



Size Matters: 3-mm Sieves Do Not Increase Richness in a Fishbone Assemblage from Arrawarra I, an Aboriginal Australian Shell Midden on the Mid-north Coast of New South Wales, Australia

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(Received 30 August 2000, revised manuscript accepted 2 March 2001)

For 30 years the prevailing viewpoint regarding the retrieval of archaeological faunal material has been: smaller sieve mesh yields more identified taxa. We discuss the findings of sieving experiments from a coastal midden site, in which an assemblage of more than 60,000 fish-bone specimens was successively sieved through 6, 3, and 1-mm mesh sieves. Against expectations, we identified no more taxa in the 3-mm sieve fraction than were apparent in the 6-mm fraction. We discuss the probable causes of a result at odds with other researchers' results and attribute the difference to (a) idiosyncratic, inter-regional variability in the range of skeletal morphologies in fish communities; (b) the possibility that processing activities will differentially delete skeletal segments such as the head; and (c) destructive physical and chemical processes that may have rendered otoliths invisible, despite the use of small-mesh. © 2002 Academic Press

Keywords: TAPHONOMY, RECOVERY, ARCHAEOLOGY, MESH SIZE, FAUNAL ANALYSIS, ZOOARCHAEOLOGY, FISHBONE.

Introduction

Correct taxonomic ascription and accurate quantification of animal bones are so vital to zooarchaeological interpretation that considerable effort has been spent developing recovery methods and analytical techniques to ensure robust inference-making (e.g. Grayson, 1984; Lyman, 1994). One insight in particular has had a profound effect on archaeological practice—i.e., the notion that sieve mesh size can bias estimates of abundance, as well as richness, one of the measures of taxonomic diversity (Casteel, 1972; Payne, 1972; Grayson, 1984; Wheeler & Jones, 1989; Shaffer, 1992; Gordon, 1993; Shaffer & Sanchez, 1994; Lyman, 1994). In this paper we present evidence to suggest there is nothing straightforward about the relationship between sieve mesh size and either taxonomic richness or abundance. As part of an archaeological investigation of a coastal shell midden, we first sieved sediments containing approximately 60,000 fish bone specimens through 6-mm mesh. What fell through the 6-mm mesh sieve was then passed through 3-mm mesh. From the smaller sieve fraction we naturally expected not only increased numbers of identified specimens (NISP), but we also expected to add substantially to the list of identified taxa. However, the 3-mm fraction contributed no new taxonomic ascriptions, in spite of tripling the numbers of ident-

ified specimens (NISP) and increasing the minimum numbers of individuals (MNI). When we subsequently passed a sub-sample of the 3-mm residue through 1-mm mesh, we added one species to the list (although in all likelihood similar additions to other assemblages would be a rare outcome). Our findings are at odds with what other researchers have reported, which led us to look for the cause of our results. We found complex processes at work. As this paper argues, our findings are the result of two main factors: (1) the peculiarities of the fish skeleton, including the size and skeletal characteristics of the suite of fish taxa available for procurement on the mid-north New South Wales coast in the Holocene; and (2) inferred Aboriginal procurement techniques.

Background

Thomas (1969) is acknowledged to have been first to note the size bias inherent in some retrieval techniques. Because of such insights, it is now common practice to sieve excavated sediments to minimize information loss. Yet, despite understanding that excavated sediments must be monitored for what they contain, it took the archaeological community some time to realize that using too large a mesh will catch more of the elements and fragments of large taxa, and only the

larger elements of smaller species, while missing the smallest elements and species altogether. Many researchers have since elaborated on Thomas's observation (e.g. Casteel, 1972; Payne, 1972; Grayson, 1984; Wheeler & Jones, 1989; Shaffer, 1992; Gordon, 1993; Nagaoka, 1994; Shaffer & Sanchez, 1994; Lyman, 1994; James, 1997). Their insights are compelling if one is working with a class of animals for which a good proportion of skeletal elements are identifiable to the specific level, so that even the elements of small animals are diagnostic to species. Mammalia is a good example. However, the fish skeleton is fundamentally different than that of a terrestrial vertebrate. Relative to tetrapod vertebrates fish skeletons possess high numbers of less distinctive ribs, spines, and vertebrae. And, while a fish skeleton may have a number of potentially diagnostic elements in the cranium, more often than not taxonomically distinct elements are fragile and therefore susceptible to degradation due to numerous processes. This degradation can in turn render them all but unidentifiable. And, since most faunal analysis aim to identify vertebrate remains to a level of specificity finer than "fish", collecting a large number of such specimens is of limited inferential utility. Taken together, the fish's skeletal characteristics can make efforts at identifying the majority of a fishbone collection unrewarding in terms of allocating each specimen a taxonomic identity, especially when dealing with the smaller sieve fractions, which will usually contain large numbers of undiagnostic, fragmented and degraded specimens.

