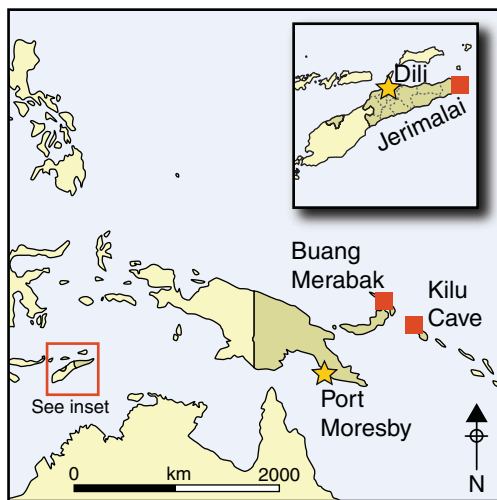


Inshore or offshore? Boating and fishing in the Pleistocene



The first settlement of Australia over 40 000 years ago provides evidence of the maritime capabilities of early modern humans. Did they also take to the sea to fish? Recent analysis of fish remains from sites in Timor-Leste and on islands off the coast of Papua New Guinea have been held to include deep sea species that must have been obtained through pelagic fishing. Here Atholl Anderson takes issue with the evidence, arguing that inshore fishing is a more likely scenario, and that deep sea fishing was beyond the scope of Pleistocene communities. Despite the early settlement of Australia, advanced boat technology was developed only during the Holocene. His

reassessment is followed by responses from Sue O'Connor and Rintaro Ono, Geoff Bailey and Jon Erlandson, and finally by Atholl Anderson's reply to those comments.

Keywords: Indo-Pacific, Timor-Leste, Jerimalai, Pleistocene, maritime technology, fishing, scombrids

The antiquity of sustained offshore fishing

Atholl Anderson*

Introduction

Discussion about the level of maritime capability required in Pleistocene voyaging includes an argument that archaeological remains of pelagic fish indicate routine travel offshore, which implies the existence of relatively sophisticated boats. In regard to Wallacea, O'Connell *et al.* (2010: 60) cite remains of tuna and deep-water shark at Buang Merabak (New Ireland, Papua New Guinea, 35–45 kya), of pelagic fish at Kilu Cave (Buka Island, Papua New Guinea, >30 kya) and of tuna at Jerimalai (Timor-Leste, 42 kya), and conclude that “these data are best read to indicate angling from boats, well offshore”. The proposition

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is plausible but validating it is more difficult than such assertions suggest. I argue here that the Jerimalai evidence does not identify tuna or sustain a conclusion of systematic offshore fishing, that inshore fishing was more probable, and that the general history of fishing for tuna, the pelagic type *nonpareil*, does not imply the existence of advanced maritime technology much before the Holocene. As there are ambiguities in defining marine zonation from an archaeological perspective (Pickard & Bonsall 2004), I will use 'inshore' to mean the coastal or neritic zone (shoreline to 200m deep), and 'offshore' to mean the oceanic or pelagic zone beyond 200m deep. Similarly, as 'systematic' implies a degree of planning that is not necessarily inherent in the relative abundance of a captured species, I prefer 'sustained' to describe archaeological data in which a species, or small group of related fish, appears at >10 per cent amongst fish numbers over a long period.

Jerimalai fish bone

Amongst fish bone from a 1m² excavation at Jerimalai shelter, on the eastern tip of Timor, Scombridae (tunas and mackerels) comprised 34 per cent of MNI in level I (42–38 kya), 26 per cent in level II (17–9 kya), and 17 per cent overall (O'Connor *et al.* 2011: tab. 3). But was the scombrid bone from tuna?

Scombridae includes 13 Thunnini tuna, 8 Sardini (of which bonito and dogtooth are commonly grouped with tuna), and 28 species of mackerels, including wahoo (Collette & Nauen 1983). With that diversity, a comparative fish bone collection for Jerimalai would have included, ideally, at least the 22 scombrid species found currently in the area (Table 1), especially as the archaeological bone, analysed by Rintaro Ono (*pers. comm.* 26 September 2012) consisted entirely of vertebrae that were identified mainly by the size and shape of centra. They appeared closer to those from yellowfin and skipjack tuna than to dogtooth tuna or Spanish mackerel, these constituting the only species available for comparison, but not sufficiently for Ono to identify any sub-family, tribe, genus or species of Scombridae.

In other words, *no tuna bone was identified from Jerimalai*. It is difficult to understand, therefore, how O'Connor *et al.* (2011: 1117, 1119) could decide to gloss the Jerimalai scombrids exclusively as 'tuna'. In addition, while O'Connor *et al.* (2011: 1117, tab. 3) locate Scombridae entirely within the 'pelagic' or 'offshore' zone, it is apparent that most scombrids around Timor occur inshore. Oceanic tunas, such as yellowfin, albacore and skipjack, are outnumbered by neritic tunas and mackerels (Table 1). The diversity of neritic scombrids contradicts the assumption in O'Connor *et al.* (2011) that the Jerimalai scombrids must have been oceanic and caught in the pelagic zone. Therefore, the two core propositions of O'Connor *et al.* (2011; O'Connor 2007, 2010), that scombrid bone from Jerimalai came only from tuna, and that tuna were caught exclusively offshore, are supported neither by fishbone identification nor by the habitat range of scombrids currently available in the area. Further considerations are possible in assessing the likelihood of offshore *versus* inshore fishing near Jerimalai.

