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# The evolution of Australian island geographies and the emergence and persistence of Indigenous maritime cultures

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ABSTRACT

Australia was first peopled by maritime voyagers who intentionally crossed from Indonesia using watercraft 65,000 years ago. Despite this, the Holocene archaeological record suggests that many Australian islands were abandoned for several thousand years after separation from the mainland, and only visited again in the last few thousand years. The implication is that coastal peoples reintroduced watercraft into their maritime repertoire only in the recent past. Since first-peopling, sea levels have fluctuated over 120 m, transforming the coastlines and offshore island geographies. In this study, we assess Australia's offshore islands over the range of past sea levels, to discover that most of the Australian coastline has far more islands now than at any time in the human past. Australia's island-rich coastlines emerged with the high sea levels of the late Holocene. The existing island geographies of the Pilbara, the Great Barrier Reef, the Bass Strait and the Rottnest Shelf have no Pleistocene equivalents, meaning coastal peoples encountered new maritime opportunities as modern sea level was established (c. 7 ka). We present regional time series, and detailed paleogeographical maps of these changes, produced by a fully reproducible GIS method. We contextualise this in a review of Australian island archaeology, and demonstrate that key exceptions to this geographical trend are the Kimberley and the Torres Strait – which have evidence for earlier and longer continuous island sequences. These exceptions provided the opportunity for regional persistence of Pleistocene seafaring.


## 1. Introduction

Australia was first peopled by maritime voyagers by at least 65,000 years BP (Bird et al., 2019; Clarkson et al., 2017). At this time sea levels were up to 100 m bmsl (below mean sea level) (Deckker et al., 2019, 2020), which likely facilitated sea crossings around this time. These first voyages were intentional (Bird et al., 2018, 2019), involved over a thousand people (Bradshaw et al., 2019), and were enabled by a culture of modern human behaviour and maritime competency (Balme, 2013; Balme et al., 2009; O'Connor et al., 2011). These early seafarers appear to have maintained their maritime culture as they migrated around the Australian coast, with evidence of marine resource use throughout the late Pleistocene (Ditchfield et al., 2018; Norman et al., 2022; Veth, 2017; Veth et al., 2017a).

The present configuration of Australia's islands and coasts is defined by sea levels much higher than they have been for most of human history (Fig. 1; Grant et al., 2012; Lambeck et al., 2014; Lewis et al., 2013). For Sea Country peoples, the islands they visited and the mainland beaches they launched from were only in their modern configuration for the last few thousand years of occupation. From 50,000 years ago, Australian habitation has been characterised by fluctuating sea levels, with shorelines regressing and transgressing across Australia's continental shelf. This has resulted in an evolving range of coastal geographies and associated environments.

The process of sea level change itself also had a cultural impact. Sea levels fluctuated during the late Pleistocene but generally trended lower, reaching a sea level minimum of −130 m at the peak of the last glacial maximum (Fig. 1, LGM). Following the termination of the LGM (circa 18,000 years BP) sea level rose rapidly and inundated vast areas of the continental shelf, reducing the size of terrestrial lands by as much as 20% (Williams et al., 2018). This event would have resulted in mass migration and increased coastal population densities, particularly along the northwest and

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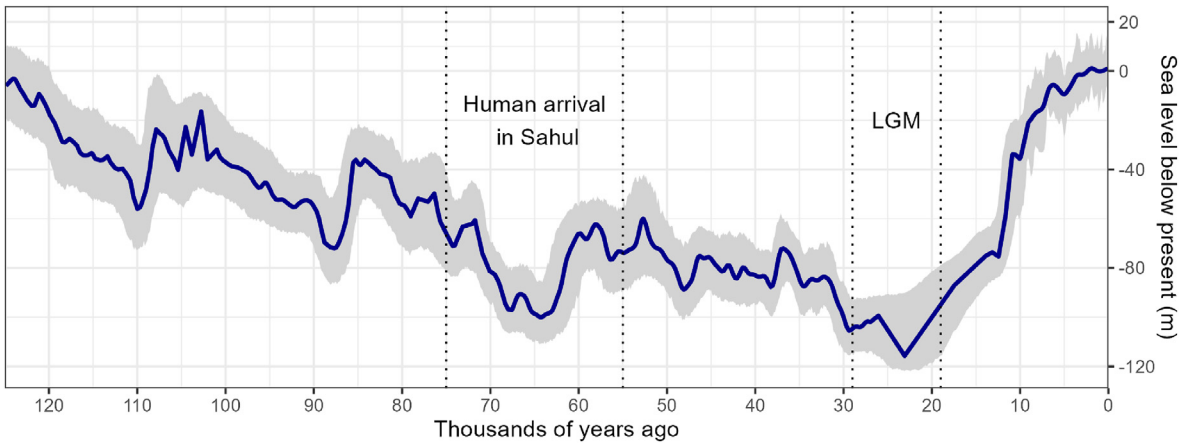


**Fig. 1.** Grant et al., (2012) Sea level curve, annotated with sea level intervals and projected key human events.

Northern Australian shelves, and the Bass Strait. In these places thousands of square kilometres of land became inundated, forcing larger and previously more scattered populations to coalesce as they retreated inland. It is suggested that these climate refugees maintained a cultural connection to the coast as it transgressed across the continental shelf (Bowdler, 1977), and that these massive migrations may have set the context for the development of more complex coastal societies in the Late Holocene (Williams et al., 2015).

Significantly, the specifics of how these evolving geographies and environments influenced human culture remains a key question in Australian archaeology. Here we attempt to address this knowledge gap by investigating sea level-driven changes in island geographies around the Australian coastal margin, and how this may be reflected in the maritime cultures of late-Holocene Saltwater Peoples.

### *1.1. Coastal foragers, maritime deserts, bark canoes and voyaging: different ways to live by the sea*

Australian Aboriginal coastal economies are connected to the sea and interstitial waterways in a variety of ways. Those that are integrally involved with the sea are considered 'maritime', and often see themselves as 'Saltwater people' (McNiven, 2004). Many other Aboriginal cultures are 'coastal' – living along the coast and accessing marine resources. This can range from heavy reliance (Beaton, 1995), to more nuanced and seasonal engagements with the coast, as part of a broad-based economy (McDonald, 2008; Monks, 2020). Many marine-focused economies retain an important terrestrial component (Hallam, 1987; O'Connor and Chappell, 2003). Archaeologists can detect coastal life through an investigation of diet - middens can reveal detailed information about the timing and nature of marine exploitation (e.g. Ulm, 2006), or isotopes in human bones can reveal the sea as the major sources of nutrition (McDonald et al., 2007; e.g. Pate, 2016). Coastal life is often profoundly influenced by climate and environmental change, which impacts associated habitats such as beaches, reefs, lagoons and mangroves (Chappell, 1982; Ditchfield et al., 2022).

Detecting seafaring is another matter altogether. In the absence of finding an actual boat in the archaeological record, watercraft can be inferred through component technologies (Balme, 2013), e.g., pelagic fishing technologies and corresponding midden deposits (McDonald, 1992; O'Connor et al., 2011), or through inferred water crossings (Bird et al., 2018, 2019; Kealy et al., 2017). For this study, we are interested in the circumstantial and opportunistic evidence for water-crossing provided by known periods of offshore island occupation and abandonment. Here we distinguish between offshore islands and those in rivers and lakes, which are excluded from this study.

We suggest a modification to Broodbank's (2006) scalar typology (which has been applied more broadly to Pleistocene seafaring (Gaffney, 2020)):

***Coastal:*** Use of marine resources with no major Ocean crossings.

***Seafaring***: Competent Ocean crossing to islands, over a few kilometres.

***Voyaging:*** Intentional Ocean crossings beyond intervisibility.

We also clarify that there are four classes of offshore island evidence (Bowdler, 1995).

- Island sites that retain evidence for occupation of former mainland (e.g., Barrow Island, some Dampier Archipelago islands)
- Island sites that represent isolated island life or abandonment without a connection to the nearby mainland (e.g. Bass Strait islands)
- Island sites that are used seasonally i.e. visited or lived on by people whose territories include the mainland (e.g., Dampier Archipelago)
- Island sites that represent intensive occupation in the recent past (e.g. the Wellesley Islands)

For the question of maritime competency, we are most interested in the third: where people are either living on the mainland coast and intermittently visiting islands; or living on islands and intermittently visiting the mainland coast. These modes of occupation can be combined with palaeogeographical knowledge to infer water-crossing distances and maritime competency. The two other classes of island evidence represent useful contrasts because their use did not necessitate water-crossing competencies.

### *1.2. Patterns of island use in the Holocene – abandonment and late reoccupation*

Bowdler's (1995) review of island archaeology in Australia found most evidence of island occupation to be late Holocene. She identified that following a period of abandonment after initial separation from the mainland, these islands were re-integrated into the coastal economy and accessed by simple watercraft. In places beyond the reach of simple watercraft, the land masses were either abandoned when they became islands (e.g. Barrow Island, see Veth

et al., 2017b) or populations became isolated and eventually vanished from the archaeological record (e.g. Flinders and King Island in the Bass Strait, Kangaroo Island off South Australia, see Bowdler, 2015; cf. Flinders Island Sim, 1991a). Bowdler posited a renewal of maritime cultures and watercraft in the late Holocene with evolving coastal environments. A test of Bowdler's model would be places where longer-distance watercraft traditions continued through the late Pleistocene/early Holocene transition. We propose that in these places, seafaring cultures persisted, perhaps even from first-peopling, and then continued throughout the Holocene.

Bowdler's reoccupation model has generally been supported through decades of coastal and island archaeological research, with similar patterns being observed in the Great Barrier Reef (Lambrides et al., 2020; McNiven et al., 2014; Rowland et al., 2015), the Gulf of Carpentaria (Sim and Wallis, 2016). It is apparent, however, that the relationship between watercraft technology and maritime practice is not straightforward.

By the late Holocene, there were huge regional differences in the use of watercraft around Australia. Along the eastern coast, as far south as Sydney, there ocean-capable watercraft used to visit islands (Bowdler, 1995). Similarly, in the north, there is a strong boat-building focus for accessing islands, from the Coral Sea Cultural Interaction Sphere (CSCIS) (McNiven, 2021; Rowland, 1987) through Arnhem Land (Mitchell, 1996) and the Kimberley coast (O'Connor, 1999). In contrast, most of the southern and western continental coastline has minimal evidence for watercraft. Some of these coastlines have simple watercraft: mangrove velocipedes in the Pilbara (Paterson et al., 2019) and light, bark rafts on the southwestern coast (Draper, 2015). This absence of reliable seaworthy watercraft occurs in the presence of contemporary productive and potentially-reachable Holocene islands - which is the conundrum.

### 1.3. Research questions

The key questions of this study are.

- Can Holocene patterns of island use in Australia be explained through evolving island geographies?
- Are enduring island geographies necessary for persistent, earlier and more intensive maritime cultures? and,
- What is the relationship between island-rich coastlines and watercraft technologies?

To answer these questions, we need to model how island geographies have changed through time in Australia, and explore the regional patterns of Aboriginal island use through the Holocene.

Our model requires us to ask three questions.

1. Where are the palaeo-islands and archipelagos in Australia?
2. How do the island geographies change both spatially and temporally around Australia?
3. How do regional differences in the timing and nature of pre-contact island occupation correspond to enduring and/or ephemeral island-archipelago sequences?

## 2. Methods

### 2.1. Compiling a database of island dates

Two major radiocarbon databases were used to establish phases of island and coastal occupation: *SahulArch v.2* (Codilean et al., 2022) and *AustArch* (Williams et al., 2014) databases. *SahulArch* is more current but additional sites in *AustArch* were identified by unique lab codes and added to the database along with some manually added metadata such as island name (Fig. 2). Some further dates were provided for Enderby Island (McDonald et al., 2022a) and the *Archaeoglobe Islands* database data for Rottnest Island were also included.

For the time series analysis, this database was filtered to only include dates that are associated with Aboriginal occupation. All dates with an island name were retained, except for those associated with inland rivers, etc. The rest were filtered to within 50 km of the modern coastline, and flagged as 'coastal', to give context to the island dates (these may not be coastal over their entire period of usage but give a good sense of the land-based archaeological record, particularly in the Holocene). The resultant database includes 911 island dates, and 3141 coastal dates. The R code for this data cleaning and the additional dates are available in the Supplementary Information.

This database has been presented by IBRA7 region, arranged in clockwise order around the continent. Islands with no dated occupation or incomplete radiocarbon information are only included in the Discussion.

### 2.2. Reconstruction of islands under the sea

This GIS method was carried out programmatically in R (see code in the Supplementary Information).

The study area is the Australian continent, as defined by the Geoscience Australia Australian Bathymetry and Topography Grid. It does not include most of Sunda and New Guinea, which have been previously assessed (Kealy et al., 2015, 2017, 2018). The continental area was computed to the maximum mainland extent of

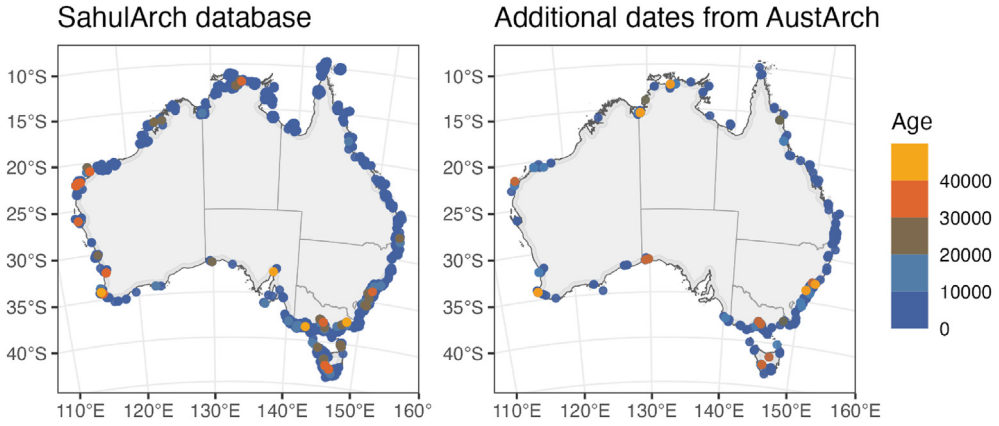


**Fig. 2.** Dates from *SahulArch* and *AustArch* databases. Showing only island and coastal dated sites. Overlapping points are sorted by oldest first.

the LGM, defined by the −130 m contour, with a 200 km buffer. Lake Eyre was excluded for obvious reasons. All data were reprojected to Australian Albers (EPSG:3577), an equal area projection suited to consistent calculations of area across the Australian continent.

Elevation values were classified as land or ocean according to different sea levels compared with present, in 40 m increments, which correspond approximately to different times of interest.

- -120 m (Last Glacial Maximum)
- -80 m (first peopling)
- -40 m (mid-deglaciation)
- and 0 m (present).

Vectorising the raster allowed metrics to be computed for each island polygon (perimeter, area, max height above sea level). The mainland was separated into a class of its own. For each island, the area was calculated in hectares and the maximum elevation was extracted from the underlying raster. Area was chosen as a stable way to quantify the 'amount' of island surface available to people. Coastlines were constructed by casting the island polygons to lines, and then calculating their length. Unfortunately, due to the resolution of this dataset coastline length was poorly resolved, biased by 1-pixel-wide noise. It is not presented for analysis.

