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Aboriginal Memories of Inundation of the Australian Coast Dating from More than 7000 Years Ago

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ABSTRACT

Stories belonging to Australian Aboriginal groups tell of a time when the former coastline of mainland Australia was inundated by rising sea level. Stories are presented from 21 locations from every part of this coastline. In most instances it is plausible to assume that these stories refer to events that occurred more than about 7000 years ago, the approximate time at which the sea level reached its present level around Australia. They therefore provide empirical corroboration of postglacial sea-level rise. For each of the 21 locations, the minimum water depth (below the present sea level) needed for the details of the particular group of local-area stories to be true is calculated. This is then compared with the sea-level envelope for Australia (Lewis et al., *Quaternary Science Reviews* 74, 2013), and maximum and minimum ages for the most recent time that these details could have been observed are calculated. This method of dating Aboriginal stories shows that they appear to have endured since 7250–13 070 cal years BP (5300–11 120 BC). The implications of this extraordinary longevity of oral traditions are discussed, including those aspects of Aboriginal culture that ensured effective transgenerational communication and the possibility that traditions of comparable antiquity may exist in similar cultures.

KEYWORDS

Australia; Aboriginal stories; sea-level rise; coastal flooding; oral traditions; cultural continuity

1. Introduction

The issue of how far back in time orally transmitted human memories can reach is a topic that has exercised many scientists (Cruikshank 2007; McNiven and Russell 2005; Shetler 2007). The consensus appears to be that memories of particular events/persons can generally survive no more than 500–800 years, largely because the original information (core) has by then become completely obscured by the layers of narrative embellishment needed to sustain transgenerational interest in a particular story (Barber and Barber 2004). While there are a few claims of considerably greater antiquity that are difficult to dismiss—the Klamath memory of the 7630-year-old eruption of Mt Mazama (Deur 2002) is one—most of these are inevitably based on sparse information from which credible arguments are difficult to construct. Most scientists hold a sceptical view of such 'deep' oral histories (Henige 2009; Owsley and Jantz 2001), a position that is prudent, although there are some who regard it as unduly cautious (Echo-Hawk 2000).

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In non-literate societies it seems that memories of events/people stand the best chance of enduring across multiple generations when:

- a particular society remains comparatively isolated, not subject to the (repeated) cultural intrusion that might lead to radical alteration or replacement of Indigenous traditions; a good example comes from isolated Niue Island in the South Pacific (Nunn 2004);
- a particular society places great importance on traditional knowledge and evolves effective culturally embedded ways of transmitting it to each new generation. This kind of situation might arise with peoples occupying environments from which it is comparatively difficult to subsist and where in consequence time-tested bodies of traditional knowledge are essential to survival; examples are Australian Aboriginal cultures and those in high-altitude India (Berndt and Berndt 1996; Lachungpa 2009);
- the attachment to place that characterises many subsistence-based societies is comparatively strong, something that might be amplified by the presence of a physical referent in the landscape. In such situations, geographical knowledge underwritten by the naming of places may be substantial and complex and require each new generation to be ritually inculcated with the corpus of traditional knowledge; examples come from Samoa (Pacific Ocean) and Malaysia (Heikkila 2014; Lefale 2010).

All these criteria are met by Australian Aboriginal (henceforth Aboriginal) societies, most of which remained isolated on the Australian continent for 50 000–60 000 years (Roberts et al. 1994). Isolation was reinforced after the most recent postglacial sea-level rise drowned the land connection between New Guinea and the Australian mainland perhaps 8000–10 000 years ago (Reeves et al. 2008). For most of Aboriginal history, groups appear to have been comparatively small and seasonally nomadic within a land-holding range, something that is commonly interpreted as a response to an environment too impoverished and too changeable to permit sedentism (Memmott and Long 2005). Survival in such environments required the evolution of a body of traditional knowledge about the requirements for successful subsistence and the geography of the land with which people and their ancestors had interacted. In Aboriginal society, great store is still placed on the learning of traditional knowledge while the geography of the land is taught systematically to new generations, locally through stories about country and totems held within patrilines, and on a larger scale through songs that describe songlines—records of ancestral beings crossing the land performing creative acts that placed totemic sites and language and people into the landscape (Rose 2011).

It is therefore unsurprising that many Aboriginal traditions appear to have endured longer than the notional limits (500–800 years) for orally transmitted knowledge. This paper focuses on knowledge about coastal inundation that appears to recall the effects of postglacial sea-level rise more than 7000 years ago. Such stories/traditions from 21 places along the Australian coast are described and analysed. This is followed by scientific assessment of the plausibility and age of the details concerning inundation.

2. Nature and sources of Australian Aboriginal stories about coastal inundation

Aboriginal memories of the 'Dreamtime' that pre-dated European settlement of Australia in 1788 portray a landscape of place and events that has widely been regarded as being

grounded in observation and experience of considerable antiquity (Berndt and Berndt 1994; David 2002; Flood 1995). The nature of remembered Aboriginal history and geography is conveyed intergenerationally through stories, songs, dances and—more broadly—the 'law' of particular Aboriginal groups with which younger members have been ritually inculcated.

With specific regard to Aboriginal oral traditions ('stories'), these were traditionally conveyed both as narratives, generally little embellished, and as myths; these two types have been characterised as 'ordinary stories' and 'sacred mythology' (Berndt and Berndt 1996). The stories about coastal inundation described below include both types and these must be analysed in different ways. The ordinary stories are generally part of a narrative body that tells of places within the environment and events that took place there. Most of these events are commonplace but some are—at least to outsiders—more remarkable; the latter include stories of the sea rising to cover land that was previously utilised by people. The sacred mythology tends to focus more on changes in the landscape and the ways in which these affected its resident peoples. The changes are often attributed to the actions of divine or ancestral beings who have been offended by breaches of the law, either by individuals or groups, that they seek to punish. As elsewhere in similar cultures, such myths may incorporate information about actual events (Barber and Barber 2004; Vitaliano 1973). The key to treating these stories as empirically informed is that, despite deriving from almost every part of the Australian coast, they say essentially the same thing, whether or not filtered through myths.

All the stories discussed below were collected from informants and written down following sustained European contact in 1788 and, while it is impossible to demonstrate a lack of recorder bias, this was a time when

> curious, observant, and relatively unprejudiced individuals in all parts of Australia wrote down descriptions of Aboriginal ceremonies, recorded versions of Aboriginal myths and tales and sometimes gave the texts and even occasionally the musical scores of songs. (Ross 1986, 233)

The *modus operandi* of at least one early recorder of such traditions gives further confidence that most were rendered authentically:

> Great care has been taken in this work not to state anything on the word of a white person; and, in obtaining information from the aborigines, suggestive or leading questions have been avoided as much as possible. The natives, in their anxiety to please, are apt to coincide with the questioner, and thus assist him in arriving at wrong conclusions; hence it is of the utmost importance to be able to converse freely with them in their own language. This inspires them with confidence, and prompts them to state facts, and to discard ideas and beliefs obtained from the white people, which in many instances have led to misrepresentations. (Dawson 1881, iii)

So although the Anglo-Australian recorders of the stories below were generally keen amateurs, without the cross-cultural sophistication that would be expected from modern ethnographers, their genuine curiosity and dedication to their task are taken as a reasonable indicator of the accuracy and authenticity of these stories—an impression shored up in many cases where several independently collected sources of the same story show high levels of consistency.

For those stories below which are known only through recounting by successive generations of Aboriginal people, we are denied what are within Western historical practices deemed to be the normal standards of proof—of being able to point to primary or secondary written records. At the same time it is recognised that this is a standard of proof that non-literate peoples cannot by definition satisfy, yet one which does not disprove accurate transmission. In these cases, the criteria for taking oral stories as empirically derived come from their consistency between tellers, and from the extraordinary uniformity of theme in stories from the entire fringe of Australia.

3. Aboriginal stories about coastal inundation: the database

The 21 locations from which stories about coastal inundation are known and described below are shown in Figure 1, which also shows the extent of the land during the Last Glacial Maximum, about 20 000 years ago, when all the places referred to in the stories as having been drowned were dry land. The geographical distribution of the places to which the stories refer is remarkably uniform. There are indications that comparable stories exist or refer to other places but these are presently inadequately known to the authors and are not therefore included here.

Each story is described below in arbitrary order (1–21 in Figure 1).

Figure 1. Map of Australia showing the 21 coastal locations from which Aboriginal stories about coastal inundation are described in this paper. Also shown is the extent of the continental shelf that was exposed during the low sea-level stage of the Last Glacial Maximum, about 20 000 years ago.

3.1. *Spencer Gulf*

About 7500 km^2 in area and triangular in shape, Spencer Gulf (Figure 2) is a fault-bounded shallow marine embayment. Between the southernmost parts of Eyre Peninsula in the west and Yorke Peninsula in the east, the lip of the embayment lies about 50 m below the present sea level, oceanwards of which the continental shelf falls sharply into

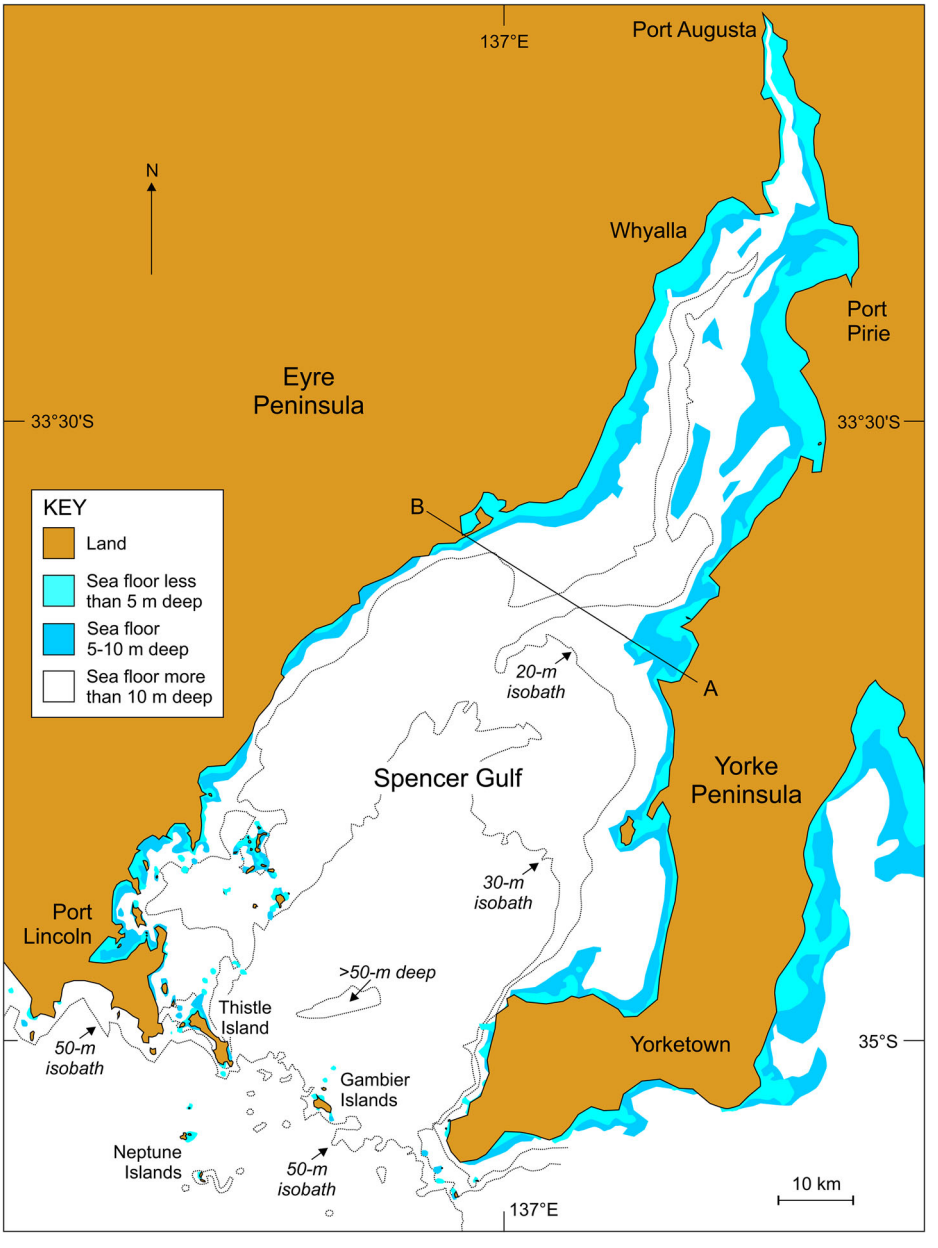

Figure 2. Map of Spencer Gulf showing the outline of its bathymetry and various places mentioned in the text. Bathymetry is from Australian Hydrographic Service chart Aus485 (March 2012).

deeper water. The distribution of sea-floor sediments in the southern Spencer Gulf is consistent with comparatively rapid inundation (Fuller et al. 1994), while a similar conclusion was obtained for the northern part of the Gulf between Whyalla and Port Pirie where water is known to have deepened rapidly 8482–6402 cal years BP (Puttonen and Cann 2006).