Fishing offshore

If there was sustained offshore fishing for tuna then several characteristics of the catch might be expected. First, fish that occur frequently in association with scombrids could

Table 1. Species of Scombridae found around and near Timor-Leste. Data from Collette & Nauen (1983). The taxa are ordered according to common size.

Common name	Scientific name	Habitat	Common size (cm)
Southern bluefin tuna	<i>Thunnus maccoyi</i>	oceanic	160–200
Wahoo	<i>Acanthocybium solandri</i>	oceanic	100–170
Yellowfin tuna	<i>Thunnus albacares</i>	oceanic	100–150
Dogtooth tuna	<i>Gymnosarda unicolor</i>	neritic	100–150
Bigeye tuna	<i>Thunnus obesus</i>	oceanic	100–130
Spanish mackerel	<i>Scomberomorus commerson</i>	neritic	70–90
Skipjack tuna	<i>Katsuwonus pelamis</i>	oceanic	70–80
Albacore tuna	<i>Thunnus alalunga</i>	oceanic	60–80
Queensland school mackerel	<i>Scomberomorus queenslandicus</i>	neritic	50–80
Australian spotted mackerel	<i>Scomberomorus munroi</i>	neritic	50–80
Broad-barred king mackerel	<i>Scomberomorus semifasciatum</i>	neritic	50–70
Longtail tuna	<i>Thunnus tonggol</i>	neritic	40–70
Kawakawa tuna	<i>Euthynnus affinis</i>	neritic	50–60
Spotted seerfish	<i>Scomberomorus guttatus</i>	neritic	40–50
Striped bonito	<i>Sarda orientalis</i>	neritic	30–50
Double-lined mackerel	<i>Thynnus bilineatus</i>	neritic	40–45
Leaping bonito	<i>Cybiosarda elegans</i>	neritic	35–40
Frigate tuna	<i>Auxis thazard</i>	neritic	25–40
Spotted chub mackerel	<i>Scomber australasicus</i>	neritic	25–30
Indian mackerel	<i>Rastrelliger kanagurta</i>	neritic	20–25
Bullet tuna	<i>Auxis rochei</i>	neritic	15–25
Short mackerel	<i>Rastrelliger brachysoma</i>	neritic	15–20

also be represented, e.g. dolphin fish (Coryphaenidae), billfish (Istiophoridae) and mackerel sharks (Lamnidae) (Gillett 2011). Bone from those families occurs often with tuna bone in archaeological assemblages, sometimes more frequently than tuna, in undoubted offshore fisheries of the late prehistoric western and central Pacific (Kuang-Ti 2001; Amesbury & Hunter-Anderson 2008) and in California (Rick *et al.* 2008). None are represented at any stage in the Jerimalai data. Of the families that are included amongst 'pelagic' taxa at Jerimalai (O'Connor *et al.* 2011: tab. 3), the jacks and trevallies (Carangidae) and the requiem sharks (Carcharhinidae) are very speciose and include many which are common inshore, while barracudas (Sphyrinae) and needlefish (Belonidae) are mainly neritic taxa.

Second, fishing offshore could hardly have avoided catching some of the large individuals characteristic of oceanic scombrids (Table 1). O'Connor (2007: 530, 2010: 50) refers to "jaws and vertebrae from large individuals of pelagic species such as tuna" but, in fact, it seems that no scombrid jaws were identified and that the distinguishing feature of the pelagic fish bones at Jerimalai is their unusually *small* size, indicative of individuals only 50–60cm in length (O'Connor *et al.* 2011: 1119). The authors suggest that they might have been immature fish caught in nets such as purse seines and leader nets, but the former have nineteenth-century origins (Morgan & Staples 2006) and the latter, in the *tonnare* form, developed out of beach seining in the last millennium (Fonteneau 2009). Consistent size selection could imply drift (gill) nets, the history of which is obscure, but they did not occur in the Pacific until the historical era. In any case, nets of most types would not preclude

catching the much larger individuals that form the 'common size' (the expected size range, by fork-length, in a catch) of the oceanic scombrids (Table 1).