Island metrics were summarised using tessellating hexagon bins, with a size of 200 km. The total area is presented on the log scale because we are interested in their magnitude. The number of islands was not calculated, as inspection showed that this metric was overwhelmed by noise in the dataset. The amount or complexity was better captured by the other two variables.

Intervisibility was computed to visualise the potential maritime seascapes around island geographies. Following Kealy et al. (2017), 'relative intervisibility' describes islands that are visible to an observer from some point at sea (assuming the observer is 0.5 m above sea level). The buffer of visibility for each island $i$ is calculated:

$$visibility_i\ (km) = \left(3.57 \times \sqrt{h}\right) + \left(3.57 \times \sqrt{max(elevation)_i}\right),\ h = 0.5m$$

Absolute intervisibility describes islands that are visible from each other's shores and is conservatively estimated as half the relative intervisibility.

Visibility buffer zones were joined if they overlapped. They were filtered by those that overlapped the mainland − representing a seascape one could voyage across without ever losing sight of landmarks. Of course, there is evidence of people voyaging much further than the intervisibility zone (McNiven, 2004).

The final step was to run this analysis using the values from the Red sea level curve (Grant et al., 2012), interpolated for every 2000 years. This was summarised by regions defined by our analysis and literature review, and includes the full extent of the LGM landmass (Fig. 3). It is presented as the total island area within the combined intervisibility zone from the mainland, and the associated area of intervisibility. This represents the area available to people on islands, and the size of the associated seascape. The spatial results for each timestep are provided in the Supplementary Information.

We note the Red sea level curve is eustatic, and does not account for the local differences in relative sea level caused by neotectonics and glacio-hydro-isostacy. At this broad scale, this assumption is appropriate, and the pattern is robust to the several metres of difference this would introduce around the continental margin (Lewis et al., 2013). To the north, in Wallacea and Papua New Guinea, tectonic uplift could have a larger influences, and this has been accounted for in previous studies (Kealy et al., 2017). For more local studies, our analysis code could be run with a local sea level curve.

## 3. Results

All published island dates for the Australian continent are presented in Fig. 4, grouped by IBRA7 region. The vertical line at 7000 years marks the approximate stabilisation of sea levels. All dates are from islands that became islands in the Holocene, prior to current sea levels they were part of the mainland. The general pattern supports an Early Holocene hiatus, with later, mid-late-Holocene reoccupation. Coastal sites are also included to give a sense of the amount of nearby mainland archaeology, and how the number of dates is generally much greater in the Holocene.

This approach also helps visualise which areas of study demonstrate evidence of absence, and where still suffers interpretively from a lack of evidence. Some clear examples of island abandonment are Barrow Island and Campbell Island in the Pilbara, and Prime Seal Island in the Furneux region. These are in clear contrast to the very few dates available for the islands on the Swan Coastal Plain, the Tasmanian West, on the NSW/Sydney coasts. The archaeological context for these dates is discussed in detail below, and is vital for assessing the relative strength of evidence. However, it appears broadly true that there is much further dating work needed to test models of continuation against models of abandonment or several-thousand-year hiatuses.

### 3.1. Islands over time

Results of the GIS analysis show the total island area and intervisibility surfaces (see Figs. 5 and 6). The intervisibility surfaces for the four (0, 40, 80 and 120 m) different sea levels were chosen because they represent key SL intervals in the Grant (2012) curve. This shows a comparatively high number and area of islands in the late Holocene, in contrast to previous periods. In most places, there were few or no islands during the LGM, with relatively straight and shelving coastlines, as originally suggested by Bowdler (2010). The exceptions to this trend are the Kimberley-Top End coastline and the Torres Strait.

A time series of this is presented in Fig. 5 showing the area and associated intervisibility areas for islands that could be accessed from the mainland without venturing beyond the sight of land. Total island area is in log sqkm to better visualise time series changes, but this can mask the sheer scale of what these changes represent. Intervisible area is presented on a linear scale to clearly demonstrate the vast increase in navigable seascapes. Every region, except the Kimberley, shows an increase in island area following the LGM. The Kimberley shows a significant contraction. The Torres Strait shows an increase in island area in the Holocene, but this follows a long and continuous sequence of island geographies, as does southern Tasmania. The full data for this figure, including spatial information, is in the Supplementary Information.

Figs. 7−13 show detailed maps of paleocoastlines and paleoislands at four timescales of interest.

The Kimberley - Top End coast was a very island-rich target for first peopling (Figs. 7 and 65 ka, sea level -~80 m). In the Pleistocene, there was a zone of intervisibility from the Sahul Banks, covering 200,000 km$^2$, which encapsulated 20,000 km$^2$ of island area (excluding Timor Roti). In the Holocene, this zone shrank to half that size, with a fraction of the island area available. Cartier Island and the Ashmore Reef are features today that correspond to

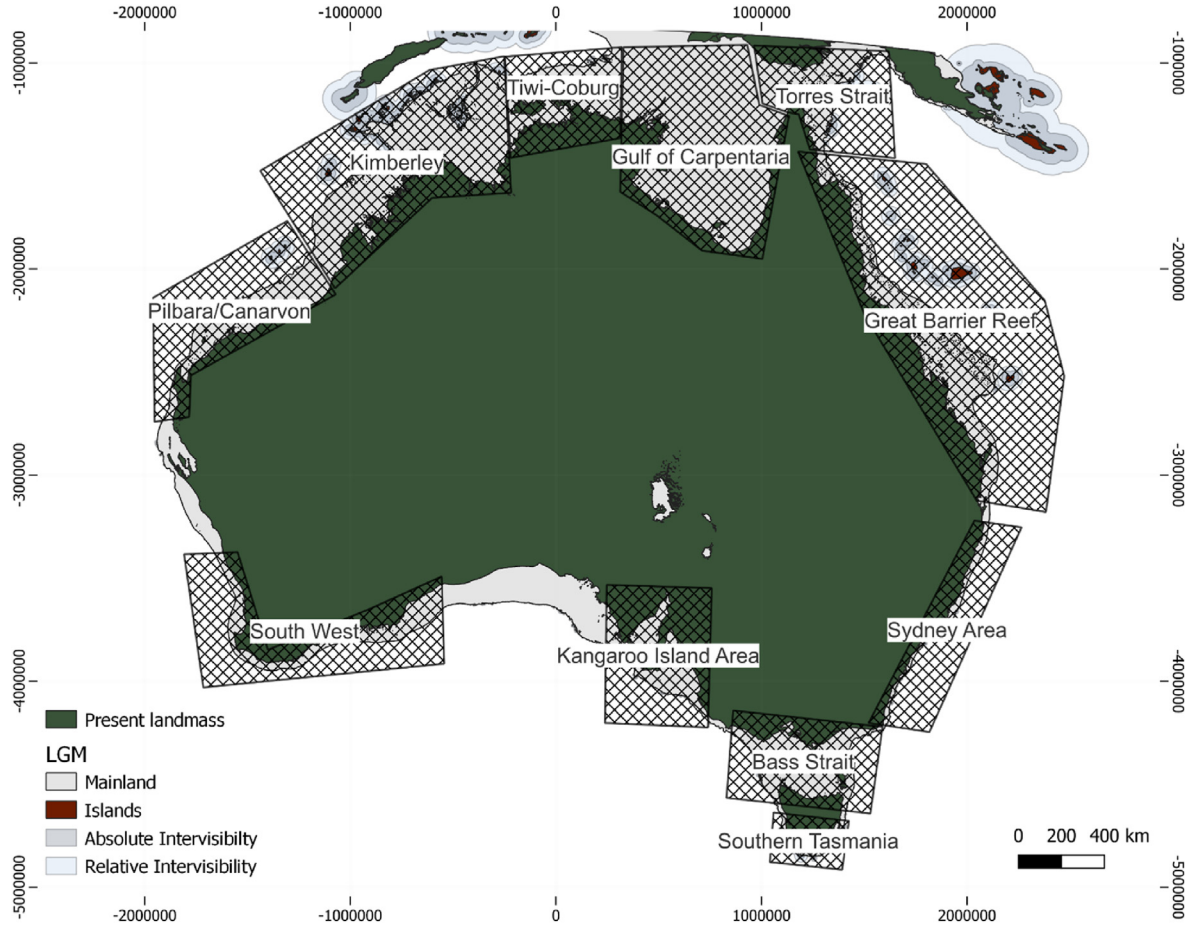


**Fig. 3.** Regions used for time series analysis, based on literature review and analysis, to include the full LGM landmass.

islands at both first-peopling and the LGM, but neither have identified archaeological records.

The Torres Strait has a similarly long history of island geographies. At first-peopling and during the LGM, there were two large islands 50 km and 160 km to the east of Murray Island (700 km$^2$ and 500 km$^2$ each, Fig. 8), and several to the south in what is now the Great Detached Reef, the Yule Detached Reef, Southern Small Detached Reef, and Raine Island. The connected intervisibility zones show that people could have crossed the ocean to these without ever losing sight of land.

South of the Torres Strait, there was much less island area throughout the Pleistocene from the Great Barrier Reef to the New South Wales coast, with a near complete absence of islands during the LGM (Fig. 10). The steep eastern coasts, described as barren by Bowdler (2010) also had no islands to visit. The few islands that did exist off the coast of the Great Barrier Reef were more than 100 km off the coast and far beyond intervisibility, beyond easy integration into a coastal economy. During deglaciation, the island area hugely expanded into what is now the Great Barrier Reef.

The Gulf of Carpentaria (Fig. 9) has several large islands at present: Groote Eylandt and Vanderlin Island. These only formed following the LGM – during which time the entire Gulf was dry land. Then the nearest coast was north of the present-day Tiwi islands, over on the Kimberley to Top End coastline.

There was a major difference between the Bass Strait and the southern margins of Tasmania (Fig. 11). The eastern and western margins of the Bassian Plain (the landmass now beneath the Bass Strait) had very few islands during the LGM, but a small concentration on its western edge. The large present islands of the Furneux group and King Island have no previous analogues. During deglaciation, the Furneux group were the final land bridge from Tasmania to the mainland, with King Island separating slightly earlier and subsequently shrinking in size. Southern Tasmania's offshore small islands persisted through the LGM. At present, the south-eastern is the most island rich, but at first-peopling and during LGM the south-western coast was the most island-rich area.

Kangaroo Island is a uniquely large island that came into existence following an absence of islands during the LGM (Fig. 11). The current size of Kangaroo Island dwarfs the total island area that existed along this southern coastline from first peopling until the LGM, and all other islands formed during the deglaciation.

The southwest corner of Australia reveals a similarly recent sequence, with Rottnest Island, the Recherche Archipelago, and the Houtman Abrolhos all being late Holocene formations following an absence of islands during the LGM (Fig. 12). However, at first-peopling, the southwest had a similar amount of island area as it does today, offshore from what is now the Recherche (Fig. 12 inset).

The Pilbara has significantly more island area available now than at any point in the past. There was an absence of islands at the LGM (Fig. 13), but during the Pleistocene there were many islands available, almost spatially continuous with the Kimberley. The current Rowley Shoals represent the top of some of these former islands, which existed during first-peopling and the LGM. This included Bedwell and Cunningham Islands (both around 100 km$^2$), and a third (unnamed) similarly-sized island to the east.

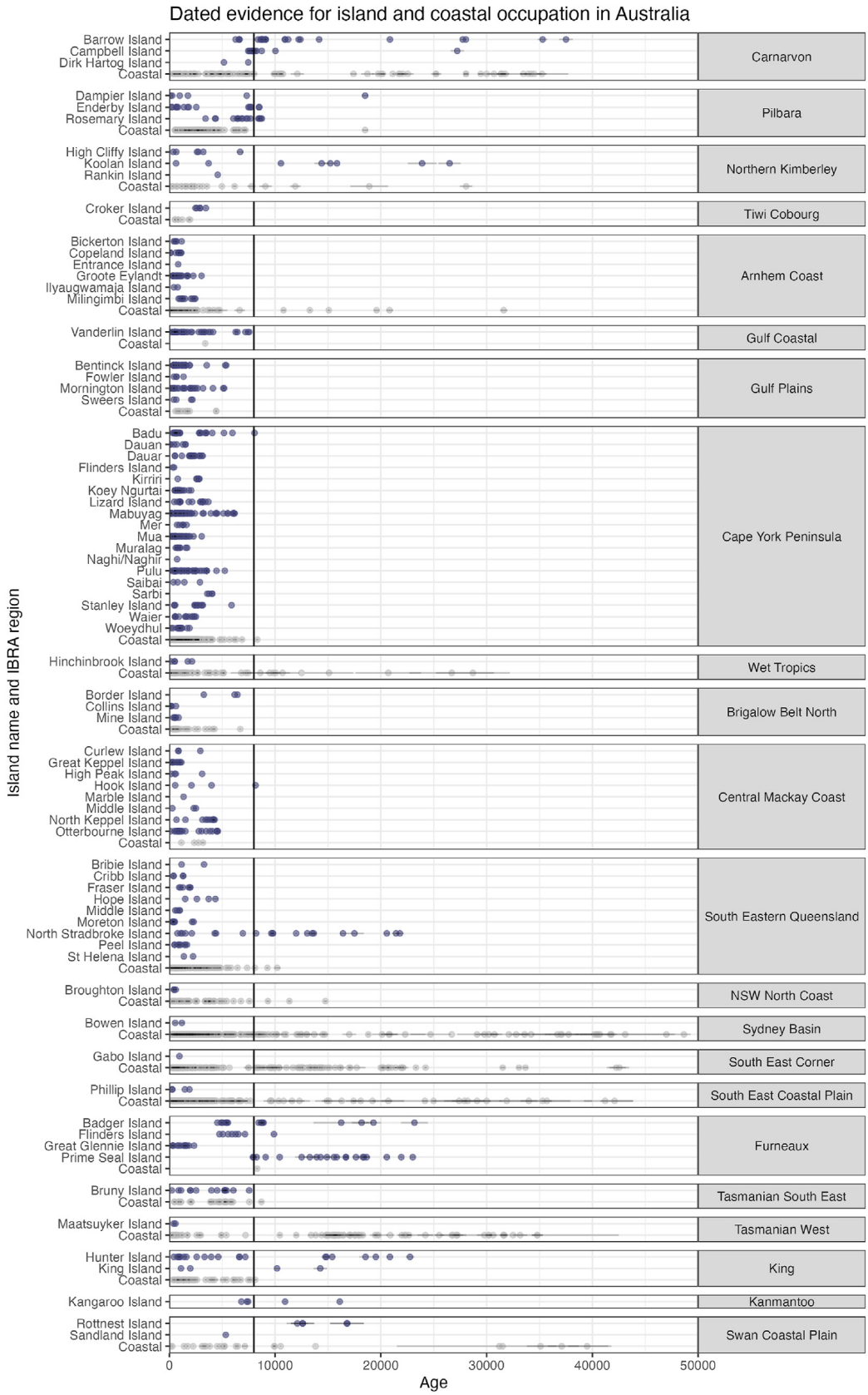


**Fig. 4.** Radiocarbon dates for islands around Australia, in the *AustArch* and *SahulArch* databases. Coastal sites (within 50 km) of the current coast have also been included for these regions. A darker line at 7000 years marks the approximate time when sea levels reached the present shoreline.

