

Research Article

Following the fish? Using ichthyoarchaeology to study the tempo and geography of human dispersals through Island Southeast Asia

Clara Boulanger^{1,2,*}, Ceri Shipton¹ and Rhiannon Stevens¹

How to cite: Boulanger, C., Shipton, C. and Stevens, R. 'Following the fish? Using ichthyoarchaeology to study the tempo and geography of human dispersals through Island Southeast Asia'. *Archaeology International*, 2025, 28 (1), pp. 103–08 • DOI: <https://doi.org/10.14324/AI.28.1.10>

Published: 31 December 2025

Peer review:

This article has been peer-reviewed through the journal's standard double-blind peer-review process, where both the reviewers and authors are anonymised during review.

Copyright:

© 2025, Clara Boulanger, Ceri Shipton and Rhiannon Stevens. This is an open-access article distributed under the terms of the Creative Commons Attribution Licence (CC-BY) 4.0 <https://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited • DOI: <https://doi.org/10.14324/AI.28.1.10>

Open access:

Archaeology International is a peer-reviewed open-access journal.

*Correspondence: clara.boulanger@ucl.ac.uk

¹UCL Institute of Archaeology, UK

²Histoire Naturelle de l'Homme Préhistorique, Muséum National d'Histoire Naturelle, France

Following the fish? Using ichthyoarchaeology to study the tempo and geography of human dispersals through Island Southeast Asia

Clara Boulanger, Ceri Shipton and Rhiannon Stevens

Abstract

Around 50,000 years ago, *Homo sapiens*' dispersal to Australia marked the earliest period of human maritime adaptation. Two models of migration routes through Island Southeast Asia and the Wallacean Archipelago are proposed – a northern one and a southern one. However, the timing and location of these migrations remains disputed. Recent studies demonstrated the presence of populations with a strong maritime culture in southern Wallacea from around 40,000 years ago, while coastal adaptation in the north remains largely unstudied. This research project, hosted at the UCL Institute of Archaeology and in collaboration with UK, Australian and local institutions, aims to understand human reliance in marine environments using samples from recently excavated archaeological sites located on the northern route. Using comparative anatomy, biomolecular techniques such as ZooMS as well as stable isotope analysis, it seeks insights into subsistence strategies and seafaring technologies, establishing a novel framework for understanding our species' adaptation and dispersal for early seafarers across challenging regions of the planet.

Keywords: *Homo sapiens*' dispersal; Island Southeast Asia; Wallacea; maritime adaptation; ichthyoarchaeology; ZooMS; stable isotope analysis; subsistence strategies; seafaring technologies; coastal archaeology

Introduction

The discovery of new environments by humans has always been one of the driving forces behind technical and cultural innovations. On the scale of hominin evolution, the appropriation of the sea certainly constituted one of the major advances in terms of discovery of new ecosystems. The state of our knowledge demonstrates that humans' relationship to the sea underwent a fundamental paradigm shift with our species, *Homo sapiens*, and its arrival in the Indo-Pacific region of seas punctuated by islands. Here,

through maritime adaptation, we can discern the origins of some specific inventions associated with what is called – although debated – modernity.

By at least 50,000 BP, *Homo sapiens*' dispersal from Asia to Australia involved the first known significant period of human maritime adaptation, which would have required substantial open water crossing via the insular Wallacean archipelago (Clarkson et al. 2017). Wallacea, encompassing the Lesser Sunda Islands (Lombok, Sumbawa, Timor, Sumba, Flores, Alor, Wetar) in the south, as well as Maluku, Halmahera and Sulawesi in the north, has never been connected to a continent through a land bridge, even during periods of considerable climate-driven sea-level reduction in the Late Pleistocene (Figure 1). Compared to the larger land masses of Sunda and Sahul, the limited size and isolation of the Wallacean islands resulted in relatively depauperate terrestrial ecosystems, giving primacy to the role of marine resources. However, the route through this Wallacean seascape and the adaptations required for successful onward migration remain disputed. A current British Academy post-doctoral fellowship (held by Clara Boulanger) aims to understand human reliance on marine environments in the northern Wallacean islands and north coast of New Guinea. It will attempt to establish a novel framework for understanding our species' adaptation and dispersal, thanks to a unique multidisciplinary study using fossil fish remains.

