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# Assessing Protocols for Identifying Pacific Island Archaeological Fish Remains: The Contribution of Vertebrae

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**Abstract:** Three fish bone identification protocols used for determining taxa composition for Pacific island archaeofaunal assemblages are evaluated. The protocols include using the following: (1) the most commonly identified five paired cranial bones and ‘specials’ or unique elements; (2) an expanded number of cranial bones; and (3) the less common inclusion of all vertebrae. Explicit identification and quantification protocols are outlined for systematically incorporating all vertebrae which, predictably, increases the number of identified specimens for an assemblage, thus providing more bones useful for reconstructing live fish biomass (weight and length). Significantly, a range of unique archaeological vertebrae are useful for calculating minimum number of individuals. Using a well-preserved assemblage from Henderson Island, Pitcairn Group, southeast Polynesia, numbering 6480 fish bones (concentration index = 21 580 m<sup>3</sup>), we demonstrate differences in rank-order abundance from three taxon identification protocols. For example, when using all vertebrae grouper (Serranidae) and surgeonfishes (Acanthuridae) are more numerically equivalent than when relying mostly on cranial bones for identification for minimum number of individuals and number of identified specimens. This has important implications for making comparisons between sites or across regions where different identification protocols were used. This pilot study demonstrates that using all vertebrae for taxon identification and quantification, not just unique hypurals (terminal vertebrae) or those from sharks and rays (Elasmobranchii), should be standard practice for identifying a greater number of bones to taxon and thereby providing better reconstructions of prehistoric fishing and subsistence practices in the Pacific.

*Keywords:* fish vertebrae analysis, prehistoric fishing, Henderson Island, Polynesia

## Introduction

Fish bone is the most ubiquitous vertebrate faunal class recovered from Pacific archaeological sites, and its study offers insights into subsistence practices, diet, economy and ritual. The analysis of Pacific archaeological fish bones was initially undertaken by zoologists or ichthyologists, such as Fowler's (1955) analysis of Gifford's (1951) Fiji assemblage. However, the importance of making taxonomic identifications of archaeological fish bone was not acknowledged in the Pacific until the early 1970s. Initially, taxonomic identifications of Pacific archaeological fish bone were restricted to 'dental jaws' or 'dental plates' (e.g., Davidson 1971; Kirch 1979), now referred to as dentaries or premaxillae. Leach and Davidson (1977) developed the first systematic and formalised fish bone identification protocol using an assemblage from Paremata, New Zealand (see also Leach 1986). Taxa were identified using five paired cranial bones—dentary, premaxilla, maxilla, articular and quadrate—as well as 'specials' (e.g., scutes, pharyngeal grinding plates, unusual vertebrae, unique anal and dorsal spines, etc.). These elements were considered the most useful for identifying fish taxa given their common occurrence in Pacific archaeological sites.

Recently, a more diverse range of cranial elements has been used in identifications of fish bone from Pacific archaeological sites increasing the richness and abundance of identified taxa (e.g., Ono and Clark 2010; Vogel 2005; Walter 1998; Weisler and Green 2013). These paired elements include: basiptyergium, ceratohyal, cleithrum, coracoid, ectopterygoid, epihyal, hyomandibular, interopercle, metapterygoid, opercle, palatine, posttemporal, preopercle, scapula, subopercle, supracleithrum, supraoccipital and symplectic as well as single elements parasphenoid and urohyal. Currently, fish bone identification protocols used by most Pacific archaeologists include the common five paired bones, an expanded set of cranial elements and the specials.

Fish bone identification protocols over the last four decades in Pacific archaeology have entirely focused on the cranial elements (Table 1), with the exception of unusual spines and vertebrae considered under the category of specials. Despite the fact that vertebrae preserve in a range of depositional site contexts, their use most commonly extends to those easily identifiable vertebrae of sharks, rays and skates (Elasmobranchii; e.g., Clark and Szabó 2009; Vogel and Anderson 2012) or hypurals (terminal vertebrae) of tuna, mackerel and bonito (Scombridae; e.g., Fraser 1998, 2001). Only Ono (2003, 2004) has emphasised the importance of considering all vertebrae in Pacific archaeological fishing studies.

Following Casteel (1976: 83–87) and Fraser (1998: 128–142), Ono and Intoh (2011: 267–271) have assessed the applicability of reconstructing live fish weight from the diameter of archaeological Scombridae vertebrae from comparisons with modern specimens. However, as vertebrae size and shape are highly variable within an individual fish, we argue that the type of archaeological vertebrae

(e.g., atlas, thoracic, precaudal, etc.) must be identified prior to allometric reconstructions of size and weight and not used as a single and uniform element class (e.g., Rolett 1998: Figure 6.2). Ono and Intoh (2011: 268) acknowledged the preliminary state of vertebrae size analysis in Pacific archaeology and assert the need for its future development. Our study expands on previous work and reviews limited studies of vertebrae in Pacific archaeology.