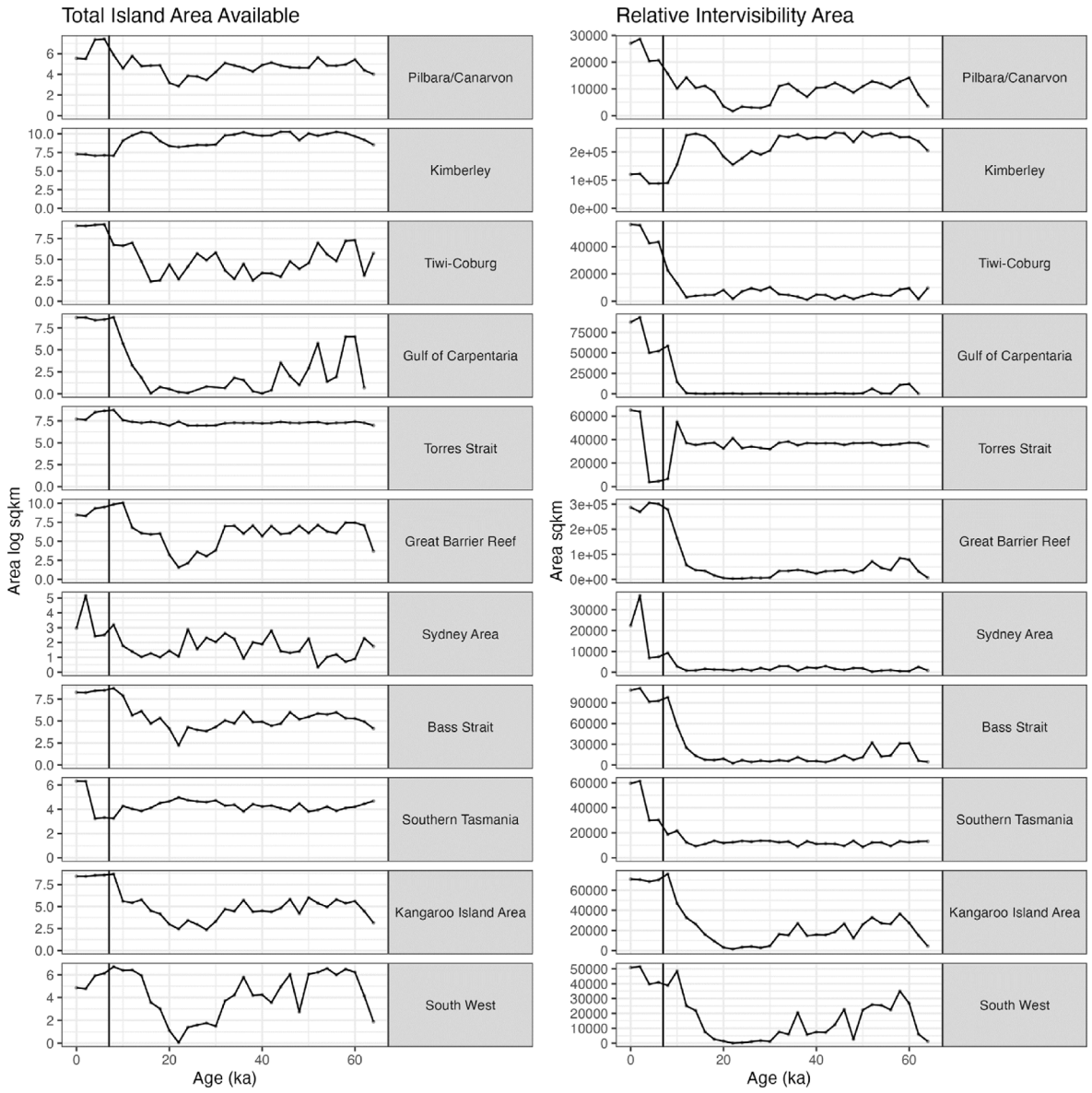


**Fig. 5.** Time series for island area and implied intervisibility surface (note the vertical scale best fits the data and is not standardised). Total island area is in log sqkm to better visualise time series changes, the intervisible area is presented on a linear scale to demonstrate the huge scale of change.

## 4. Discussion

This analysis has shown that many of Australia's offshore Pleistocene islands, now beneath the sea, provided a unique set of coastline opportunities to the first Australians. As well as providing the opportunity for travel between island south-east Asia and northern Australia (Sahul) these early archipelagos only continued at the very north – and south of the continent, making the opportunities for persistent maritime cultures extremely limited. Most of Australia's island-rich coastline regions emerged in the Holocene and there are far more islands now than at any time in the past. Persistent seascape opportunities occur in only the Kimberley–Top End and Torres Strait regions where continuous large-scale island geographies can be mapped throughout the full period of this continent's occupation (summarised in Table 1).

### 4.1. Kimberley-Top End Coastline

The first Kimberley-Top End peoples would have inhabited a much larger archipelago than exists today. This ancient seascape presented continuous intervisibility from Timor-Roti (Bird et al., 2018) providing the opportunity for peopling expanding their seafaring range, involving a few days at sea, rather than a voyage into the unknown. While similar investigations of intervisibility through Wallacea support a northern route into Sahul (Kealy et al., 2017, 2018), these also revealed the same low-cost maritime surface between Indonesia and the Kimberley-Top End coast, arguably a more attractive route for island-focused peoples. This was supported by calculating intervisibility from higher elevations on islands, which found some of the Kimberley prominences would have been visible from the higher elevations of Roti and Timor (Norman et al., 2018). The presence of skilled, maritime-capable people is confirmed by early evidence for broad maritime

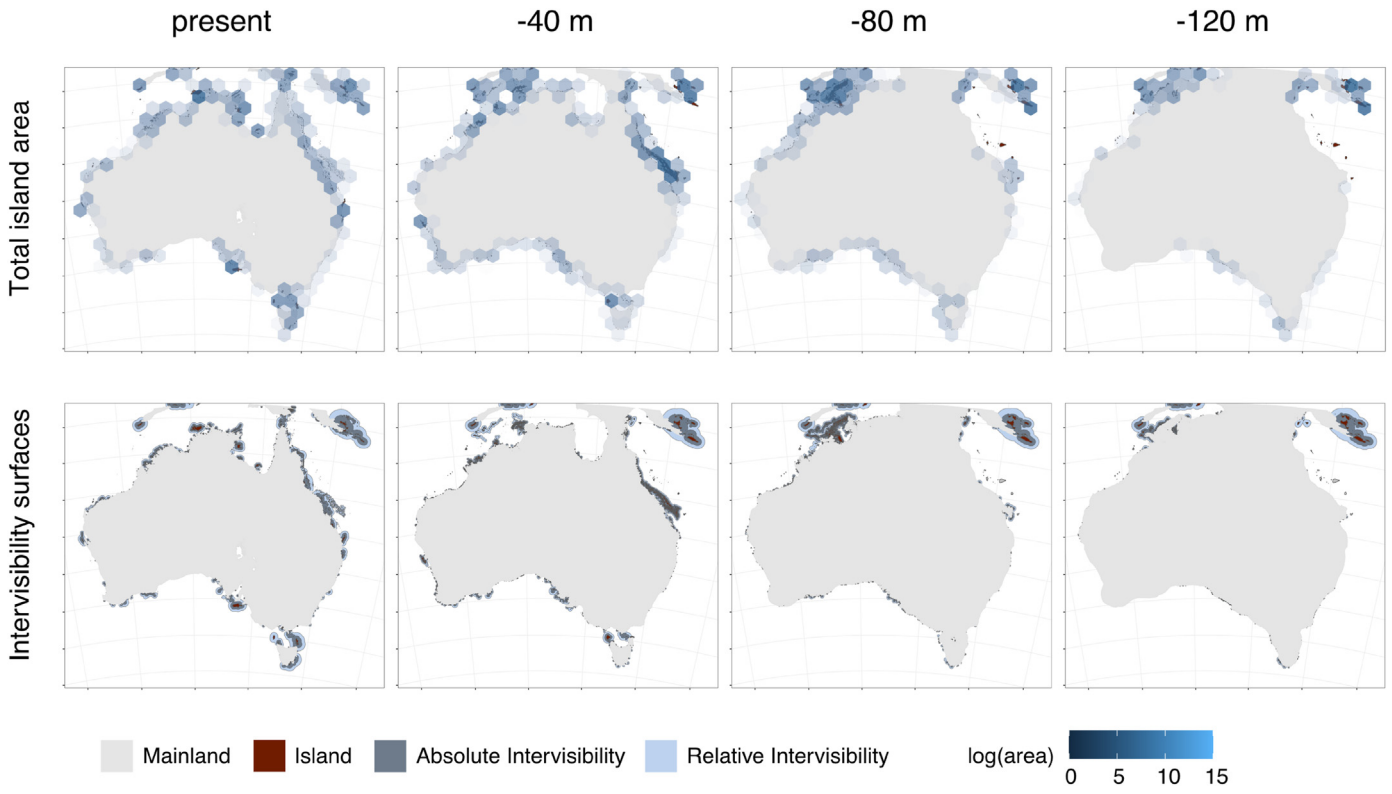


**Fig. 6.** Island area and intervisibility surfaces around Australia. Total area summarised by tessellating hexagon bins, with a size of 200 km. Intervisibility surfaces following Kealy et al. (2017).

competencies in Indonesia (Balme et al., 2009; O'Connor et al., 2011), also being recognisable in the earliest archaeological sites in the Kimberley (Balme, 2013; Balme et al., 2009; O'Connor et al., 2011), and modelling of these voyages asserts the intentionality of the voyagers (Bird et al., 2019).

This original island-rich coastline extended across the Northern Kimberley, south towards the northern Pilbara coast and as far east as today's Tiwi-Coburg Bioregion. Islands were absent further east while there was a land bridge to New Guinea in what is now the Gulf of Carpentaria (Fig. 9). During the extremely low sea level of the LGM this island seascape contracted to around the Malita Basin, and immediately to the west. This archipelago corridor was extensive but isolated: with an almost complete lack of islands on either side. Seabed coring demonstrates that the Malita Basin was a large lagoon, always connected to the Timor Sea and at least marginally marine (Andel et al., 1967; Field, 2018).

This analysis shows that the Kimberley-Top End corridor is the only continuous seascape in Australia with the opportunity for a persistent island-focused culture from the first voyagers. The lack of persistent island-rich seascapes further east and southwest may go some way in explaining the apparent disconnect between the first maritime voyagers and the subsequent opportunity for Australian maritime adaptation and adoption of island use until the mid-late Holocene. They did not 'have to burn their boats' Bowdler (2015). Rather, it is possible that a culture of island-hopping did not expand beyond this region because the landscapes were more conducive to territorial expansion than the seascapes.

So, was the late Holocene Kimberley island-hopping culture continuous from the Pleistocene? After all, the modern Kimberley coast remains a seascape with an extensive archipelago. The land-based archaeological record supports continuous occupation from first-peopling, with continuities and discontinuities observable in cultural practice and art traditions (Balme et al., 2019; O'Connor, 1999; Veth et al., 2021). Kimberley people had the opportunity to continuously adapt practices in an island-rich seascape over more than 50,000 years. And so, did they?

No archaeological work has yet been done on any Kimberley island that could have plausibly existed before the Holocene. The earliest dates of 50,000 years ago are from Widgingarri 1, which is now a 'coastal' site, but at the time of first occupation, it would have been 100 km east of the shoreline (Norman et al., 2022). Like other sites in the region, this site shows a pattern of sustained marine exploitation after the sea level reached its modern position (Norman et al., 2022). However, there was contact between Widgingarri and the distant coast, even during the LGM, revealed by a date of 28 ka on a baler shell, and 19 ka on pearl shells, which must have been selectively transported (O'Connor, 1999).

The Holocene island record provides a useful proxy for deep-time seagoing behaviour and allows interpretation of how people responded to these Holocene islands as they were forming. Given the long sequence of island-rich coastlines, we could expect to see fully-fledged island usage from the earliest stages of island formation. O'Connor's (1999) intensive study of the Kimberley coastal archaeological record shows continuous island use from the early Holocene through to the present, supported only by rafting technology. She argued the absence of canoes and fishhooks shows that Indonesian were not a big influence on the late Holocene maritime culture and suggested canoes were not a prerequisite for ocean crossings of up to 8 km. Koolan Island has evidence for the use of marine resources since 10,500 BP, when it was part of the mainland. Once it became a Holocene island, the occupation continued right through to the present. Nearby High Cliffy Island shows a broad pattern of coastal use from 8000 to 5000 BP, with seasonal intermittent visitation. This is a notable exception from the late

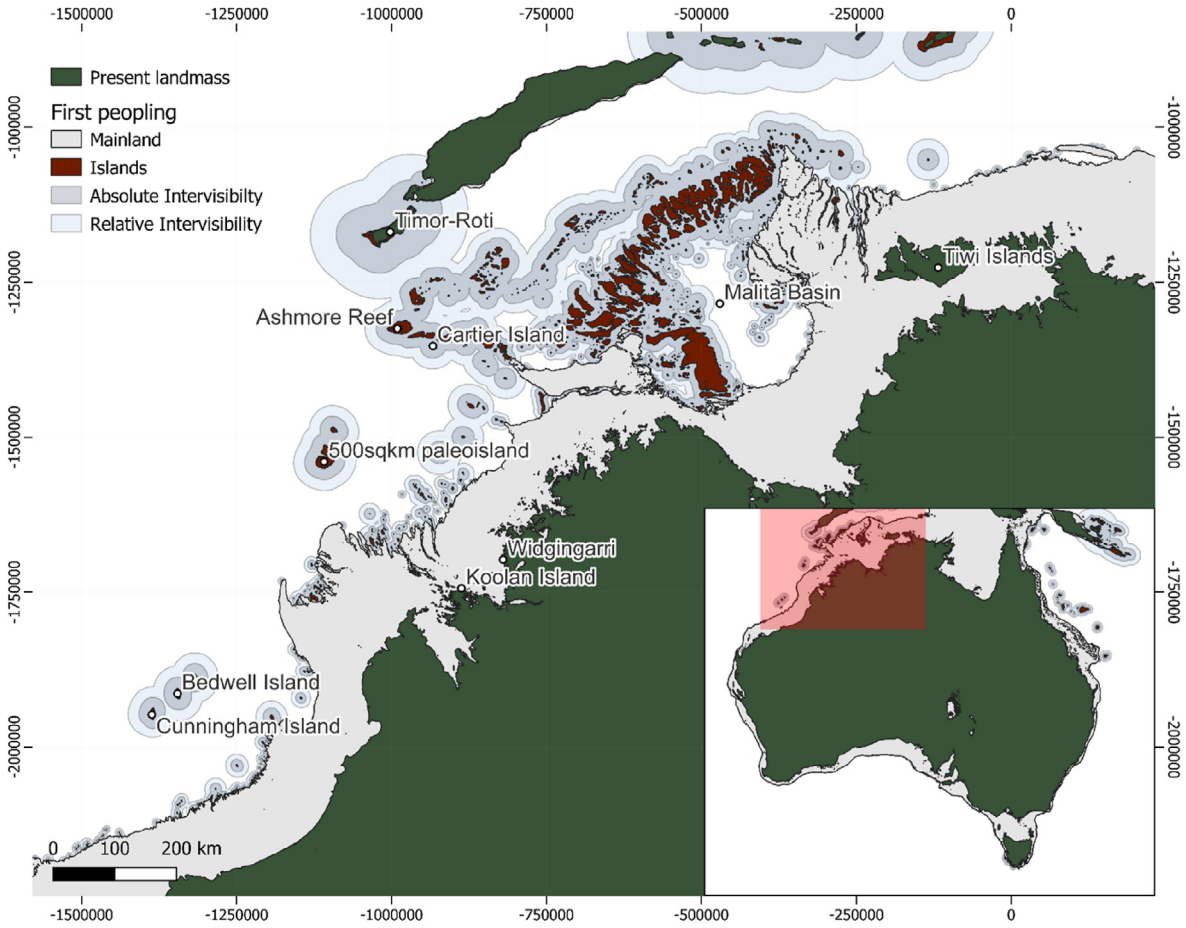


**Fig. 7.** The Kimberley to Top End Coast, showing the islands available at first peopling (−80 m sea level). The green area shows the present landmass – island rich but still much smaller than the full LGM-extent.

