Beneath the Top End: A Regional Assessment of Submerged Archaeological Potential in the Northern Territory, Australia

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Abstract

Regional-scale assessments have proven to be invaluable frameworks for research, public engagement and management of submerged archaeological landscapes. Regional-scale approaches have been implemented internationally through a variety of academic or strategic studies. Such studies represent a much-needed next step towards sub-regional and site-level prospection to support management, engagement and mitigation of the impacts of offshore development. However, these regional studies are largely absent in Australia. In this article, we build on the recent discovery of submerged archaeological sites in Western Australia and produce a novel regional-scale assessment of submerged archaeological and cultural landscape potential in the coastal and island regions of the Northern Territory. This area is of special significance in the peopling of Australia, containing some of the oldest dated archaeological evidence. We collate and synthesise regional data related to sea-level change, ethnography (e.g. oral traditions), geomorphology, and archaeology, also taking account of logistics and existing data availability to identify prospective areas for further study. We highlight the need for a coordinated national program of regional baseline studies to address a legacy of under-representation of submerged landscapes and provide vital baseline data for a wide spectrum of stakeholders, including researchers, policy makers, environmental and heritage managers, developers and Traditional Owners.

Keywords Submerged landscape archaeology, underwater cultural heritage, coastal geomorphology, archaeological prospection, Indigenous archaeology

Introduction

Submerged archaeological landscapes are a global phenomenon, with a handful of research centres in Europe and North America leading and developing new and innovative research programs and methods, and management practices (see Bailey and Flemming 2008; Bailey et al. 2020; King et al. 2020). In Australia, the combined evidence of terrestrial archaeology, coastal and marine geomorphology, and sea-level studies (

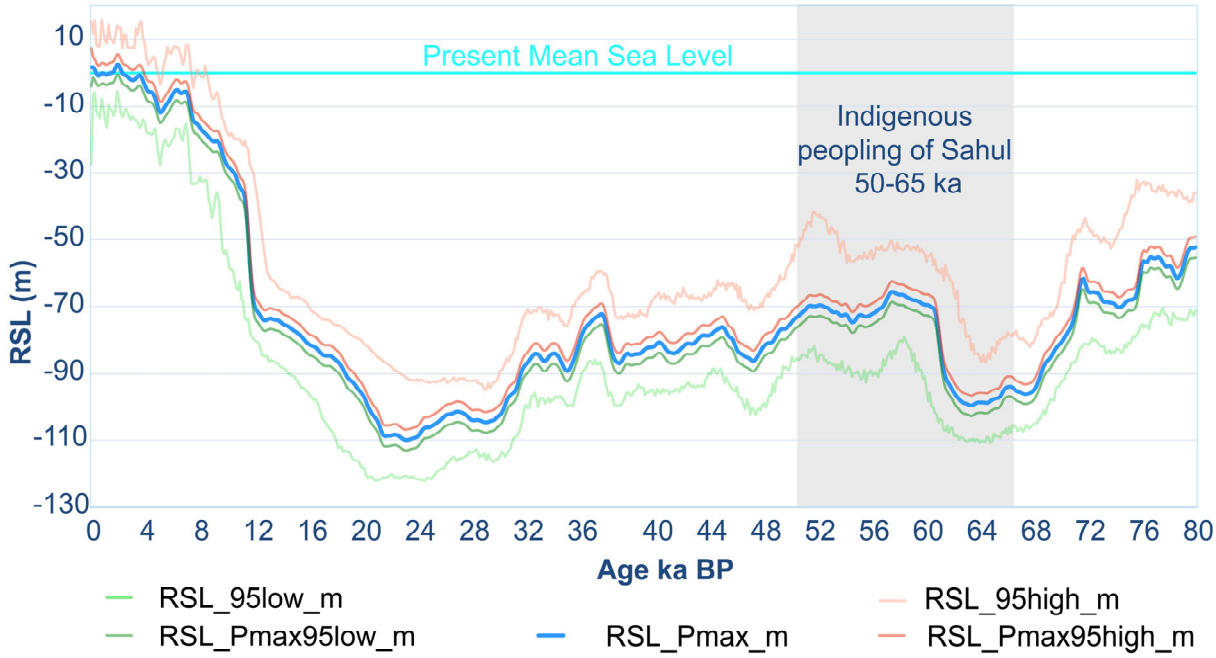

Figure ***1***) have long indicated the existence of submerged archaeological landscapes, spanning a third of the size of the continental landmass of Australia and New Guinea (Figure 2) (Williams et al. 2018). The importance of regional knowledge of sea-level change, coastal geomorphology, sedimentary budgets and biota in assessing regional potential for submerged landscapes in Australia was first recognised by Chappell (1982). A lack of direct physical evidence from subtidal marine contexts has meant that inundated archaeological landscapes have often been overlooked in regional archaeological studies. Researchers have also considered archaeological potential offshore to be minimal, suggesting that 'of the first settlements on the now submerged continental shelf it is likely that nothing has been preserved' (Hiscock 2008:43) and 'it is worth stressing the low probability of finding evidence for coastal economies associated with sea levels lower than the present one' (Meehan 1982:2). This view has been overturned by the recent discovery of intact subtidal Aboriginal archaeological sites at Murujuga in Western Australia (Benjamin et al. 2020; Wiseman et al. 2021) focussing the attention of the Australian public, cultural heritage managers, Indigenous communities, legislators, and industry on the vast submerged archaeological landscape that fringes the continent.

The key task that now faces academic researchers and cultural heritage managers is to develop a meaningful understanding of variation in archaeological potential across Australia's continental shelf. To do so would contribute significantly to many current areas of archaeological research such as the peopling of Sahul, understanding Pleistocene lifeways and coastal economies generally, and is vital to the management of this resource in the face of threats from offshore development and climate change. The continental scale of Australia and the variability in environment, geology, climate, and ecology in its many marine bioregions presents a significant challenge for researchers and heritage professionals and the Traditional Owners and custodian groups who live on and manage these physical and cultural environments.

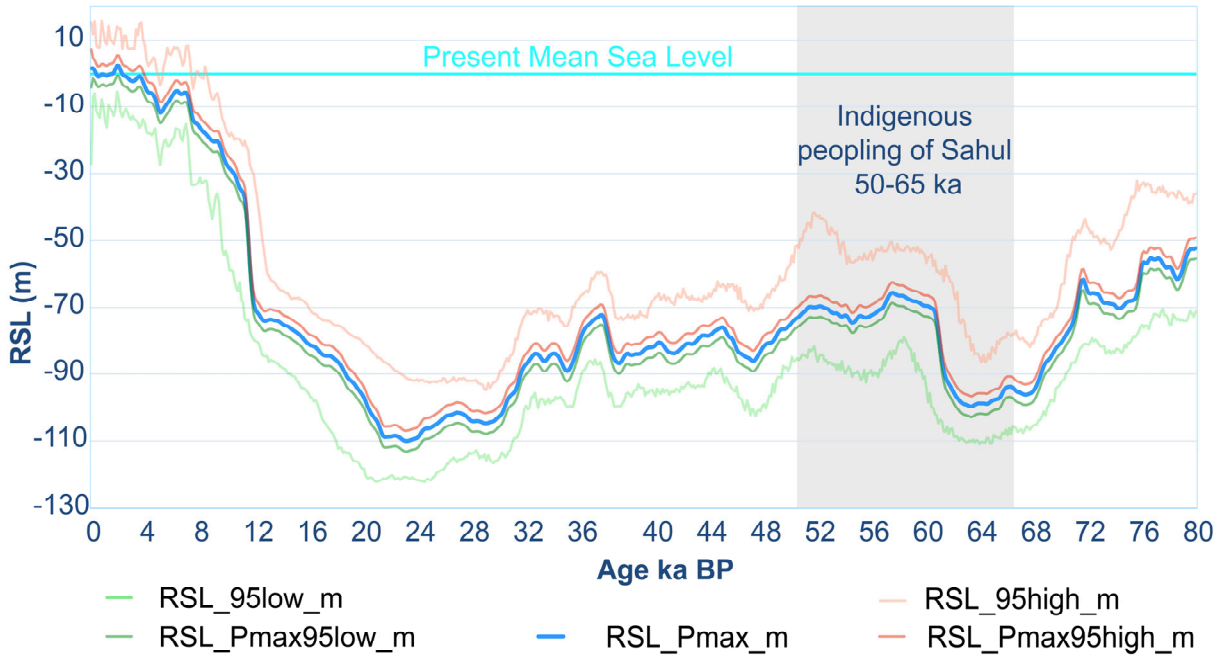

Figure 1. A section of the global relative sea-level curve (after Grant et al. 2014, based on the Red Sea) including the period of first human occupation of Australia.