The Narrangga tribe living on Yorke Peninsula 'had a story that has been handed down through the ages' which recalled a time when Spencer Gulf was dry land, 'marshy country reaching into the interior of Australia' (Smith 1930, 168–169). In another account, probably from a different source, this country is described as 'a valley filled with a line of fresh-water lagoons', each associated with particular types of water bird; the 'open country between the lagoons' was occupied by 'emus, curlews and mallee fowls' while elsewhere there were other creatures (Roberts and Mountford 1989, 18). Both versions of the story describe the initial flooding of the Gulf as having been catastrophic rather than gradual, the result of a mythical/giant kangaroo using a magic bone to cut a trench; 'the sea broke through, and came tumbling and rolling along in the track … it flowed into the lagoons and marshes which completely disappeared' (Smith 1930, 172).

If this flooding occurred along the lip of Spencer Gulf, where it would have been more noticeable than at any point further north, then the sea level at the time may have been as much as 50 m lower than today. Yet if the stories refer to a different part of Spencer Gulf, perhaps that along Line AB in Figure 2 where the palaeo-valley narrows markedly, then the sea level would have been a minimum of 22 m below present. These figures are themselves likely to be depth minima because of the unknown thickness of sediment accumulated on the floor of Spencer Gulf since it was inundated.

3.2. *Kangaroo Island*

Kangaroo Island or Karta (4405 km^2) lies at the mouth of Gulf St Vincent, its closest points to the Australian mainland being to the south coast of Yorke Peninsula (40 km) and across Backstairs Passage to the southwest end of the Fleurieu Peninsula (13.5 km) (Figure 3). The earliest and most detailed versions of the story about the drowning of Backstairs Passage were collected from the Raminyerar and Jaralde peoples of the mainland (Berndt 1940; Meyer 1846; Taplin 1873). All involve an ancestral figure named Ngurunduri whose two wives ran away from him. He pursued them relentlessly along the south coast of the Fleurieu Peninsula, finally catching sight of them as they were crossing what was then a strip of land connecting it to Kangaroo Island across Backstairs Passage. Infuriated, he caused the sea to rise and drown them; the women and their belongings became the islands known as The Pages (Meralang) and the sea never again receded from the passage.

Some of the stories are specific about the nature of the land connection that formerly existed across Backstairs Passage. While some mention 'a strip of land', most talk of a 'line of boulders' between which people could 'walk or wade', while a few refer to the need to 'swim' in places in order to complete the crossing. The location of the former land bridge is informed by the fact that several versions of the story report that Ngurunduri's wives were swept south into the 'open ocean' by the flood, to a location where The Pages now lie (see Figure 3).

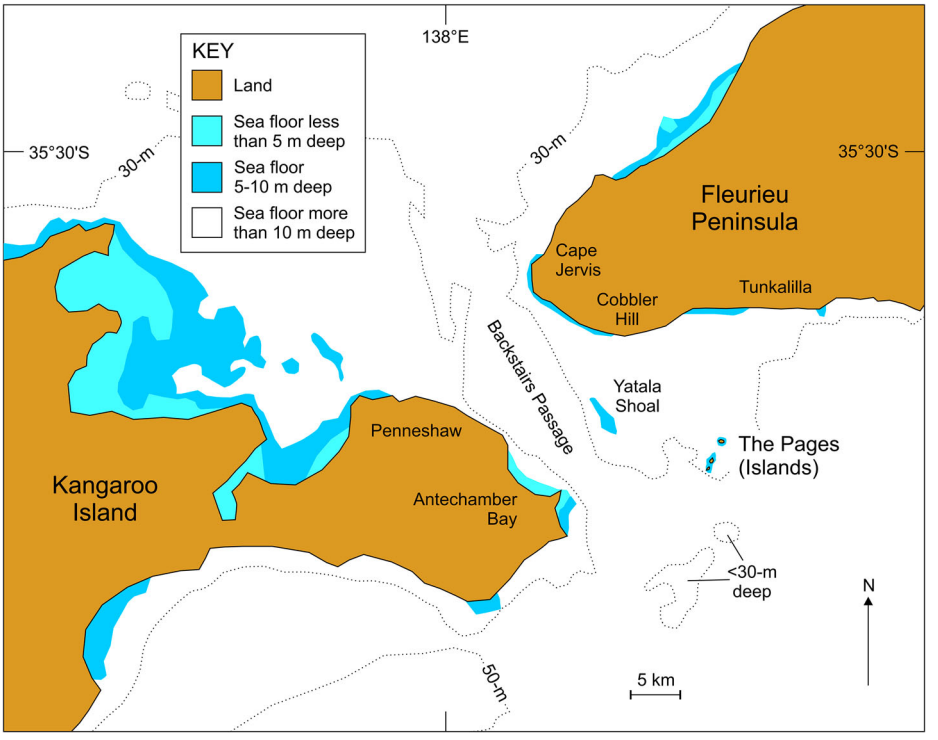

Figure 3. Map of Kangaroo Island, Backstairs Passage and part of the Fleurieu Peninsula showing bathymetry and places mentioned in the text. Bathymetry is from Australian Hydrographic Service charts Aus126 (June 2010) and Aus485 (March 2012).

There is also detail given in many of the stories about the nature of the flood/wave that drowned Ngurunduri's wives and led to the subsequent inundation of Backstairs Passage. One of the older versions states that Ngurunduri commanded the waters to 'arise' and drown his wives, which produced a 'terrible flood' (Taplin 1873) while in another the sea came in with a 'terrific rush' (Parker 1959). In the most detailed extant account, 'the waters began to come in from the west, wave upon wave, driving the two women from their course' (Berndt 1940, 181). After his wives were drowned, Ngurunduri, desirous of reaching Kangaroo Island, is said to have dived into the ocean and swum there, underlying the likelihood that this event was the one that submerged the dry-land connection.

The deepest part of Backstairs Passage today is more than 30 m below sea level but it is likely that the land connection would have been passable for people without watercraft when the sea level was 32–33 m lower; a land bridge may have been fully emergent when it was 35 m lower.

3.3. *MacDonnell Bay*

MacDonnell Bay is a 70 km long low sedimentary embayment between two rocky headlands, typical of many along the south coast of Australia (Harvey 2006). At its northwest end lies Port MacDonnell from which once 'the land extended southward as the eye could

carry' (Smith 1880). The sole extant version of the story goes on to tell how the now-submerged land was forested and bountiful but owned by a man who would not tolerate thieves. One day he found a woman stealing wattle gum and, enraged, determined to drown her:

> … he seated himself on the grass, extended his right leg towards Cape Northumberland (Kinneang) and his left towards Green Point, raised his arms above his head, and in a giant voice called upon the sea to come and drown the woman. The sea advanced, covered his beautiful land, and destroyed the offending woman. It returned no more to its former bed, and thus formed the present coast of MacDonnell Bay. (Smith 1880, 22–23)

As with some of the other stories from open coasts, it is difficult to determine where the shoreline might have lain at the time of the beginning of this story; a sea level 15 m lower would have located the shoreline 50–70 m further offshore while a sea level 50 m lower would have seen the shoreline several hundred metres further out, perhaps 'as far as the eye could carry'.

3.4. *Port Phillip Bay (Melbourne)*

Port Phillip Bay is a 1930 km^2 narrow-mouthed embayment, the entrance of which is now regularly dredged to allow shipping access to Melbourne at its northern extremity (Figure 4). Port Phillip Bay is shallow (<25 m) and believed to have dried out 2800–1000 years ago after its entrance was blocked by sediment (Holdgate, Wagstaff, and Gallagher 2011). There are Aboriginal stories that tell of just such a time and it is possible that in the case of Port Phillip Bay, most refer to this period of time.

Compared with most others in the database, the comparative lack of embellishment of Aboriginal stories about the time when Port Phillip Bay was dry and subsequently flooded is unusual, suggesting that most of the stories may recall this comparatively recent period of inundation. The earliest known story comes from William Hull (in evidence to the Victoria Legislative Council[1]) who stated that the Yarra and Coast tribes 'say that their progenitors recollected when Hobson's (Port Phillip) Bay was a "kangaroo ground"—they say "Plenty catch kangaroo and plenty catch opossum there"; and that "the river (Yarra) once went out at the Heads, but that the sea broke in, and that Hobson's Bay, which was once a hunting ground, became what it is"' (Hull 1859, 12). Another story comes from one of the Woiworrung tribes:

> The following is an account … of the formation of Port Phillip Bay: 'Plenty long ago … men could cross, dry-foot, from our side of the bay [in the east] to Geelong [in the west].' They described a hurricane—trees bending to and fro—then the earth sank, and the sea rushed in through the Heads, till the void places became broad and deep, as they are today. (McCrae 1934, 176)

Then there is the tradition that Aborigines at Dromana had hunted across the Portsea and Queenscliff terrain (see Figure 4) and in crossing had to 'walk a little, swim a little' (Rogers 1957, 49).

Yet given the greater antiquity implicit in other stories related in this paper it is possible that those for Port Phillip Bay either echo or refer to an earlier and more enduring inundation event. A sea level 9–12 m lower than present would cause the coastline to lie just

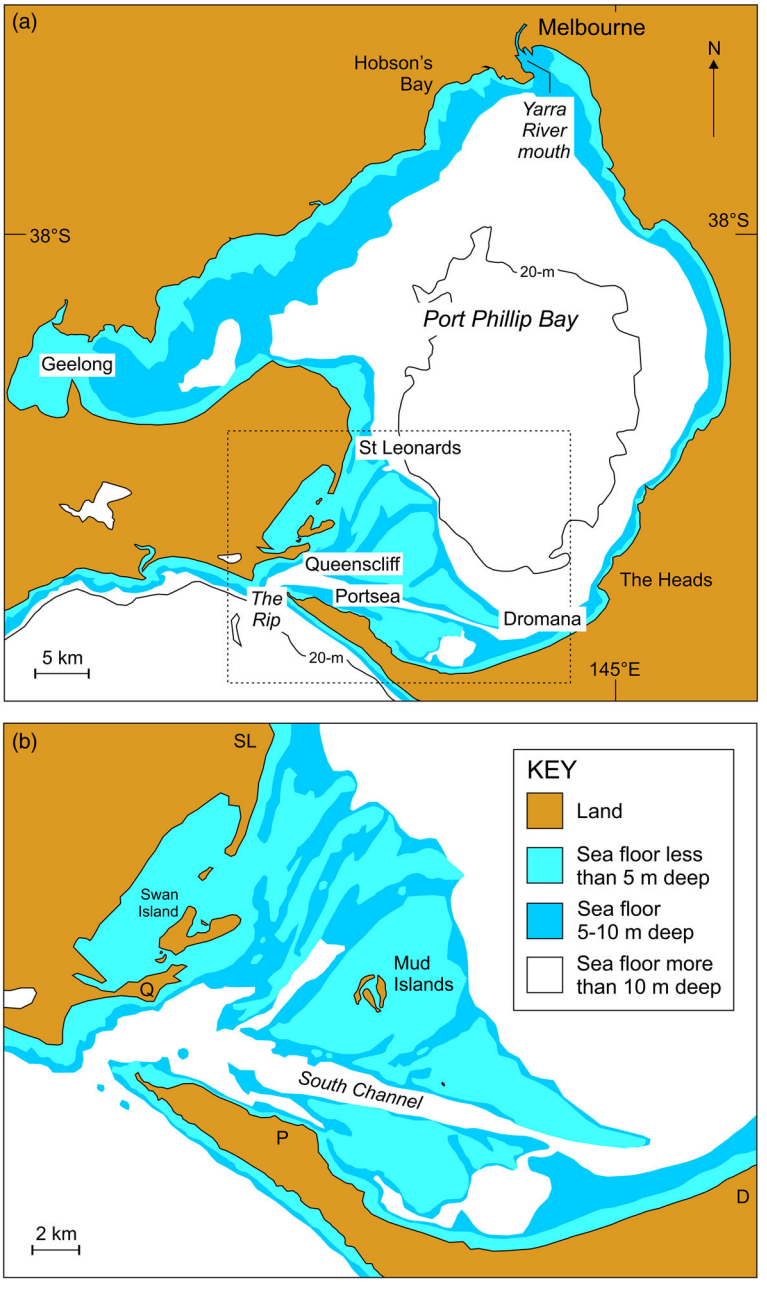

Figure 4. Maps of Port Phillip Bay showing its present form and bathymetry (A) and details of its modern entrance (B) shown by the rectangle in A. Bathymetry is from Australian Hydrographic Service chart Aus143 (May 1973).

below the outer lip of the Bay at the western end of South Channel, something broadly confirmed by studies of marine and freshwater sediments either side of the entrance (estimated from data in Holdgate et al. 2001).