Holocene reoccupation model. The assemblages are mostly marine, intertidal shellfish, with mangrove species peaking from 10,000 BP-7000 BP: a very similar pattern to sites elsewhere in the north of Australia. The focus on shellfish and the lack of fish (and fishhooks) show that this does not represent the sort of pelagic fishing likely carried out during the first peopling in Australia (O'Connor et al., 2011). Rather, this is a focus on the marine resources provided by the island coastlines.

At the present sea stand, there are only a few islands between the contemporary Kimberley and Tiwi-Coburg coasts. This is reflected in the clear differences in the contemporary boat-building traditions between these two places, with triangular mangrove log rafts in the Kimberley, and one-piece bark canoes in Tiwi-Coburg and Arnhem land (Fig. 5 in Bowdler, 1995). In the last few hundred years, the Makassan trepang industry from Indonesia regularly visited this area, and likely introduced canoes and fishhooks (Mitchell, 1994).

The only dated island evidence from Tiwi-Coburg is from Mid-Holocene shell middens on Croker Island, which shows a sharp decline of mangrove resources in the mid-Holocene and are mainly comprised of sand-flat species no longer present in the area (Mitchell, 1994). Tiwi Island has had no previous archaeological research – and has no dated Aboriginal sites: a substantial omission in Australian islands research given it is the largest island in the region and separated by a sea-crossing of at least 12 km.

### 4.2. Torres Strait

Bowdler's 1995 review does not discuss the Torres Strait, partly because it was then considered part of Melanesia, rather than Aboriginal Australia. More recent scholarship has revealed a greater complexity of island interaction, built on deep connections to New Guinea and the Coral Sea (McNiven, 2022). Our analysis highlights that this is one of the few regions in Australia with the potential for continuous island occupation over the span of human presence.

The archaeological evidence suggests that the most recent occupation phase in the Torres Strait began 3500 years ago, when the islands were occupied by Austronesian and Papuan people from the north (Linnenlucke, 2022). Interestingly, a rock shelter on the Torres Strait Island of Badu is known as a rare example of occupation immediately following islandisation (Rowland et al., 2021), with continuous Aboriginal occupation or visitation from 8000 BP until the Austronesian phase (David et al., 2004). Is this apparently anomalous behaviour related to the unusually rich Pleistocene island sequence now underwater, around 200 km to the east of the present Cape York Peninsula?

At first-peopling, and during the low sea levels of the LGM, the islands of the Torres Strait region were distributed to the far north. As the sea level rose in the late Holocene, the Torres Strait became connected to the islands of the Great Barrier Reef.

This wider region now understood as the 'Coral Sea Interaction

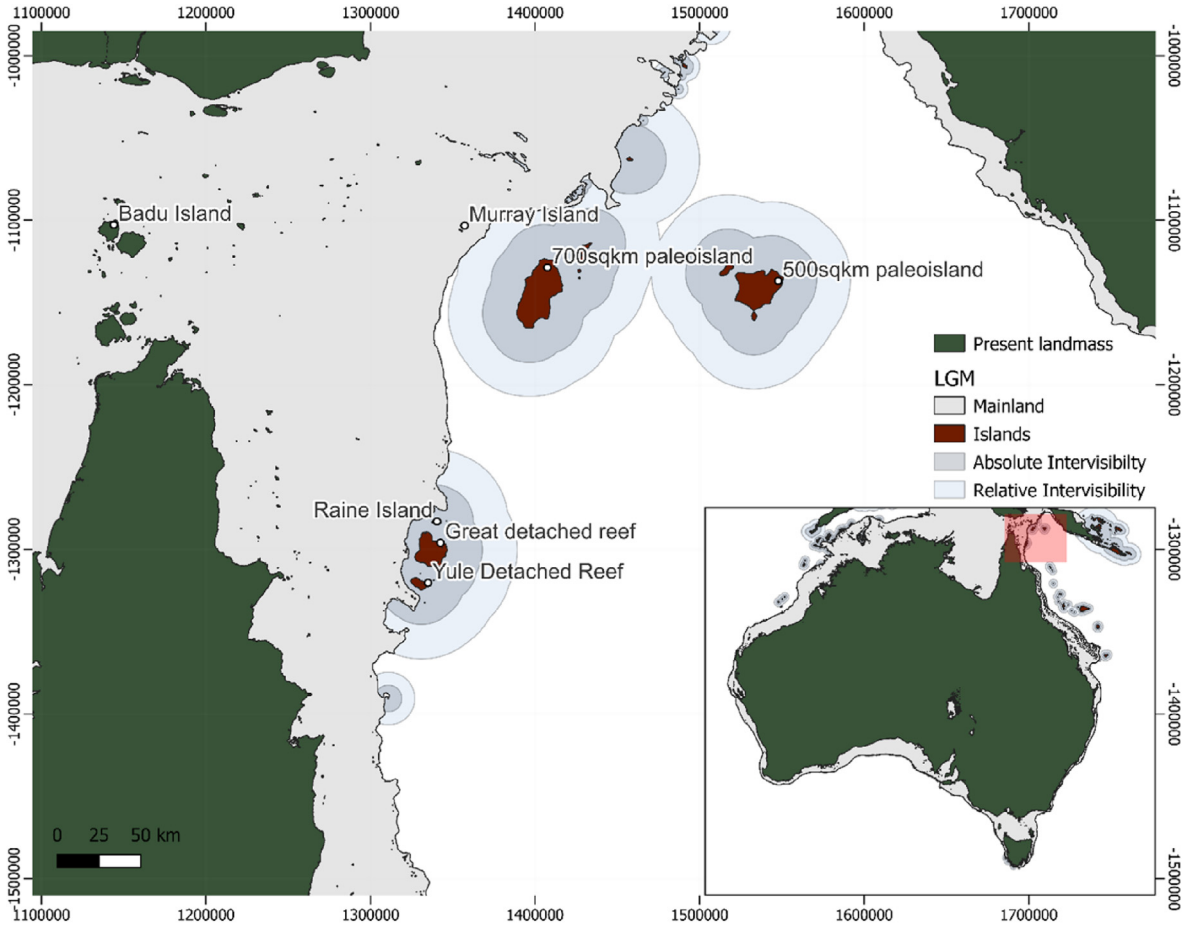


**Fig. 8.** The Torres Strait, showing the islands available during the LGM (−120 m sea level).

Sphere', represents a cultural seascape with a strong maritime focus, involving voyages of over 2000 km, enabled by the uptake of double outrigger canoes from Melanesia (McNiven, 2022). Here, the island-rich seascape is substantially broadened during the Holocene — quite the opposite of the Kimberley. For this reason, the Great Barrier Reef will be discussed separately as a 'short' sequence but must be understood with the caveat of these much deeper roots from the Torres Strait and New Guinea.

### 4.3. Southern Tasmania

Southern Tasmania has a comparatively small amount of island area available, compared with other Australian coasts. However, this sequence does appear continuous, even through the LGM. In the absence of archaeological data from these islands, this should be considered a tentative long-sequence, pending a more detailed investigation.

At first-peopling and during the LGM, the southwest had a plethora of islands, but in the Holocene this island focus shifted east to the Southern Ranges and Southeast. Bruny Island in the Southeast possibly shows a corresponding long history of island occupation (Bowdler, 1995; Reber, 1965). There was a clear period of occupation in the Mid Holocene (dates from 6000 BP and 5200 BP), and several in the late Holocene (2500 BP). This may have been continuous, or with abandonment followed by reoccupation. It was visited using watercraft in the ethnographic present (Bowdler and Ryan, 1987), with only a 1.5 km water crossing. More dates from this region are needed to establish whether a hiatus followed separation. Continuous occupation here would be an anomaly and would support our suggestion that long-term island-rich coasts enable the persistence of maritime cultures. The continuous island geography of southern Tasmania contrasts with Bassian Plain, which during the LGM and first peopling was flanked on both sides by island-free coastlines.

### 4.4. Pilbara and Carnarvon coast

The Pilbara and Carnarvon coasts currently host over 400 islands, several of which have been archaeologically investigated. There is evidence of coastal occupation from 50,000 years ago with the earliest occupation of this region on what is now Barrow Island (Veth et al., 2017b). Our analysis reveals that these coasts were island-poor at first peopling, and almost completely island-free during the LGM. Isolated from the Kimberley to the north, this region's islands provide a textbook 'short sequence' (summarised in Table 2). We would argue that any island-hopping cultural practices here had to emerge in the Holocene. Cunningham and Bedwell islands in the Rowley Shoals, are the only known modern islands that were islands since first peopling, including through the LGM.

Murujuga (the Dampier Archipelago), is a densely inscribed and occupied archaeological landscape occupied from at least 22,000 years ago, through the Holocene and until the present. The archipelago formed 7000 years ago, at which point people became clearly coastal-focused in their art (McDonald, 2015; McDonald and Berry, 2016; Mulvaney, 2015). Evidence for water-crossing in the historic period is restricted to floating mangrove logs, which were

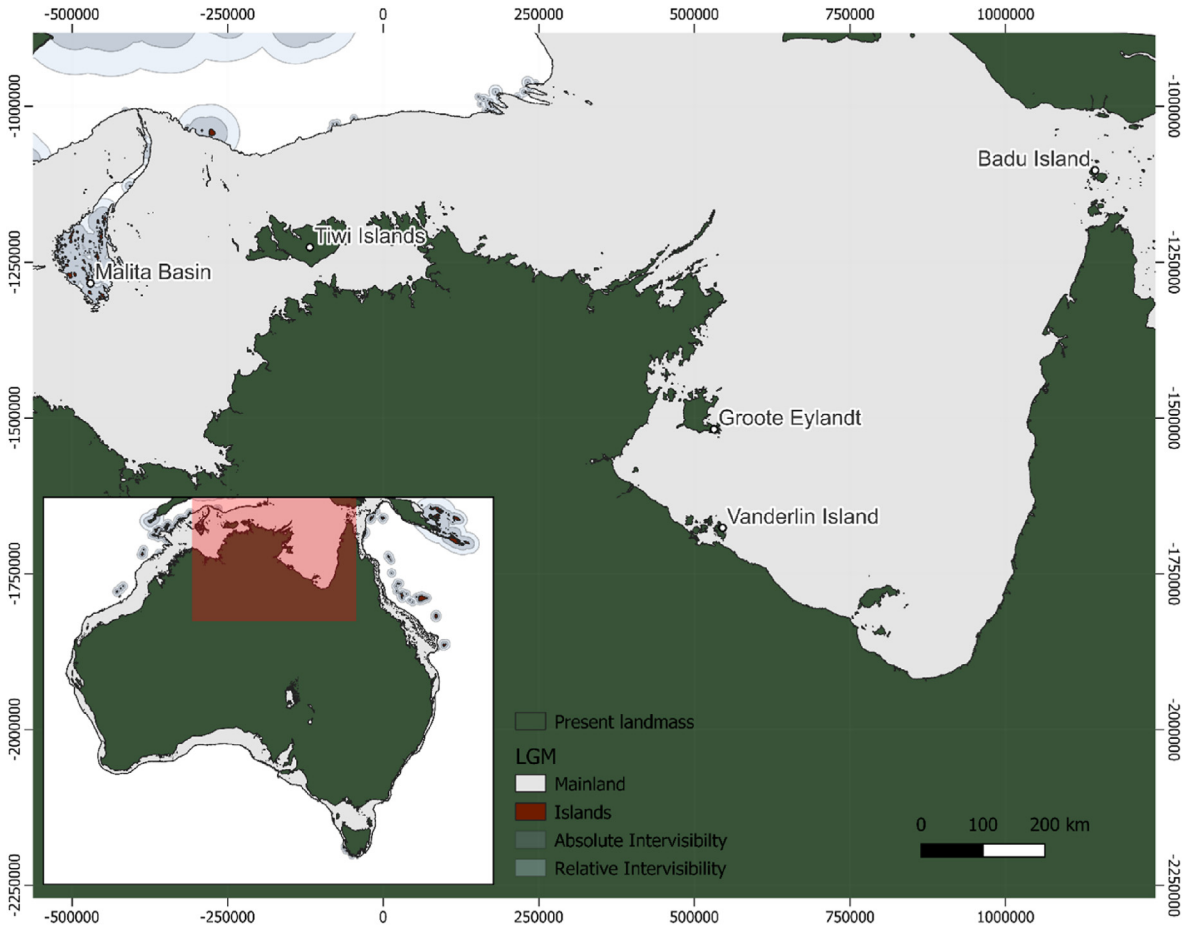


**Fig. 9.** Gulf of Carpentaria at the LGM (−120 m). Also showing the nearby Tiwi coast, with a much more enclosed Malita basin than at −80 m (Fig. 7).

used to move between islands in the wet season during the 19th century (Paterson et al., 2019). It is clear the occupation of outer islands changed following separation, but it appears that Rosemary Island was accessed up until historical contact (McDonald et al., 2022b) despite a minimum of five ocean crossings of up to 5 km distance. Murujuga's sea country is an excellent test-bed for understanding the complexities of island culture, with 42 islands at varying distances, water permanence and accessibilities: from wading at low tide to multiple open-water crossings with a distance of between 3 and 5 km.

Barrow Island and the Montebello Islands, by contrast, were occupied in the Pleistocene but abandoned after island separation (Manne and Veth, 2015; Veth et al., 2007, 2017a). Rock shelters on these islands have very early evidence of coastal resource use, with up to a 15 km distance to the (then) contemporary coastline, but the evidence for early Holocene abandonment is clear: a 50 km ocean-crossing was clearly too far.

### 4.5. Arnhem Coast and the Gulf of Carpentaria

The Gulf of Carpentaria and the eastern Arnhem coast have a surprisingly short sequence of island occupation, despite a strong contemporary maritime focus and a plethora of islands (of which only six have been archaeologically investigated). This region's island-rich geography is a post-LGM, Holocene feature. This provides a marked contrast to the Kimberley-Top End coasts, for which it is (particularly Arnhem Land) an otherwise very similar contemporary environment.