We contrast the contribution of different fish bone identification protocols towards documenting relative taxonomic abundance by using the following: (1) only the commonly identified five paired cranial bones and specials or unique elements; (2) an expanded number of paired cranial bones; and (3) the inclusion of all vertebrae. We show that these protocols can result in different interpretations of prehistoric subsistence practices and diet, which has important implications for making comparisons between sites or across regions where different identification protocols were used.

The quality of bone preservation is an important consideration when determining the most useful elements for taxonomic identification, and it cannot be assumed that preservation is consistent across the elements of different fish taxa. Therefore, for our study, we used a well-preserved fish bone assemblage from Henderson Island, Pitcairn Group, southeast Polynesia, to evaluate the efficacy of each identification protocol.

### **Archaeological context of the study assemblage**

Henderson (24.37°S, 128.33°W) is a 33 m high raised limestone or makatea island (37 km<sup>2</sup>), one of four islands in the Pitcairn Group, southeast Polynesia. An island-wide archaeological survey was conducted by Weisler in 1990–1992, where 28 habitation sites, mostly rock shelters, were found concentrated immediately above the east and north beaches, with associated gardening zones just back from the cliff edge (Figure 1; Weisler 1995, 1998). A total of 42 m<sup>2</sup> were excavated in all the major habitation sites. The only coastal midden (HEN-5), ~30 m wide and some 300 m along the leeward north coast, was defined by nine transects consisting of 16 1 m<sup>2</sup> units and 20 auger holes (Weisler 1998: Figure 4). The primary cultural layer, ~35 cm thick, consisted of calcareous midden-stained black (2.5Y N2/0) sediments with a neutral pH grading to sterile pale brown (10YR 6/3) subsoil. Features included scoop hearths, earth ovens, post holes, refuse dumps, a flat beachrock pavement and a basalt adze working area (Weisler 1995: 387). Eleven radiocarbon age determinations bracket occupation from ~1100 to 400 BP, making the basal deposits amongst the oldest in southeast Polynesia. All excavations recovered more than 150 000 well-preserved bones of mostly fish, rats, pigs, turtles and humans (Collins and Weisler 2000; Stefan et al. 2002) but also elements of extinct birds (Wragg 1995). Fish bone reported here came from TP (test pit) 12 situated towards the west end of the site and about an equal distance from the beach and base of the cliffs (Weisler 1998: Figure 4).

These are amongst the densest bone concentrations found at any of the Henderson sites (concentration index = 21 580 bones per m<sup>3</sup>).

## **Methods**

All bones from HEN-5 were retained following field wet-screening through 6.4 mm sieves and sampling through 3.2 and 1.6 mm sieves. Only the fish bone retained in the 6.4 mm screens from TP 12 is reported in this paper. Initially, all fish bones were analysed by Weisler in the early 1990s using the traditional five paired cranial bones and specials, then Weisler used an expanded set of cranial bones to determine if more identifications could be added (Weisler and Green 2013: Table 1). Weisler's identifications used comparative collections he developed over the past 30 years (Weisler 2001: Appendix 3) and those at the University of Otago (Walter et al. 1996). All vertebrae were identified by Lambrides recently to investigate changes in assemblage composition across the three protocols discussed in the previous text. Lambrides also used the comparative collections listed in Weisler (2001: Appendix 3), in addition to more than 75 new specimens. For the vertebrae analysis, reference was made to 73 fish specimens, representing eight families, 35 genera and 54 species, together comprising over 2000 vertebrae.

Some 6480 archaeological fish bones weighing 957 g were sorted into elements and identified to the lowest possible taxonomic level. Comparisons between the three identification protocols were made at the family level. It is important to acknowledge that on the basis of the two separate analyses of all the cranial bones and specials, the most abundant eight families of fish (Acanthuridae, Carangidae, Holocentridae, Labridae, Mullidae, Scaridae, Scombridae and Serranidae) recovered from HEN-5 were used to complete the vertebrae analysis. These families were chosen to facilitate the development of identification protocols utilising vertebrae against previously accepted methods of fish bone identification in the Pacific. The other taxa identified utilising all cranial bones and specials represented only 27 minimum number of individuals (MNI) from seven families including Balistidae, Belonidae, Carcharhinidae, Cirrhitidae, Diodontidae, Kuhliidae and Pempheridae; consequently, they are not explicitly discussed in this study. No formal taphonomic study was conducted when analysing the fish bone from HEN-5. However, fragmentation (defined as less than 50% of an individual vertebra) was quantified. Fragmented vertebrae could not be assigned a specific element type (see the succeeding text for explanation) and identified.