In spite of these observable differences between mammal and fish skeletons, a number of workers have noted that using smaller-meshed sieves can influence interpretations of fishbone assemblages, by increasing the number of species identified in a given assemblage, and by providing a more accurate estimate of the relative proportions of taxa in the assemblage. Both Gordon (1993: 456) and Weisler (1993: 146) found that smaller taxa and smaller diagnostic elements go unnoticed in a fishbone assemblage when deposits are sieved through 5-mm or larger mesh only. Gordon (1993: 456) observed that different taxa were identified from different sieve fractions—88% of the 24 fish families she recorded on Molokai were identified from the 3-mm sieve fraction. Butler reviewed research in the Pacific region and concluded that "screen size is a major determinant of the number and type of fish taxa recovered archaeologically" (Butler, 1988: 104). On the basis of sieving experiments on North American taxa she suspected that the use of 5-mm or larger mesh screens on Lapita sites "may have resulted in the loss of 77% or more of the identifiable fish remains" (Butler, 1988: 104).

If it were not for a zooarchaeologist's interest in past people's actions, such problems might be of little concern. However, we do worry about what the range of taxa can tell us about, for example, procurement practices, or changes in those practices through time

(e.g. Casteel, 1972; Grayson, 1984; Butler, 1988; Wheeler & Jones, 1989; Gordon, 1993; Weisler, 1993; Nagaoka, 1994). Wheeler & Jones (1989) and Butler (1988) suggest that interpreting an assemblage of fishbone on the basis of assemblages biased toward larger elements may lead to the conclusion that the procurement strategy focused on fish with larger elements, usually the larger fish. Gordon (1993: 453) concludes that using only large-mesh screens would have resulted in "serious errors in the interpretation of subsistence strategies".

As a result of such evidence of the dangers of using only large-mesh sieves, small-mesh sieving is held up as a standard example of "best practice" in archaeology. Wheeler & Jones (1989: 50) go so far as to recommend all recovered material be sieved through a 1-mm mesh when fishbone is expected in an excavation. However there is a price for such vigilance. Even for excavations that yield relatively little fishbone by volume, small mesh sieving and the subsequent sorting and identification of the retrieved material can be very time-consuming. For example, Gordon (1993: 455) determined that six times as much bone was recovered using a 3-mm (1/8 in) sieve-mesh than was recovered with the 5-mm mesh alone. And, to put a price on practice, Meighan (1971) calculated that it takes five times as long to sort the residue from a 1/16-in (~1.5-mm) mesh as it does to sort the 1/4-in (6-mm) fraction. Thus, given the time involved in sorting and identifying the small sieve fractions, one would hope that the time is repaid with concomitantly useful results.

However, in spite of what seems to be an intuitively obvious conclusion—"catch all, not just some of the faunal bone, and you'll gain the most information possible"—there seems to be some question as to the efficacy of so doing. Despite all the published claims to the contrary, and despite what she had earlier proposed, Butler (1994: 85) later found that "relative fish family abundance is similar across screen mesh fractions", precisely the opposite of what one should expect based on all of the earlier research cited above. Following Butler's revelation, we examined a large midden assemblage with a view toward monitoring the quality of observations obtained from 6-mm and 3-mm sieve fractions, and assessing the benefits of using very small mesh (i.e. 1-mm).