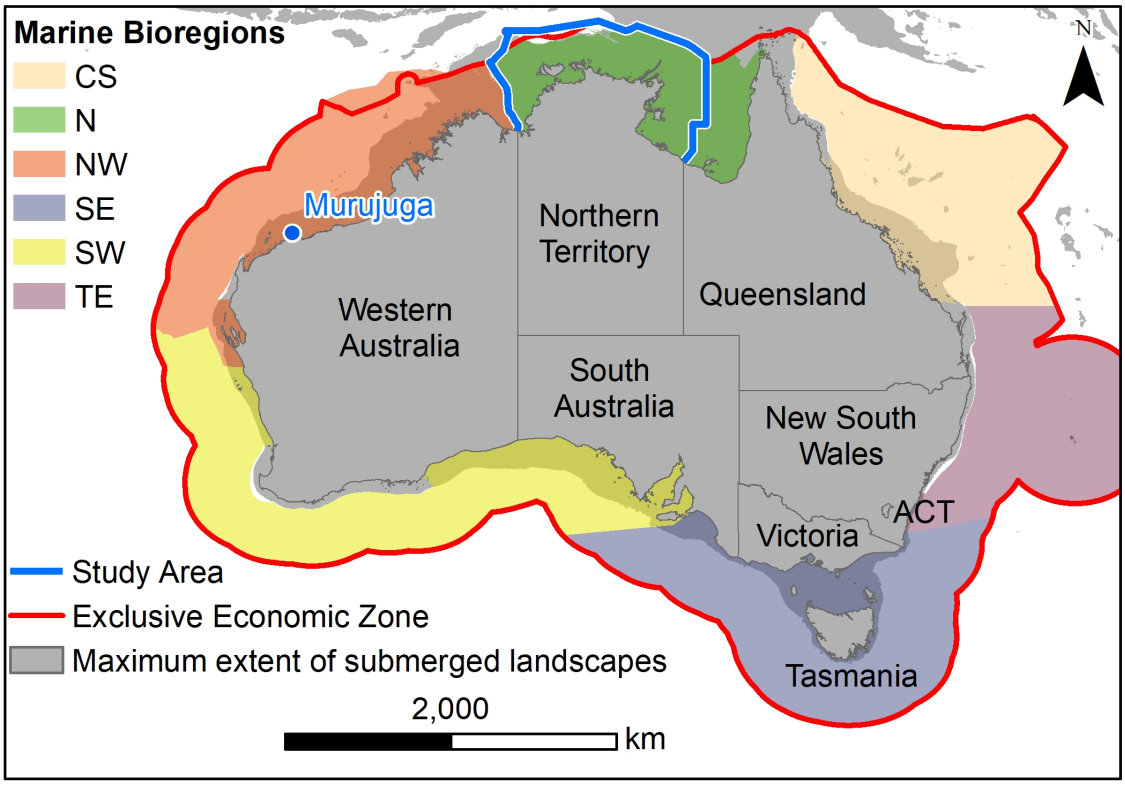

Figure 2. The Study Area relative to the main terrestrial and offshore regions of Australia, based on state and marine bioregions. Contains GEBCO 15 ArcSecond raster data (Public Domain) and Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM) (version: 11) (CCBY 4.0).

We argue that the next phase of research in many areas requires gathering and synthesising regional contextual data on variations in archaeological potential and the likely nature of the submerged archaeological resource. In this paper, we present the first State/Territory regional overview of archaeological context and potential for the existence of submerged landscapes in the Northern Territory – a key area with special significance in the peopling of Australia, with the oldest dated terrestrial sites in Australia, and thus potential for further deep-time exploration. This article provides a model for further studies of Australia's extensive coastal and island regions, and is written within the context of the existing legislative framework, specifically the *Heritage Act 2011* (NT)[1].

Background

For much of human occupation of the Earth, sea level has been much lower than present and submerged archaeological landscapes exist offshore on most coasts worldwide where humans lived prior to relative stabilisation of sea level ca. 6–7 ka (Grant et al. 2014; Lambeck et al. 2014). Oral

[1] https://legislation.nt.gov.au/Legislation/HERITAGE-ACT-2011

histories providing details of flooded landscapes exist in many cultures globally, with Western scientific understanding of submerged ancient landscapes emerging in the nineteenth century (Boyd Dawkins 1870; Reid 1913). Most evidence concerning the recovery of submerged archaeological sites was arrived at through chance finds of artefacts such as fishermen and divers locating stone tools. In recent decades, advances in diving, remote sensing and methods of scientific analysis have led to a growing momentum in research on submerged landscapes globally (Bailey et al. 2020; Benjamin et al. 2011; Evans et al. 2014; Masters and Flemming 1983).

In Australia, there has been much debate over the date of Indigenous peopling of the continent, but current research suggests dates between 50 and 65 ka (Clarkson et al. 2017; Roberts et al. 1990a, 1990b, 1994; Veth 2019a). The knowledge that human occupation stretched back to periods of much lower sea level led, in 1982, to the first diver survey for submerged archaeological landscapes in Australia, at the Cootamundra Shoals, 240 km northwest of Darwin (Flemming 1986). Despite this initial survey and sporadic surveys since then (summarised by Wiseman et al. 2021), confirmed evidence of archaeological sites in a subtidal marine context on the Australian continental shelf was not published until recently, with two locations for submerged lithic artefacts published by Benjamin et al. (2020). This discovery had major ramifications for offshore development and resource extraction, with impacts upon submerged landscapes considered for the first time by some developers. It led to calls for the protection of submerged archaeological landscapes by Traditional Owners, who maintain strong traditions of stewardship of Sea Country (e.g. Murujuga Aboriginal Corporation 2020). It was an archaeological discovery made possible by several years of regional contextual characterisation at Murujuga through remote sensing and archaeological and geomorphological analysis (Benjamin et al. 2018; McDonald 2015; McDonald and Berry 2017; Veth et al. 2019b). This analysis informed targeted prospection through diver survey (Wiseman et al. 2021). Although sub-regional in scale (Murujuga and neighbouring islands would fit within a 100 km diameter area), that work has demonstrated the value of regional characterisation to support prospection in an Australian context.

Apart from the targeted research at Murujuga, no Australian baseline studies of submerged archaeological landscapes have been undertaken at scales equivalent to terrestrial management programs, such as states and territories. Only such large-scale studies will provide a contextual framework that covers the entire country. The extent of these might be defined by state and territory boundaries, Australia's existing marine bioregions, or other relevant large-scale area definitions such as coastal and marine geomorphic provinces (Heap and Harris 2008). Internationally, there are some maritime regional study examples on which we can draw. In many parts of the world, strategic marine planning studies have provided the first detailed regional-scale assessment of submerged landscapes.