The initial stage of analysis required the identification of the five paired cranial bones: dentary, premaxilla, maxilla, articular and quadrate. These elements are the most commonly identified in Pacific literature on prehistoric fishing (Leach 1986). Furthermore, specials such as the dorsal and anal spines of acanthurids, the scutes of carangids, and superior and inferior pharyngeal grinding

plates of scarids and labrids, were all identified for their distinctiveness when conducting family-level identifications (e.g., Weisler and Green 2013). The second identification protocol incorporated an expanded number of cranial bones (listed previously). These less commonly used elements have been found to increase both species abundance and richness indices in archaeological fish bone assemblages (e.g., Jones O'Day 2004; Vogel 2005; Weisler et al. 2010).

The final stage of analysis used all vertebrae, which were divided into eight groups: proatlas, atlas, thoracic, precaudal, caudal, antepenultimate, penultimate and ultimate (after Casteel 1976: 77–78) (Figure 2). Antepenultimate (also known as the third to last vertebra) was useful for identification to taxon but is usually grouped with the caudal vertebrae in the biological literature. Our identification order went from proatlas, atlas, ultimate, penultimate to antepenultimate. These elements are the most easily identified as an individual fish has only one of each proving ideal for calculations of MNI. On the basis of these identifications, a list of known families was compiled to facilitate identification of thoracic, precaudal and caudal vertebrae. These three vertebrae groups are the most difficult to identify because of intra-group variation; an extensive reference collection will, however, facilitate their identification. In this regard, all Carangidae vertebrae have considerable variability across genera, whereas the other seven families in our study presented less genera level variation.

Vertebrae counts for thoracic, precaudal and caudal vertebrae—based on family, genus and species—were recorded for comparison with the archaeological assemblage. For example, the Acanthuridae comparative specimens used for these analyses each comprised two thoracic, six precaudal and 10 caudal vertebrae; therefore, 50 archaeological caudal vertebrae represents an MNI of five (after Casteel 1974). The list of all cranial elements and specials is provided to assess the distribution of elements used for the identification of each taxon (e.g., Weisler et al. 2010: Table 1). Vertebrae types are also included to ensure the transparency of quantification calculations and replication of methods to facilitate comparisons between studies.

Weisler et al. (2010: 135) provided a detailed account of the strengths and weaknesses of quantifying archaeological fish bone using MNI or number of identified specimens (NISP); Grayson (1984) has shown the strong correlation between these values. Lyman (2008: 80–81), however, has argued that MNI is redundant with NISP as ‘interdependence of identified specimens is randomly distributed across taxa’, and as MNI is a derived value and heavily affected by aggregation, NISP is a more suitable method to measure taxonomic abundance. Nonetheless, Lyman’s conclusions were largely based on the analysis of mammalian remains; in contrast, ‘special’ elements are commonly used for taxonomic identification as well as vertebrae, which significantly inflate NISP. The inflation of NISP resulting from the identification of specials and vertebrae can be corrected by dividing the NISP for each taxon by the number of unique elements used to make the identifications. The implications for

fishing studies require further analysis, as MNI is predominately utilised to discuss taxonomic abundance in the Pacific literature. In this study, both quantification methods are reported to facilitate better comparisons between all Pacific fishing literature irrespective of whether MNI or NISP were calculated (Allen et al. 2001: 61; Weisler et al. 2010: Table 2).

## **Results**

Tables 2 and 3 present the NISP, MNI and rank-order abundance determined by the three identification protocols—five paired cranial bones and specials, expanded set of cranial bones and vertebrae—based on the eight dominant fish families identified from the HEN-5, TP 12 assemblage. Of the 6480 fish bones in our study, 1773 (27%) were vertebrae (including fragments) weighing 268 g and 4707 other elements weighing 689 g.

### *Five paired cranial bones and specials*

A total of 547 fish bones (28% of the total NISP across the three identification protocols) were identified using the five paired cranial bones and specials. Of the eight families identified, the dominant fish taxa, in rank order, were Serranidae, Acanthuridae and Carangidae, contributing 95% of NISP and 86% of MNI. Serranidae accounted for 51% of total NISP and 55% of total MNI; Acanthuridae had only 28% of total NISP and 24% of total MNI; Carangidae inventoried 17% of total NISP and 7% of total MNI.