Theoretical approaches to the peopling of Sahul

Since the 1960s, zoologists and archaeologists have been working to comprehend the dispersal of *Homo sapiens* from continental Asia through Wallacea to Sahul by constructing various theoretical models of migration routes. Birdsell's (1977) model favoured two routes: a northern route from Borneo to north-west Papua and a southern route leading from Bali to north-west Australia (Figure 1). Guided by the principle of parsimony, the selection of these routes considered factors such as distance, visibility between islands, bathymetric data and sea-level variations. Kealy et al. (2018) devised a series of spatial variables, including bathymetric data, water-crossing distances, intervisibility between islands, topographical steepness, palaeo-currents, winds and access to necessary resources. They also emphasised the significance of submerged islands that would have been exposed during low sea-level periods. By comparing this data with current archaeological records, they constructed a least-cost pathway model of *Homo sapiens*' dispersal through the Wallacean archipelago. This research identified the most probable route taken by humans to reach Sahul: a northern route from Sulawesi to New Guinea's Bird's Head Peninsula (Kealy et al. 2018). Similarly, Bird et al. (2019), incorporating demographic models, concluded that *Homo sapiens* reached Sahul using multiple short maritime crossings through Wallacea, indicating that the northern route demanded less effort and time, making it more likely for successful colonisation of Sahul by a viable population. Conversely, employing visual connectivity network analyses, agent-based simulations and ocean current flow modelling, Norman et al. (2018) concluded that the southern pathway was statistically the more likely favoured route. As a result, the timing, location and details of these migrations continue to be the subjects of debate within the scholarly community.



Figure 1 Least-cost pathway model routes from Sunda to Sahul following Kealy et al. (2018). The study sites are represented by a red star. Orange dots indicate Pleistocene sites where fish remains assemblages have been found, while red dots represent Pleistocene sites where no fish remains assemblages have been discovered

Using ichthyoarchaeology to study the tempo and geography of human dispersals in Island Southeast Asia

In the southern region of Wallacea, restricted access to terrestrial resources on small islands has been argued to have fostered the development of subsistence strategies centred on the acquisition of aquatic resources at numerous coastal sites (Figure 1). Concomitantly, aquatic resources are a more transferable subsistence base between islands than terrestrial resources, so they permit rapid colonisation of multiple islands (Boulanger et al. 2023; Kealy et al. 2018; Shipton et al. 2024). Notably, the southern pathway has stood out as the sole location where evidence of systematic use of advanced fishing technologies has been discovered. The early development of fishing in the region seems to have initially focused on a diverse range of fish taxa, indicating the use of a range of fishing methods and technologies suited to both local marine and freshwater habitats (Boulanger 2023; Boulanger et al. 2022; 2023). At the site of Asitau Kuru in East Timor, fishing activities appear to have extended to trolling scombrids (mackerel, tuna, bonito) from watercraft (Boulanger 2023; Boulanger et al. 2022; O'Connor et al. 2011). According to the archaeological record, marine resource acquisition intensified during the current interglacial climatic amelioration that began approximately 18,000 years ago, leading to a dramatic rise in sea levels (Samper Carro et al. 2016). This coincided with the emergence of maritime networks, where obsidian was distributed over long distances among the Lesser Sunda Islands, likely facilitated by the use of more advanced seafaring techniques, in particular dugout canoes (Shipton et al. 2019). Moreover, the discovery of shell fishhooks in burial contexts at Tron Bon Lei, on Alor Island, dating back to approximately 12,000

years ago, underscores the significance of maritime culture for the populations inhabiting the Lesser Sunda Islands (O'Connor et al. 2017). These findings suggest that the use of marine resources and the development of seafaring technologies played a crucial role in shaping the cultural and social aspects of the human communities in the region during this transitional period between the Pleistocene and the Holocene. Therefore, the southern islands emerge as an especially promising path where maritime technologies conducive to extensive long-distance travel could have held great significance.