In the United States, the pronounced variation in marine environments between east and west coasts and regions such as the Gulf of Mexico and Great Lakes has naturally driven research at a regional scale (Gusick and Faught 2011:34-37). Recent trends have been towards a more formal regional approach, as 'marine inundated prehistoric archaeology demands that archaeologists be knowledgeable about the local or regional prehistory' (Gusick and Faught 2011:35). In 2020 the *Bureau of Ocean Energy Management* (BOEM) concluded a six-year study on best practice in submerged landscape research, recommending development of 'a confirmed regional model developed by regional experts working in collaboration with regional Tribes', to 'streamline the desktop study process for offshore project proponents and ensure that the best data is [sic] being used as the basis for new survey designs and data interpretations' (King et al. 2020:21).

These substantial baseline studies on the nature and extent of offshore environmental resources support long-term strategic marine planning, which is increasingly important due to global increases in offshore development and human impacts on the marine environment. One of the earliest examples of this planning system-based approach was in the United Kingdom, where development pressure from offshore windfarms and aggregate dredging increased rapidly in the early 2000s. Potential long-term impacts on submerged landscapes were assessed at a high level through a series of regional-scale studies (e.g. Flemming 2002; Wickham-Jones and Dawson 2006). Strategic marine planning studies have been developed for Australia (e.g. Australian Government 2012a; Australian Government 2012b) across six marine bioregions spanning the continental shelf (Figure 2). These focus on ecology and while they consider some underwater cultural heritage (i.e. shipwrecks), they neglect the submerged archaeological landscapes.

Archaeological Research Frameworks are another mechanism used to evaluate regional potential, and studies of this nature have been undertaken in parts of Europe. Cross-disciplinary collaborative attempts at national or regional levels have been used to define future research priorities, founded on detailed archaeological baseline studies. In some cases, such studies have provided a mechanism for regional assessment of submerged landscapes. In 2009 the United Kingdom, Netherlands and Belgium collaborated on a research and management framework for the submerged archaeology of the Southern North Sea (Peeters et al. 2009), which was recently updated for the Netherlands section (Peeters et al. 2019). Occasional calls have been made to develop similar Archaeological Research Frameworks for Australia (Iacono 2006; Schacht 2010) but they have yet to be produced. The Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf (SPLASHCOS) Network in Europe was funded by the European Science Foundation through their Cooperation in Science and Technology Trans-Domain Framework (TD-902), and was designed to facilitate the communication and formation of a European-wide network of researchers, policy makers, managers

and industrial partners, specifically devoted to the archaeology of submerged landscapes. This has led to a series of national baseline studies and the integration of data in an online viewer (see the various contributions in Bailey et al. 2020).

The omission of regional baseline studies in Australia through any of these approaches has resulted in a 'blind spot' for submerged ancient landscapes at a state- and territory-level outside of individual locations of active research This has limited engagement with submerged landscapes by legislators, planners, heritage managers and developers at a regional scale.

The Northern Territory's Coastal and Island Regions

The Northern Territory's coastline and island regions are often referred to as Australia's 'Top End' and are located in a seasonal wet-dry tropical monsoon climate. The coastline extends for 5500 km, stretching from its western boundary shared with Western Australia, and east to the Northern Territory/Queensland border and encompasses several major islands and island groups including (from west to east) the Tiwi Islands (Bathurst and Melville Islands), Croker Island, Goulburn Islands, Crocodile Islands (Milingimbi), Elcho Island, Wessel Islands, English Company Islands, the Groote Eylandt archipelago, and the Sir Edward Pellew Islands. These areas are home to a wide range of present-day marine habitats including coral reefs, mangrove swamps, seagrass beds, and mudflats (Smit et al. 2018). While the Top End is dominated by Eucalypt open savannah woodlands, coastal and island environments range from low-lying, seasonally inundated floodplains, through perennial swamps and coastal dune systems, to steep-sided, craggy sandstone outcrops (Baker et al. 2005). There is extensive archaeological evidence for continuous Holocene occupation of the Northern Territory's coastal and island regions with the oldest date coming from Vanderlin Island at around 8000 BP (Brockwell et al. 2009; Sim and Wallis 2008). While comparatively younger than Madjedbebe's 65,000 BP date, this occupation record indicates the sustained presence of people in these areas during the Holocene (Brockwell et al. 2009; Clarkson et al. 2017). Some Aboriginal people who live in these areas identify as 'Saltwater People', that is, people whose worldviews, subsistence and technology have, and continue to be, centred around the sea (e.g. Bradley 2010; Keen 2002; McNiven 2003; National Oceans Office 2004; Peterson and Rigsby 2014; Sharp 2002). These maritime specialists have complex and intimate relationships with their sea country that transcend the landscape/seascape divide and are part of complex relational networks underpinned by the creative acts of major Ancestral Beings (Dreamings) (e.g. Sharp 2002; see below). Many of these coastal and island regions have, in recent times, been the scene of complex patterns of interaction, trade and exchange with outsiders, namely Macassan trepangers from Sulawesi from the late 1600s until early

1900s, European mariners from the mid-1600s, and Japanese pearl divers in the twentieth century (Macknight 1976; Powell 2000; Taçon et al. 2010; Wesley et al. 2016).

Methodology

The initial step for this study was an audit of available contextual and qualitative data to develop a regional, baseline perspective on submerged archaeological landscapes for the Northern Territory. This audit focussed on datasets available at a regional scale and across the study area. A synthesis was undertaken of the regional character of geography, geology, sea-level change, archaeological proxy evidence from terrestrial contexts, and Aboriginal oral traditions about submerged landscapes and sea-level change.

Regional characterisation of submerged archaeological potential often relies heavily on survey and remote sensing data. The audit initially examined the most relevant data available at the Northern Territory regional scale (Figure 3), including high-resolution bathymetry, satellite bathymetry, coastal LiDAR (Light Detection and Ranging), seabed geomorphic character and marine seismic data. Much of the relevant data in Australia are centralised through Geoscience Australia, including datasets on terrestrial and marine geology, seabed character and bathymetry. High-resolution multibeam (sonar-derived bathymetry) coverage is limited in this region, but full satellite bathymetric coverage is available via the General Bathymetric Chart of the Oceans (GEBCO). Coverage for industry-gathered seismic data, which can be effectively repurposed for analysis of palaeolandscapes (O'Leary et al. 2020), were also gathered from the National Offshore Petroleum Information Management System (NOPIMS) and show that there are extensive data in the study area that can potentially be analysed in future.