The NISP for both Acanthuridae and Carangidae were significantly increased by the identification of ‘special’ elements; these included dorsal and anal spines (94% of identified elements) and scutes (84% of identified elements), with only ~7–15% of total identified elements for Acanthuridae and Carangidae represented by the commonly used five paired cranial bones. Importantly, only the five paired cranial bones were used for identifying Serranidae, which only has two special elements, parasphenoid and vomer, utilised for taxonomic identification in the Pacific fishing literature.

### *Expanded set of paired cranial bones*

The expanded set of cranial bones added 201 NISP (10% of the total NISP across the three identification protocols). Identical to the distribution of taxa inventoried by the five paired cranial bones and specials, the two highest ranked taxa were Serranidae and Acanthuridae, together representing 81% of total NISP and 78% of total MNI. Serranidae accounted for 54% of total NISP and 51% of total MNI, and Acanthuridae contributed 28% of total NISP and 26% of total MNI. Significantly, the MNI for Carangidae, Labridae, Scaridae, Scombridae and Serranidae was not increased by the identification of the expanded set of cranial bones. However, the NISP for Carangidae, Scaridae and Serranidae was increased between 10% and 45% (some percentage

increases are inflated by small sample size, for example, the NISP for Scaridae increased from three to four).

The MNI of Acanthuridae, Holocentridae and Mullidae had small increases of only one to three, with the inclusion of an expanded set of cranial bones but, significantly, an approximate doubling in NISP values (from 151 to 206, 1 to 3 and 13 to 23, respectively). Importantly, these results demonstrate that including the expanded set of cranial bones significantly increases the taxonomic abundance for Acanthuridae, Holocentridae and Mullidae.

### *Vertebrae*

Some 1246 vertebrae from eight families (62% of the total NISP across the three identification protocols) were identified (Table 4). As inventoried by all cranial bones (five paired and expanded) and specials, the dominant taxa using vertebrae remained Serranidae and Acanthuridae, representing 85% of total NISP and 78% of total MNI. Significantly, the highest ranked taxon changed to Acanthuridae, accounting for 45% of total NISP and 40% of total MNI, whereas the second ranked Serranidae, contributed 39% of total NISP and MNI. Acanthuridae and Serranidae clearly dominated the TP 12, HEN-5 assemblage across all three identification protocols (Table 2). The use of vertebrae for taxonomic identifications documents that, at least in our sample, Acanthuridae and Serranidae are more economically equivalent than was originally determined by all the inventoried cranial bones and specials. For Acanthuridae, there was a significant increase in both NISP (206 to 907) and MNI (20 to 40) values when the vertebrae were routinely identified. In contrast, the MNI and NISP across all three identification protocols remained similar for Serranidae, which suggests that the five paired cranial bones are adequate for its taxonomic identification. Similar rank-order abundance based on MNI and NISP was noted for Carangidae, Labridae, Mullidae, Scaridae and Scombridae across all three identification protocols (Table 3). Conversely, Holocentridae, when represented by all cranial bones and specials, had low NISP (3) and MNI (2) values but markedly increased to 36 NISP and 4 MNI with the inclusion of vertebrae. The overall increase in NISP and MNI for Holocentridae following the inclusion of vertebrae is not as pronounced as the change noted for Acanthuridae but still warrants the inclusion of vertebrae for documenting abundance values for archaeological fish bone assemblages. Significantly, using vertebrae for determining the taxonomic abundance for our study assemblage more than doubled the NISP counts (Tables 2 and 3).

The distribution of archaeological vertebrae was largely equivalent to the natural distribution of vertebrae counts in an individual fish (Table 4). Accordingly, the most commonly identified vertebra type was the caudal and is likely to be the most highly represented in an archaeological assemblage.

## **Discussion**

Several studies of archaeological fish bone assemblages have suggested that increasing the kind of elements used for taxa identification increases the abundance and diversity of reported species (Butler 1994; Ono and Clark 2010; Vogel 2005). None of these studies have systematically compared the results from using the three identification protocols on the same assemblage. It is especially important to know the limitations and contributions of each protocol when comparing regional studies that used different protocols. For example, Ono and Clark (2010: 650) compared NISP and MNI values when eight and 19 elements are used for taxonomic identification; the former comprised the five paired cranial bones and some specials, and the latter an increased number of specials, as well as vertebrae and some additional cranial elements. This study examined the use of these protocols in the Pacific over time and the corresponding effect on taxa identification.

#### *Limits of using only cranial bones*

Butler (1994) and Ono and Clark (2010) have argued that increasing the number of cranial elements identified in conjunction with the traditional five paired cranial bones and specials does not change relative faunal abundance of the most dominant fish taxa. (However, this is not the case when all vertebrae are analysed.) Similarly, this analysis has demonstrated that total MNI of our study assemblage was not significantly affected by the inclusion of an expanded number of cranial elements for taxonomic identification, aside from a minimal increase in the abundance of Acanthuridae, Holocentridae and Mullidae. This limits interpretations based on potentially underrepresented taxa by restricting element selection for fish bone analysis.