Northern Wallacea likely offered a wider range of subsistence opportunities due to the availability of diverse terrestrial resources. The Pleistocene inhabitants of archaeological sites in northern Wallacea, such as Leang Sarru in the Talaud Islands, Golo Cave on Gebe Island and the Goa Topogaro sites in Central Sulawesi, seem to have relied on a combination of terrestrial resources and shellfish gathering (Figure 1). These discoveries emphasise the significance of terrestrial game hunting, plant foraging and rainforest exploitation in their daily lives, creating a distinct contrast with the southern Wallacean record (Ono et al. 2020). While several studies highlight the importance of the northern route in the colonisation of Island Southeast Asia and Sahul (Bird et al. 2019; Norman et al. 2018), we possess limited knowledge about their inhabitants' maritime skills and relationship with the sea. Moreover, it is essential to consider potential factors that might influence the archaeological record, such as variations in recovery methods. These variations could have potentially resulted in a lack of information about fishing activities in the northern region, where aquatic environments nevertheless hold great significance in the island landscapes. Recent excavations along the northern route have illuminated this adaptation through the discovery of unique fish bone assemblages.

This project aims to study fish bone assemblages from four sites located on the northern route, spanning the end of the Pleistocene from approximately 55,000 BP to the present. Mololo Cave is situated in the Raja Ampat Islands, Indonesia, near north-west New Guinea (Figure 1). It boasts a chronology ranging from 55,000–50,000 BP, extending up to the late Holocene. It is currently being excavated by Dr D. Gaffney from the University of Oxford, Dr D. Tanudirjo from the University of Gadjah Mada, and M. Tolla from the Regional Office of Archaeological Research for Papua, who started excavation in 2018. The other three sites – Lachitu, Watinglo and Taora – are located on the north coast of New Guinea, Papua New Guinea (Figure 1). They were excavated by Professor S. O'Connor from the Australian National University and by the National Museum and Art Gallery of Papua New Guinea. Lachitu is dated from around 20,000 BP to approximately 5000 BP. Watinglo dates to approximately 45,000 BP, while Taora has a more recent stratigraphic profile, with dates from 6500 BP to the present.

This project integrates classical zooarchaeological methods with advanced biomolecular and geochemical techniques. Fish remains will be identified using comparative anatomy, supported by quantitative measures (NISP, MNI, MNE) and taphonomic analysis. For a selection of specimens unidentifiable through morphology, Zooarchaeology by Mass Spectrometry (ZooMS) will be applied to determine taxonomic identity. Stable isotope analysis ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{18}\text{O}$) of fish bone collagen and tooth enamel will provide ecological and dietary insights, allowing differentiation between freshwater, nearshore and pelagic environments (for example, Boulanger et al. 2024). Together, these methods will illuminate human adaptation and interactions to diverse marine environments, particularly during periods marked by significant cultural and climatic transformations.

By examining these remains, this project aims to provide crucial insights into how fishing and marine resources exploitation influenced through time the lives of ancient inhabitants in the northern Wallacean and New Guinea region by evaluating the maritime skills of these prehistoric communities. As a result, it will provide fresh perspectives to determine the favoured migration route and determine the ecological contingencies and cultural variations between the northern and southern dispersal routes on their way to Oceania.

Acknowledgements

The authors thank Dr Loukas Kongoulos and Dr Shimona Kealy for their assistance with sorting the material studied in this research. We acknowledge the CartoGIS Services (ANU College of Asia and the Pacific, The Australian National University) for providing the base map (Creative Commons Attribution-ShareAlike 4.0 international license (CC BY SA)).

Funding

Research funding was provided by the British Academy Postdoctoral Fellowship Programme (PFSS24\240002).

Declarations and conflicts of interest

Research ethics statement

Not applicable to this article.

Consent for publication statement

Not applicable to this article.

Conflicts of interest statement

The authors declare no conflicts of interest with this article. All efforts to sufficiently anonymise the authors during peer review of this article have been made. The authors declare no further conflicts with this article.

References

Bird, M. I., Condie, S. A., O'Connor, S., O'Grady, D., Reepmeyer, C., Ulm, S., Zega, M., Saltré, F. and Bradshaw, C. J. A. 2019. 'Early human settlement of Sahul was not an accident', *Scientific Reports* 9 (1): 8220. <https://doi.org/10.1038/s41598-019-42946-9>.