3.5. *Gippsland*

To the east of Port Phillip Bay lies the southeast-facing Gippsland coast for which a sole Aboriginal tradition of inundation is known. It comes from the Kurnai people and states that

> long ago there was land to the south of Gippsland where there is now sea, and that at that time some children of the Kurnai, who inhabited the land, in playing about found a *turndun*,[2] which they took home to the camp and showed to the women. 'Immediately', it is said, 'the earth crumbled away, and it was all water, and the Kurnai were drowned.' (Fison and Howitt 1880, 269)

The Gippsland coast represents the modern northern limit of the Bass Strait which was dry land during the Last Glacial Maximum and may have remained traversable by people until about 11 000 years ago (Porch and Allen 1995). There is archaeological evidence from both the islands of Bass Strait and its mainland fringes (in South Australia and Tasmania) that people were adapting around this time to the effects of sea-level rise by moving with the changing coastline (Bowdler 2014; Jones 1977).

The sea floor off the Gippsland coast is generally steeper than in MacDonnell Bay (see above); if the sea level was 20 m lower, the shoreline would have been some 50 m further out to sea, while when the sea level was 50 m lower, the shoreline would have been about 100 m further seaward.

3.6. *Botany Bay and Georges River*

Botany Bay, south of Sydney Harbour, marks the place where the Georges River (south) and Cooks River (north) enter the sea and is the place where Captain James Cook first landed in Australia in 1770. To the chagrin of later visitors, Cook described the fringes of Botany Bay as 'some of the finest meadows in the world' whereas they, 'instead of grass, are covered with high coarse rushes, growing in a rotten spongy bog' (Tench 1996, 176).

Aboriginal (Dharawal) stories suggest that landscape changes had occurred in Botany Bay at earlier times. One tells of the time when

> the river now known as the Georges River, but then known as Kai'eemah, joined with the Goolay'yari, or Cooks River and flowed through one of the swamps that once were Botany Bay. Together they then flowed out through the place called Kurunulla, or Cronulla. (Bodkin and Andrews 2012, 10)[3]

Then, one day, 'a great storm came up, and huge waves washed into the Kai'eemah destroying much of the swampland used for food gathering. The waves crashed into the shore so fiercely that they washed over the land' (12). The coastal people fled inland to escape the flooding; some time later, returning to the coast at the mouth of Georges River, they found

> that what they had once known was no longer. Instead of the swamps, there was a great bay, and where the Kai'eemah had met the sea there was high mountains of sand. The two rivers now no longer joined together, but ran into the sea separately. (14)

It is likely that the flooding of Botany Bay recalled in this Dharawal story pre-dates Cook's visit, not least because he sailed into the Bay and anchored on its shore. Botany

Bay would have been drier, unnavigable, and largely 'swampland' before the sea level reached the lip of the narrow entrance to the Bay: a time when the two rivers referred to in the story would likely have come together before reaching the coast. Given the changes that have taken place in Botany Bay in the last century and more since the expansion of the Sydney conurbation along its shores, Cook's original (1770) chart is considered the most reliable guide to the original bathymetry. If the sea level was 9–16 m lower than today, the Bay would be dry, the most recent time at which the configuration of the landscape was like that referred to in the Aboriginal story.

3.7. *Moreton and North Stradbroke Islands*

Off the mouth of the Brisbane River lie two large sand islands (Figure 5)—Moreton (or Moorgumpin) and North Stradbroke (or Minjerribah)—that grew during the late Quaternary around small bedrock cores from both fluvial sediments from Brisbane's hinterland as well as aeolian sands that accumulated during periods of low sea level when much of the surrounding sea floor was dry (Brooke et al. 2008; Ward 2006). Sand islands of this kind are intrinsically changeable in form so it is no great surprise that there should be Aboriginal stories recalling a time when these two islands were connected. In fact, when Captain James Cook saw North Stradbroke Island on 17 May 1770, he may have thought it contiguous with Moreton Island, as perhaps it was at the time (O'Keeffe 1975).

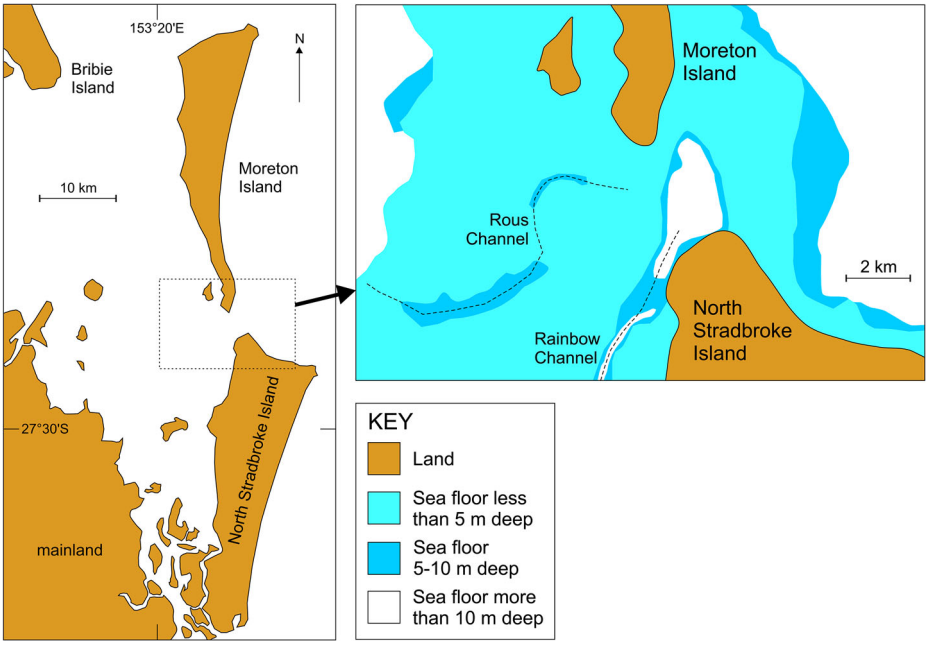

Figure 5. Map of the area around Moreton and Stradbroke Islands showing bathymetric detail (right) of the modern area of sea floor between the two. Bathymetry is from Australian Hydrographic Service chart Aus814 (April 2011).

The principal story concerns two Aboriginal tribes, the Noonuccal of North Stradbroke and the Nughies of Moreton. One version states that a bailer shell kept by the Noonuccal contained power over the winds and was coveted by the Nughies. When the keeper of the bailer discovered this, he summoned the winds and commanded them to blow so hard that the connection between the islands would be severed, something that caused the Nughies to become stranded thereafter on Moreton Island (Noonuccal 1990).

In the early twentieth century, a story was

> learnt from the lips of Mary Ann, the oldest native woman of Moreton Bay, that she had been told by her parents that the passage between the two islands was in their day but narrow, and that the Nooghies (of Moreton) could easily converse [across the gap] with the Noonuckles (of Stradbroke). (Welsby 1967, vol. 2, 34)

The same informant recalls when an island once existed between Moreton and North Stradbroke; she remembers that 'bopple bopple trees'[4] grew there and that the nearby Pelican Banks were covered with prickly weed and were presumably emergent (Welsby 1967, vol. 1, 274).

A land connection between Moreton and North Stradbroke Islands may have existed when the distribution of sediments in the area was different from today. Sea level would not need to have been lower although a land connection would have been larger and easier to maintain had it been so, even by 2 m, certainly by 8 m.

3.8. *Hinchinbrook and Palm Islands*

Aboriginal stories exist about how it was once possible to walk across to (now) offshore Hinchinbrook and Palm Islands (Figure 6). The two islands are quite different. Hinchinbrook is larger (393 km^2) and is separated from the mainland by the 50 km long Hinchinbrook Channel that is less than 1 km wide in places. Palm Island (or Bwgcolman) is smaller (55 km^2) and lies about 25 km off the mainland today.

While many Aboriginal tribes in this area 'have stories recounting how the shore-line was once some miles further out' (Dixon 1980, 46), the only one recorded that is specific to Hinchinbrook and Palm Islands concerns a 'legendary man' named Giɽugar who travelled across the land naming various places at a time when it was possible to walk to these islands from the (present) mainland (Dixon 1972).

It would have been possible to walk to Hinchinbrook when the sea level was 5 m lower than today, and to Palm Island when the sea level was 22 m lower.

3.9. *Cairns—Great Barrier Reef*

Between Cairns and the fringe of the Great Barrier Reef (Figure 7) lie a number of sizeable reefs (Green, Thetford, Moore, Elford, Sudbury) that are likely to be founded on erosional remnants of the coastal plain exposed during the Last Glacial Maximum. At this time, about 20 000 years ago, the land's edge in most places would have been marked by a steep cliff where today the reef edge plunges down to the continental shelf. Flora Pass is likely to have been the site of a lowland river valley that cut through a wide gorge before reaching the sea.

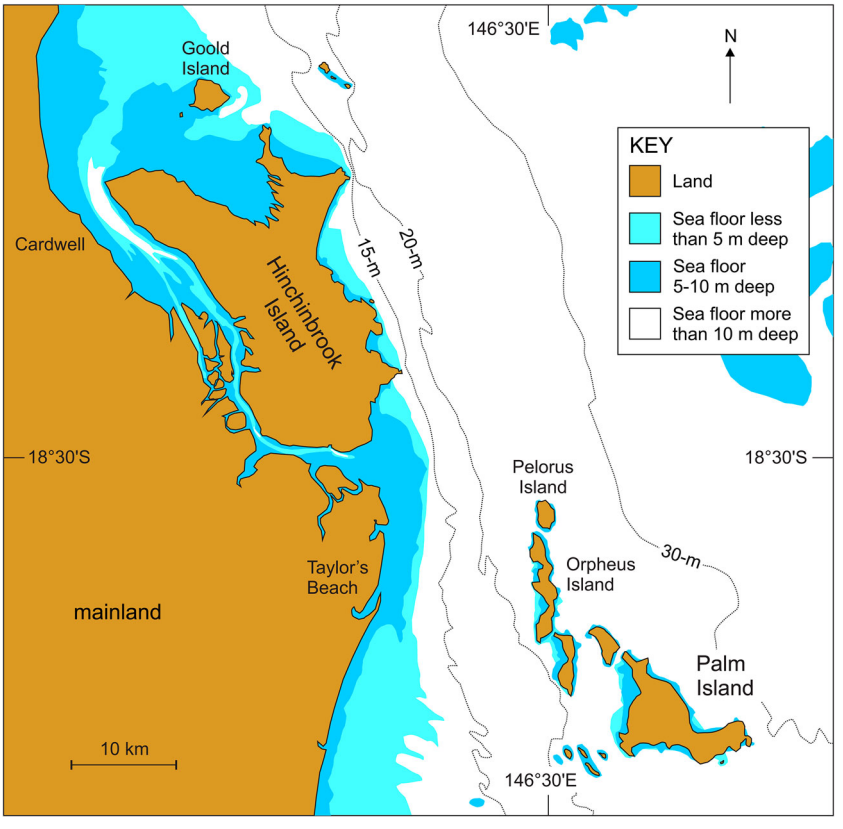

Figure 6. Map of the area around Hinchinbrook and Palm Islands showing an outline of the bathymetry from Australian Hydrographic Service chart Aus828 (September 2012).

As noted above, there are numerous Aboriginal stories from this area about a time when the shoreline was further out 'where the barrier reef now stands' (Dixon 1980, 46). According to Gungganyji informants from Cape Grafton (see Figure 7), the barrier reef was the original coast here at a time when a man called Gunya (Goonyah) was living here. Having consumed a customarily forbidden fish, the gods caused the sea to rise in order to drown him and his family. He evaded this fate by fleeing to the hills but 'the sea … never returned to its original limits' (Gribble 1932, 56–57).