It has been demonstrated that reconstructions of taxonomic abundance are limited when utilising predominantly cranial elements, especially if a dominant economic taxon, such as Acanthuridae, has fragile mouth parts that are more susceptible to post-depositional and taphonomic processes, and even differential recovery (e.g., Leach et al. 1988; Nagaoka 2005; Weisler and Green 2013). Conversely, a bias towards taxa with larger and denser cranial bones, such as Serranidae, will occur when only utilising these elements for taxonomic identification (Table 2 and 3). An overall increase in NISP of ~37% was reported following the inclusion of an expanded set of cranial elements (Table 2). The significance of this increase in NISP has often been underemphasised in the Pacific fishing literature as the focus has been whether rank-order abundance of dominant taxa is affected by element selection (e.g., Butler 1994: 85–86). There are two major benefits of increasing NISP: (1) a more comprehensive analysis of taphonomic and site formation processes can be completed and (2) an increase in the frequency of elements available for size reconstructions is available. The incorporation of an expanded set of cranial bones to the traditional five paired cranial bones and specials resulted in an overall increase in MNI and NISP for the TP 12 assemblage but did not significantly influence rank-order abundance (Table 3).

### *Benefits of vertebrae*

The use of vertebrae has contributed to a more comprehensive understanding of relative taxonomic abundance for the HEN-5, TP 12 assemblage. Importantly, the total MNI for Acanthuridae increased by 100%, from 20 to 40, surpassing the total MNI of Serranidae, which remained 39 across all three identification protocols. MNI using the five paired cranial elements for Acanthuridae contributed 42%, expanded cranial elements added 8%, whereas, significantly, vertebrae added a further 50%. This is an important increase and highlights the robust nature of Acanthuridae vertebrae in contrast to their paired cranial bones. In our study, the results document that the rank-order abundance was changed by the inclusion of vertebrae (Table 3).

A complete analysis of vertebrae at HEN-5 is beyond the parameters of this pilot study, but future analyses of the more than 100 000 fish bones recovered from the site may highlight more pronounced distinctions in taxonomic richness and evenness, as well as rank-order abundance. The inclusion of vertebrae in Pacific archaeofish bone assemblages allows a much larger portion of an assemblage to be analysed and, as such, provide a larger sample to access species variation and reconstructed live fish size within and across taxa at a site. By analysing elements from the entire fish skeleton, differential preservation and processing/ butchering of fish can be more accurately inferred. The application of archaeological vertebrae analysis has been further developed outside the Pacific, with a focus on the use of morphometrics for size reconstructions and taxonomic identifications (e.g., Desse-Berset and Desse 2008; Gabriel et al. 2012; Huber et al. 2011). In the Pacific fishing literature there has been a trend towards completing morphometrics of unidentified fish vertebrae to ascertain broad changes in fish size over time (e.g., Jones 2009; Jones and Quinn 2009; Rolett 1998; Weisler et al. 2010). 'This procedure is based on the assumption that both the identified and unidentified fish vertebrae represent a cross section of the species present in the assemblage' (Jones 2009: 622), an assumption that may not be true for all assemblages due, at least, to varying taphonomic conditions within the same site. A generalised decline in fish vertebrae size is less meaningful than a specific analysis of the abundance and changes in the size of individual taxa over time. A method of analysis that utilises unidentified fish vertebrae fails to incorporate assemblage composition as a critical factor influencing fish size reconstructions; consequently, vertebrae should be identified to taxon prior to estimating overall reconstructed fish size between layers and across sites. Estimating fish size at the family level may inform that specific families demonstrate a change in size over time that is masked when all vertebrae are grouped together.

Furthermore, Jones' (2009: 625) analysis of the Na Masimasi, Lapita site produced a low overall MNI (59) for fish but a comparatively high NISP (7570), as 'the low number of MNI from Na Masimasi is due to an extremely high frequency of vertebrae in the assemblage and the somewhat preliminary

nature of fish bone identifications'. Jones' analysis did not utilise vertebrae to the full extent to significantly increase the MNI values at the Na Masimasi site.