Third, the eastern tip of Timor-Leste is a hazardous area for unmotorised watercraft, and local fishermen work the inshore waters for scombrid mackerel and trevally, leaving tuna and billfish offshore to recreational fishers in large boats (Lloyd *et al.* 2008). Powerful tidal rips are overlaid upon a main branch of the Indonesian Throughflow, which moves Pacific water to the Indian Ocean. The strongest mean wind-flow in Timor-Leste also curls around the eastern tip creating heavy seas offshore. At 40 kya, sea level was around 80m lower than today, with Jaco Island joined to the mainland. The eastern strait would have been narrowed to less than half its present width, forcing higher current and surface-wind velocities in which boats would have little manoeuvrability and a strong chance of being carried beyond return. A sustained offshore fishery would have been a very high-risk endeavour. Could scombrid fishing represented in Pleistocene Jerimalai have occurred without boats?

Inshore fishing

A preponderance of small scombrids at Jerimalai suggests that fishing occurred more probably inshore, where at least six neritic species, three tuna and three mackerel, existed in common sizes overlapping with the estimated size range of the Jerimalai specimens (Table 1). The catch could also have included immature scombrids of oceanic taxa chasing baitfish inshore, but equally it could have included large individuals of the small neritic scombrids. On balance it was most likely to have been composed mainly of the neritic mackerels and tuna that overlapped the Jerimalai size range.

There is no clue to catching methods in the material culture at Jerimalai, except for a few pieces of shell bait-hooks after about 20 kya. If the basic coastal structure was much the same at 40 kya as it is now, which is a reasonable assumption on these steep coasts, then it would have alternated headlands dropping almost directly into deep water with stretches of wave-cut intertidal platform, upon which there was either coral reef or beaches of coral sand. These too dropped away steeply into deep water, often <150m from the tideline. Intertidal platforms around the eastern tip of Timor-Leste would have suited the use of fish-traps built from coral slabs and boulders or, on soft shores, of fences constructed from stakes and wattling. These were methods employed widely in the Indo-Pacific (e.g. Pernetta & Hill 1981; Barham 2000).

Simple seines of a traditional Pacific type where foliage is twisted into and suspended from a top rope could have been used on beaches. Seines of this kind were held at short intervals by people, instead of floats, and an apparent wall of turbid water, legs and foliage deterred fish from escaping. Woven seine nets, if available, could have been dragged out by wading, swimming or paddling a small raft. Beach seines are common in tropical regions and often catch scombrids. In Southeast Asia, fence traps catch king mackerel, Indian mackerel and short mackerel, while beach seines catch bullet tuna, frigate tuna, kawakawa, skipjack tuna, Spanish mackerel, Indian mackerel, king mackerel and seerfish (Tietze *et al.* 2011).

Angling from headlands, or reefs at low tide, is also possible. Shore-based tuna fishing, including for oceanic species, is a modern sport (Hays 2000), and most scombrids take bait readily. It could have been conducted at Jerimalai without hooks by using baited gorges

made from bone, bamboo or large fish spines. High ground close to the coast may have facilitated the tracking of scombrid schools and the deployment of fishing gear.

Discussion and conclusions

The very small fish bone sample size from Pleistocene levels at Jerimalai (386 pieces) precludes any more profound conclusion than that it had a high incidence of scombrid vertebrae (63 per cent). Whether this suggests that fishing sought scombrids especially, or only that they were relatively abundant in areas where fishing occurred, is unknown. Systematic targeting cannot be assumed. Strong currents and upwelling probably supported large scombrid populations near Jerimalai at 40 kya, as they do today, and deep water adjacent to the intertidal zone probably facilitated catching of scombrids, including small tunas, by shorebound fishing methods. However, which scombrid species were caught at Jerimalai is unknown. The claim for tuna fishing is without empirical foundation. There is no evidence of a systematic offshore fishery. If there is a lesson to be drawn from the Jerimalai case it is that most fish families referred to casually as 'pelagic' include neritic as well as oceanic species, and establishing the difference securely is often critical to arguments about maritime technology.

When, then, did sustained tuna fishing begin anywhere? It is not evident in the Pleistocene Wallacean evidence, as has just been demonstrated. In European cases, northern bluefin tuna (*Thunnus thynnus*), at 28 kya in Gorham's Cave, Gibraltar, is doubtfully cultural (Morales-Muñiz & Roselló-Izquierdo 2008), and bluefin and little tunny (*Euthynnus alleteratus*) occur only sparsely in Holocene levels at Cueva de Nerja, Spain (Morales-Muñiz & Roselló-Izquierdo 2008). At Franchthi Cave, Greece, however, bluefin appear at the end of the Pleistocene, and sustained fishing for them is apparent by the early-mid Holocene (Stiner & Munro 2011). In the Americas, tuna occur archaeologically at 11 kya in Ecuador, 9 kya in California (Rick *et al.* 2001: tab. 5), and 7.5 kya in Peru (Béarez 2000), but sustained fishing began in the mid-Holocene for bluefin on the northern Pacific coast (Crockford 1997) and for albacore, skipjack and black skipjack (*Euthynnus lineatus*) in Mexico (Kennett *et al.* 2008). In the Californian Channel Islands, occupied since 10 kya, tuna fishing began about 1.5 kya (Rick *et al.* 2008), and it was similarly late, <2 kya, in the West Indies (Wing & Wing 2001; Steadman & Jones 2006). In the Indo-Pacific, *Thunnus* sp. and *Euthynnus affinis* are evident in frequencies of 5–40 per cent at Arabian Gulf sites of the sixth to fourth millennia BC (Beech 2002; Popov *et al.* 2005). Frequent fishing for *Thunnus* sp. and *Katsuwonus* sp. began in Japan by the early Holocene (Habu 2010). In the central Pacific, where colonisation occurred 3 kya, tuna fishing is mostly later than 2 kya, often later than 1 kya (e.g. Ono & Clark 2010). Most data refer only to Scombridae (tuna values unknown) but, of 34 sites (Amesbury & Hunter-Anderson 2008; Ono & Intoh 2011), only five have NISP values greater than 10 per cent.