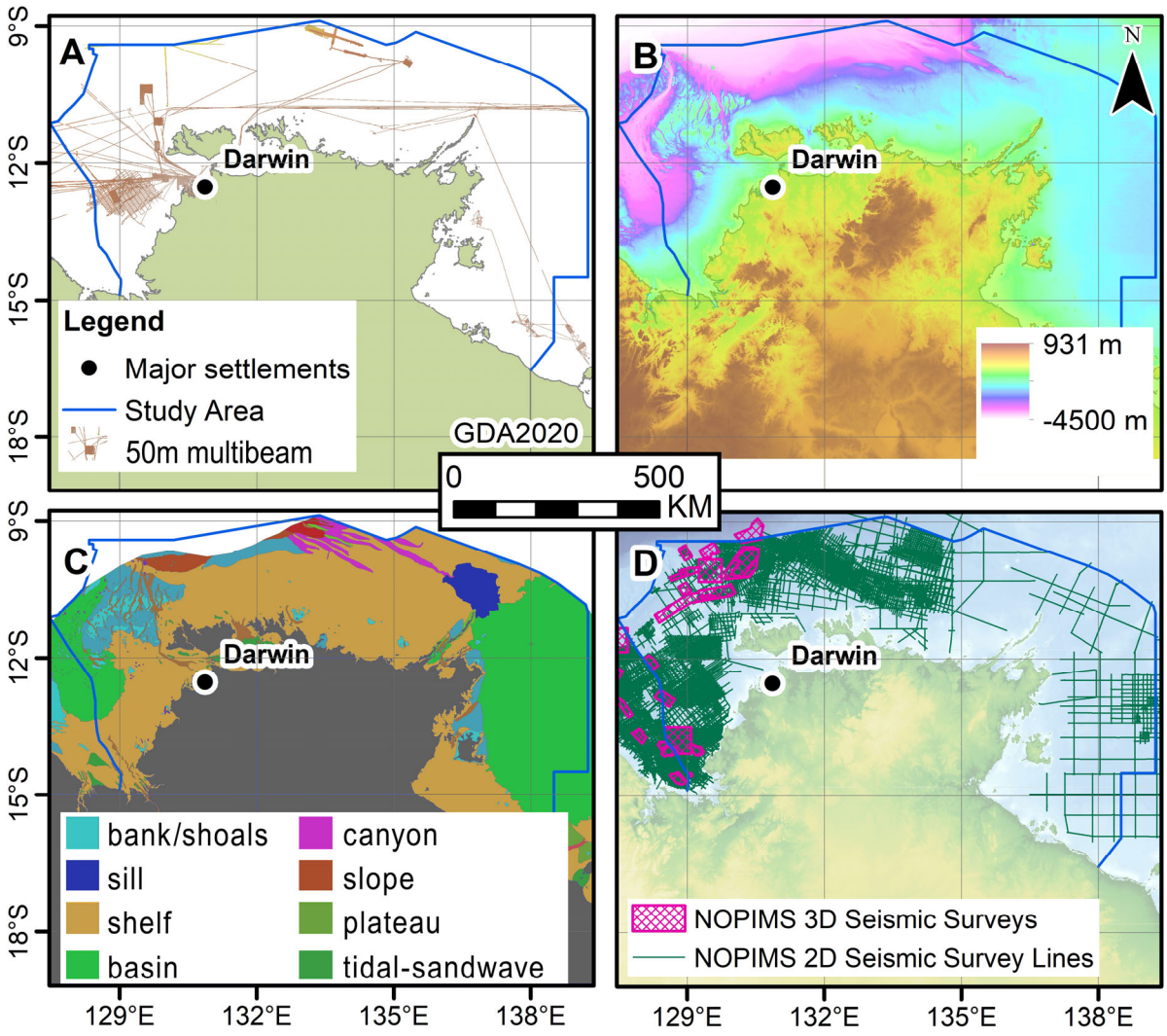

Figure 3. A selection of the regional scale data available to support submerged landscape research in the Northern Territory, including A: 50 m Multibeam Dataset of Australia, B: GEBCO 15 arc-second topo-bathy, C: Seabed geomorphic features, D: coverage of 2D and 3D seismic survey. All data are from Geoscience Australia (CCBY 4.0) or from GEBCO (Public Domain).

Bathymetry and Sea-Level Change

The history of relative sea-level change throughout the human past often varies strongly by region but has been relatively uniform across the Australian continent. This is because the effects of isostatic factors (where tectonic plates are pressed down by the weight of sediments, water, ice or volcanic material causing local variation in relative sea level) have had minimal impacts in Australia during human occupation. Relative sea-level change during the period of human occupation has therefore been driven largely by global sea-level change or eustasy.

Sea-level reconstruction in Australia can be undertaken at a national rather than regional scale. A series of regional relative sea-level reconstructions were generated for the Northern Territory (Figure 4), based on Williams et al. (2018, Table S1) who provide estimates of relative sea-level data at 200-year intervals for the period between 8 ka and 36 ka. For dates older than 36,000 years, sea-level estimates have been published by Grant et al. (2014), Brooke et al. (2017:30) and Lambeck et al. (2014).

Isostasy, or uplift, cannot be completely discounted as a factor and plays a small role in regional sea-level change (Lambeck et al. 2014). Isostatic effects account for proportionally more of the change in regional coastline position towards the late Pleistocene and early Holocene, as relative sea levels approached modern levels, particularly in large shallow plains, such as the Gulf of Carpentaria (cf. Sloss et al. 2018). There is some uncertainty in geoscientific literature about when sea level attained its present level in the Northern Territory, and whether it continued to rise by a metre or two above present sea level before subsiding (see Lewis et al. 2013 for a summary). The most recent research (Sloss et al. 2018) suggests that the maximum highstand was reached at 6880±50 cal BP, and that within the Gulf of Carpentaria, sea level reached a height of 1.5–2 m above present sea level and stayed at this level until around 4 ka, dropping back to present mean sea level by ca. 3.5 ka (Sloss et al. 2018:1411). This higher sea level would have submerged some of the modern river mouths and inlets all along the coast of the Northern Territory for almost 3,000 years.

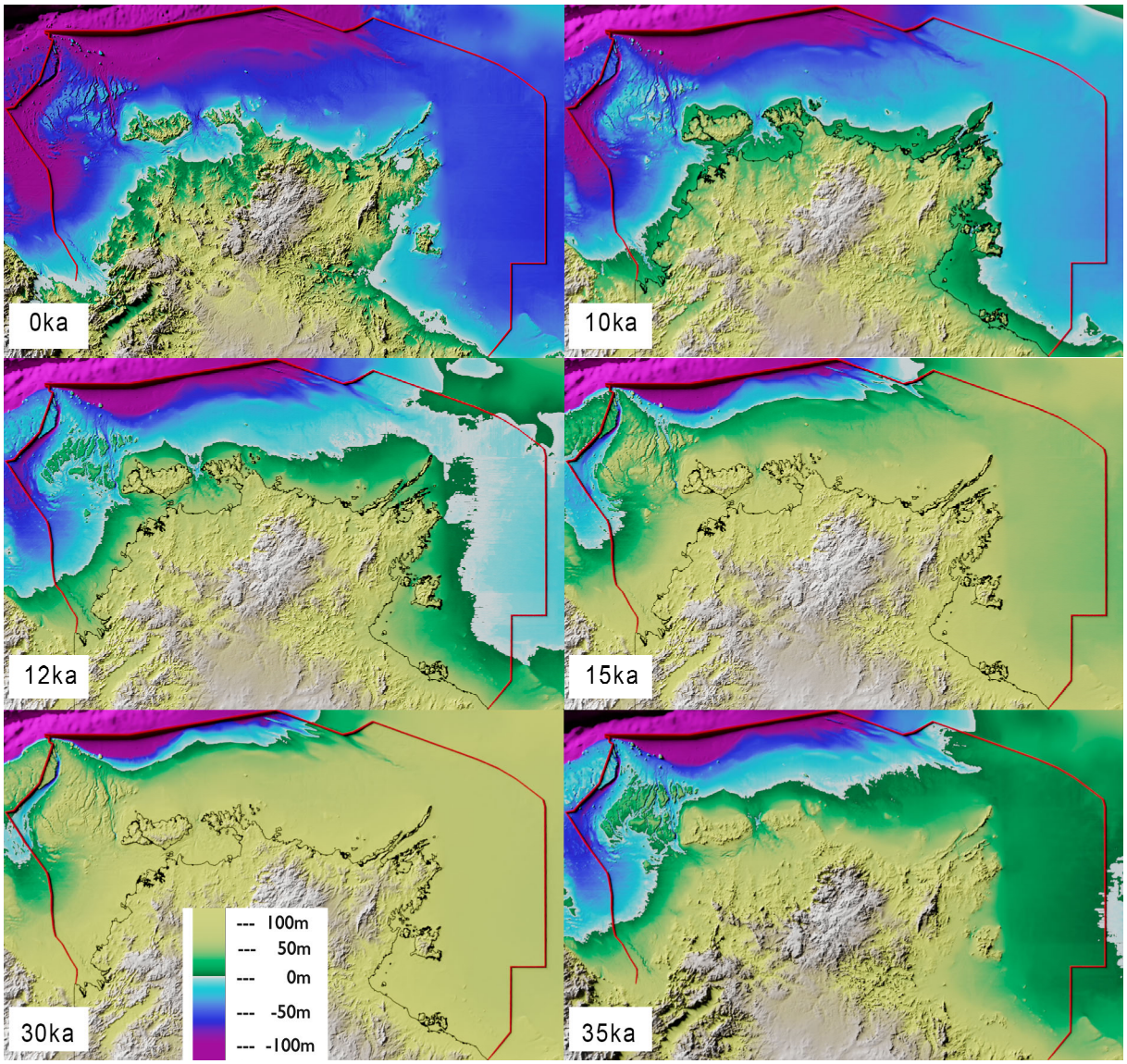

Figure 4. Relative sea-level at different stages of human occupation of the study area based on elevations from the Williams et al. (2018) curve and modern topography and bathymetry (elevation data from AusBathyTopo grid (Whiteway 2009, CC BY 4.0).