The overall pattern of late island reoccupation is exemplified by the records of two large, well-studied islands. Groote Eyelandt on the eastern Arnhem Coast has only been occupied in the last 2500 years – it appears uninhabited for the first few thousand years after islandisation (Clarke, 1994). This is surprising, given it is only an 8 km ocean crossing, but is not due to lack of study – with 24 dates available from 14 sites (including 5 rock shelters). Further, in the last 1000 years, there was a shift in focus towards coastal sites, coinciding with the deposition of middens focused on sand and mudflat species. Clark suggests two factors influencing this: 1) the formation of sand/mud habitats due to the formation of the dunes and swamps (the 'time-lag'), and/or 2) contact with Makassans (sea cucumber fishers from Indonesia), both of which are supported by the archaeological and paleo-environmental evidence.

Vanderlin Island, 6 km from the southwest coast of the Gulf provides a similar story. Here there was intensive occupation before separation from the mainland, followed by a 2000-year hiatus, and reoccupation from 4200 BP (Sim and Wallis, 2016). This is well demonstrated, with a clear gap between numerous radiocarbon dates across the island is conspicuous evidence of absence, rather than a lack of available data. Interestingly, there is another possible hiatus between the mid-Holocene phase of occupation (4200–2500 BP), and the late Holocene phase (1300 BP-modern). Sim and Wallace suggest this may have been related to a harsher maritime climate caused by strong ENSO, and relate it to a change from mangrove to mud/sandflat species. Despite an absence of evidence for Makassan contact in any excavated assemblage, regional rock art and linguistic evidence suggest that this likely

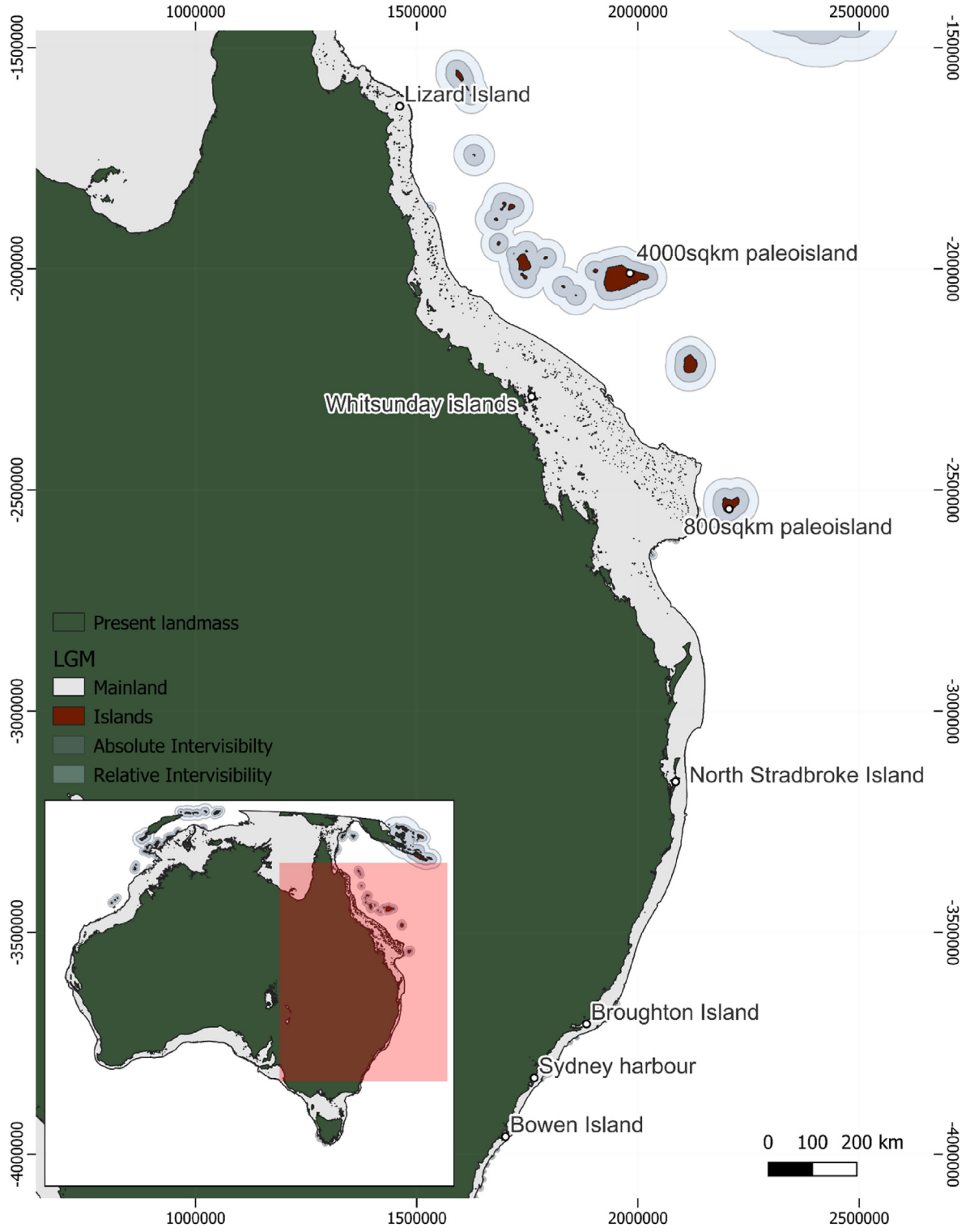


**Fig. 10.** The east coast at the LGM, including the Great Barrier Reef and the New South Wales coast (−120 m sea level).

played a role in the intensification of marine resource use in the last 1000 years, particularly the last 300 years. There is no evidence that this Makassan contact was a complicating causal factor behind the reoccupation of islands. Like in the Coral Sea, Makassan contact comes much later.

### *4.6. Great Barrier Reef/Coral Sea interaction sphere*

The Great Barrier Reef and the broader Coral Sea have a clear record of late Holocene maritime culture, supported by complex coastlines and island-rich waters. The timing and range of

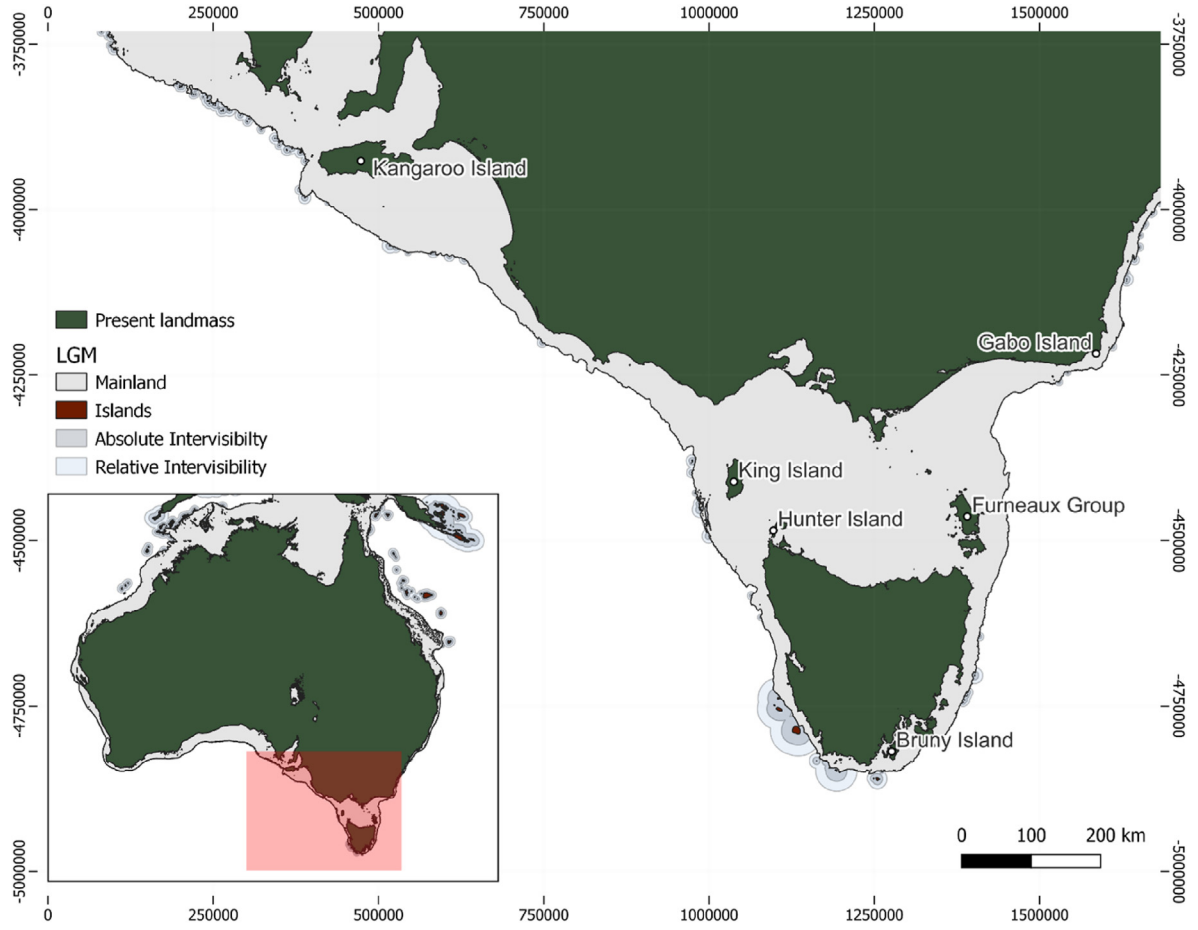


**Fig. 11.** Tasmania and Kangaroo Island at the LGM (−120 m sea level). This coast shows a pattern of a few very small islands during the LGM, in contrast to the much larger islands of the present.

occupation evidence have been recently reviewed (Rowland et al., 2015), and broadly support a pattern of late re-occupation, with the exceptions of continuous occupation in the Whitsundays (Barker, 2004) and a mid-Holocene date from Stanley Island (Wright, 2018). The mid-Holocene Stanley Island date comes from a midden dominated by rocky and mangrove species, with few sand/mudflat species compared with recent. Importantly, it also contains evidence for very long journeys at sea – the longest being at least 27 km of island hopping to the Percy Group, by 3000 BP (Rowland, 1984). These are not associated with long sequences and appear to be evidence of water-crossing emerging in the Holocene at different times. An influential study that tests the timing of occupation is McNiven et al.'s (2014) Darumbal voyaging, which looked at the Shoalwater Bay Islands in central Queensland. This study showed the typical hiatus of several thousand years before the islands are reoccupied around 3500 BP. The assemblages of islands with substantial ocean crossings (Collins, Otterbourne, and High Peak Islands) show short-term visits targeting fish and turtles, in contrast to islands closer to the coast (Keppel and Whitsundays) with more diverse taxa.

McNiven suggests that the 'time-lag' is down to the development of the island habitats (Beaton, 1985), which made the risk of crossing worthwhile, particularly the beaches for turtle nesting, the mangrove for shellfish, and the development of reef systems for fishing. This would suggest seasonal occupation during the wet season, focusing on turtles and reliable drinking water, in contrast to the year-round occupation of closer islands. They also argue that resources alone cannot mechanistically explain island occupation alone, given that all these habitats would have been available on the mainland. Nor can the introduction of watercraft technology fully explain water-crossing capacity, with visits to Otterbourne Island several thousand years before contact with the Torres Strait and Lapita cultures. They point to cultural reasons that would make the risk of water crossing worthwhile, using the example of a major quartz vein quarried on Collins Island.

This argument makes sense in relation to a relatively short time depth for the presence of islands on this coast. The cultures moving inland here would likely not be focused on island visitation, so without a clear cultural reason or a familiarity with ocean crossings, it could take a considerable time for the island habitats to become attractive enough to be worth the effort and risk. Conversely, one would expect this mechanism not to cause a hiatus in places with island-hopping traditions, because the risk would be lower, and the cultural draw to islands would be much greater.

Before concluding this section, we briefly return to the question of Torres Strait interactions, and why it is appropriate to consider the Great Barrier Reef as a short sequence in this analysis. Recent work on Lizard Island (Jiigurru) has demonstrated a focused exploitation of diverse marine resources and manufacture of quartz artefacts from 4000 years ago. Increased island use occurs from around 2250 years ago, at a time when a hiatus or reduction in offshore island use has been documented elsewhere along the Great Barrier Reef. This is seen as coinciding with the expansion of the Torres Strait Cultural Complex, and likely signalling its

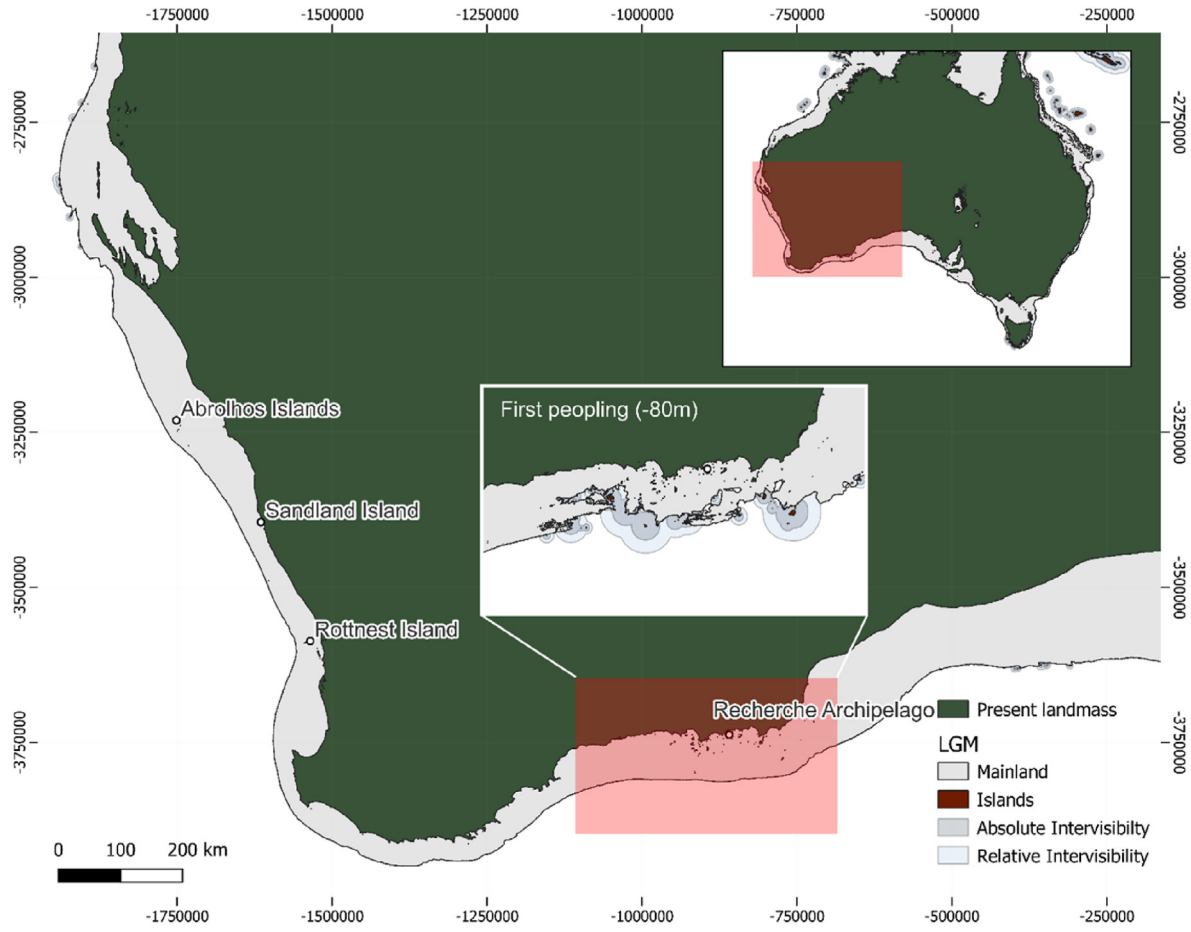


**Fig. 12.** The island-less South-west at the LGM (−120 m sea level). An inset showing the paleo-Recherche archipelago that would have been present at first peopling, but was interrupted by the LGM.

integration into the Coral Sea Interaction Sphere (Lambrides et al., 2020)supported also by pottery being found in the lagoon (Ulm and McNiven, 2021). While it impacts the interpretations of regional late Holocene watercraft this contact happened much later than island reoccupation and is not implicated in its timing. For now, the evidence is that island reoccupation is a practice that emerged from existing coastal Aboriginal communities, rather than one that was introduced.