Another more detailed version of this story was told by Dick Moses of the Gungganyji in 1973 that describes the effects of the rising sea level on a number of places and groups of people in this area. Gunya, the principal character, came across a number of places where people from different tribes had congregated, 'driven from their previous homes by the flood', who then 'dispersed and went to their present-day territories' (Dixon 1991, 94).

A theme running through stories from the coastal Indindji (Yidiɲḍi) people of this area 'is that the coastline was once where the barrier reef now stands … but the sea then rose and the shore retreated to its present position' (Dixon 1977, 14). Some of these stories recall that the Aboriginal name of Fitzroy Island is *gabaɽ* or 'lower arm' of a former mainland promontory that became partly submerged. Another recalls the name of a place

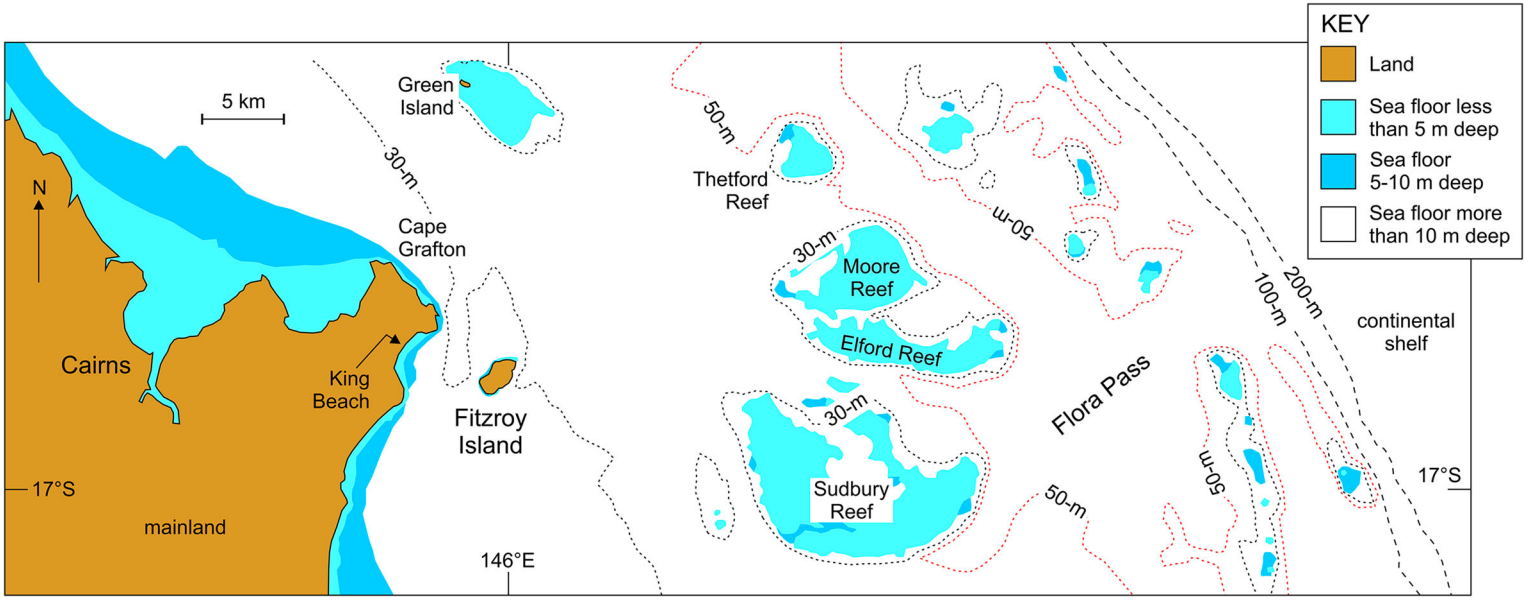

Figure 7. Map of the area between Cairns and the edge of the Great Barrier Reef showing an outline of the bathymetry from Australian Hydrographic Service chart Aus830 (November 2002).

halfway between Fitzroy Island and King Beach that is now submerged; its name was *Mudaga* (the Indindji word for the pencil pine, *Athrotaxis cupressoides*) after the trees growing there. Another recalls a time when Green Island was four times larger than it is today, all but its northwest part having since been submerged (Dixon 1977).

While Green Island might have been significantly larger when the sea level was 5–10 m lower, Fitzroy Island could not have been connected to the mainland unless the sea level was 30 m lower. The sizeable discrete reefs between the modern coast and the edge of the barrier reef could have been dry and contiguous when the sea level was 40–50 m lower but, if the stories truly recall a time when the shoreline was 'where the barrier reef [edge] now stands', then the sea level would have to have been 65 m lower.

3.10. *Gulf of Carpentaria and the Wellesley Islands*

The widest continental shelf around Australia that was exposed during the Last Glacial Maximum (see Figure 1) lies off the north coast of Australia, particularly off Arnhem Land and within the Gulf of Carpentaria, which was a lake within the land bridge connecting Australia and New Guinea at this time (Chivas et al. 2001; Yokoyama et al. 2001). Owing to the width of this continental shelf, postglacial sea-level rise would have caused more rapid shoreline retreat here than in any other part of the Australian coastline, making the phenomenon more noticeable to its inhabitants than perhaps those elsewhere.

There are Aboriginal stories about the formation of the Gulf of Carpentaria, but since these are generalised rather than specific they are mentioned here only in passing. The common story, similar to one explaining the origin of Spencer Gulf (see above), talks of a giant kangaroo who thrust a magic digging-bone into the ground where it excavated a trench. 'White-capped waves and a torrent of water' rushed along the channel the bone had made, 'spilling into the marsh lands, flooding the lagoons until they overflowed … that is how the great gulf was formed' (Reed 1965, 192).

The Aboriginal inhabitants of the Wellesley Islands (Figure 8) in the southern part of the Gulf of Carpentaria have a rich extant body of oral tradition that includes 'oral accounts of channels being cut between islands elaborated into sacred histories of ancestral beings' (Memmott et al. 2006, 42). Several accounts recall a time when the Wellesley Islands were part of a mainland peninsula but then the 'seagull woman' named Garnguur dragged her raft back and forth across its neck causing it to be submerged and the islands to form (Isaacs 1980; Roughsey 1971). Stories with this theme are told to explain the creation of at least five islands in the Wellesley group (Memmott and Trigger 1998).

For the Wellesley Islands to be joined to the mainland, the sea level would have to have been perhaps just 5 m lower, although substantial connections would have existed when the sea level was 10 m lower.

3.11. *Elcho Island*

Like several coastal Aboriginal groups, the Yolŋu people of northeast Arnhem Land have a knowledge of the area's geography that includes places claimed to have been submerged for as much as 10 000 years (Corn 2005).

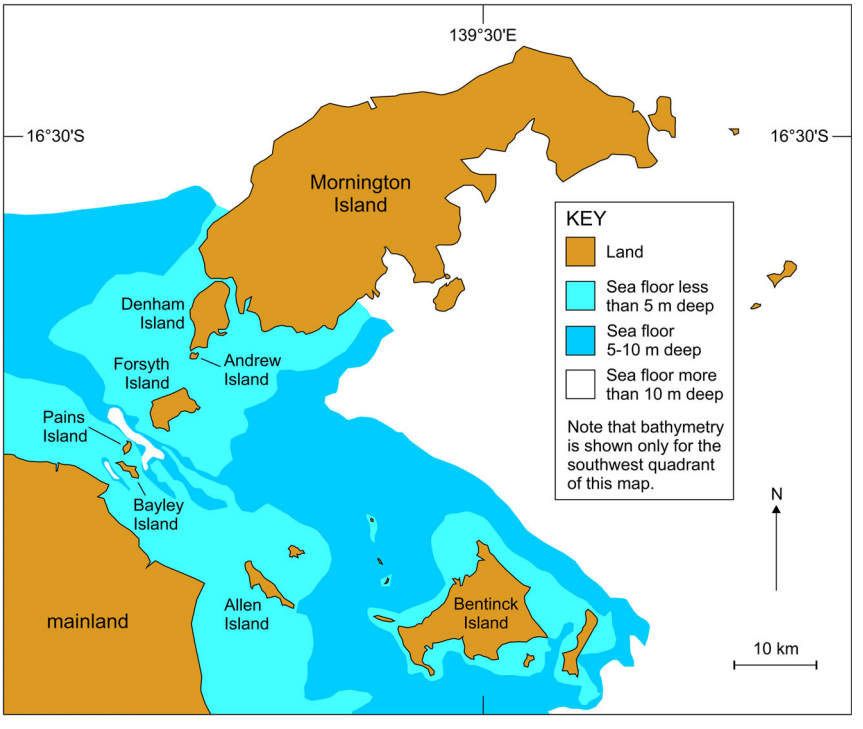

Figure 8. Map of the Wellesley Islands and adjacent mainland, southern Gulf of Carpentaria. Bathymetry is from Australian Hydrographic Service chart Aus303 (June 1996).

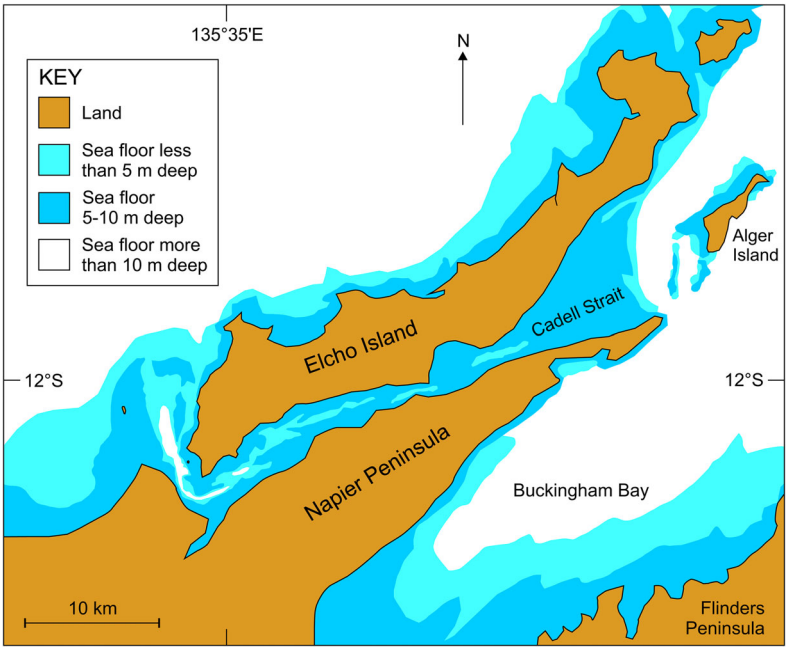

Figure 9. Map of Elcho Island and the adjoining mainland showing an outline of the bathymetry from Australian Hydrographic Service chart Aus716 (September 1995).

Elcho Island is close to the mainland (Figure 9) yet is sufficiently inaccessible to be the subject of several extant traditions about how it became an island. One refers to a man named Djankawu residing on Elcho Island who tripped and accidentally thrust his walking stick into the sand 'causing the sea to rush in' (Isaacs 1980, 108). Another tells of the Ancestresses who, when they needed to cross to Elcho, 'made a long sand-bar' that survived only until their crossing was completed (Chaseling 1957, 134).

A sea level 5 m lower than present would have allowed people to cross between Elcho and the mainland but a sea level 10 m lower than today would have seen a complete land connection.

3.12. *Goulburn Islands*

The Goulburn Islands lie within a few kilometres of the coast of northern Arnhem Land. Like the Yolŋu (see above), their Aboriginal inhabitants have a knowledge of places that must have been submerged several millennia ago, including the islands of Wulurunbu and Lingardji that have been identified as a shoal about 20 km east of North Goulburn Island in waters now 9–11 m deep (Cooke and Armstrong 1998).

One story explains the drowning of a former land connection between South Goulburn Island (Warruwi) and North Goulburn Island (Weyra) as the result of an ungifted fisherman cutting down a big paperbark tree that fell into the water with a big splash and flooded the narrow strip of land connecting the two islands[5] (Berndt and Berndt 1994); a similar story was collected more recently (Veland et al. 2013). Other stories attribute the separation of the islands to the activities of supernatural beings (Cooke and Armstrong 1998).

The stories refer to a former land connection between North and South Goulburn Islands (not between the latter and the mainland), between which a wide, deep channel exists today. It is unlikely that people could have crossed on foot between the islands unless the sea level was 17–20 m lower.