The difficulty of reconstructing the submerged cultural landscapes beneath Australia's seas undoubtedly contributes to a historical lack of engagement across many sectors of society, including industry and planning. Although high-resolution multibeam surveys are only available in some areas (Figure 3A), regional-scale bathymetry is available by merging this with coarser satellite bathymetry at 30 m resolution. A geospatial reclassification of available bathymetry was created with reference to sea-level curves to show how long each part of the seabed off the Northern Territory was exposed during human occupation (

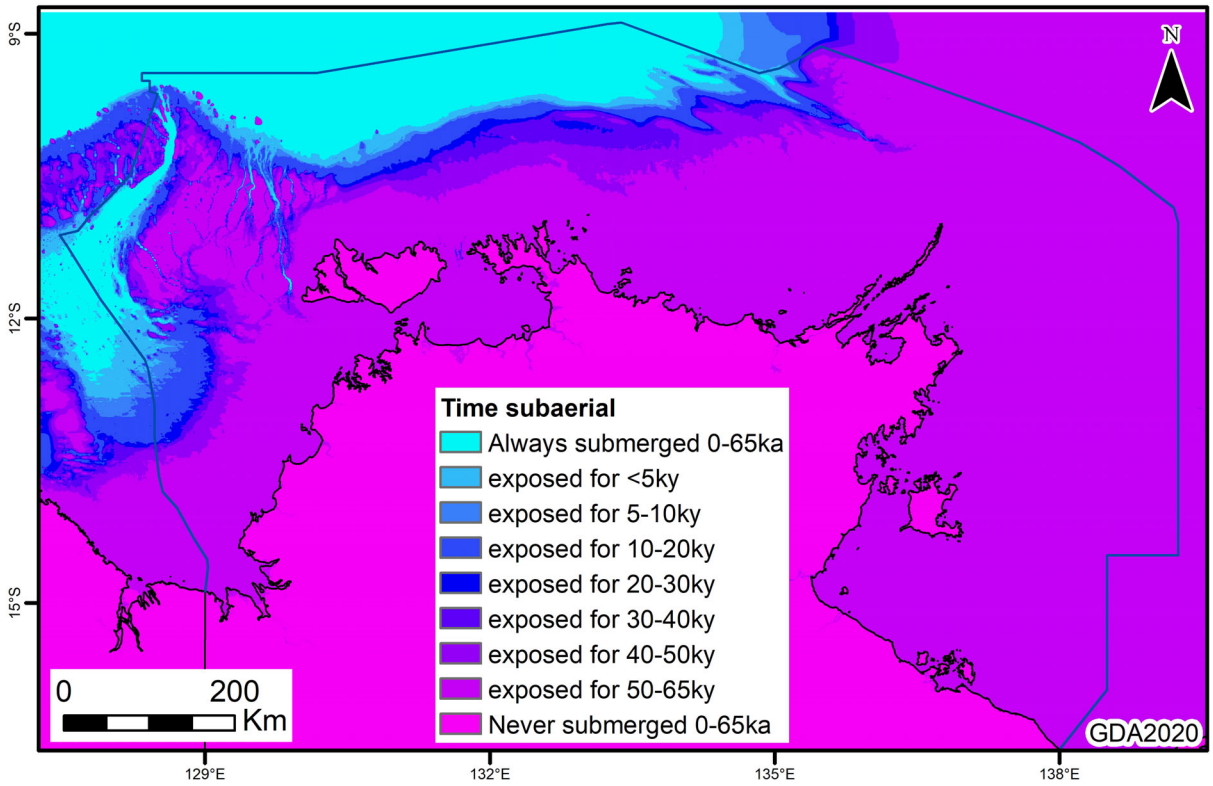

Figure ***5***). This analysis shows that most of the shelf was exposed subaerially for at least 50,000 of the last 65,000 years, excluding a much smaller area that could only have been occupied for less time. Although total duration of sub-aerial exposure does not correlate directly with archaeological potential, this map provides a useful visualisation of the typical landscape configuration through the period of human occupation.

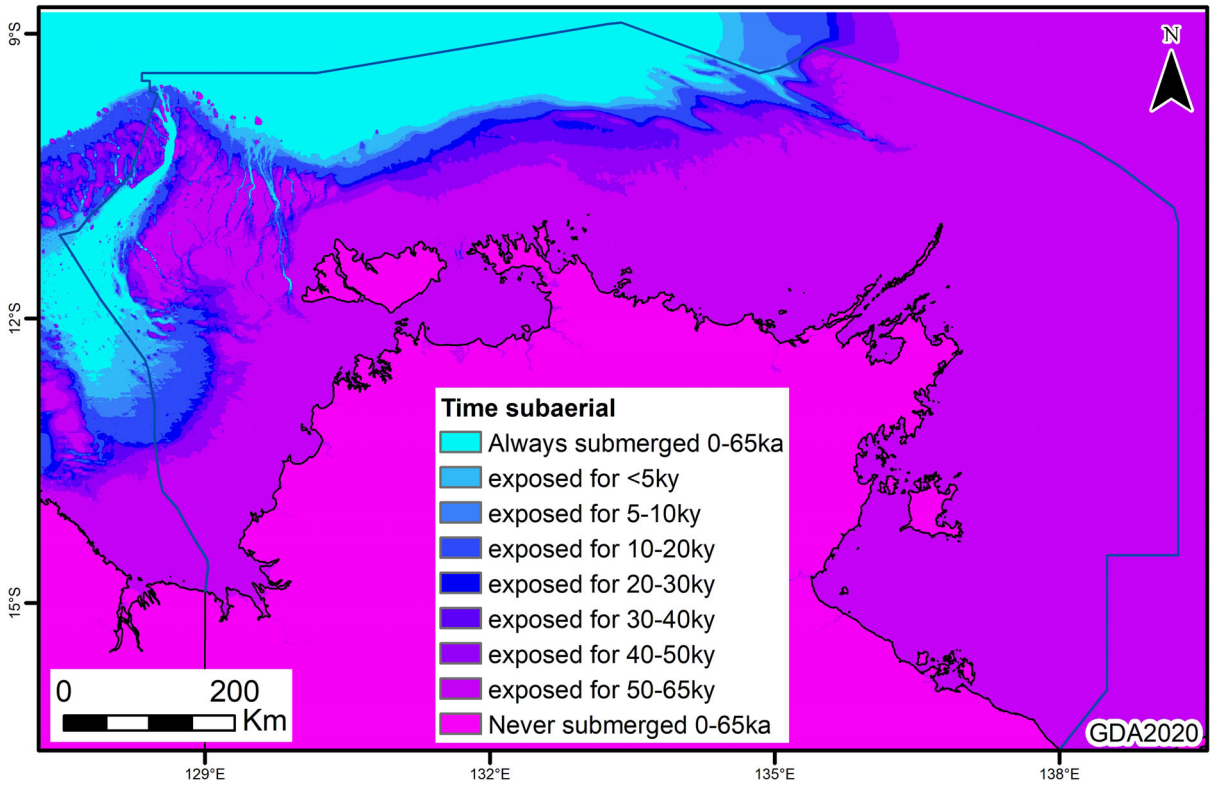

Figure 5. A map showing the relative length of time that parts of the Study Area have been exposed during the last 65,000 years of human occupation (this figure does not show freshwater features such as palaeo-Lake Carpentaria). Contains GEBCO 15 ArcSecond raster data (Public Domain) and Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM) (version: 11) (CCBY 4.0).