### 4.7. NSW coast and the Sydney basin

There is very limited archaeological island evidence for the NSW coast, paired with a very limited set of islands in the present and the past. Broughton Island is just 3 km off the coast and has dates ranging back just 500 years (Sullivan, 1982). Bowen Island to the south, just 500 m off Jervis Bay has a slightly longer record, going back 1000 years (Sullivan, 1982). Overall, this is a very late sequence, with no clear island focus. The Sydney coast is interesting because, despite the lack of islands, there is clear evidence of maritime competency in the late Holocene. Gender-restricted hook and line fishing from canoes was historically reported (men used barbed fishing spears from the rock platforms), using hooks made by the women from turbo shell (Attenbrow, 2010; McDonald, 1992). Sydney demonstrates that despite the absence of pre-Holocene islands, maritime technologies and watercraft can develop and thrive in estuarine and offshore environments: in this case, provided by the drowned ria landscape of Sydney Harbour and the other major tributaries of the region. The origin of the local fish hook technology is not yet known, but these appear in the archaeological record around 1000 years ago (Walters, 1988).

### 4.8. The Bass Strait

The Bass Strait has been a focus of island archaeology for decades. Bowdler's 1995 review followed her earlier work here, and her recent review (Bowdler, 2015) supports the same interpretation: of island abandonment and a very late revisitation. The Furneux group has no dates after 4500 BP, which has been interpreted as abandonment or extinction, driven by difficult climate conditions (Bowdler, 2015). Great Glennie Island is the exception (see Fig. 4), this being 7 km off Wilsons Promontory in Victoria, and significantly distant from the other islands. People visited this island in the last few thousand years by canoe from mainland Australia (Head et al., 2020; Jones and Allen, 1979). Visitation in the last few thousand years at Hunter Island has been interpreted as Tasmanian seasonal visitation by canoe (Bowdler, 2015), and there is less substantial visitation to King Island (Sim, 1991b). For such a major set of archipelagos, it has always been surprisingly non-maritime, although people managed to survive seemingly isolated on the islands for thousands of years.

Our analysis has shown that despite the current island-rich waters, at the LGM the Bassian Plain coastlines were relatively simple. During inundation, there would have been islands continuously forming, but the 40 m contour shows these islands are very large compared with other parts of Australia. During this relatively

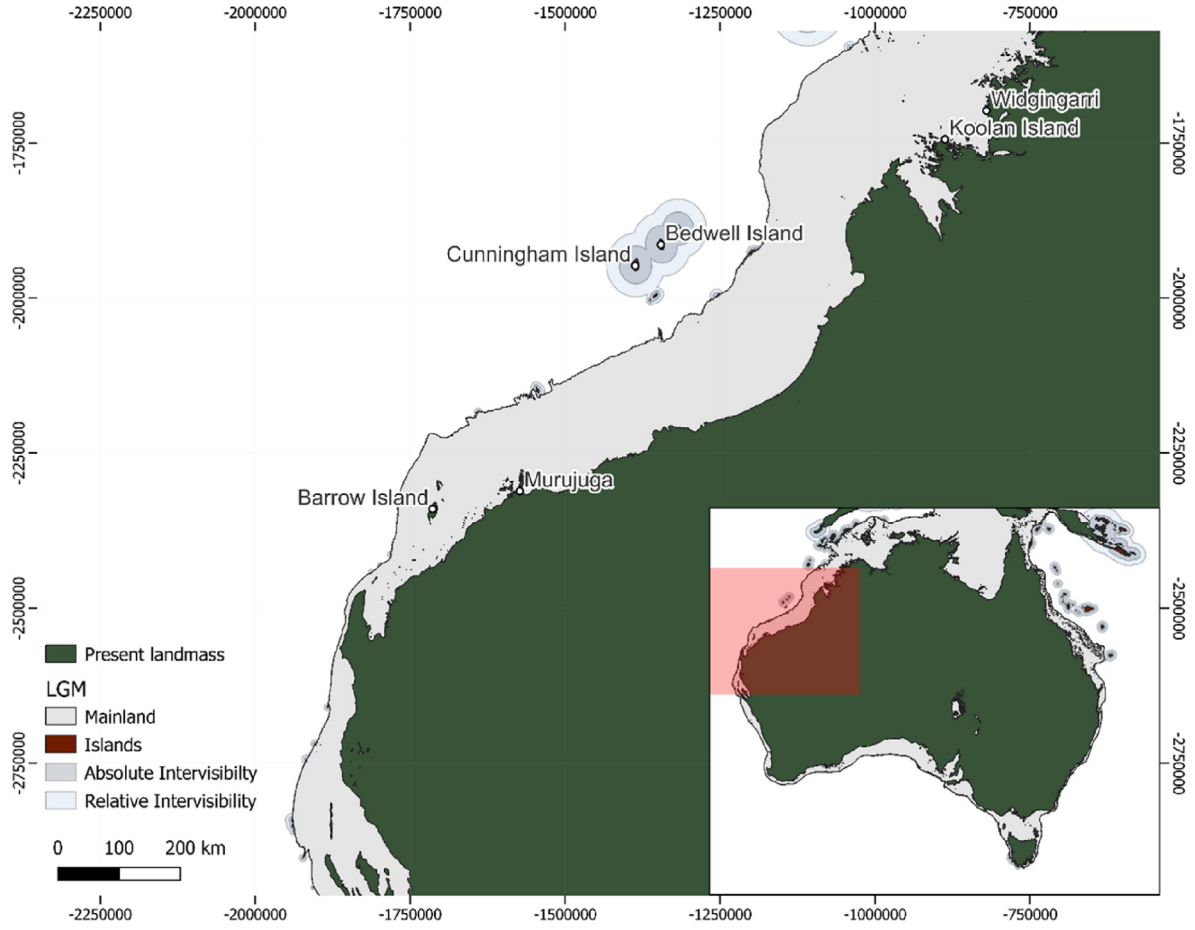


**Fig. 13.** The Pilbara and Carnarvon at the LGM (−120 m sea level).

**Table 1**
Summary of long sequences (Pleistocene – present) discussed in this paper.

| Region | Occupation timing | Range of crossing distances | Late Holocene typology |
|---|---|---|---|
| Northern Kimberley and Tiwi Coburg (Kimberley-Top End Coastline) | Coastal pulse, continuous but intermittent occupation into the present (O'Connor, 1999) | 8 km to Koolan Island (O'Connor, 1999) | Seafaring (rafts only) |
| Torres Strait | Continuous from the early Holocene to the present (David et al., 2004). | Over 2000 km into the Coral Sea (McNiven, 2022). | Voyaging |
| Southern Tasmania | Mid-Holocene, late Holocene and present, maybe continuous | 1.5 km to Bruny Island (Bowdler and Ryan, 1987) | Seafaring |

**Table 2**
Summary of short sequences (early Holocene – present) discussed in this paper.

| Region | Occupation timing | Max crossing distances | Typology |
|---|---|---|---|
| Pilbara and Carnarvon | Coastal pulse, possible hiatus, some island abandonment depending on distance (McDonald, 2015; Veth et al., 2017b) | 5 km (Rosemary Island, McDonald, 2018) but not to 50 km (Barrow, Veth et al., 2017a) | Seafaring |
| Arnhem coast and Gulf of Carpentaria | Coastal pulse, clear hiatus, late Holocene reoccupation (Clarke, 1994; Sim and Wallis, 2016) | 6–8 km (Vanderlin and Groote Eyelandt) (Clarke, 1994; Sim and Wallis, 2016) | Seafaring |
| Great Barrier Reef/ Coral Sea | Late Holocene with mid-early Holocene (Rowland et al., 2015) | 27 km island crossing to Percy Isles. (Rowland, 1984) | Seafaring (then voyaging incl. Torres Strait) |
| NSW Coast | Late Holocene island use (Sullivan, 1982). | 3 km to Bowen (Sullivan, 1982). | Seafaring |
| Bass Strait | Coastal pulse, island Abandonment, limited late Holocene reoccupation (Bowdler, 2015) | 55 km to King Island (Sim, 1990) | Seafaring |
| Kangaroo Island (Kanmantoo) | Abandonment following inundation (Draper, 2015) | Not to 12 km (Draper, 2015) | Coastal |
| Esperance | Unknown | Unknown | Unknown |
| Swan Coastal Plain | Early-mid Holocene. Absence of sites post-dating inundation. | 500 m to Sandland (Dortch et al., 1984). Likely not to 20 km (Dortch and Morse, 1984). | Coastal |

short sequence, the size of the islands may have made it even less conducive to island-hopping practices. It remains unclear if the people of the Bass Strait were particularly 'maritime' before the Holocene, with continued debate over whether fish was a substantial part of the economy (Collard et al., 2016). These large islands possibly functioned more like smaller versions of a mainland economy until that became untenable due to shrinking size or climate pressure (Bowdler, 2015), similar to Kangaroo Island, and less like islands in places like the Kimberley and the Great Barrier Reef, which were coastally-tethered mainland maritime economies.

### 4.9. Kanmantoo (Kangaroo Island)

Kangaroo Island is 14 km off the coast of South Australia. When Australia was first-peopled, the Kanmantoo coast was relatively-island rich, but this was truncated entirely during the LGM. Many islands were formed in the terminal Pleistocene, but islands are far more common now than at any other time. Kangaroo Island is uniquely large for the Australian coast, and while island-hopping would not have been continuous through the LGM, it makes more sense during the late Holocene than at any time in the past.

The dated archaeological evidence suggests island abandonment following a period of coastal occupation (Hope et al., 1977; Lampert, 1981). Draper's recent review challenged the assumption that the absence of historical evidence and lack of watercraft necessarily meant there is no visitation in the late Holocene (Draper, 2015). However, there is a conspicuous absence of maritime culture and an absence of recent dates, and the early Kangaroo Island assemblages are similar to ancient mainland assemblages. Even accounting for the possibility of limited, sporadic or seasonal voyaging, there is no evidence that people are focussed on island resources and no island adaptation has been observed.

### 4.10. South-west WA: the Geraldton sandplains, the Swan Coastal Plain, Warren and the Esperance plains

South of the Pilbara there is very little evidence of island use, despite a strong coastal record. The Houtman-Abrolhos Islands, 60 km offshore of the Geraldton sandplains have no records of visitation in the Holocene, and only one plausible Aboriginal lithic discovered, despite extensive archaeological excavation of historical deposits (Marwick, 2002). Our analysis shows this landmass would have been disconnected in the early Holocene, during which it would have been a very rich archipelago seascape. It is possible the sea level high-stand in the mid-Holocene removed most of the archaeological deposits on these very low-lying sandy islands.

On the Rottnest Shelf (off the Swan Coastal Plain) there are many islands, but not much of an island archaeological record. Sandland island, just 500 m offshore in the midwest, is the only one with radiocarbon-dated archaeological material, which dates to the mid-Holocene (Dortch et al., 1984). This coincides with a period of increased coastal resource use in the region (Monks, 2020). During the final stages of inundation, there would have been far more islands than there are at present – and it is possible that this geography played a role in the increased coastal focus.

Other major islands, such as Rottnest Island (Wadjemup) and Garden Island, have revealed few artefacts in only broadly-dated deposits (Dortch, 1991; Dortch and Morse, 1984; Hesp et al., 1999; Peitsch et al., 2016), none of which plausibly date beyond the mid-Holocene, or post-date separation (Dortch and Dortch, 2019). There is no ethnographic evidence for late Holocene visitation, and it is assumed that the 19.7 km ocean crossing to Rottnest Island was too far to swim.

On the Esperance plains on the south coast, the Recherche Archipelago presents another short sequence in a group of more than 100 islands. Our analysis suggests the existence of a paleo-archipelago to the south of the modern Recherche at first peopling, but this seascape geography was interrupted by a simple, steep coastline during the LGM. Further work here could represent a very interesting case study for an interrupted island-geography sequence. There are no published dates for Aboriginal archaeology on the islands, but there is ethnohistoric evidence for island visitation (Draper, 2015), and some artefacts are thought to pre-date inundation, with a few tentative exceptions (Dortch and Morse, 1984).

More work is required to establish the timing of island occupation in the southwest corner of the continent, but these coasts are a much more island-rich seascape now – compared with any time in the past. Hence, island hopping as a coastal strategy likely emerged following the LGM. In accordance with other Australian coastal regions, one would expect the pattern here to be Early Holocene transition coastal occupation, abandonment following island separation, and then reoccupation of closer islands during the late Holocene. Without more dated evidence, this remains speculation.

## 5. Conclusion

Australia was first peopled by maritime voyagers, who intentionally crossed from Indonesia using watercraft 65,000 years ago. The Australian record, however, does not indicate that seafaring remained part of the deep-time competencies of the First Australians. We argue that this is most likely because the current Australian coastline is richer in islands now than it ever was in the past, becoming island-rich only during the Holocene. As was initially suggested almost three decades ago (Bowdler, 1995), with rising seas after the LGM, there is a pattern of newly-formed island abandonment with reoccupation of these offshore resource zones in the late Holocene (Bowdler, 1995).

We base this argument on regional time series, and detailed paleogeographical mapping of coastal and island changes, using a fully duplicable GIS method. We contextualise this in a review of Australian island archaeology. We found that only the Torres Strait, the Kimberley-Tiwi and Southern Tasmanian seascapes have retained persistent and enduring islands. These are the only seascape that could have supported continuous island-hopping practices since first-peopling. Archaeological evidence (albeit limited at this stage) indicates that it is only these northern geographic exceptions that have evidence for regional persistence of Pleistocene seafaring.

The contemporary island geographies of the Pilbara, the Great Barrier Reef, Bass Strait and the Rottnest Shelf have no Pleistocene equivalents. This means that coastal peoples experiencing rapid and inevitable sea-level rise post-LGM, moved inexorably inland through the terminal Pleistocene and Early Holocene encountering only rare and discontinuous opportunities for practising sea-faring as part of their economic repertoire.