Incomplete as this survey is, it suggests that while tuna bone can be found in Pleistocene sites, though rarely, sustained fishing did not begin until the Holocene, when bone from other offshore species and direct evidence of complex gear and boats support a conclusion of routine offshore fishing. It is possible that earlier sustained offshore fishing is evident in regard to some other fish species, but the argument cannot be made for tuna. I conclude that there is no evidence yet available to support a hypothesis of sustained pelagic fishing in

Wallacea or anywhere else much earlier than the Holocene. On that ground, the argument for advanced boat technology in the Pleistocene fails, as it does on others, not least in the Indo-Pacific (Anderson 2000, 2010) where the level of a seafaring capability sufficient to find Australia from Timor was unable to breach the boundary of Near Oceania for a further 40 000 years.

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The case for complex fishing technologies: a response to Anderson

Sue O'Connor¹ & Rintaro Ono²

For one who is so intent on factual accuracy and precision in others, Anderson is surprisingly lenient on himself, and misrepresents our arguments. Some points of clarification are required before we proceed to address the more substantive issues regarding Pleistocene fishing and fishing technology. In the introduction to his critique, Anderson (above) states that “in regard to Wallacea, O’Connell *et al.* (2010: 60) cite” the evidence for fishing at Buang Merabak and Kilu Cave (Papua New Guinea), and Jerimalai (Timor-Leste) and that

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they conclude that “these data are best read to indicate angling from boats well offshore”. Firstly, as outlined in O’Connor *et al.* (2011) Wallacea is a strictly defined biogeographic region which comprises the Indonesian Islands lying to the east of Sundaland and to the west of Sahul and Near Oceania. Kilu Cave and Buang Merabak are in Near Oceania, not in Wallacea, and while the two island regions share depauperate terrestrial faunas the biota of the two are very different.

We also take issue with Anderson’s definition of ‘pelagic’. Pelagic literally means ‘open sea’ and pelagic fish are those that inhabit both shallow inshore and oceanic offshore regions. They are not found exclusively in the deep ocean below 200m. In fact, as Anderson notes, tuna and other oceanic pelagic species within the Scombridae family often swim inshore and are usually captured close to the surface. Those at Jerimalai may have been caught close to the shore, but they are fast-moving, powerful fish that are a less predictable resource than reef fish, which are more sedentary. We therefore argued that the sustained presence of pelagic species indicated planned capture using some form of advanced fishing technology. We did not suggest that the pelagic species were caught exclusively by angling from boats, although they may have been. In fact we believe that netting is a likely strategy based on the size of the individual scombrids in the site. Tuna and other fast moving oceanic species tend to congregate under or be attracted to floating objects (Lal & Fortune 2000: 8). Modern versions of these ‘fish attracting devices’ (FADs) are used in commercial tuna fisheries, although a simple version of this craft is employed widely in Indonesia today and has been used since at least the late nineteenth century (Zerner 2003). Zerner (2003: 84) reports how “*roppong* are rafts of lashed and layered bamboo anchored in the Makassar Strait by lines of braided rattan”. The rafts are anchored in depths ranging from several hundred to thousands of feet using long rattan cables attached to massive anchors made of rocks and limestone chunks. “Near the surface, fronds of bright green banana leaves are attached to the underside of *roppong*, where their undulating presence attracts schools of scad and tuna” (Zerner 2003: 84) which are then netted by the fisherfolk on the raft. The simplicity and effectiveness of these craft suggests they may have a great antiquity.

Anderson suggests that the scombrids from Jerimalai may have been fished inshore using:

- long lines cast from headlands or shore with baited gorges made of bone or shell;
- stone or brush fish traps set atop the reef;
- simple beach seines using long leaves or other foliage twisted into a top rope or fastened to vine, as traditionally in the Pacific, the net being held at short intervals by people, instead of floats.