Geography, Geology and Geomorphology

The coastal regions of the Northern Territory are part of a diverse landscape ranging from the cyclone-swept northern islands to the vast Gulf of Carpentaria with its major river systems and islands. As sea level changed in the Northern Territory, the regional character of the area changed radically. The now topographically elevated hinterland fringed with islands, would have once been uplands to vast flat plains extending at times as far as the (now) island of New Guinea with the extensive Lake Carpentaria being a notable feature of the glacial landscape. The most characteristic regional factor relating to submerged landscape prospection was the high degree of sedimentation in the study area during the period of human occupation. This sedimentation derives from terrigenous sources such as sand, blown from the eroding sandstone bedrock of the region, which settled on the continental shelf both before and after inundation, as well as from deposition of marine sediments, driven by large river system outflows. The evidence for reef formation in the Northern Territory, which may also both protect and obscure submerged archaeological evidence, is relatively limited, with sparsely distributed Late Quaternary reefs on the outer slope of the Arafura shelf (Heap et al. 2004) and the Gulf of Carpentaria (Harris et al. 2008).

The delivery of terrigenous sediments to the coast including semi-enclosed gulfs such as the Gulf of Carpentaria and Joseph Bonaparte Gulf (Chappell 1993; Jongsma 1974; Short 2020), increased from 14 ka due to the advent of the Australian summer monsoon (Wyrwoll and Miller 2001). The resulting sedimentary sequence effectively buried palaeolandsurfaces under several metres of sediment, protecting them from erosion but making it very difficult to reconstruct these buried landforms without extensive geotechnical and geophysical investigation. There are also many topographic features (such as offshore shoals) located on the open shelf that are exposed to high wave energy events (e.g. cyclones), whereas the more protected inter-island channels and straits located between offshore islands and the mainland are exposed to strong tide-driven currents. Tidal patterns also vary substantially, with large tidal swings over five metres in the western NT, and micro-tidal conditions of less than one metre in the southwestern Gulf of Carpentaria. Highly tidal environments may be scoured, impacting archaeological potential but the transition zones between heavily sedimented and heavily scoured seabeds may offer the best opportunities to locate submerged archaeological land surfaces.

Recently, a Digital Earth Australia Coastlines nationwide dataset has been released which combines satellite data with tidal modelling to map the position of the coastline at mean sea level between 1988 and 2020, providing a more nuanced understanding of where shorelines are prograding and retrograding across the entire region (Figure 6). By extrapolating into shallow waters this may provide a useful indicator of areas where ongoing erosion might expose submerged paleolandsurfaces.

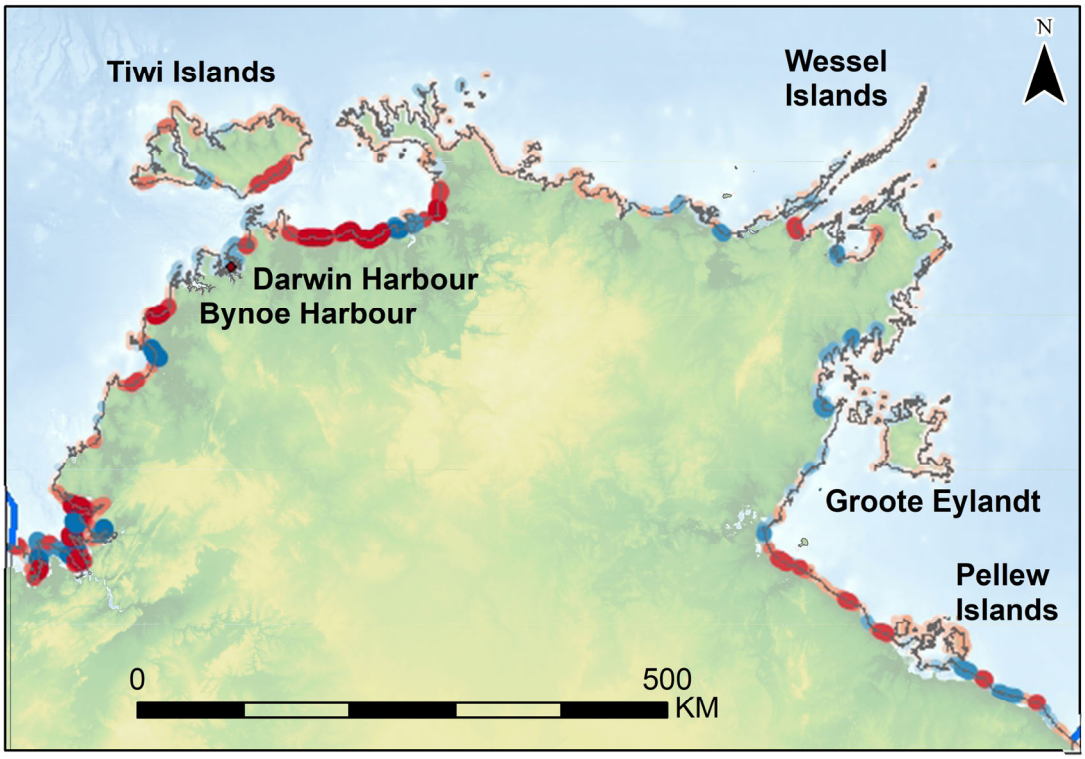

Figure 6. Prograding (blue) and retrograding (red) shorelines around the NT, where strength of colour reflects strength of effect (Digital Earth Australia). Geoscience Australia (CCBY 4.0).

Oral Traditions

Many Traditional Owners of the coastal Northern Territory maintain a close cultural connection with the sea, as highlighted by the Yolŋu of northeast Arnhem Land in their Sea Country Plan:

> More of our totems come from the sea than from the land; sacred sites, although they have been underwater for thousands of years now, are still sung about (Dhimmurru 2016:6).

Elsewhere, Bradley (2014) has noted among the Yanyuwa in the southwest Gulf of Carpentaria, relationships to 'underwater country' are complex, places are known, named, and form part of people's social organisation (e.g. certain tracts have clan affiliations and 'owners'). Bradley (2014:205) also draws attention to the lack of a mainland-sea dichotomy:

> The sea and underwater country of the Yanyuwa is, as with the mainland, often called by the term *awara*. It is a word which conveys a large number of meanings, such as earth, ground, place, country, camp, sea, reefs and sandbars. The term highlights the Yanyuwa concept that the sea and the underwater country are

known places, that they are named. As such, it is perfectly reasonable to ask for the name of a stretch of sea, reef, sandbar or sea grass bed.

The general existence in the Northern Territory of traditions of drowned places far out at sea has been noted on several occasions (e.g. Corn 2005:25; Nunn 2016; Yumbulul and Djiniyini 1997). Several specific locations have been named along the coast (Figure 7) including the Gulf of Carpentaria, Elcho Island, Goulburn Islands, Cape Don/Cobourg Peninsula and the Bathurst and Melville Islands (Nunn and Reid 2016:25-29). These examples include submerged crossings, including from the mainland to Elcho Island, from North to South Goulburn Island (Berndt and Berndt 1996; Chaseling 1957:134; Cooke and Armstrong 2014:286; Nunn and Reid 2016:27) and at Entrance Island/Maningrida (Cooke and Armstrong 2014:286).

