Pacific prehistory. Unpublished MA Thesis, Anthropology, University of Otago.

Kellum-Ottino, M. 1971. *Archéologie d'une Vallée des Iles Marquises*. Publications de la Société des Océanistes 26. Musée de l'Homme, Paris.

Kirch, P.V. 1973. Prehistoric subsistence patterns in the Northern Marquesas Islands, French Polynesia. *Archaeology and Physical Anthropology in Oceania* 8(1): 24–40.

Kirch, P.V. 1986. Rethinking East Polynesian Prehistory. *Journal of the Polynesian Society* 95(1): 9–40.

Leach, B.F. 1976. Prehistoric communities in Palliser Bay, New Zealand. Unpublished PhD thesis, Anthropology, University of Otago.

Leach, B.F. 1986. A method for analysis of Pacific island fish bone assemblages and an associated data base management system. *Journal of Archaeological Science* 13(2): 147–59.

Leach, B.F. and Davidson, J.M. 1977. Fishing methods and seasonality at Paremata (N160/50). *New Zealand Archaeological Association Newsletter* 20(3):166–75.

Leach, B.F. and Davidson, J.M. 1988. The quest for the rainbow runner: prehistoric fishing on Kapingamarangi and Nukuoro atolls, Micronesia. *Micronesica* 21(1, 2): 1–22.

Leach, B.F., Davidson, J.M., Horwood, L.M. and Boocock, A. 1997a. Prehistoric Māori fishermen of Te Ika a Maru Bay, Cook Strait, New Zealand. *New Zealand Journal of Archaeology* 17 (1995): 57–75.

Leach, B.F., Davidson, J.M., Horwood, L.M. and Ottino, P. 1997b. The fishermen of Anapua Rock shelter, Ua Pou, Marquesas Islands. *Asian Perspectives* 36(1): 51–66.

Leach, B.F. and de Souza, P. 1979. The changing proportions of Mayor Island obsidian in New Zealand prehistory. *New Zealand Journal of Archaeology* 1: 29–51.

Leach, B.F., Fleming, M., Davidson, J.M., Ward, G.K. and Craib, J. 1988. Prehistoric fishing at Mochong, Rota, Mariana Islands. *Man and Culture in Oceania* 4: 31–62.

Leach, B.F., Intoh, M. and Smith, I.W.G. 1984. Fishing, turtle hunting, and mammal exploitation at Fa'ahia, Huahine, French Polynesia. *Journal de la Société des Océanistes* 40(79): 183–97.

Leach, B.F. and Ward, G.K. 1981. *Archaeology on Kapingamarangi atoll: a Polynesian outlier in the eastern Caroline Islands*. Privately published by B.F.Leach, Wellington.

Munro, I.S.R. 1967. *The fishes of New Guinea*. Department of Agriculture, Stock and Fisheries, Port Moresby, New Guinea.

Nelson, J.S. 1994. *Fishes of the World*. John Wiley, New York.

Plessis, Y.B. and Maugé, L.A. 1978. Ichthyologie des Iles Marquises. *Cahiers du Pacifique* 21: 215–35.

Rolett, B. V. 1989. Hanamiai. Changing Subsistence and Ecology in the Prehistory of Tahuata (Marquesas Islands, French Polynesia). Unpublished PhD dissertation, Yale University.

Sinoto, Y.H. 1966. A tentative prehistoric cultural sequence in the Northern Marquesas Islands. *Journal of the Polynesian Society* 75(3): 287–303.

Sinoto, Y.H. 1967. Artifacts from excavated sites in the Hawaiian, Marquesas and Society Islands: a comparative study. *In* G.A. Highland, R.W. Force, A. Howard, M. Kelly and Y.H. Sinoto (eds), *Polynesian Culture History: Essays in Honor of Kenneth P. Emory*, pp. 341–62. Bishop Museum Special Publication 56.

Sinoto, Y.H. 1968. Position of the Marquesas Islands in East Polynesian Prehistory. *In* I. Yawata and Y.H. Sinoto (eds), *Prehistoric Culture in Oceania. A Symposium*, pp. 111–18. Bishop Museum Press, Honolulu.

Sinoto, Y.H. 1970. An archaeologically based assessment of the Marquesas as a dispersal center in East Polynesia. *In* R.C. Green and M. Kelly (eds), *Studies in Oceanic Culture History Vol. 1*, pp. 105–32. Pacific Anthropological Records 11.

Sinoto, Y.H. 1979. The Marquesas. *In* J.D. Jennings (ed.), *The Prehistory of Polynesia*, pp. 110–34. Harvard University Press.

Sinoto, Y.H. and Kellum, M. 1965. Preliminary report on excavations in the Marquesas Islands, French Polynesia. Unpublished report, Bishop Museum, Honolulu.

Snedecor, G.W. and Cochran, W.G. 1967. *Statistical methods*. Iowa State University Press.

Sweeney, M., Graves, M.W. and Hunt, T.L. 1993. A reappraisal of evidence for subsistence change at the Hane Dune Site, Marquesas Islands, French Polynesia. *Asian Perspectives* 32: 225–38.

Suggs, R.C. 1961. Archaeology of Nuku Hiva, Marquesas Islands, French Polynesia. *Anthropological Papers of the American Museum of Natural History* 49(1): 1–205.

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