Long lines cast from shore are a possibility but would still necessitate angling using hooks or gorges and strong line. We consider it unlikely that brush or stone traps would have caught scombrids. Brush traps are not employed in this part of Timor-Leste today as the coastal waters at the eastern end of the island are not suitable for their use. Simple stone fish traps are used along parts of the north-eastern coast but one of the present authors (R.O.) reports on the basis of interviews with locals from the coastal communities who maintain and use the traps, and from his broader ethnoarchaeological research in Southeast Asia and the Pacific,

that these traps rarely capture scombrid species. In view of the fact that scombrids make up 34 per cent of the fish in the lowest Pleistocene level at Jerimalai we believed this was the least likely capture method.

Anderson correctly points out that as we did not appreciate the scombrids at Jerimalai we cannot be certain that oceanic species are represented. One of the authors (R.O.) reports that the scombrid vertebrae at Jerimalai were identified using centrum size and shape compared to reference material from yellowfin, skipjack and dogtooth tuna, as well as Spanish mackerel. Most were thought to be from skipjack and yellowfin tuna, although R.O. preferred to be conservative in his identifications in the *Science* paper (O'Connor *et al.* 2011). O'Connor (2007) does state that the site 'contained jaws and bones from large tuna', but this paper was written soon after the excavation in order to provide a preliminary overview of the entire assemblage of this important site prior to the detailed analysis of the finds undertaken by the present authors and others. O'Connor (2007) refers to all the fish bone in Jerimalai from test pits A and B whereas R.O.'s identification in O'Connor *et al.* (2011) refers only to the material in Square B. The identifications in O'Connor *et al.* (2011) are our best effort thus far at identification and description of the fish found in Square B and they took R.O. many months. The fish bone from Square A awaits a detailed identification but a preliminary assessment by author S.O. indicates it contains some scombrid jaw parts. In 2014 we plan a much larger excavation at Jerimalai and, with this bigger sample, will hopefully also recover items of fishing technology from the earliest occupation level.

We believe that Anderson exaggerates the difficulty of boating off the eastern end of Timor. While it is true that these waters can be dangerous, fishermen from the village of Tutuala fish them today using small motorised canoes and hook and line. The north coast of Timor-Leste drops steeply offshore and this factor coupled with the deep channel running past the eastern end of the island provides ideal fishing conditions for pelagic species, since deep water is found close to the shore. It would not have been necessary to travel more than a few hundred metres offshore to access deep water. Prior to Timor-Leste's independence from Indonesia, families from the island of Kisar off the north-eastern tip of Timor travelled to visit relatives in Tutuala. The maintenance of relationships between these two islands is recorded in oral histories, shared language and place names. One village on Kisar shares the Papuan language spoken in Tutuala (Fataluku) as well as its name, Oirata, with a village in Tutuala. Oral tradition and place names similarly record seasonal visits from other islands to the east and north of Timor.

Our primary goal in writing the *Science* article (O'Connor *et al.* 2011) was to point out that at Jerimalai there is a significant amount of evidence for fishing in the period between 42 000 and 38 000 cal BP, and that the species caught were not simply gleaned at low tide from natural pools in the reef or substrate. The scombrids at least required some form of what we regard as complex technology for their capture (although clearly what is regarded as complex technology will depend on the criteria used to recognise complexity), and that the Jerimalai evidence demonstrated that modern humans had these skills very early on. We believe that the evidence from Timor-Leste is important and of a different order of magnitude to the previous evidence for fishing reported at this date such as the sparse remains found in the sites in New Ireland, Papua New Guinea. Although fish remains are present in the lowest

levels of the New Ireland sites the “bones are few in the earliest levels at Matenkupkum and suggest neither specialized technology (nets, lines, poisons, fish spears) nor deliberate pursuit. Fortuitous accidental or deliberate trapping or spearing on reefs on outgoing tides would account for the evidence” (Allen 1993: 144). At Buang Merabak only two elements of shark and a solitary fish bone were recovered from the lowest Pleistocene unit (Leavesley & Allen 1998: 75). Aside from shellfish, the Pleistocene faunal assemblages of the New Ireland sites are dominated by rats, bats and reptiles (Leavesley & Allen 1998: 75; Allen 2000). The New Ireland sites also lack evidence for specialised maritime equipment. Although Smith and Allen (1999) have suggested that some cut *Trochus* shell pieces in the Pleistocene unit at Matenkupkum in New Ireland may be blanks for fish hooks, the evidence is thus far inconclusive. The subsistence remains in the Pleistocene horizon at Kilu Cave on Buka Island (geographically in the northern Solomon Islands) contain a significant quantity of fish bone, including some pelagic species as well as sharks and rays (Wickler 2001) but the majority of the fish are inshore reef species and fishing at Kilu did not occur until 10 000 years after it did at Jerimalai. Having said this, we think that other early colonisation sites are likely to be found as further research is undertaken on uplifted coastlines of the limestone islands in Wallacea and that these are likely to evidence a heavy dependence on the marine environment, including the exploitation of pelagic species.