3.13. *Cape Don (Cobourg Peninsula)*

Cape Don lies at the westernmost extremity of the Cobourg Peninsula (see Figure 10A) and its Aboriginal inhabitants have traditions of a submerged island (as for the Goulburn Islands—see above) from which their ancestors came. The story[6] refers to the island of Aragaládi where one day someone mistakenly knocked a sacred rock whereupon 'rain fell for a long time there in the middle of the sea … then that place went underwater' (Berndt and Berndt 1994, 88). The story describes the nature of the place and its occupants who were drowned, only those who had canoes being able to reach the mainland at Cape Don. Superficially this sounds like a sudden event, perhaps a tsunami, but the details also align with scenarios suggested for the inhabitants of islands off the Australian mainland increasingly stressed by sea-level rise and isolation (Bowdler 2014; Sim and West 1998).

When the sea level was lower along this part of the Australian coast, not only would the exposed continental shelf have been wider but beyond the coast islands would have existed, some of which may have been completely submerged as the sea level rose. Aragaládi may have been such an island although its precise location is unknown. Other stories from Arnhem Land people trace their origins to an island in the northeast named Baralku that may be (a memory of) an ancient drowned homeland, perhaps part of submerged Sundaland (Oppenheimer 1998).

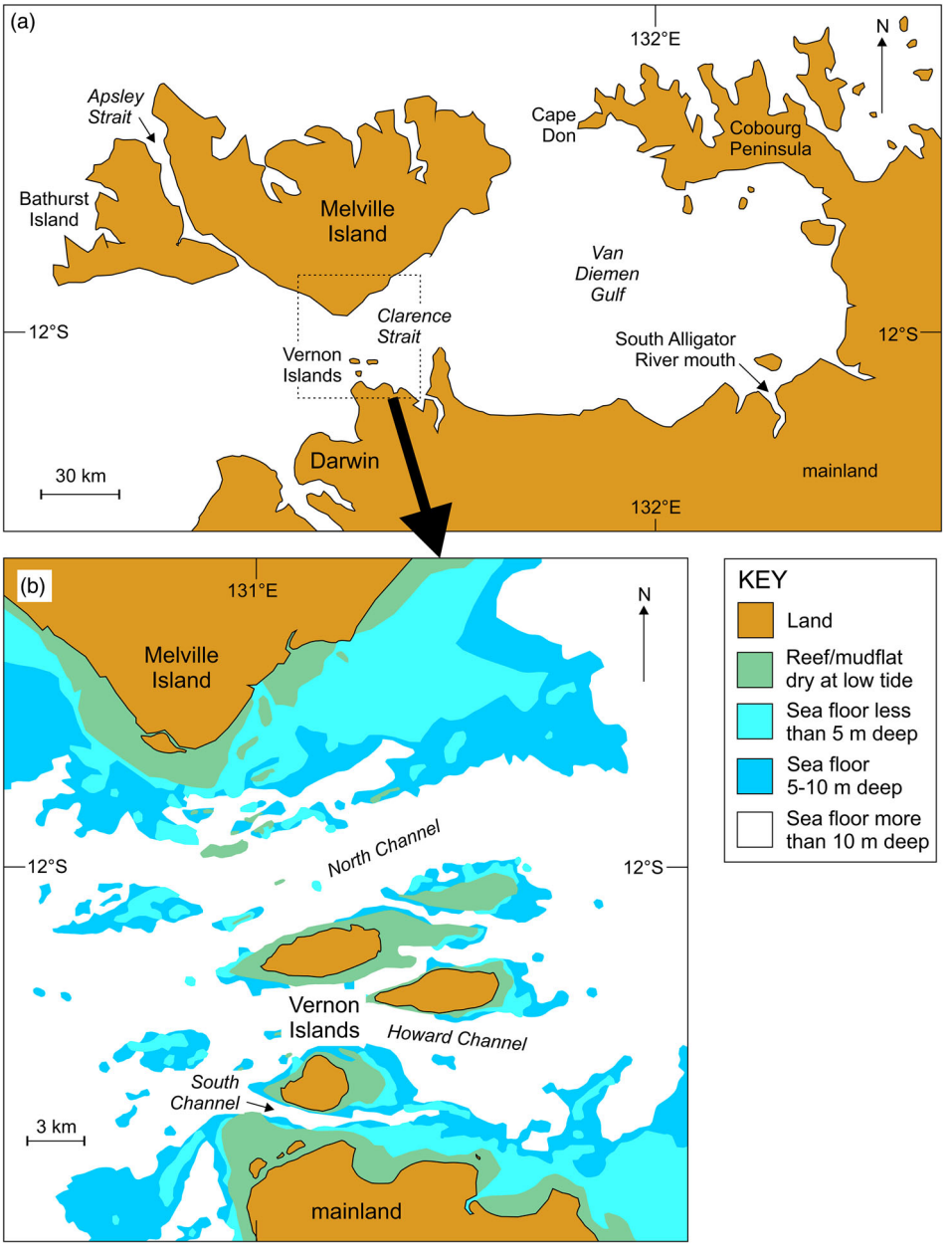

Figure 10. Maps of Bathurst and Melville Islands and adjoining parts of the mainland including Cape Don. Detailed bathymetry of the most likely crossing (B) is from Australian Hydrographic Service chart Aus722 (June 1997).

3.14. *Bathurst and Melville Islands*

The large islands of Bathurst and Melville (Figure 10A), themselves separated only by the narrow Apsley Strait, are separated from the Australian mainland by a 30 km deepwater channel in the east (Melville to Cape Don) and a shallower, island-dotted 25 km wide

channel in the south (Melville to mainland via the Vernon Islands). There are no known Aboriginal (Tiwi) stories about a crossing of the former channel but several that talk of people crossing the latter:

> In the beginning of the Tiwi world there was complete darkness … then one day an old blind woman, named Mudangkala, appeared miraculously … As Mudangkala crawled along, the freshwater followed her … The flow of water continued to increase and is today known as Clarence Strait. She continued to move over the land known as Bathurst Island till finally water flowed on to form what is now known as Apsley Strait. (Sims 1978, 165)

This is most plausibly interpreted as the memory of a person crossing from the southern mainland via the Vernons to Melville, perhaps through a combination of walking, wading and swimming.

Another version of the story implies that it recalls the first settlement of these islands:

> The Tiwi hold that their islands were created by a woman, in this case an old blind lady named Murtankala [Mudangkala] … in the distant past the land was covered in darkness and contained no geographical features, animals or humans. Below the earth lived some spirit people, including Murtankala and her three children. One day she dug her way up to the land's surface. As she crawled about searching for food for herself and her infant children she gradually carved out the outlines of the Tiwi Islands … Water flowed in behind Murtankala to surround the islands. (Morris 2001, 14)

Key to both accounts is that water 'followed' the old woman, a detail that could be interpreted as meaning that after people reached these islands from the mainland, the sea level rose thereby making it impossible for them to cross subsequently without using a boat or raft.

The easiest crossing from the mainland to the Tiwi Islands is via the Vernon Islands (Figure 10B) and, if this was the route taken by Mudangkala (perhaps an early Tiwi settler group), then it is likely to have been possible without watercraft only when the sea level was about 12 m lower, but even then it may have been necessary to swim or wade, which may explain the 'crawling' allusion. Had the sea level been 20 m lower, it is likely that the crossing would have been circuitous yet significantly easier.

3.15. *Brue Reef*

There are several stories known among the Bardi and Jawi people that recall a time when Brue Reef (Juljinabur), which is today awash at high tide, was an inhabited island.[7] One set of stories originates with a group of men whose boat drifted from Tallon Island (close to the mainland) to Juljinabur where they encountered cannibals from whom they eventually escaped. Subsequent infighting among the cannibals of Juljinabur is said in some stories to explain why the island later sank and became a reef. An explanation in another story speaks more generally about one of the ancestral beings causing the island to be inundated by seawater to punish its anthropophagous inhabitants.

A plausible interpretation is that these stories date from a time when Brue Reef, unlike today, was habitable and supported a population likely to have numbered 10–100 individuals, judging from the size of the land area and the detail in the stories. This may have been possible if the sea level was 4 m lower than today but more convincing were the sea level

10 m lower, a situation that would also have rendered this remote reef/island closer to people from nearby lands.

3.16. *Rottnest, Carnac and Garden Islands*

The islands of Rottnest (19 km^2), Carnac (0.19 km^2) and Garden (12 km^2) lie off the mouth of the Swan River (Figure 11) and were part of the mainland during the Last Glacial period and much of the postglacial, which is held to account for the archaeological evidence of their prehistoric settlement (Collard 2010). There is a sole extant Aboriginal tradition specifically recalling this time which explains

> that Rottnest, Carnac and Garden Island, once formed part of the mainland, and that the intervening ground was thickly covered with trees; which took fire in some unaccountable way, and burned with such intensity that the ground split asunder with a great noise, and the sea rushed in between, cutting off these islands from the mainland. (Moore 1884; Dictionary, 8)

Given the ubiquity of this tradition in popular histories of this part of Western Australia, it is possible that similar stories existed until quite recently among local Aboriginal groups.

It would be possible to cross, perhaps wading in some places, from the mainland to all three islands if the sea level were 5 m lower than today. A sea level that was 10 m lower would have seen a considerable area of land emerge, certainly enough to create a landscape similar to that described in the story.

3.17. *Cape Chatham*

Cape Chatham is a rocky headland just west of Mandalay Beach. There is an Aboriginal legend about the area that states that

> in those olden days there was a large plain extending from the main land out to the White-topped Rocks, about nine miles out [14.5 km west] from Cape Chatham. On one occasion two women went far out on the plain, digging roots … After a while they looked up, and saw the sea rushing towards them over the great plain. (Mathews 1909, 341)

They were drowned and transformed into the White-topped Rocks (Calf and Cow Rocks) that lie off the coast of southwest Australia at Broke Inlet.

The position of the Rocks and knowledge of the intervening sea floor suggest that this story describes a situation when the sea level was 55–60 m lower than today.

3.18. *Oyster Harbour*

The mouth of the Kalgan River opens up into Oyster Harbour, an elliptical-shaped inlet with a narrow deepwater entrance, just northeast of Albany (Figure 12). The only story known about the sea flooding that created Oyster Harbour was reported by Captain Collet Barker in the 1830s who was told by local Aboriginal people that a woman with a broken leg once dragged herself along the valley of the King River to the place where Green Island now lies, where she died. A dog smelt her putrefying body from afar and

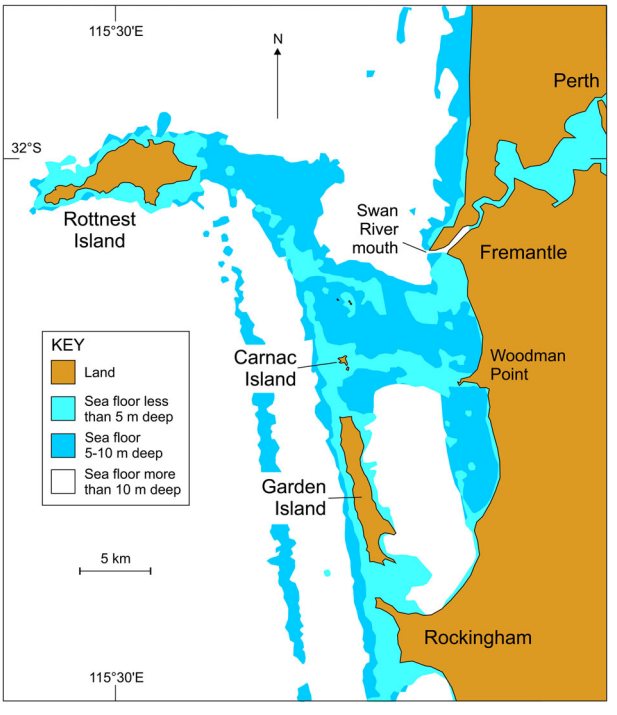

Figure 11. Map of Rottnest, Carnac and Garden Islands and adjacent mainland. Outline bathymetry is from Australian Hydrographic Service charts Aus112 (January 1992) and Aus117 (August 1972).