It was only after modern sea level was established (c. 7 ka) that fully coastal economic strategies were re-established. There were likely very different drivers for this depending on the size of the available coastal plain, whether this was arid or fertile, and the resident populations that were being supported in this re-structured land and seascape. At Murujuga we know the (now) outer islands demonstrate that highly mobile coastal foragers took advantage of interior ranges across the Abydos Plain as sea levels rose after the Last Glacial Maximum (McDonald and Berry, 2015) and that the most intensive use of these landscapes were in the Early Holocene when they were still coastal and proximal to rich estuarine resources. We also know that people continued to use

these landscapes after islandisation, but that this use was different, and often only seasonal in the late Holocene (McDonald et al., 2022a, 2022b). The high mobility of arid zone peoples no doubt affected how these sea-scapes were re-adapted into their re-established coastal landscapes.

Since first-peopling, sea levels have fluctuated over 120 m, transforming the coastlines and offshore island geographies. Australian coastal peoples reintroduced watercraft into their maritime repertoire in the recent past. We suggest that this widely apparent hiatus was due to the many millennia of non-seafaring coastal forager groups occupying Australia's coast with limited opportunity to integrate islands into their sea country economies (McNiven et al., 2014). The influential maritime contact with Melanesians and Makassans during the last millennium, post-date island reoccupation and are not implicated the reestablishment of occupation on Australia's offshore islands.

### 5.1. Future directions

There is currently an absence of any direct evidence for Pleistocene island use (i.e. from those islands which are now under the sea) and the best evidence for late Pleistocene seafaring currently comes from the Early Holocene use of several Kimberley Islands. The Early Holocene peoples of the Kimberley and Tiwi coasts would have been well-adapted to persistent island occupation, because of their uniquely-long sequence of appropriate geography. This could plausibly have persisted since first-peopling, although it has obviously changed in character, i.e. given the lack of distinctive pelagic fishing practices, such as found in Pleistocene Indonesia (O'Connor et al., 2011). The Torres Strait and Southern Tasmania are the only other areas with continuous island geographies through the LGM, and these have mixed evidence to support persistent sea-faring through to the Holocene. The relative dearth of archaeological research focussed on Australian island seascapes means these conclusions remain to be tested (Ditchfield et al., 2022).

This work represents a first assessment of paleo-island geographies around Australia, and a novel reproducible method for quantifying the change over time of available islands for human usage. It provides a framework for more detailed reconstructions of island formation, and the associated environments and resource availabilities.

The use of modern bathymetry to estimate past-land surfaces over a broad scale is an established technique, and a necessary first step for analysis at this scale (Kealy et al., 2015; McCarthy et al., 2021). However, it will be possible to do even better – through consideration of sedimentation (or vertical reef accretion) since inundation (Hale et al., 2021) and direct geomorphological observations of submerged coastlines on a regional scale (Lebrec et al., 2021; O'Leary et al., 2020). We expect our broad analysis to be updated in the coming years, with huge increases in the availability of continental-shelf bathymetry and increasing radiocarbon dates for island archaeology. A significant output of this research is the analytical R-code, which is reusable and legible. We encourage interested researchers in this field to mobilise this in their geographical area of research focus, and re-run it with new data.

## Author contributions

**Patrick Morrison**: Conceptualization, Methodology, Software, Formal analysis, Data Curation, Writing Original Draft, Writing Review and & Editing, Visualisation **Jo McDonald**: Conceptualization, Writing Review and & Editing, Supervision, Project administration, Funding acquisition **Michael O'Leary**: Conceptualization, Writing Review and & Editing, Supervision, Project administration, Funding acquisition.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

I have shared the link to all data and code in the manuscript.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.quascirev.2023.108071.

## References

Andel, T.H. v, Heath, G.R., Moore, T.C., McGeary, D.F.R., 1967. Late Quaternary history, climate, and oceanography of the Timor sea, northwestern Australia. Am. J. Sci. 265, 737–758. https://doi.org/10.2475/ajs.265.9.737.

Attenbrow, V., 2010. The Natural History of Sydney, pp. 16–34. https://doi.org/10.7882/fs.2010.004.

Balme, J., 2013. Of boats and string: the maritime colonisation of Australia. Quat. Int. 285, 68–75. https://doi.org/10.1016/j.quaint.2011.02.029.

Balme, J., Davidson, I., McDonald, J., Stern, N., Veth, P., 2009. Symbolic behaviour and the peopling of the southern arc route to Australia. Quat. Int. 202, 59–68. https://doi.org/10.1016/j.quaint.2008.10.002.

Balme, J., O'Connor, S., Maloney, T., Vannieuwenhuyse, D., Aplin, K., Dilkes-Hall, I.E., 2019. Long-term occupation on the edge of the desert: Riwi Cave in the southern Kimberley, Western Australia. Archaeol. Ocean. 54, 35–52. https://doi.org/10.1002/arco.5166.

Barker, B., 2004. The Sea People : Late Holocene Maritime Specialisation in the Whitsunday Islands, Central Queensland. Canberra, ACT : Pandanus Books in Association with the Centre for Archaeological Research and the Dept. Of Archaeology and Natural History. The Australian National University.

Beaton, J.M., 1995. The Transition on the coastal fringe of Greater Australia. Antiquity 69, 798–806. https://doi.org/10.1017/s0003598x0008234x.

Beaton, J.M., 1985. Evidence for a coastal occupation time-lag at Princess Charlotte Bay (North Queensland) and implications for coastal colonization and population growth theories for Aboriginal Australia. Archaeol. Ocean. 20, 1–20. https://doi.org/10.1002/j.1834-4453.1985.tb00096.x.

Bird, M.I., Beaman, R.J., Condie, S.A., Cooper, A., Ulm, S., Veth, P., 2018. Palaeogeography and voyage modeling indicates early human colonization of Australia was likely from Timor-Roti. Quat. Sci. Rev. 191, 431–439. https://doi.org/10.1016/j.quascirev.2018.04.027.

Bird, M.I., Condie, S.A., O'Connor, S., O'Grady, D., Reepmeyer, C., Ulm, S., Zega, M., Saltré, F., Bradshaw, C.J.A., 2019. Early human settlement of Sahul was not an accident. Sci. Rep.-uk 9, 8220. https://doi.org/10.1038/s41598-019-42946-9.

Bowdler, S., 2015. The Bass Strait islands revisited. Quat. Int. 385, 206–218. https://doi.org/10.1016/j.quaint.2014.07.047.

Bowdler, S., 2010. The empty coast: conditions for human occupation in southeast Australia during the late Pleistocene. Terra Aust. 32, 177–185.

Bowdler, S., 1995. Offshore islands and maritime explorations in Australian prehistory. Antiquity 69, 945–958. https://doi.org/10.1017/s0003598x0008248x.

Bowdler, S., 1977. The coastal colonisation of Australia. In: Allen, J., Golson, J., Jones, R. (Eds.), Sunda and Sahul: Prehistoric Studies in Southeast Asia, Melanesia and Australia. Academic Press, London, pp. 205–246.

Bowdler, S., Ryan, L., 1987. Chapter 16 - southeast Tasmania: the Nuenonne in 1788. In: Mulvaney, D.J., White, J.P. (Eds.), Australians to 1788. Broadway, N.S.W., Australia.

Bradshaw, C.J.A., Ulm, S., Williams, A.N., Bird, M.I., Roberts, R.G., Jacobs, Z., Laviano, F., Weyrich, L.S., Friedrich, T., Norman, K., Saltré, F., 2019. Minimum founding populations for the first peopling of Sahul. Nat. Ecol. Evol. 3, 1057–1063. https://doi.org/10.1038/s41559-019-0902-6.

Broodbank, C., 2006. The origins and early development of Mediterranean maritime

activity. J. Mediterr. Archaeol. 19, 199–230. https://doi.org/10.1558/jmea.2006.v19i2.199.
Chappell, J., 1982. sea levels and sediments: some features of the context of coastal archaeological sites in the tropics. Archaeol. Ocean. 17, 69–78. https://doi.org/10.1002/j.1834-4453.1982.tb00040.x.
Clarke, A.F., 1994. Winds of Change: an Archaeology of Contact in the Groote Eylandt Archipelego, Northern Australia. Australian National University.
Clarkson, C., Jacobs, Z., Marwick, B., Fullagar, R., Wallis, L., Smith, M., Roberts, R.G., Hayes, E., Lowe, K., Carah, X., Florin, S.A., 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., Pardoe, C., 2017. Human occupation of northern Australia by 65,000 years ago. Nature 547, 306–310. https://doi.org/10.1038/nature22968.
Codilean, A.T., Munack, H., Saktura, W.M., Cohen, T.J., Jacobs, Z., Ulm, S., Hesse, P.P., Heyman, J., Peters, K.J., Williams, A.N., Saktura, R.B.K., Rui, X., Chishiro-Dennelly, K., Panta, A., 2022. OCTOPUS Database v.2. Earth Syst. Sci. Data Discuss. 2022, 1–30. https://doi.org/10.5194/essd-2022-50.
Collard, M., Vaesen, K., Cosgrove, R., Roebroeks, W., 2016. The empirical case against the 'demographic turn' in Palaeolithic archaeology. Phil. Trans. Biol. Sci. 371, 20150242. https://doi.org/10.1098/rstb.2015.0242.
David, B., McNiven, I., Mitchell, R., Orr, M., Haberle, S., Brady, L., Crouch, J., 2004. Badu 15 and the Papuan-Austronesian settlement of Torres Strait. Archaeol. Ocean. 39, 65–78. https://doi.org/10.1002/j.1834-4453.2004.tb00564.x.
Deckker, P.D., Arnold, L.J., Kaars, S., van der, Bayon, G., Stuut, J.-B.W., Perner, K., Santos, R.L. dos, Uemura, R., Demuro, M., 2019. Marine Isotope Stage 4 in Australasia: a full glacial culminating 65,000 years ago – global connections and implications for human dispersal. Quat. Sci. Rev. 204, 187–207. https://doi.org/10.1016/j.quascirev.2018.11.017.
Deckker, P.D., Moros, M., Perner, K., Blanz, T., Wacker, L., Schneider, R., Barrows, T.T., O'Loingsigh, T., Jansen, E., 2020. Climatic evolution in the Australian region over the last 94 ka - spanning human occupancy -, and unveiling the Last Glacial Maximum. Quat. Sci. Rev. 249, 106593. https://doi.org/10.1016/j.quascirev.2020.106593.
Ditchfield, K., Manne, T., Hook, F., Ward, I., Veth, P., 2018. Coastal occupation before the "big swamp": results from excavations at John Wayne country Rockshelter on Barrow island. Archaeol. Ocean. 53, 163–178. https://doi.org/10.1002/arco.5164.
Ditchfield, K., Ulm, S., Manne, T., Farr, H., O'Grady, D., Veth, P., 2022. Framing Australian Pleistocene coastal occupation and archaeology. Quat. Sci. Rev. 293, 107706. https://doi.org/10.1016/j.quascirev.2022.107706.
Dortch, C.E., 1991. Rottnest and Garden island prehistory and the archaeological potential of the adjacent continental shelf, western Australia. Aust. Archaeol. 33, 38–43. https://doi.org/10.1080/03122417.1991.11681430.
Dortch, C.E., Kendrick, G.W., Morse, K., 1984. Aboriginal mollusc exploitation in southwestern Australia. Archaeol. Ocean. 19, 81–104. https://doi.org/10.1002/j.1834-4453.1984.tb00088.x.
Dortch, C.E., Morse, K., 1984. Prehistoric stone artefacts on some offshore islands in western Australia. Aust. Archaeol. 19, 31–47.
Dortch, J., Dortch, C., 2019. Late quaternary aboriginal hunter-gatherer occupation of the greater swan region, south-western Australia. Aust. Archaeol. 85, 1–15. https://doi.org/10.1080/03122417.2019.1594556.
Draper, N., 2015. Islands of the dead? Prehistoric occupation of Kangaroo Island and other southern offshore islands and watercraft use by Aboriginal Australians. Quat. Int. 385, 229–242. https://doi.org/10.1016/j.quaint.2015.01.008.
Field, E., 2018. Unlocking the Kimberley's Past: the Applicability of Organic Spring Deposits for Reconstructing Late Quaternary Climatic and Environmental Change. The University of Queensland.
Gaffney, D., 2020. Pleistocene water crossings and adaptive flexibility within the Homo Genus. J. Archaeol. Res. https://doi.org/10.1007/s10814-020-09149-7.
Grant, K.M., Rohling, E.J., Bar-Matthews, M., Ayalon, A., Medina-Elizalde, M., Ramsey, C.B., Satow, C., Roberts, A.P., 2012. Rapid coupling between ice volume and polar temperature over the past 150,000 years. Nature 491, 744–747. https://doi.org/10.1038/nature11593.
Hale, J.C., Benjamin, J., Woo, K., Astrup, P.M., McCarthy, J., Hale, N., Stankiewicz, F., Wiseman, C., Skriver, C., Garrison, E., Ulm, S., Bailey, G., 2021. Submerged landscapes, marine transgression and underwater shell middens: comparative analysis of site formation and taphonomy in Europe and North America. Quat. Sci. Rev. 258, 106867. https://doi.org/10.1016/j.quascirev.2021.106867.
Hallam, S.J., 1987. Coastal does not equal Littoral. Aust. Archaeol. 25, 10–29. https://doi.org/10.1080/03122417.1987.12093122.
Head, J., Jones, R., Allen, J., 2020. Calculation of the 'marine Reservoir effect' from the dating of shell-charcoal paired samples from an aboriginal midden on Great Glennie island, Bass Strait. Aust. Archaeol. 17, 99–112. https://doi.org/10.1080/03122417.1983.12092914.
Hesp, P.A., Murray-Wallace, C.V., Dortch, C.E., 1999. Aboriginal occupation on Rottnest Island, Western Australia, provisionally dated by Aspartic Acid Racemisation assay of land snails to greater than 50 ka. Aust. Archaeol. 49, 7–12. https://doi.org/10.1080/03122417.1999.11681647.
Hope, J.H., Lampert, R.J., Edmondson, E., Smith, M.J., Tets, G.F. van, 1977. Late Pleistocene faunal remains from seton rock shelter, Kangaroo island, South Australia. J. Biogeogr. 4, 363. https://doi.org/10.2307/3038194.
Jones, R., Allen, J., 1979. A stratified archaeological site on Great Glennie island, Bass Strait. Aust. Archaeol. 9, 2–11. https://doi.org/10.1080/03122417.1979.12093355.
Kealy, S., Louys, J., O'Connor, S., 2018. Least-cost pathway models indicate northern human dispersal from Sunda to Sahul. J. Hum. Evol. 125, 59–70. https://doi.org/10.1016/j.jhevol.2018.10.003.
Kealy, S., Louys, J., O'Connor, S., 2017. Reconstructing palaeogeography and inter-island visibility in the Wallacean archipelago during the likely period of Sahul colonization, 65–45 000 Years ago. Archaeol. Prospect. 24, 259–272. https://doi.org/10.1002/arp.1570.
Kealy, S., Louys, J., O'Connor, S., 2015. Islands under the sea: a review of early modern human dispersal routes and migration hypotheses through Wallacea. J. I. Coast Archaeol. 11, 364–384. https://doi.org/10.1080/15564894.2015.1119218.
Lambeck, K., Rouby, H., Purcell, A., Sun, Y., Sambridge, M., 2014. Sea level and global ice volumes from the last glacial maximum to the Holocene. Proc. Natl. Acad. Sci. USA 111, 15296–15303. https://doi.org/10.1073/pnas.1411762111.
Lambrides, A.B.J., McNiven, I.J., Aird, S., Lowe, K.A., Moss, P., Rowe, C., Harris, C., Maclaurin, C., Slater, S.A., Carroll, K., Cedar, M.H., Petchey, F., Reepmeyer, C., Harris, M., Charlie, J., McGreen, E., Baru, P., Ulm, S., 2020. Changing use of Lizard Island over the past 4000 years and implications for understanding offshore island use on the Great Barrier Reef. Qld Archaeol. Res. 23, 43–109. https://doi.org/10.25120/qar.23.2020.3778.
Lampert, R.J., 1981. The Great Kartan Mystery, Terra Australis. Canberra, ACT : Dept. Of Prehistory, Research School of Pacific and Asian Studies. The Australian National University.
Lebrec, U., Paumard, V., O'Leary, M.J., Lang, S.C., 2021. Towards a regional high-resolution bathymetry of the North West Shelf of Australia based on Sentinel-2 satellite images, 3D seismic surveys, and historical datasets. Earth Syst. Sci. Data 13, 5191–5212. https://doi.org/10.5194/essd-13-5191-2021.
Lewis, S.E., Sloss, C.R., Murray-Wallace, C.V., Woodroffe, C.D., Smithers, S.G., 2013. Post-glacial sea-level changes around the Australian margin: a review. Quat. Sci. Rev. 74, 115–138. https://doi.org/10.1016/j.quascirev.2012.09.006.
Linnenlucke, L., 2022. Chronological Modelling of the Torres Strait: a Re-evaluation of Occupation Trends, and Expansion of Village and Ritual Sites. PhD thesis. James Cook University. PhD thesis, James Cook University.
Manne, T., Veth, P.M., 2015. Late Pleistocene and early Holocene exploitation of estuarine communities in northwestern Australia. Quat. Int. 385, 112–123. https://doi.org/10.1016/j.quaint.2014.12.049.
Marwick, B., 2002. Eocene fossiliferous chert artefact from Beacon Island: first evidence prehistoric occupation in the Houtman Abrolhos, Western Australia. Record West Aust. Mus. 20, 461–464.
McCarthy, J., Wiseman, C., Woo, K., Steinberg, D., O'Leary, M., Wesley, D., Brady, L.M., Ulm, S., Benjamin, J., 2021. Beneath the Top End: a regional assessment of submerged archaeological potential in the Northern Territory, Australia. Aust. Archaeol. 88, 65–83. https://doi.org/10.1080/03122417.2021.1960248.
McDonald, J., 2015. I must go down to the seas again: or, what happens when the sea comes to you? Murujuga rock art as an environmental indicator for Australia's north-west. Quat. Int. 385, 124–135. https://doi.org/10.1016/j.quaint.2014.10.056.
McDonald, J., 2008. Dreamtime Superhighway (Terra Australis 27): Sydney Basin Rock Art and Prehistoric Information Exchange, Terra Australis. ANU Press. https://doi.org/10.22459/ds.08.2008.
McDonald, J., 1992. The Great Mackerel Rockshelter excavation: women in the archaeological record? Aust. Archaeol. 35, 32–50. https://doi.org/10.1080/03122417.1992.11681467.
McDonald, J., Berry, M., 2016. Murujuga, northwestern Australia: when arid hunter-Gatherers became coastal foragers. J. I. Coast Archaeol. 12, 1–20. https://doi.org/10.1080/15564894.2015.1125971.
McDonald, J., Reynen, W., Blunt, Z., Ditchfield, K., Dortch, J., Leopold, M., Monks, C., Paterson, A., Veth, P., 2022a. Enderby island excavations. In: McDonald, J., Mulvaney, K. (Eds.), Murujuga: Dynamics of the Dreaming: CRARM Monograph No 2. UWA Publishing, Perth.
McDonald, J., Reynen, W., Blunt, Z., Ditchfield, K., Monks, C., Dortch, J., 2022b. Rosemary island excavations. In: McDonald, J., Mulvaney, K. (Eds.), Murujuga: Dynamics of the Dreaming: CRARM Monograph No 2. UWA Publishing.
McDonald, J.J., Donlon, D., Field, J.H., Fullagar, R.L.K., Coltrain, J.B., Mitchell, P., Rawson, M., 2007. The first archaeological evidence for death by spearing in Australia. Antiquity 81, 877–885. https://doi.org/10.1017/s0003598x00095971.
McNiven, I., 2004. Saltwater People: spiritscapes, maritime rituals and the archaeology of Australian indigenous seascapes. World Archaeol. 35, 329–349. https://doi.org/10.1080/0043824042000185757.
McNiven, I.J., 2022. Beyond bridge and barrier: reconceptualising Torres Strait as a co-constructed border zone in ethnographic object distributions between Queensland and New Guinea. Qld Archaeol. Res. 25, 25–46. https://doi.org/10.25120/qar.25.2022.3885.
McNiven, I.J., 2021. Coral Sea cultural interaction Sphere. In: McNiven, I.J., David, B. (Eds.), The Oxford Handbook of the Archaeology of Indigenous Australia and New Guinea. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190095611.013.28.
McNiven, I.J., Maria, N.D., Weisler, M., Lewis, T., 2014. Darumbal voyaging: intensifying use of central Queensland's Shoalwater Bay islands over the past 5000 years. Archaeol. Ocean. 49, 2–42. https://doi.org/10.1002/arco.5016.
Mitchell, S., 1996. Dugongs and dugouts, sharptacks and shellbacks: Macassan contact and aboriginal marine hunting on the Cobourg Peninsula, north western Arnhem Land. Bull. Indo. Pac. Pre. Hi. 15. https://doi.org/10.7152/bippa.v15i0.11547.
Mitchell, S.R.A., 1994. Culture Contact and Indigenous Economies on the Cobourg Peninsula, Northwestern Arnhem Land. Student Thesis: Doctor of Philosophy (PhD) - CDU.