It is also important to include the distribution of vertebrae types used to complete taxonomic identifications. There are two main issues regarding the analysis of vertebrae in the Pacific fishing literature: (1) vertebrae are often presented as a uniform category when presenting the distribution of identified elements (e.g., Ono and Clark 2010: Table 2) and (2) measurements of vertebral centra are completed without specifying the distribution of vertebrae types (e.g., Jones 2009: Table 5). This is significant as there is natural size variation along a fish vertebral column, and by treating archaeological vertebrae as a uniform class, the variation in a vertebrae assemblage may not be accurately determined. It is argued that by analysing and reporting archaeological vertebrae on the basis of type (Figure 2), there can be standardisation in the use of vertebrae in Pacific archaeology and an improvement in the overall replicability of results.

#### *Implications for prehistory: the Henderson case study*

Weisler et al. (2010, 2013) commented that the fish bone assemblages from raised limestone (makatea) islands such as Henderson are usually dominated by Serranidae, unlike the majority of other Pacific island fish assemblages, where Scaridae have been reported as the most abundant taxa (Leach and Davidson 2000: 414). Consequently, the dominance of Serranidae may be 'a unique signature of makatea assemblages' (Weisler et al. 2010: 130). Given the ecology of makatea islands and frequency of fishhooks in the Henderson assemblage, it was inferred that angling was probably the dominant capture technique for Serranidae. Yet, based on the distribution of taxa for TP 12 as determined by the inclusion of vertebrae, Acanthuridae is the most dominant fish taxon (commonly captured by netting).

#### **Conclusions**

This paper provided a detailed identification and quantification protocol for the consistent application of vertebrae analysis in prehistoric Pacific fishing studies. Archaeological vertebrae should be identified to the highest taxonomic level and vertebra type prior to allometric reconstructions of live fish size and weight. Vertebrae should not be considered as a single uniform element class. The distribution of vertebrae types used for identifications requires inclusion in tables to ensure the transparency of quantification calculations and replication of methods to facilitate comparisons between studies.

In our study for Henderson Island, the inclusion of vertebrae suggested that angling may have been a less important capture technique, with netting more common than previously interpreted. We agree with Ono and Clark (2010: 652) that only when more comprehensive methods are implemented for

the identification of archaeological fish bone across the Pacific can archaeologists begin to assess the dialogue between humans and their marine ecosystems throughout prehistory. As such, our comprehensive vertebrae analysis demonstrated that by considering a wider number of elements for the analysis of archaeological fish bone assemblages, relative taxonomic abundance can be more accurately determined, thereby leading to more accurate interpretations of prehistoric human behaviour with the marine ecosystem. Furthermore, regional syntheses must be approached cautiously when using older studies that utilised a limited number of fish elements for identification. We therefore suggest that identification of all vertebrae become standard practice for archaeological fish bone studies in the Pacific.

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**Table 1.** The dominant elements used to make archaeological fish identifications from Pacific assemblages from the 1970s to contemporary literature.

Elements	Time Period			
	1970s	1980s	1990s	2000 - present
‘Dental jaws’, ‘mouth parts’, ‘head bones’, or ‘dental plates’ etc. (= dentary/ premaxilla)	(Davidson 1971; Kirch 1971, 1975, 1979; Kirch and Rosendahl 1973)	(Allen 1986; Best 1984; Goto 1986; Nichol 1986)		
Five paired cranial bones + ‘specials’	(Leach 1976; Leach and Davidson 1977)	(Anderson 1981; Davidson and Leach 1988; Green 1986; Leach et al. 1988; Masse 1989)	(Allen 1992; Davidson et al. 1998; Leach et al. 1997; Weisler 1999)	(Allen et al. 2001; Clark 2005; Davidson et al. 2000; Fitzpatrick and Kataoka 2005; Weisler 2001)
Five paired cranial bones (excl. articular and/or quadrate) + ‘specials’		(Leach and Davidson 1988; Rolett 1989)	(Allen and Steadman 1990; Dye 1990; Rolett 1998; Walter 1991)	
Expanded number of cranial bones			(Walter 1998)	(Jones O'Day 2004; Ono 2003, 2004; Ono and Clark 2010; Ono and Intoh 2011; Vogel 2005; Weisler et al. 2010; Weisler and Green 2013)
Vertebrae ‘special’ <sup>a</sup>	(Davidson 1971; Leach and Davidson 1977)	(Davidson and Leach 1988; Leach 1989; Leach et al. 1988)	(Davidson et al. 1999; Davidson et al. 1998; Fraser 1998; Leach et al. 1994; Leach et al. 1997; Weisler 1999)	(Clark and Szabó 2009; Jones O'Day 2004; McAlister 2002; Vogel and Anderson 2012; Weisler 2001; Weisler and Green 2013)
Vertebrae <sup>b</sup>				(Ono 2003, 2004; Ono and Clark 2010; Ono and Intoh 2011)

<sup>a</sup> A select range of vertebrae that were considered under the category of ‘specials’, which predominately refer to Elasmobranchii (sharks, rays and skates) vertebrae and Scombridae (mackerels, tunas and bonitos) ultimate vertebrae.