Submerged islands are also said to be inhabited by ancestral spirits at a location 20 km east of North Goulburn Island (Cooke and Armstrong 2014:286-287; Nunn and Reid 2016:27). More recently, fieldwork by Daryl Wesley in 2018 with Golpa Traditional Owners identified the location of a submerged rockshelter at the north end of the Marchinbar Islands and a seabed depression (possibly a cave or rockshelter) observed in a marine survey in the Wessel Islands was recognised as a location previously known from oral traditions. While oral histories relating to times of lower sea level would have had to persist since before sea levels stabilised near current levels (c. 8 ka), many such land bridges, rockshelters and caves, which are now submerged, would have been occupied before that time. It is also worth noting from the discussion of relative sea level given above, that the sea had risen above current levels by a few metres in much more recent times in the Northern Territory, so that some traditions inspired by sea-level change would only have needed to preserve such memories since c.4 ka.

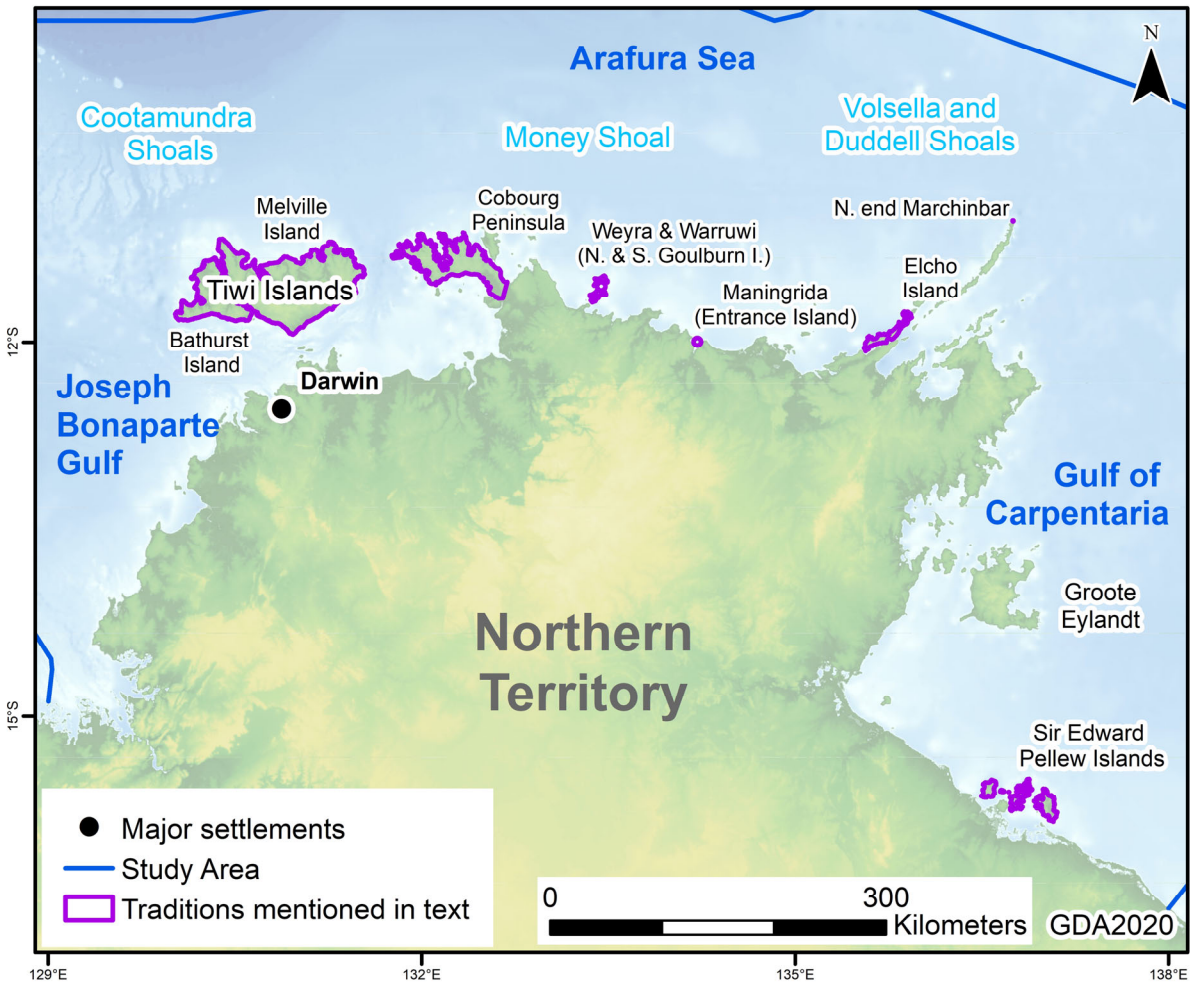

Figure 7. Locations of oral traditions with possible connections to sea-level change recounted by Aboriginal communities in the Northern Territory (topography and bathymetry from the SRTM30-plus v 8.0 via the eAtlas service, CC BY 4.0).

Genetic, Linguistic and Archaeological Evidence and Modelling

Archaeological potential off the Northern Territory coast is heavily influenced by geographical, environmental and cultural factors at a regional level. These include regionally available raw materials and proximity to the northern land bridge to what is now Indonesia and Papua New Guinea. The Northern Territory is the only place in Australia with a full 65,000-year record of Indigenous occupation (c.f. Clarkson et al. 2017). With a complete lack of direct archaeological evidence from submerged areas, initial colonisation and the impact of later sea-level rise has often been analysed through modelling (e.g. O'Connell and Allen 2012). Models based on palaeoclimatology and ethnographic studies identify the region as a key geographical point for understanding initial and later peopling, and habitation of coastal environments (Bird et al. 2019; Bradshaw et al. 2021; Crabtree et al. in press; Malaspinas et al. 2016). In the Northern Territory, the relationships between past cultures

and submerged landscapes are also reflected in genetic, linguistic and terrestrial archaeological evidence.

Genetic studies provide that, after the first peopling of Sahul, humans spread quickly across the future continent of Australia, beginning in the north and expanding rapidly down the east and west coasts (Bird et al. 2016; Tobler et al. 2017). Mathematical modelling of this process has suggested a number of possible routes would have been particularly suitable and one of these runs through the study area, from Cape Cobourg eastwards across the northern edge of the Wessel Islands and the northern edge of palaeo-Lake Carpentaria (Bradshaw et al. 2021; Crabtree et al. in press). Genetic evidence further outlines that, following a period of rapid dispersal, there was low population mobility across the continent (Tobler et al. 2017) but this does not preclude smaller-scale regional population movement (Williams et al. 2013). The most significant such movements are likely to have resulted from rising sea level between 20 and 7 ka, which would have driven coastal populations to higher ground and disrupted established territories (Williams et al. 2018). This process would have been most evident in northern Australia where the continental shelf is most extensive.

Regional linguistic data appear to show some evidence of this population movement. Northern Australia shows by far the greatest linguistic diversity in Australia with Non-Pama-Nyungan (NPN) languages found across the upper part of the Northern Territory (large parts of Arnhem Land, southwestern Gulf of Carpentaria) (Evans and McConvell 1998). It is possible that this diversity may partly reflect a concentration of languages and populations pushed inland from the extensive submerged continental shelf.