Monks, C., 2020. The role of terrestrial, estuarine, and marine foods in dynamic Holocene environments and adaptive coastal economies in Southwestern Australia. Quat. Int. https://doi.org/10.1016/j.quaint.2020.07.020.
Mulvaney, K., 2015. Murujuga Marni : Rock Art of the Macropod Hunters and Mollusc Harvesters. UWA Publishing, Crawley, Western Australia.
Norman, K., Inglis, J., Clarkson, C., Faith, J.T., Shulmeister, J., Harris, D., 2018. An early colonisation pathway into northwest Australia 70-60,000 years ago. Quat. Sci. Rev. 180, 229–239. https://doi.org/10.1016/j.quascirev.2017.11.023.
Norman, K., Shipton, C., O'Connor, S., Malanali, W., Collins, P., Wood, R., Saktura, W.M., Roberts, R.G., Jacobs, Z., 2022. Human occupation of the Kimberley coast of northwest Australia 50,000 years ago. Quat. Sci. Rev. 288, 107577. https://doi.org/10.1016/j.quascirev.2022.107577.
O'Connor, S., 1999. 30,000 Years of Aboriginal Occupation : Kimberley, North West Australia. Dept. Of Archaeology and Natural History, the Australian National University. and Canberra, ACT. Centre for Archaeological Research, The Australian National University., Canberra, ACT.
O'Connor, S., Chappell, J., 2003. Colonisation and coastal subsistence in Australia and Papua New Guinea: different timing, different modes? In: Sand, C. (Ed.), Pacific Archaeology: Assessments and Prospects. Proceedings of the International Conference for the 50th Anniversary of the First Lapita Excavation. Le Cahiers de l'Archéologie, New, pp. 17–32.
O'Connor, S., Ono, R., Clarkson, C., 2011. Pelagic fishing at 42,000 Years before the present and the maritime skills of modern humans. Science 334, 1117–1121. https://doi.org/10.1126/science.1207703.
O'Leary, M.J., Paumard, V., Ward, I., 2020. Exploring Sea Country through high-resolution 3D seismic imaging of Australia's NW shelf: resolving early coastal landscapes and preservation of underwater cultural heritage. Quat. Sci. Rev. 239, 106353. https://doi.org/10.1016/j.quascirev.2020.106353.
Pate, F.D., 2016. Bone collagen stable nitrogen and carbon isotopes as indicators of past human diet and landscape use in southeastern South Australia. Aust. Archaeol. 46, 23–29. https://doi.org/10.1080/03122417.1998.11681603.
Paterson, A., Shellam, T., Veth, P., Mulvaney, K., Anderson, R., Dortch, J., McDonald, J., 2019. The Mermaid? Re-Envisaging the 1818 exploration of Enderby island, Murujuga, western Australia. J. I. Coast Archaeol. 15, 1–21. https://doi.org/10.1080/15564894.2019.1604007.
Peitsch, I.W.T., Rhodes, E., Miller, G., Hellstrom, J., Dortch, C., 2016. Chronostratigraphic context for artefact-bearing palaeosols in late Pleistocene Tamala Limestone, Rottnest island, western Australia. J. Roy. Soc. West Aust. 99, 17–26.
Reber, G., 1965. Aboriginal carbon dates from Tasmania. Mankind 6, 264–268. https://doi.org/10.1111/j.1835-9310.1965.tb00359.x.
Rowland, M., Shaw, B., Ulm, S., 2021. The Oxford Handbook of the Archaeology of Indigenous Australia and New Guinea. https://doi.org/10.1093/oxfordhb/9780190095611.013.29.
Rowland, M.J., 1987. The distribution of Aboriginal watercraft on the east coast of Queensland: implications for culture contact. Aust. Aborig. Stud. 38–45.
Rowland, M.J., 1984. A long way in a bark canoe: aboriginal occupation of the percy Isles. Aust. Archaeol. 18, 17–31. https://doi.org/10.1080/03122417.1984.12092928.
Rowland, M.J., Wright, S., Baker, R., 2015. The timing and use of offshore islands in the Great barrier reef marine Province, Queensland. Quat. Int. 385, 154–165. https://doi.org/10.1016/j.quaint.2015.01.025.
Sim, R., 1991a. Prehistoric Archaeological Investigations on King and Flinders Islands, Bass Strait. Unpulished Master Thesis, ANU, Tasmania. https://doi.org/10.25911/5d723f767dc6a. Canberra.
Sim, R., 1991b. Prehistoric Sites on King Island in the Bass Strait Results of an Archaeological Survey. Thesis (Masters) ANU.
Sim, R., 1990. Prehistoric sites on king island in the Bass Strait results of an archaeological survey. Aust. Archaeol. 31, 34–43. https://doi.org/10.1080/03122417.1990.11681386.
Sim, R., Wallis, L., 2016. Northern Australian offshore island use during the Holocene: the archaeology of Vanderlin island, sir Edward Pellew group, Gulf of Carpentaria. Aust. Archaeol. 67, 95–106. https://doi.org/10.1080/03122417.2008.11681882.
Sullivan, M.E., 1982. Exploitation of offshore islands along the New South Wales coastline. Aust. Archaeol. 15, 8–19. https://doi.org/10.1080/03122417.1982.12092853.
Ulm, S., 2006. Coastal Themes: an Archaeology of the Southern Curtis Coast. https://doi.org/10.22459/ta24.2006. Queensland.
Ulm, S., McNiven, I., 2021. Excavating Jiigurru: archaeological discoveries on Lizard island. In: Mitchell, B., Ridgeway, R. (Eds.), Connections across the Coral Sea: A Story of Movement. Brisbane, Queensland Museum and CABAH. Exhibition Catalogue., pp. 28–33.
Veth, P., 2017. Breaking through the radiocarbon barrier: Madjedbebe and the new chronology for Aboriginal occupation of Australia. Aust. Archaeol. 83, 1–3. https://doi.org/10.1080/03122417.2017.1408543.
Veth, P., Aplin, K., Wallis, L., Manne, T., 2007. The Archaeology of Montebello Islands, North-West Australia: Late Quaternary Foragers on an Arid Coastline. https://doi.org/10.30861/9781407301037.
Veth, P., Harper, S., Ditchfield, K., Ouzman, S., Aboriginal, B., 2021. The case for continuity of human occupation and rock art production in the Kimberley, Australia. In: McGrath, A., Russell, L. (Eds.), The Routledge Companion to Global Indigenous History. Routledge, London and New York, pp. 194–220. https://doi.org/10.4324/9781315181929-10.
Veth, P., Ward, I., Manne, T., Ulm, S., Ditchfield, K., Dortch, J., Hook, F., Petchey, F., Hogg, A., Questiaux, D., Demuro, M., Arnold, L., Spooner, N., Levchenko, V., Skippington, J., Byrne, C., Basgall, M., Zeanah, D., Belton, D., Helmholz, P., Bajkan, S., Bailey, R., Placzek, C., Kendrick, P., 2017a. Early human occupation of a maritime desert, Barrow Island, North-West Australia. Quat. Sci. Rev. 168, 19–29. https://doi.org/10.1016/j.quascirev.2017.05.002.
Veth, P., Ward, I., Manne, T., Ulm, S., Ditchfield, K., Dortch, J., Hook, F., Petchey, F., Hogg, A., Questiaux, D., Demuro, M., Arnold, L., Spooner, N., Levchenko, V., Skippington, J., Byrne, C., Basgall, M., Zeanah, D., Belton, D., Helmholz, P., Bajkan, S., Bailey, R., Placzek, C., Kendrick, P., 2017b. Early human occupation of a maritime desert, Barrow Island, North-West Australia. Quat. Sci. Rev. 168, 19–29. https://doi.org/10.1016/j.quascirev.2017.05.002.
Walters, I., 1988. Fish hooks: evidence for dual social systems in southeastern Australia? Aust. Archaeol. 27, 98–114. https://doi.org/10.1080/03122417.1988.12093166.
Williams, A., Ulm, S., Smith, M., Reid, J., 2014. AustArch: A Database of 14C and Non-14C Ages from Archaeological Sites in Australia - Composition, Compilation and Review (Data Paper). https://doi.org/10.11141/ia.36.6. Internet Archaeol.
Williams, A.N., Ulm, S., Sapienza, T., Lewis, S., Turney, C.S.M., 2018. Sea-level change and demography during the last glacial termination and early Holocene across the Australian continent. Quat. Sci. Rev. 182, 144–154. https://doi.org/10.1016/j.quascirev.2017.11.030.
Williams, A.N., Veth, P., Steffen, W., Ulm, S., Turney, C.S.M., Reeves, J.M., Phipps, S.J., Smith, M., 2015. A continental narrative: human settlement patterns and Australian climate change over the last 35,000 years. Quat. Sci. Rev. 123, 91–112. https://doi.org/10.1016/j.quascirev.2015.06.018.
Wright, M., 2018. Rocky Shores, Mud, and Mangroves: an Assessment of Economic Intensification at the Yindayin Rockshelter. University of Sydney Unpublished Honours Thesis, Stanley Island.