The Arrawarra I Midden: Recovery and Identification

The fishbone assemblage used in this research was recovered from the Arrawarra Beach foredune, 30 km north of Coffs Harbour, on the mid-north coast of New South Wales, Australia. The shell midden consisted of a single, consolidated lens of cultural material, atop unconsolidated white sand, approximately 1.6 m above the present beach. Wave and wind action had

eroded the culturally sterile, unconsolidated white sand underlying the midden, leaving it undercut. The 30-cm-deep lens was overlain by 25 cm of humic soil with a high sand content. Fragile elements such as articulated fishbone, fish scales, charcoal and fine stone debitage were present along with large stone artefactual material and shell. Smith (1998) infers that this is an undisturbed section of what was previously an extensive coastal midden system. The Traditional Landowners, the Garby Elders of the Gumbaingirr Nation and Yarrawarra Aboriginal Corporation, requested a salvage excavation. Arrawarra Beach is the site of an enigmatic stone structure located on a rocky platform at the southern end of the beach. This structure has been the subject of some controversy and the Aboriginal Elders were interested to know if the archaeological fishbone assemblage implied the use of fishtrapping technology in the past.

As the cultural layer was largely unsupported, an excavation from the top of the dune was not possible. For this reason the midden lens was cut into sections and removed *en bloc* in plastic-lined boxes. Slumped material was collected from the talus slope at the base of the dune, as was material that fell during the process. In this way, four linear metres of midden were removed.

Radiocarbon determinations made on charcoal collected from the north, south and middle sections of the excavated midden lens returned ages of 1230 ± 50 BP (Beta-114723), 1330 ± 70 (Beta-114724), and 1130 ± 60 (Beta-114725), all in all suggesting deposition in a tightly constrained temporal context (Smith, 1998).

All of the retrieved sediments were sieved through 6-mm and 3-mm mesh, and small samples of sediment were screened through 1-mm mesh. Vale (1998) examined the effects of retrieval practices on measures of diversity and abundance. All of the fishbone retrieved from the 6-mm and 3-mm screens was sorted and examined. However, time-pressure did not allow sorting and examination of all of the 1-mm residue. Instead, 15 50-g samples were taken from the consolidated midden and from the material that had slumped prior to, or during the excavation. These were passed through a 1-mm mesh sieve, and all of the fishbone was removed. In all, over 60,000 pieces of well-preserved fishbone were recovered, the majority of which was highly fragmented.

Identifications were made using a comparative collection Vale prepared for the project. By agreement, all of the archaeological material was studied at the Yarrawarra Aboriginal Community Centre, which precluded the use of larger museum collections of comparative specimens. The Garby Elders of the Gumbaingirr Nation and local anglers provided insights as to which taxa to include in the collection.

As is the case in most studies of fishbone researched on the NSW coast, taxonomic identifications of the Arrawarra I assemblage were most commonly achieved using the five elements of the dentition—the maxilla,

Table 1. Arrawarra I midden species composition

Common name	Family	Species
bream	Sparidae	<i>Acanthopagrus australis</i>
tarwhine	Sparidae	<i>Rhabdosargus sarba</i>
blackfish	Girellidae	
whiting	Sillaginidae	
rock cod	Serranidae	
flathead	Platycephalidae	
wrasse	Labridae	
tailor	Pomatomidae	
mullet	Mugilidae	
sweep	Scorpididae	
trevally	Carangidae	

Table 2. Arrawarra I midden. Total weight, weight identifiable and percentage identifiable

Sieve fraction	Total weight (g)	Weight identifiable (g)	Proportion identifiable (%)
6-mm	160.5	14.8	9.3
3-mm	477.3	7.8	1.6
Total	637.8	22.6	3.5

premaxilla, dentary, quadrate and articular. Some vertebrae were also distinctive. One, the terminal vertebra, allows one unequivocally to count numbers of individuals, because it is a unique element in the fish skeleton. Another taxonomically distinct part of the fish skeleton, the otolith, was conspicuously absent from this assemblage, which was a surprise, considering Weisler's (1993) findings, a point to which we return in the discussion. For the purposes of this study, "identified" means that the specimen could be ascribed to family or species; "unidentified" means that the specimen could at best be ascribed to Class (i.e., fish).