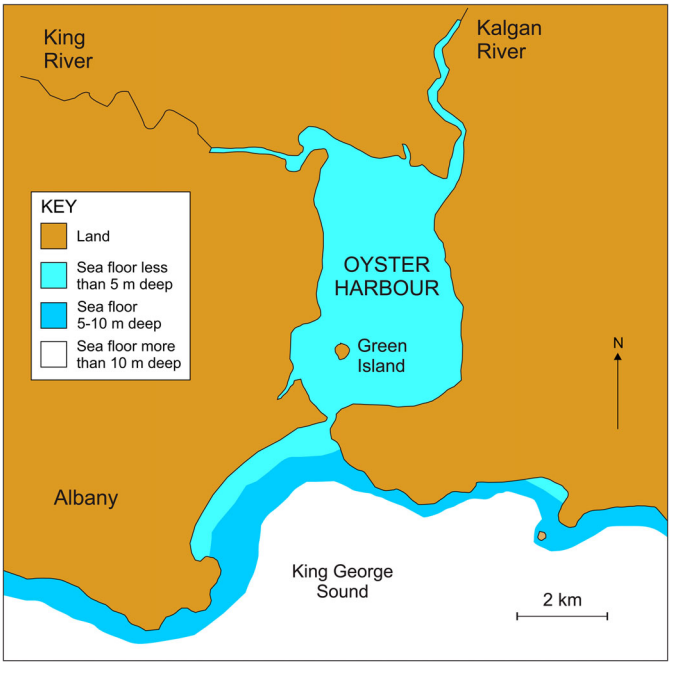

Figure 12. Map of Oyster Harbour showing an outline of the bathymetry from Australian Hydrographic Service chart Aus759 (March 1984).

followed her trail to Green Island where he 'commences scratching, which he continues so long that he digs a great hollow & the sea comes in & forms Oyster Harbour' (Mulvaney and Green 1992, 361).

As for Port Phillip Bay (see above), a lower sea level is not necessary for Oyster Harbour to become dry land; it could simply be that the narrow entrance which exists today was breached only quite recently, perhaps during a river flood or an extreme-wave event. Yet unequivocally Oyster Harbour would have been dry land when the sea level was lower by at least 4 m, and would have been part of a much larger emergent area around King George Sound when the sea level was 10 m lower.

3.19. *Bremer Bay*

Where the Bremer River meets the sea at Bremer Bay there is a barrier beach enclosing a brackish lake (Wellstead Estuary). Like many such barriers, it is likely that this one is periodically ruptured during floods or extreme-wave events allowing water mixing and increasing lake salinity until such time as the barrier forms again. The Aboriginal (Wheelman) story below may recall a comparatively recent event or, more likely, have been sustained by observations of its repetition through time. Yet it is given here because it may also contain a memory of the sea level reaching the level of the lake for the first time.

Inland of Bremer Bay there was once 'a large shallow lake not far from the sea' (Hassell 1935, 142). To stop people from spearing all the lake fish, the willy wagtails[8] sought the help of Marget (a water spirit), who 'had made a resting place at the … end of the lake near the sea' (145). Then

> a number of the Willy Wagtails got a long, slender stick, and drove it into one of the mud springs near the lake … The stick slowly sank in the ground … and disappeared, but they got another thicker stick and put it on the top, and did the same thing over again. This time the bottom stick touched the sea which ran under the lake and the water gushed up and ran into the lake. (145)

Eventually 'Marget responded to their call and the sea bubbled and roared through the hole in the lake made by the long sticks' (145). But the people were not finally driven away so the willy wagtails pestered Marget who eventually 'made the hole bigger in the lake and the sea roared in harder than ever, making the lake overflow' (146).

The critical detail in this story is the 'roaring in' of the sea that eventually, it can be inferred, 'finally' displaced people living around the lake. This detail is consistent more with rising sea level than an isolated breach of the barrier which, it should be noted, is not mentioned explicitly in this story and may therefore not have existed at the time it recalls. Notwithstanding, the most parsimonious interpretation of this story is that it recalls a time when a long-established sediment barrier across the mouth of Bremer Bay was breached, something that does not require a lower sea level. Yet the story is more believable if it refers to a time when the sea level was even 3 m lower than today.

3.20. *Eucla*

The coastal fringe of the Nullarbor Plain is marked by a line of 50–90 m high sea cliffs marking the erosional limits of Quaternary high sea-level stands (Doerr et al. 2012).

Seaward of the cliffs, the ocean floor is shallow and slopes gently south for several tens of kilometres in places,[9] making it likely that postglacial sea-level rise would have been more noticeable here than in many other parts of southern Australia.

There is an Aboriginal (Wati Nyiinyii) tradition from the Nullarbor that is claimed to represent 'a mythical history of the rise in sea level following the last ice age' (Cane 2002, 91). It recalls a journey in which an old man uproots 'water trees' (mallee eucalypts) causing 'scarce desert water to be lost. The water drains into the ground, creating a huge flood to the south … the Wati Nyiinyii are obliged to travel to Eucla to stop the encroaching flood' (89):

> The Wati Nyiinyii then pour over the Eucla escarpment, rather like an army of ants … Once the Wati Nyiinyii reach the sea, they begin bundling thousands of spears to stop the encroaching water. These bundles were stacked very high and managed to contain the water at the base of what is today the Nullarbor (or Bunda) cliffs and the Hampton escarpment. (91)

While circumspect, this tradition can indeed be interpreted as meaning that sea-level rise across the dry plain south of the Nullarbor cliffs was noticed by local Aboriginal groups and viewed with such concern that ways of halting it were planned and implemented. As with other open-coast examples in this collection, the determination of where the coastline was at the time to which this story refers is somewhat subjective. Yet it clearly refers to a time before the sea had reached the base of the Nullarbor cliffs and, given that it is described as 'encroaching', is likely to have covered lands that had formerly been dry. A sea level 10 m lower than today would see the Nullarbor shoreline shift several kilometres seaward while a sea level 50 m lower would involve tens of kilometres of emergent shelf in this area.

3.21. *Fowler's Bay*

Fowler's Bay is a shallow embayment, typical of many along this part of the Australian coast (cf. MacDonnell Bay above), where the sea has risen across a broad shelf during postglacial times (Figure 13). Several versions of a story involving the piercing of a skin waterbag that led to inundation are extant. The most detailed was told by the Bidjandjara people of the Great Victoria Desert:

> Malgaru and Jaul were two brothers travelling south from the 'desert' country … Malgaru, the elder, had a kangaroo skin waterbag, as well as two firesticks; but he would not give the other any water. Jaul became thinner and thinner, and his throat more parched. Eventually they came to a place near the south coast—Biranbura, west of Fowler's Bay. There was nothing but dry land there. Malgaru hid his waterbag under some rocks, which were dry at that time, although the sea now breaks over them. There the two brothers quarrelled. Malgaru went out hunting, but as soon as he was out of sight Jaul rushed to the waterbag. In a hurry to get at the water he jabbed at the taut skin with his club, making a hole in it. Water poured out. Malgaru came running back and tried to save the bag, but he could not stem the onrush of water. It spread across the land, drowning them both, and forming what is now the sea. (Berndt and Berndt 1996, 401)

Other versions report the detail that the water pouring from the bag filled 'a deep depression that is now part of the sea' (Reed 1993, 109) and that the water 'spread across the countryside … to become the Southern Ocean' (Berndt and Berndt 1994, 44).[10]

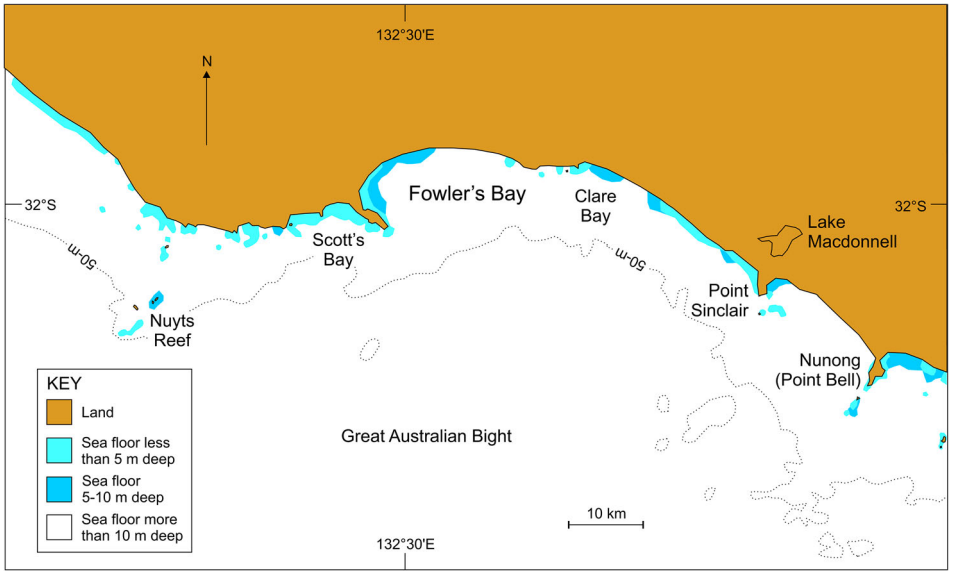

Figure 13. Map of Fowler's Bay showing the outline of the bathymetry of the adjacent ocean floor from Australian Hydrographic Service chart Aus341 (January 1979).

For the shoreline to be 70–100 m seaward of its modern position, the sea level would need to be 10 m lower; a sea level 50 m lower would see 1–2 km of sea floor emerge along this coast.

4. Analysis

The 21 groups of stories summarised in Section 3 are all similar in that they recall a time when a particular part of the Australian coastline, which is now under water, was dry land. Some of the stories are mythologised, some plain narrative. About half came directly from Aboriginal informants, the others relayed through Europeans which may have caused details of the original stories to be altered. Some stories refer to shallow-water places, some to much deeper-water areas. Some refer to comparatively open coasts, some to quite constrained areas (with narrow openings to the ocean). These attributes are summarised in Table 1.

Most stories are mythologised (67 per cent), fewer are narrative (48 per cent) and some are of both kinds (14 per cent). Bearing in mind that the range of extant stories is probably just a fragment of those that formerly existed, it is enough to note that the split in story type is much as noted in previous work and not unduly biased towards one type (Berndt and Berndt 1996).

Almost all stories (86 per cent) can be traced to Aboriginal sources and, while in some cases it is impossible to demonstrate an absence of recorder bias, it is plausible to suppose that none existed given either the profession or the ethnicity of the recorder. Only three stories are known solely from indirect (non-Aboriginal) sources but the details of none of these suggest the imposition of non-Indigenous views.

Table 1. Characteristics of the Aboriginal stories featured in this study.

Story no.	Story location	Nature of stories		Aboriginal sources		Nature of coast	Water depths (m)		Source of depth information
		Myth	Narrative	Direct	Indirect		Minimum	Maximum	
1	Spencer Gulf	✓	✓		✓	Wide-mouthed embayment	22	50	Australian Hydrographic Service chart Aus485 (2012)
2	Kangaroo Island	✓		✓		Gap with islands	32	35	Australian Hydrographic Service charts Aus126 (2010) and Aus485 (2012)
3	MacDonnell Bay	✓			✓	Open embayment	15	50	Australian Hydrographic Service chart Aus4709 (2004)
4	Port Phillip Bay		✓	✓		Bay with narrow entrance	8	12	Australian Hydrographic Service chart Aus143 (1973)
5	Gippsland	✓		✓		Open straight coast	20	50	Australian Hydrographic Service chart Aus357 (2010)
6	Botany Bay and Georges River		✓	✓		Bay with narrow entrance	9	16	Captain Cook's chart of Botany Bay (1770)
7	Moreton and North Stradbroke Islands		✓	✓		Low soft-sediment coasts	2	8	Australian Hydrographic Service chart Aus814 (2011)
8	Hinchinbrook and Palm Islands		✓	✓		Linear gap	5	22	Australian Hydrographic Service chart Aus828 (2012)
9	Cairns—Great Barrier Reef		✓	✓	✓	Open coast	30	65	Australian Hydrographic Service chart Aus830 (2002)
10	Wellesley Islands (Gulf of Carpentaria)	✓		✓	✓	Wide-mouthed embayment	5	10	Australian Hydrographic Service chart Aus303 (1996)
11	Elcho Island	✓		✓		Linear gap	5	10	Australian Hydrographic Service chart Aus719 (2010)
12	Goulburn Islands	✓		✓		Gap with islands	17	20	Australian Hydrographic Service chart Aus716 (2010)
13	Cape Don (Cobourg Peninsula)		✓	✓		Submerged island[a]	9	15	Australian Hydrographic Service chart Aus718 (2010)
14	Bathurst and Melville Islands	✓		✓	✓	Gap with islands	12	20	Australian Hydrographic Service chart Aus722 (1997)
15	Brue Reef	✓		✓		Broad reef platform	4	10	Australian Hydrographic Service chart Aus732 (1991)
16	Rottnest, Carnac and Garden Islands		✓		✓	Open straight coast	5	10	Australian Hydrographic Service chart Aus112 (1992) and Aus117 (1972)
17	Cape Chatham	✓	✓	✓		Open straight coast	55	60	Australian Hydrographic Service chart Aus758 (2009)
18	Oyster Harbour	✓	✓	✓		Bay with narrow entrance	4	8	Australian Hydrographic Service chart Aus759 (1984)
19	Bremer Bay	✓		✓		Bay with narrow entrance	0	3	Australian Hydrographic Service chart Aus4709 (2004)
20	Nullarbor Plain near Eucla	✓		✓		Open straight coast	10	50	Australian Hydrographic Service chart Aus4709 (2004)
21	Fowler's Bay	✓		✓		Open embayment	10	50	Australian Hydrographic Service chart Aus341 (1979)

Notes: numbers and locations as in figure 1. 'Nature of story' refers to whether it is mythologised or plain narrative, or whether versions in both forms exist. 'Aboriginal sources' refers to whether or not the story has reached us today directly from Aboriginal sources. 'Nature of coast' refers to the (modern) configuration of the coast to which the story refers. 'Water depths' refers to the minimum and maximum ocean depths to which a particular story is likely to refer.