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Dynamic shorelines and submerged topography: the neglected variables

Geoffrey N. Bailey*

Atholl Anderson's comment (above) on the recent finds from Jerimalai draws attention to the dangers of over-interpreting the wider significance of marine resources present in Pleistocene coastal sites without careful evaluation of at least three variables: (1) the accurate identification of the species represented and hence of their behaviour and accessibility to capture; (2) the actual quantities and rates of accumulation of the marine food remains; and (3) local ecological and oceanographic conditions. To these I would add a fourth variable: the bathymetry and submerged topography of the marine environment adjacent to the sites in question—the physical structure of what one might call the 'offshore catchment'—and changes resulting from relative sea level variation (including eustatic and isostatic/tectonic effects).

This last variable is fundamental to all the others. It can affect (1) the quantity and even the visibility of marine evidence deposited at a given coastal location because of variations in the distance from site to sea shore with variable topography and sea-level position—a taphonomic effect of variable landscape conditions; (2) the abundance of the marine resources locally available because of varying ocean currents and marine fertility associated with varying topography; and (3) the relative accessibility of mobile marine resources from the sea shore. Both O'Connor *et al.* (2011) and Anderson touch on some of these issues. Yet it is the one group of variables that is habitually ignored or treated at best anecdotally, perhaps because accurate data in many cases would have to be collected by archaeologists themselves with specially targeted underwater survey, using technologies that are either unfamiliar or out of reach of most archaeological budgets.

There is reason to think that a number of coastlines in Wallacea and Melanesia have offshore topography that plunges steeply to great depth because of the effects of subduction at the south-western edge of the Pacific Plate. In such circumstances, a drop in sea level of 130m at the Last Glacial Maximum might have little impact on the lateral shift of the shoreline, meaning that marine activities practised when sea level was low would remain visible at locations on the present day shoreline, rather than shifting to contemporaneous shorelines that are now deeply submerged on the continental shelf, many kilometres offshore. Similar topography might make it likely that pelagic species associated with deep sea habitats could approach close inshore at some times of year, where they could be captured by line fishing from the shore. Such conditions of inshore fish migrations, or deep offshore canyons close to the present coastline, have been claimed or identified in parts of Europe and on the Pacific coast of North America, and they may occur more widely, but in highly localised conditions specific to particular times and places.

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Until these variables are properly investigated, it will remain unclear whether the unusual prominence of marine resources at sites in Wallacea and Melanesia in the 30–42 000 year BP range reflects unusual seafaring and navigational skills, forced reliance on marine resources on islands with limited food on land, a precocious socio-economic development unique at this time in world prehistory to the southern Pacific region, or simply an unusual window of archaeological visibility. If the latter looks like a strong possibility, then we should expect to find similar evidence at the same period in other parts of the world with the same conditions of visibility, although the reality is that on most coastlines such evidence will have to be sought deep underwater on now-submerged palaeoshorelines. More generally, archaeologists will continue to be tempted into misreading isolated examples of marine resources as rungs on a ladder of human evolutionary and socio-economic development, rather than as outcomes of a complex matrix of variables, amongst which ecological and taphonomic factors are likely to be prominent.

The evidence from Jerimalai is of great interest and importance, but its real significance remains tantalisingly out of reach. Just what the relationship was between fishing and seafaring, and the more general significance of both to patterns of Pleistocene human dispersal, remains obscure. What is certain is that significant advances in understanding will require a more thorough investigation of the dynamic history of the continental shelf including the search for submerged coastlines, and that is a task that has barely begun (Bailey *et al.* 2012a & b).

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Interpreting archaeological fish remains

Jon M. Erlandson*

In an important paper, O'Connor *et al.* (2011) described evidence for marine fishing from around 42 000-year-old (cal BP) deposits at Jerimalai Shelter on Timor-Leste. The paper's

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title referred to evidence for pelagic fishing and the maritime skills of anatomically modern humans (AMH). Considering that not long ago human seafaring and marine fishing were considered to be limited to the terminal Pleistocene or early Holocene (see Erlandson 2001), the paper's broader significance lies in the further evidence for Pleistocene voyaging required to colonise Timor-Leste and the quantities of fish bone that represent a substantial marine fishing effort at a relatively early date.

In his essay, Atholl Anderson (above) questions the pelagic nature of early fishing at Jerimalai, raising objections that suggest that these early fishers focused on nearshore rather than pelagic habitats. I will leave specific responses to Anderson's questions about the Jerimalai assemblage to O'Connor and her colleagues. Here, I discuss some broader issues raised about the antiquity of fishing, including some of my own experience regarding the antiquity of pelagic fishing and the interpretation of archaeological fish remains.