Results

Eleven taxa from 10 families were identified from the Arrawarra I midden (Table 1). The assemblage comprises bream (Sparidae *Acanthopagrus australis*), tarwhine (Sparidae *Rhabdosargus sarba*), blackfish (Girellidae), whiting (Sillaginidae), rock cod (Serranidae), flathead (Platycephalidae), wrasse (Labridae), tailor (Pomatomidae), mullet (Mugilidae), sweep (Scorpididae), and trevally (Carangidae), all of which are locally available (some only seasonally). Of the 11 taxa identified, the 6-mm mesh recovered all but 1. The 3-mm fraction did not add to the number of identified taxa. The 1-mm sieve yielded the additional taxon.

Table 2 presents the weight of fishbone recovered in the 6- and 3-mm sieves, as well as the total weight. The 6-mm fraction accounts for only 1/3 of the total weight, but nearly 2/3 of the identifiable elements. Almost 10%

Table 3. Arrawarra I midden NISP and MNI from the 6-, 3-, and 1-mm sieve fractions

Taxon	MNI		NISP				
	6	6 and 3	1	6	3	1	6 and 3
Sparidae	12	20	0	84	91	9	175
Girellidae	7	20	0	27	53	1	80
Sillaginidae	1	3	0	7	25	0	32
Epinephelidae	1	1	0	1	1	0	2
Platycephalidae	2	5	0	9	7	3	16
Labridae	1	1	0	1	0	0	1
Pomatomidae	1	1	0	2	0	0	2
Mugilidae	2	7	0	19	70	2	89
Scorpididae	1	9	0	3	15	0	18
Carangidae	0	0	1	0	0	2	0
Total identified	28	67	1	153	262	17	415
Total unidentified	31	155	n/a	n/a	n/a	n/a	

by weight of the 6-mm fraction was identifiable, while only about 2% by weight of the 3-mm fraction was identifiable. However, even this comparably small percentage of identifications resulted in an increase of 262 identified specimens. By comparison, only 0.5%, by weight, of the 1-mm sample was identifiable.

Table 3 presents NISP and MNI for identifiable specimens, and tallies the “unidentified” MNI based on the non-diagnostic terminal vertebrae in the 6-mm and 3-mm fraction. This provides an unequivocal assessment of MNI across the taxa present.

Identified

The 6-mm sieve contributed 42% of the identifiable MNI. Astonishingly the 3-mm sieve caught almost 70% more fishbone than the 6-mm sieve, yet yielded no additional taxa. Moreover, the 3-mm sieve contributed 58% of the MNI. Thus the 3-mm fraction added significantly to total MNI. In addition, the 3-mm fraction more than doubled identifications of blackfish, whiting, flathead, mullet and sweep.

Unidentified

In all, taxonomically distinct elements yielded an MNI of 68. However the terminal vertebrae yielded an MNI of 155. The vast majority (80%) of the unidentified specimens were recovered from the 3-mm sieve.

Discussion

No one would deny that it makes sense to recover as much of an archaeofaunal accumulation as is possible, as long as there is an “improvement” in our understanding of what went on in the past. Yet, in the analysis of the Arrawarra I midden, poring over the 3-mm sieve fraction made no contribution to the numbers of species identified. This is a puzzling result, considering the number of researchers who have concluded that using small (i.e. 3-mm or less) mesh sieves will increase measures of taxonomic richness in

archaeological faunal assemblages (Gordon, 1993; Weisler, 1993; Nagaoka, 1994). Given Butler’s (1994: 85) finding that “mesh size does not bias recovery of fish remains or fish taxa of particular sizes” in her Lapita research, and now our own results, we felt that there is no reason to accept unreservedly that smaller-meshed sieves will always contribute usefully to archaeological interpretations of fishbone accumulations. But, what best explains such contradictory conclusions?

In this section, we discuss several factors that have a bearing on the results of fish faunal analyses; factors that will influence the “improvement” to be gained when employing the 3-mm (or smaller) sieves, either in numbers of species, or of identified specimens. The first of these is the taxonomic makeup of the assemblage, which is in part determined by the range of taxa available for procurement.

Species composition

The range of fish that can potentially enter an archaeological site will vary from place to place, according to any number of variables-community structure, for example. It goes without saying that the fish taxa available on North America’s northwest coast are very different from those inhabiting the waters off the mid-north coast of New South Wales. There is nothing startling in such a statement. However, we would argue that such variability affects the inferential “improvement” to be made when using a fine-mesh sieve. This is due mainly to the nature of the fish skeleton, and the characteristics of the community from which a given fish archaeofauna is drawn.