[a]In the absence of evidence, this assumes for the sake of analytical completeness that the submerged island of Aragaládi is the shoal marked on the cited chart at 133°48′ E, 11°18′ S.

The nature of the coast to which particular stories refer varies considerably, from straight stretches of coast open to the ocean to bays with confined entrances of varied dimensions. Unlike most other types, it is possible that bays with narrow entrances have had these blocked regularly by sediment plugs formed during floods or large-wave events, meaning that the stories may refer to (or have been renewed by) successive events; this is likely in the cases of Oyster Harbour and Bremer Bay and may apply to Port Phillip Bay (Holdgate, Wagstaff, and Gallagher 2011).

The water depths to which a particular story refers depend on linking the geographical information it contains to the bathymetry of the location to which it refers. In this way, depth minima and maxima are obtained (see Table 1) and plotted in mean rank order (Figure 14). The degree of variability reflects either narrative uncertainties and/or ocean-floor slopes. There is no apparent geographical concentration of 'deep' and 'shallow' stories along the Australian coast.

The data in Figure 14 can be interpreted in various ways. They could represent a time series of observations of successive phases of submergence of the Australian continental shelf attributable to postglacial sea-level rise from a time when the sea level was 65 m below its present level. Uncertainties in the stories and their relationship to local bathymetry militate against such a simple analysis. Yet since there is no possibility anywhere along the Australian coast that the sea level was much lower than present within the past 7000 years, most of the stories are likely to refer to the period of postglacial sea-level rise that occurred more than 7000 years ago, an assumption that informs the dating of these stories below (see Section 5).

The uncertainties in this analysis should be made explicit, given the unconventional uses of the data presented.

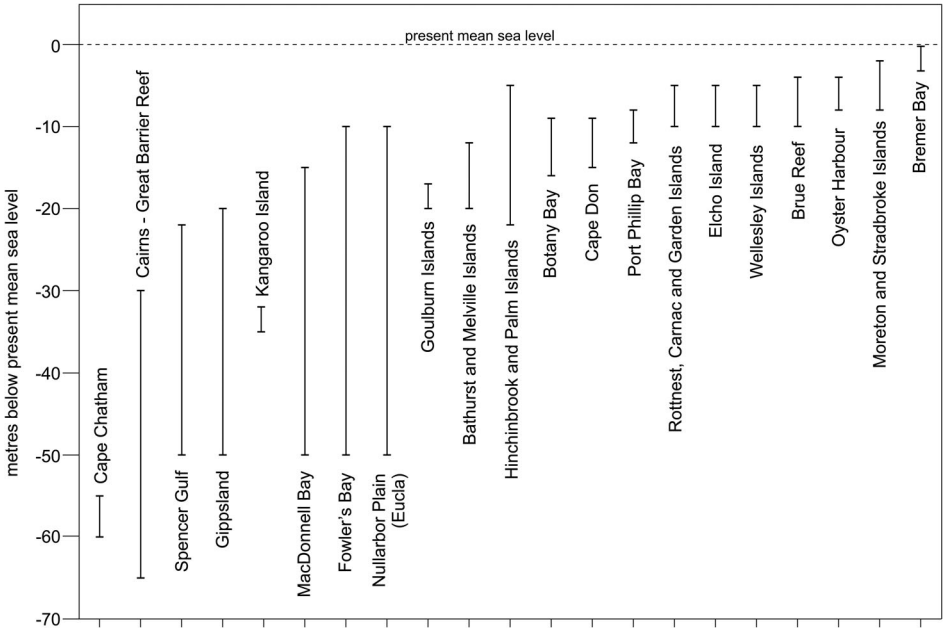

Figure 14. Water depths (m) plotted in modal rank order for each of the 21 locations. Data from Table 1.

There are obvious uncertainties in the stories themselves, as might be expected in ones originating more than 7000 years ago. Many of these arise from the lack/imprecision of geographical information contained in the stories; for example, the statement that

> many [Aboriginal] tribes along the south-eastern and eastern coasts have stories recounting how the shore-line was once some miles further out; that it was—on the north-east coast—where the barrier reef now stands (Dixon 1980, 46)

is difficult to interpret, given the generality of the locations and the width of the barrier reef—more than 130 km wide east of Mackay. It is possible that those stories with more precise geographical detail are actually more recent.

Uncertainties also exist in the calculation of water depths, given that coastal submergence leads to more than mere flooding of a coastline but also erodes it, and in places mobilises loose sediments while elsewhere it causes these to accumulate. Thus sea-level rise will cause changes to the form and composition of the coastline, underscoring the point that modern bathymetry is not necessarily a reliable guide to past bathymetry, especially that from several millennia ago.

Another uncertainty is the potential for stories to be 'read back into the landscape', where geographical features might obviously suggest an event that might then be recounted as though witnessed. There are such cases with meteorites in Australia, where observed meteors become linked with the formation of meteor-strike craters, but those craters turn out to have been formed hundreds of thousands of years ago, predating human occupation (Hamacher 2014). With respect to sea-level changes, this seems more likely to be a problem where the sea level has fallen, exposing evidence of a submarine environment, rather than where the sea level has risen. Given the complexities of any coastline, it is not clear that any environment would be retrospectively read as 'breached or inundated' in the absence of any actual sea-level change.

The most compelling arguments for the authenticity of these 21 stories is that

- they come from almost every part of the Australian coast; and
- they tell essentially the same story, yet one that is specific to a particular coastal geography.

Had stories been found in just one small part of the Australian coast, told by only a few Aboriginal tribes, then one might suspect they had their roots in a single event, possibly even one that was imagined rather than based on observation. Similarly, if stories differed significantly in their key detail—perhaps the number of those involving inundation equalled by the number recalling coastal emergence (perhaps from sea-level fall)—then one would rightly question whether any meaning could be attached to the corpus of stories. Yet no Aboriginal stories are known that talk of the sea level falling and exposing coastal lands.

If it is accepted that most Aboriginal stories summarised above are memories of times when the ocean rose across the various parts of the continental shelf to which they refer, then it is possible to assign ages to each story by plotting the minimum and maximum water depths derived for each (Table 1) against postglacial sea-level changes. While variations in the course of postglacial sea-level change around Australia are known (Fletcher and Thomas 2010; Gouramanis et al. 2012; Switzer et al. 2010; Woodroffe 2009), it is deemed sufficient, given the imprecision of the estimated water depths, to use a well-regarded synthesis for this purpose: the sea-level envelope of Lewis et al. (2013).

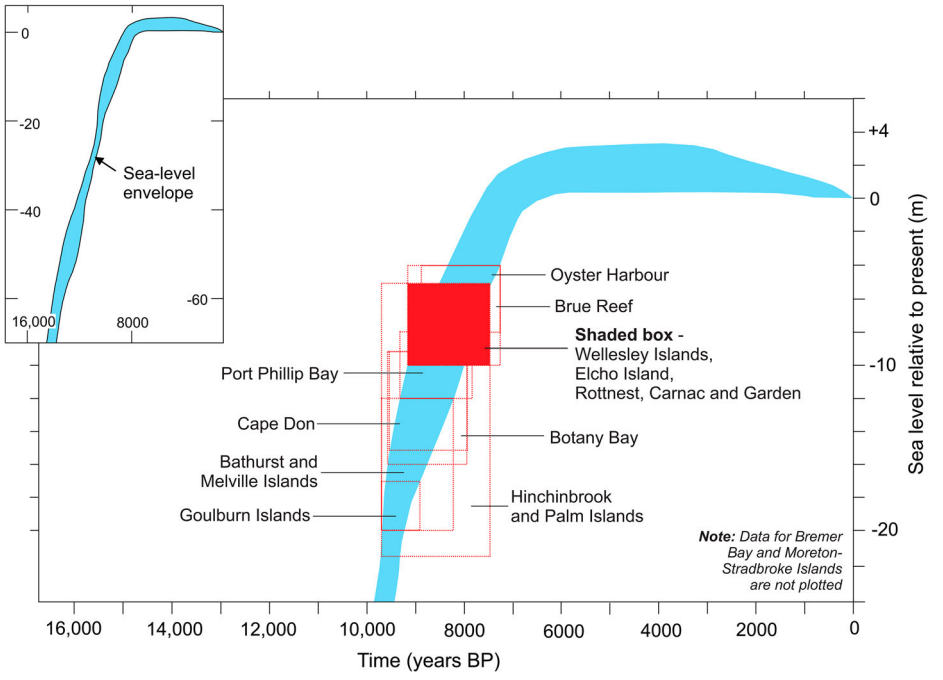

Figure 15. Shallow-water depths for each location plotted against postglacial sea-level data for Australia (Lewis et al. 2013) to allow for the calculation of minimum and maximum ages for particular stories (as in Table 2).

In Figure 15, each of the 'shallow' (≤20 m maximum in Table 1) locations is plotted against postglacial sea level. The others (>20 m maximum) are plotted in Figure 16. Minimum and maximum ages derived graphically for the most recent time at which each story would have been valid are given in Table 2.

5. Implications and caveats

This study suggests that Aboriginal stories of coastal drowning in Australia, from locations thousands of kilometres apart, date from 7250–13 070 cal years BP (5300–11 120 BC). If this is the case, then not only does it corroborate the fact—hitherto inferred but never shown to have been observed—of postglacial sea-level rise (Murray-Wallace and Woodroffe 2014) but it also demonstrates an extraordinary longevity for these stories, which is worth exploring in some detail.