Years ago, I travelled to Gibraltar to examine stratigraphic sections and museum collections from Gorham's Cave, where a deep sequence of Middle and Upper Palaeolithic strata was excavated by Waechter between 1948 and 1954. Waechter's (1951, 1964) publications suggested that shellfish were regularly harvested by Neanderthals and Upper Palaeolithic peoples, a rare case of Pleistocene marine resource use at the time. In examining the Gibraltar Museum collections, I was surprised to open a box full of large Atlantic bluefin tuna (*Thunnus thynnus*) vertebrae that were not mentioned in the excavation reports. The bones from as many as five bluefin tuna had come from Waechter's Upper Palaeolithic strata D and E. From the latter, we obtained an AMS ¹⁴C date of 27 800±350 uncal BP for a charred pine cone fragment, with a calibrated age range of c. 32 940 to 31 340 cal BP (Erlandson & Moss 2001). Understanding that bluefin tuna were pelagic, I concluded that Upper Palaeolithic peoples at Gibraltar engaged in pelagic fishing—which may or may not have been the case. What I didn't realise then was that even large pelagic fish can often be found close to shore—or scavenged along the shore—especially in areas such as Gibraltar where bathymetry is steep and submarine canyons or narrow straits can funnel pelagic fish into inshore waters. I later heard from a cultural anthropologist that local people sometimes simply opened a swinging gate and let bluefin tuna swim into a large corral where they were slaughtered. At times along the California coast, normally-pelagic species such as yellowfin tuna (*Thunnus albacares*), which Anderson defines as 'oceanic', can also be caught close to shore in shallow waters. The problem is that fish are mobile and don't always follow the behavioural norms described in textbooks or nature guides.

These experiences leave me quite sympathetic to Anderson's cautions about interpreting the fish remains from Jerimalai as coming from pelagic versus nearshore habitats. Commendably, Anderson clearly defines most of the terms he uses, but terms such as 'pelagic' or 'systematic' are inevitably somewhat arbitrarily defined and fuzzy when addressed with archaeological data. He is explicit in defining inshore (coastal) *versus* offshore (pelagic) fishing zones, based on a water depth of 200m, a definition that works for Jerimalai with its steep bathymetry. I would hesitate to use such a definition globally, however, as it would require 'pelagic' fishers to venture hundreds of kilometres offshore in areas with broad continental shelves. In his conclusions, Anderson also uses the phrase 'advanced boating technology' without explicit definition. Clearly, 'advanced' is a relative term and some advance occurred between 800 000 years ago when *Homo erectus* may have crossed a few short straits to reach

Flores, and c. 50 000 to 15 000 years ago when AMH made multiple voyages from Sunda to Sahul, the Bismarck Archipelago, the Ryukyu Islands and beyond (Erlandson 2010).

Ultimately, Anderson may be correct that most of the fish from the Pleistocene strata at Jerimalai come from nearshore habitats. In the broader scheme of things, I remain deeply impressed by O'Connor and colleagues' continuing documentation of Pleistocene colonisation and marine resource use in the islands of Wallacea. At Jerimalai and a growing number of sites worldwide, it is becoming clear—despite the difficulties caused by rising post-glacial seas—that marine and aquatic resources were considerably more important to AMH and other hominins in the deep past.

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Response to O'Connor and Ono, Bailey and Erlandson

Atholl Anderson*

I thank the contributors for their comments. We all agree that the Jerimalai data provide an intriguing glimpse of maritime activity in the Wallacean Pleistocene by showing that Scombridae were unusually prominent amongst 15 families of fish that had been caught around 40 000 BP. In various ways, we also agree that the hypothesis interpreting these data in O'Connor *et al.* (2011) is far from robust. Its fundamental proposition was that the scombrids were oceanic tuna, but O'Connor and Ono (above) now concede that, 'as we did not speciate [sic] the scombrids at Jerimalai we cannot be certain that oceanic species were represented'. Their description of samples and methods, which confirms the inadequacy of the comparative collection and notes that scombrid bone from Jerimalai Square A also may not be from tuna, simply underlines the thrust of my critique. Some of the scombrids might be oceanic tuna but since no tuna were identified, either as a class or species, the marine zones involved in scombrid fishing cannot be inferred, and the empirical argument for offshore tuna fishing collapses.

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O'Connor and Ono seek to keep the hypothesis alive by shifting their ground on the meaning of 'pelagic'. The term is problematical, as Erlandson (above) also observes. It can mean the entire sea beyond the low tide mark or, as I used it, the sea beyond the edge of the continental shelf, at about 200m deep, which commonly divides the littoral or neritic from the pelagic or oceanic zones (Stow 2004: 194). Fish could be caught at any depth in a pelagic zone, so defined, not just below 200m. O'Connor *et al.* (2011: 1119, tab. 3) also used 'pelagic' in this way to distinguish inshore from offshore zones. However, O'Connor and Ono now use 'pelagic' in another sense (opposed to 'demersal') to mean the upper level of the sea both inshore and offshore. This legitimates 'a sustained presence of pelagic species' at Jerimalai, but it sidesteps their former commitment to offshore fishing. They do not object to my assertion that the composition of the Jerimalai catch data and the consistently small size of the scombrids are uncharacteristic of offshore fishing, and of course I agree with their revised assessment that the Jerimalai scombrids might have been caught close inshore: indeed that is my argument.