At the heart of the differences in “improvement” is the identifiability of smaller parts of some fish, and of fragments of larger elements. Species A, for example, may have smaller bones that are on the whole more diagnostic than the smaller elements of Species B. This means that A will be visible in the 3-mm sieve, while B will not be. Additionally, fragments of Species A might be more diagnostic than similar-sized fragments of

Species B. This may mean that Species A will “turn up” in the 3-mm fraction, while Species B will not. Thus, the taxa available for exploitation determine whether or not the species represented in the Arrawarra I assemblage are those whose elements and fragments are visible in both the 6-mm and the 3-mm sieve, and not any inherent characteristics of the fish skeleton, per se (although taphonomy cannot be ignored as a determinant of assemblage composition, in this or any other). For Butler to have arrived at a similar conclusion to ours, the Mussau fishbone assemblage must have contained a similar range of fish taxa as the one in our sample. And, quite clearly, Gordon (1993), Weisler (1993) and Nagaoka (1994) are dealing with a range of fish taxa where the diagnostic elements and fragments of a large number of fish are more visible in the 3-mm than the 6-mm sieve. Gordon, Weisler and Nagaoka all work in Hawaii, which may explain the similarity of their findings. It seems clear that the differences between, on the one hand, Gordon, Weisler and Nagaoka’s results, and on the other hand, Butler’s and ours, may simply be the skeletal differences in the fish taxa represented in their assemblages, and the skeletal characteristics of that faunal suite.

Specifically, in the Arrawarra I assemblage the fishbone retained in the 6-mm sieve consisted of larger bones, or more-or-less complete elements, which make identification more straightforward. This appears to be the case because the 6-mm assemblage is predominantly Sparidae (bream, tarwhine and bone identified only as Sparidae), followed by Girellidae (blackfish) (Figure 1), both of which have a robust jaw element. On the other hand, in the 3-mm sieve much of the bone was too fragmented to enable taxonomic identification. That fraction thus accounted for 71% by weight of the total fishbone retrieved, but only 1.64% of the total identifications. In addition, the degree of fragmentation and surface wear was more obvious in the elements retained in the 3-mm sieve, i.e. the more broken elements of the robust dentitions, and numerous vertebrae. Of greatest importance in this discussion, the 3-mm fraction yielded nearly 80% of the terminal vertebrae in the collection. We feel that the MNI of 155 is a much more accurate estimate of the original number of fish captured. That nearly 80% were recovered from the 3-mm sieve indicates that there are large numbers of taxonomically distinct elements that are either not being preserved or not preserving in identifiable condition.

While the 3-mm sieve fraction did not contribute new species identifications, it did alter the NISP and MNI differentially for certain species, in particular boosting the numbers of identification for species with fragile jaw elements, such as the economically significant mullet. This is an important contribution, which alone justifies the routine use of 3-mm mesh sieves. However, this result contradicts Butlers’ (1994) subsidiary finding that the smaller sieve fractions do not alter the relative proportions of taxa in a fishbone

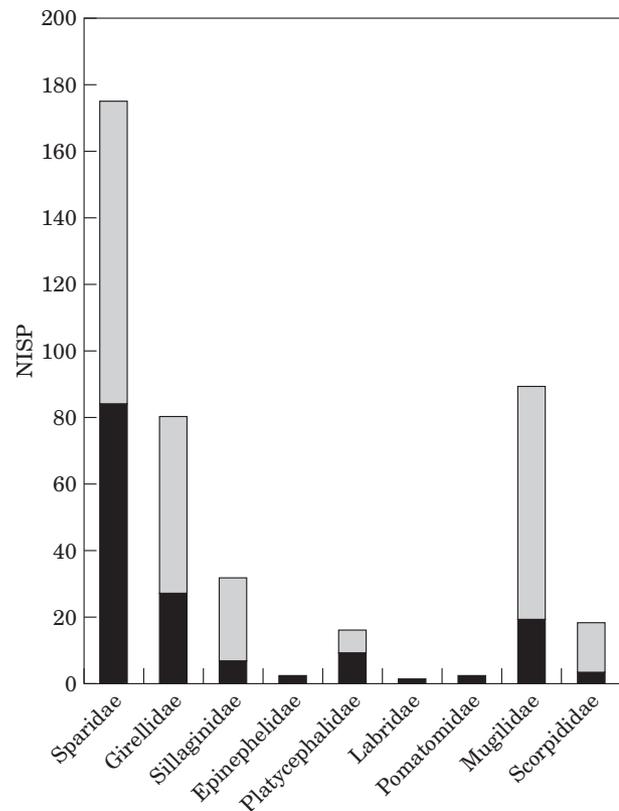


Figure 1. Arrawarra I: NISP from 6-mm and 3-mm sieve fractions. □, 3mm; ■, 6mm.