<sup>b</sup> All vertebrae are analysed and identified (where possible) in an assemblage, beyond what would be considered as ‘specials’.

**Table 2.** Fish bone MNI and NISP from TP 12, Henderson Island as represented by three separate identification protocols: (1) the five paired cranial bones and ‘specials’, (2) an expanded number of cranial bones; and (3) vertebrae (Acanthuridae, Carangidae, Holocentridae, Labridae, Mullidae, Scaridae, Scombridae and Serranidae only).

Taxon	Five paired cranial bones + ‘specials’			Expanded number of cranial bones			Vertebrae		
	Layer IA MNI (NISP)	Layer IB MNI (NISP)	Layer III MNI (NISP)	Layer IA MNI (NISP)	Layer IB MNI (NISP)	Layer III MNI (NISP)	Layer IA MNI (NISP)	Layer IB MNI (NISP)	Layer III MNI (NISP)
Acanthuridae	1 (4)	15 (145)	1 (2)	2 (8)	17 (195)	1 (3)	2 (42)	37 (855)	1 (10)
Carangidae	1 (3)	4 (89)	0	1 (3)	4 (98)	0	1 (7)	5 (175)	1 (2)
Holocentridae	0	1 (1)	0	1 (1)	1 (2)	0	1 (4)	3 (32)	0
Labridae	0	3 (8)	0	0	3 (8)	0	0	3 (14)	0
Mullidae	1 (1)	2 (11)	1 (1)	1 (2)	3 (20)	1 (1)	1 (3)	3 (41)	1 (1)
Scaridae	0	1 (3)	0	0	1 (4)	0	0	1 (10)	0
Scombridae	1 (2)	0	0	1 (2)	0	0	1 (3)	1 (11)	0
Serranidae	5 (11)	33 (264)	1 (2)	5 (18)	33 (381)	1 (2)	5 (38)	33 (739)	1 (7)
Total identified	9 (21)	59 (521)	3 (5)	11 (34)	62 (708)	3 (6)	11 (97)	86 (1877)	4 (20)
Total unidentified	250	5593	84	237	5406	83	174	4237	69
Total bones (including vert.)	271	6114	89	271	6114	89	271	6114	89
% identified	7.7	8.5	5.6	12.5	11.6	6.7	35.8	30.7	22.5

Note that MNI for Acanthuridae doubled when using vertebrae, in contrast to all cranial bones and ‘specials’.

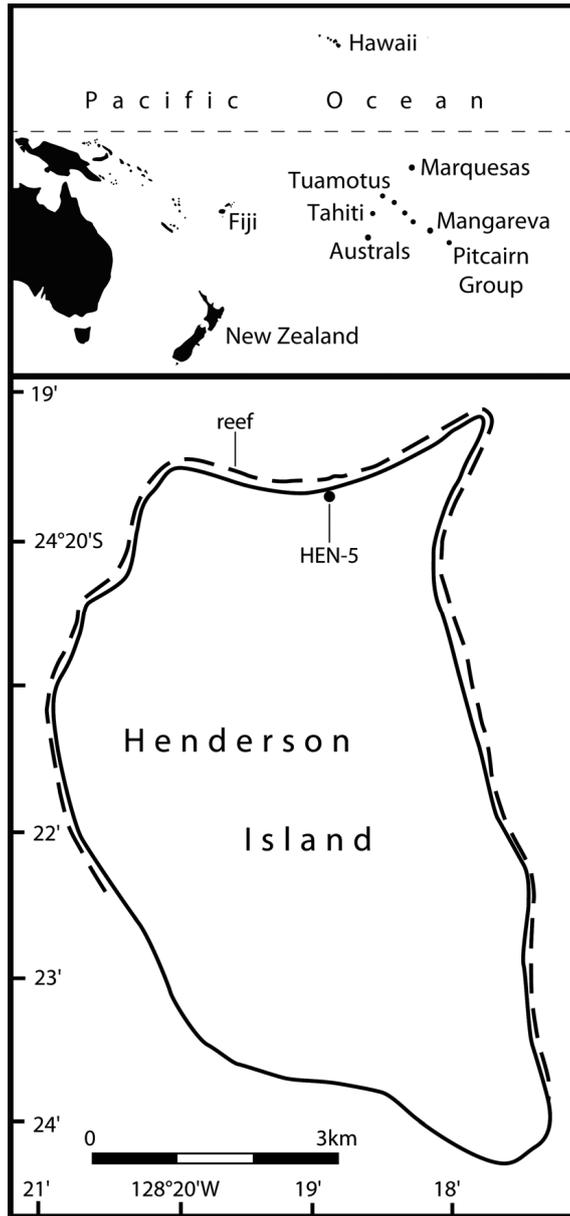
**Table 3.** Rank-order abundance based on NISP and MNI for five paired cranial bones and ‘specials’, expanded number of cranial bones and vertebrae for all cultural layers from TP 12, Henderson Island (Acanthuridae, Carangidae, Holocentridae, Labridae, Mullidae, Scaridae, Scombridae and Serranidae only).