Birdsell, J. B. 1977. 'The recalibration of a paradigm for the first peopling of Greater Australia', in *Sunda and Sahul: Prehistoric studies in Southeast Asia, Melanesia, and Australia*, edited by J. Allen, J. Golson and R. Jones, 113–67. Academic Press.

- Boulanger, C. 2023. *The Exploitation of Fishing Resources and the Maritime Skills of Early Modern Humans in Island Southeast Asia*. International Series 3153. BAR Publishing.
- Boulanger, C., Hawkins, S., Ono, R. and O'Connor, S. 2022. 'Continuity and variability in prehistoric fishing practices by *Homo Sapiens* in Island Southeast Asia: New Ichthyofaunal data from Asitau Kuru, Timor-Leste', *World Archaeology* 54 (2): 288–316. <https://doi.org/10.1080/00438243.2023.2192518>.
- Boulanger, C., Hawkins, S., Shipton, C., Ingicco, T., Sémah, A.-M. and O'Connor, S. 2023. 'Inland fishing by *Homo Sapiens* during early settlement of Wallacea', *Frontiers in Environmental Archaeology* 2. <https://doi.org/10.3389/fearc.2023.1201351>.
- Boulanger, C., Roberts, P., Lucas, M., Ingicco, T., O'Connor, S., Ono, R. and Sémah, A. M. 2024. 'Stable isotope variation in east and southeast Asian marine ecosystems and its relevance for archaeological analysis', *Environmental Archaeology*. <https://doi.org/10.1080/14614103.2024.2352666>.
- Clarkson, C., Jacobs, Z., Marwick, B., Fullagar, R., Wallis, L., Smith, M., Roberts, R. G., Hayes, E., Lowe, K., Carah, X., Florin, A. S., McNeil, J., Cox, D., Arnold, L. J., Hua, Q., Huntley, J., Brand, H. E. A., Manne, T., Fairbairn, A., Shulmeister, J., Lyle, L., Salinas, M., Page, M., Connell, K., Park, G., Norman, K., Murphy, T. and Pardoe, C. 2017. 'Human occupation of Northern Australia by 65,000 years ago', *Nature* 547: 306–10. <https://doi.org/10.1038/nature22968>.
- Kealy, S., Louys, J. and O'Connor, S. 2018. 'Least-cost pathway models indicate northern human dispersal from Sunda to Sahul', *Journal of Human Evolution* 125: 59–70. <https://doi.org/10.1016/j.jhevol.2018.10.003>.
- Norman, K., Inglis, J., Clarkson, C., Faith, C. T., Shulmeister, J. and Harris, D. 2018. 'An early colonisation pathway into northwest Australia 70–60,000 years ago', *Quaternary Science Reviews* 180: 229–39. <https://doi.org/10.1016/j.quascirev.2017.11.023>.
- O'Connor, S., Mahirta, Samper-Carro, S. C., Hawkins, S., Kealy, S., Louys, J. and Wood, R. 2017. 'Fishing in life and death: Pleistocene fish-hooks from a burial context on Alor Island, Indonesia', *Antiquity* 91 (360): 1451–68. <https://doi.org/10.15184/aqy.2017.186>.
- O'Connor, S., Ono, R. and Clarkson, C. 2011. 'Pelagic fishing at 42,000 years before the present and the maritime skills of modern humans', *Science* 334: 1117–21.
- Ono, R., Pawlik, A. and Fuentes, R. 2020. 'Island migration, resource use, and lithic technology by anatomically modern humans in Wallacea', in *Pleistocene Archaeology: Migration, technology, and adaptation*, edited by R. Ono and A. Pawlik. Intechopen.
- Samper Carro, S. C., O'Connor, S., Louys, J., Hawkins, S. and Mahirta Mahirta. 2016. 'Human maritime subsistence strategies in the Lesser Sunda Islands during the Terminal Pleistocene–Early Holocene: New evidence from Alor, Indonesia', *Quaternary International, Southeast Asia: Human Evolution, Dispersals and Adaptation*, 416: 64–79.
- Shipton, C., O'Connor, S., Reepmeyer, C., Kealy, S. and Jankowski, N. 2019. 'Shell adzes, exotic obsidian, and inter-island voyaging in the Early and Middle and Holocene of Wallacea', *The Journal of Island and Coastal Archaeology* 15 (4): 525–46.