assemblage. Our 3-mm sieve made a large contribution to the NISP (Table 3) of the assemblage, and a significant contribution to estimated MNI for some taxa, especially for the “unidentified” individuals (Figure 1). Importantly, the 3-mm sieve increased abundance for some species more than others. For example, the 6-mm sieve fraction is dominated by the Sparidae. Yet, when the 6-mm and 3-mm sieve fractions are combined, the Girellidae (blackfish) MNI equals that of the Sparidae (Table 3). Moreover the Sillaginidae (whiting), Platycephalidae (flathead), Mugilidae (mullet) and Scorpididae (sweep) take on a greater importance in the total assemblage (Figure 1). Taxa such as the ethnographically important mullet (Mugilidae) were only identified by their distinctive vertebrae, most of which passed through the 6-mm mesh. In contrast to the skeletal characteristics of Sparidae and Girellidae, the mullet has a very small and fragile dentition, which would not be expected to preserve in archaeological sites, and which would therefore be underrepresented in an archaeological record comprised of archaeofaunas recovered using only 6-mm mesh (Weisler, 1993: 145).

Natural versus cultural processes

In the present study, separating natural from cultural processes proved to be difficult—and in the end

required using all available evidence, most of which points superficially to natural destructive processes to explain the assemblage characteristics. In the Arrawarra I assemblage, there is great disparity between the MNI based on all elements—67, and the MNI of 39 made possible by cranial bones. There is an even greater disparity between the MNI of 39 based on cranial elements and that of 155 based on terminal vertebrae (Table 3). This means that 75% of the 155 positively enumerated individuals contributed no taxonomically identifiable cranial elements to the assemblage. Thus, despite the apparently good preservation of fish bone at Arrawarra, the evidence suggests that one or more processes have selectively deleted head parts, or rendered them archaeologically invisible.

At least one line of evidence suggests that fragmentation of the Arrawarra I fishbone into minimally identifiable pieces, and not, in fact, deletion of head parts was responsible for our results. Only the more robust jaw elements and vertebrae were identified in significant numbers. Nearly 20% of the identified taxa are Sparidae and Girellidae, fish with large or robust cranial parts. Together these taxa represent more than half of the identified MNI (i.e. identified from elements other than the terminal vertebra). Moreover, nearly half (i.e. 19 of 40) of the individuals of these two taxa were identified from material caught in the 6-mm mesh.

In tandem, these observations suggest that it may not be an absence of cranial parts, but rather the dearth of identifiable fragments in the 3-mm fraction that contributed to the seeming disproportion of cranial elements in the assemblage. For, when the less robust, smaller elements of species with relatively smaller head parts are subjected to destructive processes, the resulting fragments are, on the whole, less diagnostic than similarly affected elements of taxa with relatively larger homologous elements. Therefore it seemed possible to us that post-depositional mechanical processes were contributing to the element frequencies observed in the Arrawarra I midden.

This would be the straightforward conclusion, and we would be happy to settle on this as the explanation, were it not for the absence of otoliths and otolith fragments in the collection. We believe destructive post-depositional, mechanical processes can be ruled out as the explanation for this characteristic of the assemblage, since fragmentary otoliths would be identifiable as such, and would likely lend themselves to taxonomic ascription, even in a fragmentary state. However, there is some question whether or not otoliths would resist chemical degradation, even in a shell midden such as Arrawarra I. Weisler (1993) reports their recovery in a calcareous Hawaiian sand dune. Butler and Chatters (1994: 419) aver “The fact that [salmon otoliths] are scarce in all coastal or near coastal sites suggests that other intrinsic factors, e.g. compositional or structural differences between otoliths and bone, account for their absence.” Wheeler & Jones (1989: 63) maintain that otolith survival depends