The question of the uniqueness of the Australian Aboriginal stories in recalling events that occurred at least 7000 years ago is key. There are flood (including tsunami) stories found in almost every part of the world (Huggett 1989; Van 1993) that superficially might be regarded as comparable to those from Australia. Yet these stories appear to have diffused from a few sources, retold in multiple versions—such as the Abrahamic religions' versions of the Gilgamesh flooding story—and, critically, involve a flood/tsunami that eventually recedes, restoring the Earth to the condition it was in before. Stories of coastal drowning similar to those from Australia are far fewer, generally more fragmented

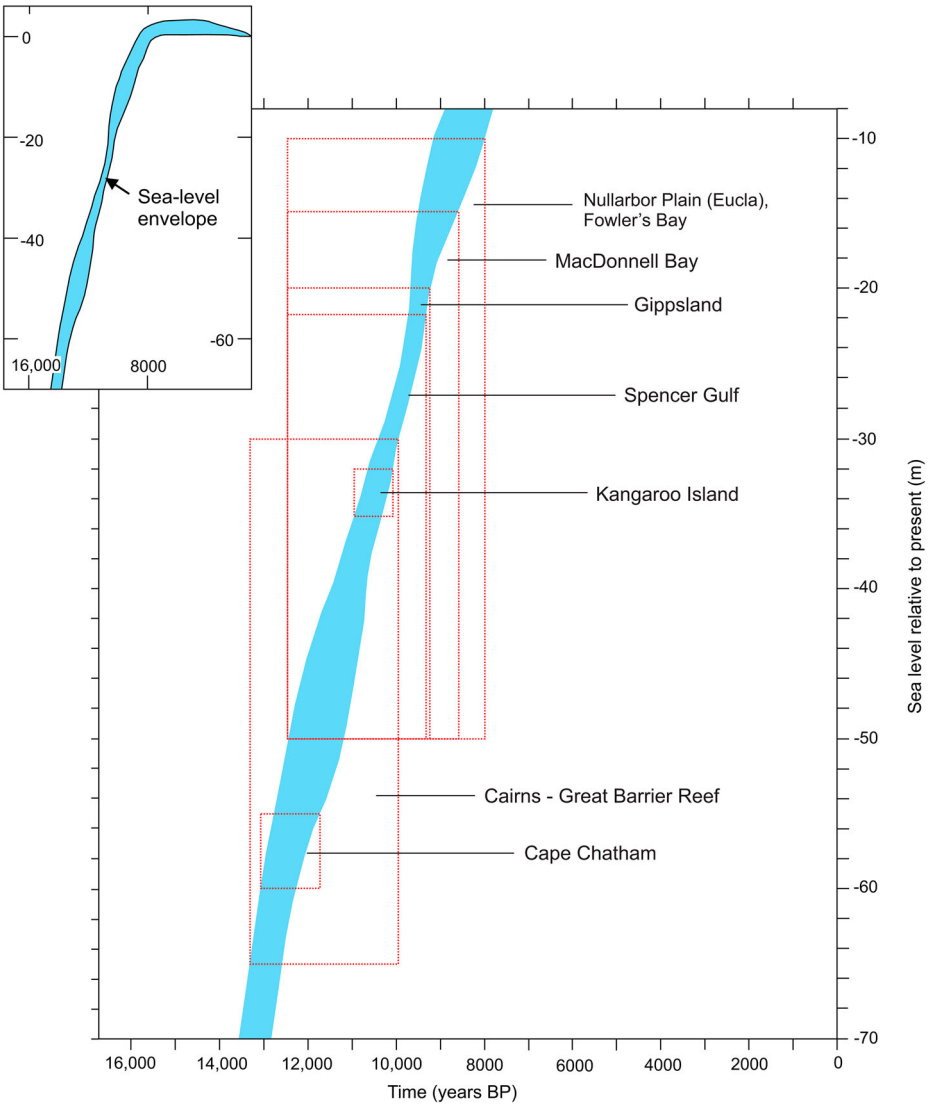

Figure 16. Deep-water depths for each location plotted against postglacial sea-level data for Australia (Lewis et al. 2013) to allow for the calculation of minimum and maximum ages for particular stories (as in Table 2).

and more mythologised; examples come from India and the eastern Mediterranean (Dalley 1989; Nunn 2014). No other continent currently offers up a body of 21 stories like those discussed here—Australia does seem unusual in this respect.

If we accept that Australian Aboriginal people's wealth of such deep time-depth stories stands out as exceptional among the corpus of such traditions globally, either such stories do/did exist elsewhere and have either disappeared or not been adequately documented, or there may be some particular narrative culture amongst Australian Aborigines that fosters high levels of transmission fidelity. There are several attributes of Aboriginal storytelling that stand out as noteworthy.

Table 2. Ages for the Aboriginal stories, derived graphically from figures 15 and 16.

Story no.	Story location	Age (cal years BP)	
		Minimum	Maximum
1	Spencer Gulf	9330	12 460
2	Kangaroo Island	10 080	10 950
3	MacDonnell Bay	8590	12 460
4	Port Phillip Bay[a]	7820	9300
5	Gippsland	9240	12 460
6	Botany Bay and Georges River	7930	9560
7	Moreton and North Stradbroke Islands	Recent	
8	Hinchinbrook and Palm Islands	7450	9680
9	Cairns—Great Barrier Reef	9960	13 310
10	Wellesley Islands (Gulf of Carpentaria)	7450	9140
11	Elcho Island	7450	9140
12	Goulburn Islands	8890	9680
13	Cape Don (Cobourg Peninsula)	7930	9520
14	Bathurst and Melville Islands	8210	9680
15	Brue Reef	7250	9140
16	Rottnest, Carnac and Garden Islands	7450	9140
17	Cape Chatham	11 730	13 070
18	Oyster Harbour	7250	8870
19	Bremer Bay	Recent	
20	Nullarbor Plain near Eucla	7990	12 460
21	Fowler's Bay	7990	12 460

Note: these ages refer to the most recent time at which the observations of lower-than-present water depths (as in Table 1) could have been valid.

[a]Palaeoenvironmental investigations show that when the postglacial sea level reached the lip of the entrance to Port Phillip Bay, this entrance was blocked for about 1000 years while the sea level continued rising. Inundation occurred finally at 7217 cal years BP (Holdgate et al. 2001).

Firstly, Aboriginal societies have been described as having a conservative rather than innovative cultural orientation (Rose 2013). While this view runs the risk of essentialising cultural practices, the real environmental changes that Aboriginal people have lived through and the subsequent social changes they have had to adapt to have largely 'been subsumed within a philosophy of time immemorial' (Rose 2011). In Aboriginal storytelling, this orientation manifests as a frequently and overtly stated focus on the importance of telling stories properly. Often expressed by Aboriginal people as 'gotta tell this story right way', this involves not just an explicit focus on story content but also on story ownership and control—on establishing who has the authority to tell this story.

Secondly, storytelling among contemporary Aboriginal people can involve the deliberate tracking of teaching responsibilities. For example, a man teaches the stories of his country to his children. His son has his knowledge of those stories judged by his sister's children—for certain kin are explicitly tasked with ensuring that those stories are learned and recounted properly—and people take those responsibilities seriously. Of course it is important to be cautious about using aspects of contemporary Aboriginal narrative culture and assuming that they have relevance at deep time depths. Yet this kind of system, often labelled in Aboriginal English as the 'owner-manager' relationship, requiring a story to be discussed explicitly across three generations of a patriline, constitutes a cross-generational mechanism which may be particularly successful at maximising precision in replication of a story across successive generations (Rose 2013).

And thirdly, it is important to consider the particular intimate way in which Aboriginal people relate to country. The highly territorial nomadism described for the Wagaity MakMak clan (Rose 2011), for instance, involving conceptualisations of country

producing a communicative web: where lands talk to people and people to land; where totemism makes people consubstantial with species and places; where people are known to country and where country's health is dependent on people's actions; where people's lives are formed and their well-being sustained through knowing country; and where belonging arises through knowing to the extent that people feel like strangers off-country—all these epistemological threads make intimate knowledge of landscapes and seascapes central to Aboriginal cosmology, and this too may be a key factor in facilitating transmission of very old stories about changes to that country.

It can never be proven that the Aboriginal traditions of Australian coastal inundation described here actually recall postglacial sea-level rise and are indeed of the suggested antiquity. Yet are they then 'impossible to disprove?': a paradox discussed at length by Henige (2009) who is especially critical of the unsupported assertion of antiquity of oral tradition by those with undisguised socio-political agendas. That said, there are concerns about the arguments presented in this paper that should not go unremarked upon.

First is that if the events believed to be recalled took place more than 7000 years ago then how plausible is it that they continued to be remembered, particularly as sea level has not been rising—except for short periods of time—since that time? While it is clear that some memories are not effectively transmitted between generations in Aboriginal societies (Sansom 2006), it might be assumed that the kinds of oral stories most likely to survive with replication fidelity over long time periods are those vital for people's survival. The location of a water source in harsh arid terrain, possibly just a tiny waterhole hidden under a rock to prevent evaporation, would be an excellent candidate for such a story, for survival of travellers might depend upon it.

Postglacial sea-level rise must have had a massive impact on the social lives of Aboriginal coastal dwellers. Within 12 000 years, greater Australia lost 23 per cent of its landmass, about 85.5 per cent of which might have been occupied (Gautney and Holliday 2015).[11] Generation after generation must have had to renegotiate land tenure arrangements with inland neighbours, and make stay-or-go decisions about island/lowland clan estates. So while the noteworthiness of slow inexorable sea-level rise might appear to pale against sudden flooding events, Australian Aborigines must have lived with high levels of awareness that inundation was taking place, and had been so for a long time; at this time 'on the gently sloping northern plains [of Australia] the sea inundated 5 km of land annually. Even in the Great Australian Bight, 1 km of coast disappeared every fifteen years' (Flood 2006, 194).

Yet since the sea level stabilised 6000–4000 years ago, is it feasible to suppose that the motivation for telling sea-level-rise stories remained in Aboriginal societies? Hunter-gatherer cultures with strong land attachments often invest in complex land-naming and land-relating processes that become inculcated in ritualised ways within a corpus of traditional knowledge, and are usually explicit in rite-of-passage ceremonies as evidence of claims to land. For example, the only plausible explanation for the Indindji people of coastal Queensland continuing to tell the story of Mudaga, the island named after the pencil pines that once grew on it (Dixon 1977), for thousands of years after it was no longer visible, is if that story were part of an explicitly taught package of stories inherited through land-owning Indindji patrilines. For the existence of Mudaga, even submerged, constitutes evidence of knowing one's country, and thus establishing one's relationship with that country. Without such ritualised

framing, the transmission of such stories across perhaps over 100 generations would seem to be implausibly vulnerable to chance link-breaking.

Finally, whether or not living people can establish continuity of culture with ancestors previously occupying their land is a hotly contested issue that has been fought out in the courts with respect to land tenure under native title, and with respect to archaeological remains. In general, Western legal systems have remained sceptical of the possibility that cultural continuity might be establishable across time-depths of thousands of years. The outcome of the landmark Kennewick Man case was the ruling that 9000-year-old remains could be considered as 'Indigenous to the United States' but that they could not be 'definitively linked with a current tribe' (Owsley and Jantz 2001). If the scenario set out in this paper is valid—that a body of commonly themed stories does point to unbroken transmission over hundreds of generations—then this speaks of cultural continuity in multiple instances across time-spans previously deemed highly improbable.

6. Conclusions

From 21 locations in mainland Australia, this paper has sourced (collections of) Aboriginal stories about coastal drowning that in most cases are considered likely to recall the effects of postglacial sea-level rise more than 7000 years ago. Given earlier views on the probable longevity of oral traditions, which doubt they could be sustained in recognisable form more than 500–800 years, this conclusion is somewhat radical, even allowing for its mentions by earlier authors (Dixon 1980; Sharpe and Tunbridge 1999) and the possibility that at least one oral tradition from elsewhere in the world might be of comparable age (Deur 2002).

In a global context, this raises the possibility that stories of comparable antiquity both in Australia and elsewhere in the world exist and may yield information that is likewise of interest and significance to a range of questions. Yet more parochially, the fact that stories with a similar narrative are known from 21 locations in Australia raises the possibilities that both more details/versions of these stories are known and that comparable unreported stories referring to other places in Australia also exist. Given the range of current threats to oral traditions, globally as well as in Aboriginal Australia, it would seem to be a priority to rediscover these stories, given that those presented in this paper may be some of the world's earliest extant human memories.

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Notes

1. Answer to Q. 213, Report of Select Committee, Victoria, Legislative Council Votes & Proceedings, 1859, 12.
2. A musical instrument made in Gippsland from cherry-tree wood and used in ceremonies (Fison and Howitt 1880, 267–268). The *turndun* was traditionally only for men's use so its discovery by children and women was an invitation to disaster.
3. This story was related by Frances Bodkin, a Dharawal woman, who heard it from her mother.
4. These are likely to have been either *Hicksbeachia pinnatifolia* or *Macadamia integrifolia*, both of which bear edible fruits/nuts.
5. This story was told by Peter Namiyadjad in the Maung language.
6. Told by Mangurug of the (northern) Gunwinggu people.
7. All stories related in this section come from research by Dr Katie Glaskin.
8. *Rhipidura leucophrys*.
9. 35 km south of the coastal town of Eucla, the sea floor is just 55 m deep (data from Australian Hydrographic Service chart Aus4709 (2004).
10. This latter detail is part of a story recounted by Mushabin (Bidjandjara), Harry Niyen (Antingari), and Marabidi (Ngalia-Andingari).
11. Using data in Gautney and Holliday (2015), the original area of Sahulland was 11 021 024 km^2; modern areas of Australia, Papua New Guinea and Irian Jaya (Indonesian Papua) are 7 692 000, 462 800 and 319 036 km^2 respectively, meaning that an area of about 2 547 188 km^2 (26 per cent) was inundated within this 12 000-year period. Gautney and Holliday (2015) also show that 9 418 731 km^2 (85.5 per cent) of Sahulland was habitable during the Last Glacial Maximum.

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