Taxon	Five paired cranial bones + ‘specials’		Expanded number of cranial bones		Vertebrae	
	NISP	MNI	NISP	MNI	NISP	MNI
Acanthuridae	2	2	2	2	1	1
Carangidae	3	3	3	3	3	3
Holocentridae	8	6	7	5	5	5
Labridae	5	5	5	4	6	6
Mullidae	4	4	4	3	4	4
Scaridae	6	6	6	6	7	8
Scombridae	7	6	8	6	6	7
Serranidae	1	1	1	1	2	2
Total ID bones	547	71	748	76	1994	101

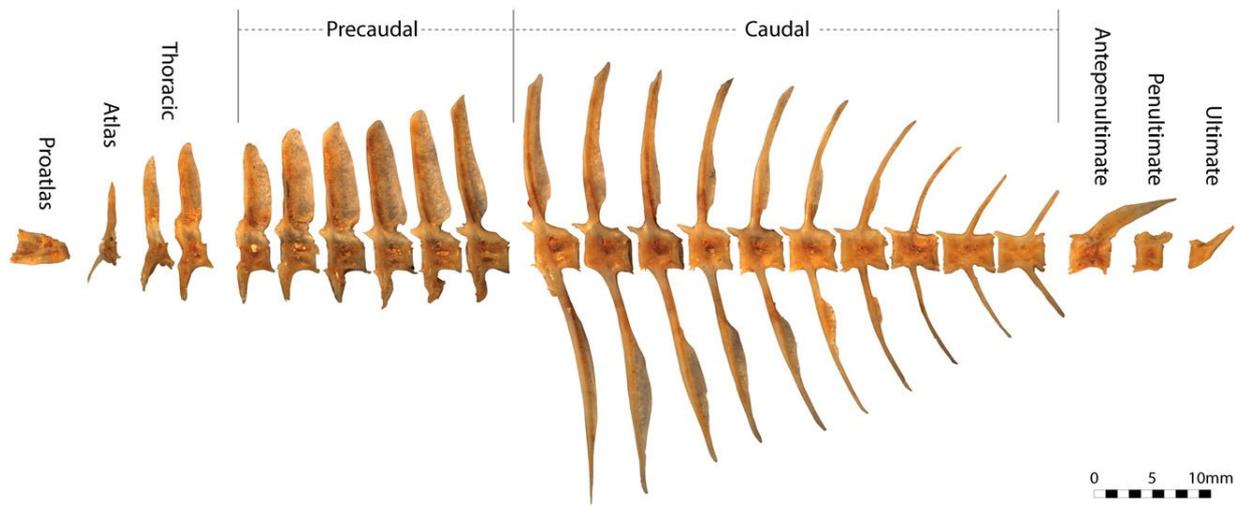
**Table 4.** Distribution of vertebrae types used for the identification of TP 12, Henderson Island fish bone assemblage (Acanthuridae, Carangidae, Holocentridae, Labridae, Mullidae, Scaridae, Scombridae and Serranidae only).

Taxon	Proatlas	Atlas	Thoracic	Precaudal	Caudal	Antepenultimate	Penultimate	Ultimate	Number of types
Acanthuridae		14	54	217	396	15		5	6
Carangidae		2	21	15	36	3	1	5	7
Holocentridae	1		7	19	6				4
Labridae				1	4			1	3
Mullidae			3	12	5		1	1	5
Scaridae				2	3			1	3
Scombridae	1		1	2	8				4
Serranidae	10	23	66	71	186	5	14	8	8
Unknown		3	21	23	192	1	7		6
Total	12	42	173	362	836	24	23	21	1493

Note that proatlas, atlas, antepenultimate, penultimate and ultimate are single elements useful for MNI calculations.



**Figure 1.** Map of the South Pacific with Henderson Island (Pitcairn Group) and the location of site HEN-5.



**Figure 2.** Articulated Acanthuridae (surgeonfish, *Acanthurus lineatus*) vertebral column with the eight vertebrae types marked. Note that proatlas, atlas, antepenultimate, penultimate and ultimate are single elements useful for MNI calculations.