on very special matrix chemistry—i.e. base rich or alternatively in alkaline or neutral sediments (i.e. pH 7 or higher) (1989: 125). The Arrawarra I midden is pH 7. Would otoliths have survived, or not? Clearly more empirical observation is required before this question can be adequately answered. As to the interpretation of Arrawarra I, we are left in a quandary. The absence of otoliths cannot be interpreted unambiguously. Their absence could point to the conclusion that some head parts were not entering the midden, or at least did not enter the midden in the same location as the terminal vertebrae or skeletal parts. However, it is also quite possible that they were destroyed by diagenetic processes.

Until another explanation presents itself, or until the present ambiguity about otoliths is removed, we must conclude that the two possibilities are equally plausible. Either an as-yet-unidentified cultural practice was selectively deleting at least some of the heads or the head parts, or diagenetic processes were dissolving the otoliths. And, while cultural practices will not always be in play in archaeological fishbone assemblages, they would always be a possibility. Where does this leave our examination of recovery and analysis techniques? The answer is equally ambiguous. However, since cranial elements provide the bulk of taxonomic identifications in many fishbone analyses, cultural practices that selectively delete head parts will always reduce the number of species identifications. In such cases searching the 3-mm and 1-mm sieves will be inherently less rewarding.

Value of using a 1-mm sieve

The 1-mm sieve retains large numbers of specimens, but it has to be questioned if the amount of time taken to sieve, sort, and try to identify these pieces can be justified by the end result. The only taxonomically distinct elements from the 1-mm sieve fraction were the “special” intermuscular bones and some vertebrae. Moreover, there is some question as to whether or not sieving through so many stages actually damages fishbone. Contrary to Walters (1986: 251) findings, we observed that the fishbone retrieved from the 1-mm sieve fraction appeared to have sustained a higher degree of damage and wear to surface topography, especially of the vertebrae, than elements retrieved from larger sieve fractions. We could not determine in the present study if this is the result of the sieving methodology, or an indication of the preservational properties of very small fishbone. Finally, we observed that the vertebrae retained in the 1-mm sieve residue were very small specimens with a centrum diameter less than 2-mm. While fishing technologies which target very small fish have been reported in other parts of the world, on the basis of the very small sample of vertebrae from the 1-mm sieve available for examination from the Arrawarra I midden, there is thus some

question as to whether or not these elements were introduced into the deposit as a result of direct cultural practices which selected for very small fish, or arrived in the stomach contents of larger fish.

Conclusion

Our investigation of a small remnant of the Arrawarra I midden yielded more than 60,000 fishbone specimens. These were recovered by sieving the entire deposit through 6- and 3-mm mesh sieves, and by sieving a further sub-sample through 1-mm mesh. Identifications and quantification of the assemblage revealed that the 3-mm fraction did not contribute any new taxa to the species list, however it did alter the relative abundance of identified taxa. The 1-mm fraction contributed one additional taxon, but little else in the way of useful data.

Zooarchaeologists have long maintained that using only 5-mm or larger sieves biases an assemblage in favour of large taxa, and severely limits the visibility of the complete range of taxa represented in an assemblage. They have therefore counselled that 3-mm mesh be used at all times when fishbone is expected. However, the rationale for this conclusion, and for the recommendation to use 3-mm sieves at all times needs to be amended. The Arrawarra I midden comprises many fish taxa with small diagnostic elements, which become less identifiable when fragmentary, thus rendering these taxa “invisible” in the 3-mm fraction. Thus, the overall size is less important than the size and robusticity of diagnostic elements.

We argue that the contribution of 3-mm mesh sieves will depend on (1) the characteristics of the fish community represented in a given accumulation, in conjunction with the nature of the fish skeleton; (2) cultural practices, which have the potential to affect the visibility of small and small-boned taxa; (3) the research questions being addressed by the examination of the fishbone assemblage; and (4) the post-depositional conditions which affect the remains. However, as we discovered, there will always be useful quantitative information to be gained from the 3-mm mesh sieve fraction. By increasing sample size, a much clearer picture of fishing practices was revealed than if only the larger sieve fraction had been studied. In this case we cannot say the same for the 1-mm fraction, the meagre benefits of which did not repay the effort spent to sort, and to attempt to identify the huge numbers of fragmentary, unidentifiable remains it contained.