The Pleistocene use of rudimentary FADs ('fish attracting devices') is unlikely, given the absence of any long history for them, but it is possible. They are equally effective inshore and much easier to moor and monitor there. Scombrids attracted to small rafts tethered to the reef could have been taken on fish spears or in dip nets. The extent to which traps or shore seines caught scombrids at 40 000 BP is almost unknowable because submarine topography and ecology were very different, as Bailey emphasises (above). However, a 'Jaco peninsula' at 40 000 BP might have sheltered beaches suited to seine fishing, judging by a high incidence of sea-turtle bone at Jerimalai. Perhaps we could agree that McWilliam's (2003: 8) description of recent small-scale artisanal fishing in Timor-Leste presents (substituting net traps and seines for modern gill nets) a plausible scenario for the Jerimalai data: "low-technology inshore fishing...[involving] the use of handlines and gill net techniques to catch demersal species such as snapper, croaker and bream, and pelagics like tuna, mackerel, scad and sardines...Plaited fish traps and stone enclosures utilizing tidal action are also used extensively."

The dangers of fishing in small unmotorised canoes along the coast of Timor-Leste are discussed by Tsujimura *et al.* (2012), who note both the high incidence of problems attributable to weather and sea conditions and the very poor stability and strength of small canoe hulls. The modern use of larger motorised boats, and formerly of sailing craft, for oceanic fishing and access to other islands cited by O'Connor and Ono is hardly relevant to offshore fishing at 40 000 BP. O'Connor *et al.* (2011: 1117) did not specify the 'complex' and 'advanced' technology used to reach offshore fisheries, and their later remark that "what is regarded as complex technology will depend on the criteria used to recognise complexity" scarcely advances the topic.

Erlandson asks what I meant by 'advanced boat technology'. I think that design features such as curved sheer and rocker, lateral expansion and topsides planking in canoe construction, outrigger or multi-hull stabilisation, lanceolate paddles, any form of rowing or the use of sails are advanced technological traits that, to the extent they can be found archaeologically or inferred from prehistoric colonisation patterns, did not occur until the Holocene (Anderson 2000, 2010). At 40 000 BP, this probably leaves bundle rafts of light timber, possibly logboats (although early stone technology at Jerimalai (O'Connor *et al.*

2011) seems insufficient for logboat construction), and bamboo rafts. The latter could have been made large enough, and sufficiently stable, to carry multiple crew offshore, but in the absence of sails their drawback of high wetted surface would have made them unmanageable against wind and current, and liable to be carried away—to Australia for example.

O'Connor *et al.* (2011) consider offshore fishing a marker of fully modern human behaviour. I would suggest, however, as Bailey seems to imply, that catching scombrids is in itself no more an illustration of the cleverness of AMH than was habitual shellfishing a mark of intellectual backwardness amongst Fuegians or Tasmanians. Besides, if it were true at Jerimalai then why is it evidently contradicted in the Pleistocene sites on New Ireland where, as O'Connor and Ono observe, offshore fish are vanishingly scarce? Repeated evidence of sustained offshore fishing in the Pleistocene would demand some explanation, but probably not this one. After all, no new manifestation of humanity can be implicated in the known rise of tuna fishing in late prehistory. O'Connor and Ono note that scombrids are a less predictable resource than reef fish and that point could serve to suggest that strategic intelligence amongst AMH at 40 000 BP was manifested less in unpredictable high sea adventures than in the development of prudent, efficient and productive fishing inshore.

Of course, the debate depends crucially upon interpretation of the fish bone from Jerimalai, and questions remain about that. Does identification of 18 scombrid individuals in only 62 vertebral pieces at 40 000 BP suggest an unusual sample? Is there a taphonomic or alternative explanation for MNI identification favouring the early end of the sequence? The MNI:NISP ratios for the main taxa (Scaridae, Balistidae, Serranidae, Scombridae, Carangidae) combined are, earliest (40 000 BP) to latest (Recent) phase, in round numbers: 1:2, 1:4, 1:5; 1:4. For Scombridae they are: 1:3, 1:8, 1:14, 1:8 (O'Connor *et al.* 2011: tab. 3). As Jerimalai was up to 5km distant from the sea at periods of low sea level, is it possible that high representation of scombrids simply reflects preferential return to the site while other fish, caught in much greater abundance, were consumed mainly at shoreline sites, now submerged? In that case the real proportion of scombrids in the catch might have been insignificant. Sending the Jerimalai fish bone collection out for independent analysis and interpretation might be a useful first step in re-thinking an hypothesis that was widely promulgated and is beginning to appear unexamined in the journals (e.g. O'Connell & Allen 2012).

Lastly, O'Connor and Ono assert that I have misrepresented their argument. I have not done so. If there is such an issue in this debate then it lies in the decision by O'Connor *et al.* (2011) to represent unidentified scombrid data as referring to oceanic tuna and deep-sea fishing; a claim they now accept was unwarranted. On that basis the O'Connor *et al.* (2011) hypothesis of sustained offshore fishing before the LGM can be rejected.

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