Acknowledgements

We wish to thank the Garby Elders of the Gumbaingirr Nation for their permission to use the archaeological material from the Arrawarra I midden, and all of the members of the Yarrowarra Community for their support of our research. We would also like to thank

the Directors of the “Ecotourism at Corindi” Project, an ARC Industry Grant Project between the Yarrowarra Aboriginal Corporation and the University of New England, Wendy Beck, Margaret Somerville and Dee Murphy; Research Fellow, Anita Smith; and Associate Researchers, Tony Perkins and Cheryl Brown, for their encouragement and support. We also acknowledge the financial support of the Jean M. Oxley Bursary and the Professor Gray Postgraduate Scholarship; and sincerely thank students from the Department of Archaeology and Palaeoanthropology, U.N.E., for their help with sieving. We also wish to thank the referees for their thoughtful comments.

References

- Butler, V. L. (1988). Lapita fishing strategies: the faunal evidence. In (P. V. Kirch & T. L. Hunt, Eds) *Archaeology of the Lapita Cultural Complex: A Critical Review*. Thomas Burke Memorial Washington State Museum Research Report, No. 5. Seattle, pp. 99–115.
- Butler, V. (1994). Fish feeding behaviour and capture: the case for variation in Lapita fishing strategies. *Archaeology in Oceania* **29**, 81–90.
- Casteel, R. W. (1972). Some biases in the recovery of archaeological faunal remains. *Proceedings of the Prehistoric Society* **38**, 382–388.
- Gordon, E. A. (1993). Screen size and differential faunal recovery: A Hawaiian example. *Journal of Field Archaeology* **20**, 453–459.
- Grayson, D. K. (1984). *Quantitative Zooarchaeology*. Orlando: Academic Press Inc.
- James, S. R. (1997). Methodological Issues Concerning Screen Size Recovery Rates and their Effects on Archaeofaunal Interpretations. *Journal of Archaeological Science* **24**, 385–397.
- Lyman, R. Lee. (1994). *Vertebrate Taphonomy*. Cambridge: Cambridge University Press.
- Meighan, C. W. (1971). Molluscs as Food Remains in Archaeological Sites. In (D. Brothwell & E. Higgs, Eds) *Science in Archaeology: A Survey of Progress and Research*. London: Thames and Hudson, pp. 415–422.
- Nagaoka, L. (1994). Differential recovery of Pacific Island fish remains: evidence from the Moturakau Rockshelter, Aitutaki, Cook Islands. *Asian Perspectives* **33**, 1–17.
- Payne, S. (1972). Partial recovery and sample bias: the results of some sieving experiments. In (E. S. Higgs, Ed.) *Papers in Economic Prehistory*. Cambridge: University Press, pp. 49–64.
- Shaffer, B. S. (1992). Quarter-inch screening: Understanding biases in recovery of vertebrate faunal remains. *American Antiquity* **57**, 129–136.
- Shaffer, B. S. & Sanchez, J. L. J. (1994). Comparison of 1/8 inch and 1/4 inch mesh recovery of controlled samples of small-to-medium-sized mammals. *American Antiquity* **59**, 525–530.
- Smith, A. (1998). Preliminary results of a midden excavation at Arrawarra Beach, mid-north coast NSW. *Australian Archaeology* **47**, 61–62.
- Thomas, D. H. (1969). Great Basin Hunting Patterns: A quantitative method for treating faunal remains. *American Antiquity* **34**, 392–401.
- Vale, D. (1998). *Go Fish! Using archaeological fishbone to investigate the enigmatic stone structure at Arrawarra Beach, NSW*. Unpublished B.A. (Hons) Thesis, University of New England, Armidale.
- Walters, I. N. (1986). *Another Kettle of Fish: the prehistoric Moreton Bay Fishery*. Unpublished PhD Thesis, University of Queensland, Brisbane.
- Weisler, M. I. (1993). The importance of fish otoliths in Pacific Island archaeofaunal analysis. *New Zealand Journal of Archaeology* **15**, 131–159.
- Wheeler, A. & Jones, A. K. G. (1989). *Fishes*. Cambridge: Cambridge University Press.