The post-sea level distribution of languages is partly obscured by the later spread of Pama-Nyungan (PN) languages, which were found across the rest of Australia up to 1788 (Evans and Jones 1997). These are generally thought to have emerged c.6 ka near the southern margin of the Gulf of Carpentaria, near Burketown in Queensland (cf. Bowern 2010). However, on the northwest edge of the Gulf of Carpentaria, the Yolŋu-matha (Ym) languages form an enclave of PN, now geographically isolated from the rest of their language group in the southern part of Australia. The inundation of palaeo-Lake Carpentaria was one of the most dramatic alterations to the Australian coastline arising from sea-level change. At times of lower sea level from around 70 ka to ca. 12.2 ka, Lake Carpentaria was a large freshwater body. It varied greatly in size and salinity but reached a maximum extent of 190,000 km^2 at 14 ka. Around 11.7 ka, rising sea levels breached its northern edge at the Arafura Sill, leading initially to brackish conditions then to fully marine environments (Reeves et al. 2008, Yokoyama et al. 2001; Sloss et al. 2018). This now marine bay continued to expand far beyond the former edge of the lake until 4 ka, before shrinking slightly to its current extent around 500 years later as the sea settled back to its current level. Morphy et al. (2020) have speculated that the isolation of

Ym is not due to its migration into the area after sea-level stabilisation, but to the fact that Ym speakers might have formed part of a wider PN group around palaeo-Lake Carpentaria who became isolated in place by the marine inundation. Morphy et al. further suggest that all PN languages originated in the plains now submerged in the Gulf of Carpentaria, dating Proto-PN further back in time to 8 ka. The relationship between linguistics and sea-level change remains obscure but there may well be links between sea-level change and the emergence of a major linguistic group at the margins of the Gulf (Memmott et al. 2016).

The regional character of archaeological material culture from the Northern Territory has a significant bearing on the search for submerged sites. Caves and overhangs have been attractive targets for submerged site prospection in Australia (Dortch 2002; Nutley et al. 2016) and these features are strongly associated with archaeological activity in the Northern Territory (Clarkson et al. 2017; Shine et al. 2015; Wesley et al. 2018). Such features occur in bedrock outcrops, which are common in the terrestrial part of the Northern Territory but appear to be relatively rare offshore, although some may not be visible due to low quality bathymetric coverage. Their apparent rarity, as well as the large size of those that can be traced, suggests they would have been important landmarks on the relatively flat coastal plains of the now-submerged continental shelf, and perhaps foci of activity and places of cultural significance (**Error! Reference source not found.**). These features can be traced through bathymetric data and seabed mapping literature, and the most substantial are the Volsella and Duddel Shoals (Jongsma 1974, 40; US Defense Mapping Agency 1978:32), the Money Shoal (US Defense Mapping Agency 1978:38) and the Cootamundra Shoals, where some submerged caves have been identified by divers (Flemming 1986).

Stone tools are common features of submerged archaeological sites, and account for all the material thus far found at Murujuga (Benjamin et al. 2020). Their form and raw material vary substantially by region. Typical lithic forms of the Northern Territory include unifacial points, bifacial points, bipolar cores, flaked pieces, retouched and unretouched flakes, ground stone axes, and grindstones (Allen and Barton 1989; Clarkson 2007; Clarkson et al. 2015; Faulkner and Clarke 2009; Hayes 2015; Hiscock 1996, 1999; Schrire 1982). In the terrestrial contexts of the Northern Territory, they are typically made from quartz, quartzite, silcrete, fine-medium grained sandstones, mudstone, siltstone, and a wide range of volcanic stone (Allen and Barton 1989; Clarkson 2007; Hayes 2015; Hiscock 1996, 1999; Schrire 1982), although this may vary in now-submerged areas. Lithic transport and trading may have had increased importance at times of lower sea level, given the greater rarity of bedrock outcrops which are often exploited as quarries.

Rock art in the Northern Territory is prolific and is known to date back to the Pleistocene (Hiscock 2008:110), including possible motifs of extinct megafauna (Chalmin et al. 2017; Cobden et al. 2017;

Lewis 2017; Murray and Chaloupka 1984). In this region, rock art is produced using ochre, haematite and beeswax, and by the techniques of pecking, abrading, and engraving (e.g. Brady et al. 2020; Chaloupka 1993; Jones and May 2017; Lewis 1988; May et al. 2017, 2020; O'Connor and Fankhauser 2001; Taçon and Chippindale 1994; Watchman et al. 2000; Wesley et al. 2018). Ochre and haematite crayons have also been recovered from early contexts in archaeological sites (Clarkson et al. 2017; Jones and Johnson 1985; Taçon and Brockwell 1995). Unless protected by sediment prior to inundation, exposed pigments produced from claystone, kaolinite or charcoal are unlikely to have survived inundation, although haematite applied to sandstone is more resilient (Nutley 2005:94) and has proven resistant to weathering in early western Arnhem Land rock art assemblages (Chaloupka 1993). Pecked, abraded, or engraved rock art is more likely to survive inundation; petroglyphs from the Northern Territory have been recorded on hard durable stone such as granite in open site contexts on the Reynolds River coastal plains (Guse 2006).

Northern Territory rock art shows potential connections to periods of lower sea-level. Research undertaken by Aubert et al. (2014) and David et al. (2012) has significantly shifted the timeline for the existence of figurative ancient rock art systems in South East Asia and northern Australia well into the Pleistocene. Aubert et al. (2014) have highlighted 'marked similarities' between rock art in Sulawesi dating to 39.9 and 17.4 ka with Large Naturalistic Style (LNS) figures in northern Australian rock art provinces. The LNS style is thought to have been followed by the Dynamic Figure style, found in western Arnhem Land (Chaloupka 1993). These figures wear headdresses and bustles similar to those known from Papua New Guinea and West Papua, and Chaloupka (1993:110) suggests that they reflect cultural connections in the period when Australia and Papua were still connected. Even those styles once thought to be relatively late in the chronological sequence in the Northern Territory are now thought to predate sea-level stabilisation, with the Northern Running Figures found to have a minimum age of 9.4 ka and a maximum age likely to be much older (Jones et al. 2017:88). Taçon et al. (1996) used several lines of evidence to suggest that the emergence of the Rainbow Serpent as a common theme in Australian rock art from around 6 ka may reflect cultural shifts resulting from changes in sea level.

Shell mounds, shell middens and earth mounds are some of the most common coastal site types in the Northern Territory and across northern Australia (Allen 1989, 1996; Bourke 2000, 2002, 2004; Brockwell 2006; Faulkner 2013; Hiscock 1999; Hiscock et al. 1992; Hiscock and Hughes 2001; Hiscock and Mowat 1993; Kamminga and Allen 1973; Mowat 1995; Schrire 1982; Woodroffe et al. 1989). Australian midden specialists have speculated that there is a low probability of finding shell middens offshore in Australia (Meehan 1982:2) but there is increasing evidence from other countries of shell middens surviving inundation at least partially intact (Astrup et al. 2019; Astrup et al. 2021;

Cook Hale and Garrison 2019; Larsen et al. 2018). Distinguishing anthropogenic shell middens from natural shell deposits is typically determined by the presence of artefacts, charcoal, burnt shell, non-molluscan faunal remains, stratigraphic layers, and consistency in the size of shells (Rosendahl et al. 2007). Identifying these features in submerged contexts is challenging but may be facilitated by recent methodological developments in sediment analysis to discriminate between natural and anthropogenic shell deposits (Cook Hale et al. 2021).

Sub-tidal fish traps and weirs are another important site type that has been traced internationally, often in the form of stone walls or traps made with organic materials such as bark or fibres (McNiven and Lambrides 2021). Recent and historical records suggest fish traps in the study region were mainly constructed using organic materials (Barber and Jackson 2015; Meehan 1982; Thomson 1938). These can survive inundation (see Bailey et al. 2017) but are less robust than stone-built features. Some regional types of stone fish traps are known in the Northern Territory, including numerous fish traps with stone bases along the coastline of the Crocodile Islands, built with a combination of fibre on a stone base, thought to predate Macassan contact (James 2019). Stone-built fish traps have also been recorded on the Queensland side of the Gulf of Carpentaria (Kreij et al. 2018; Memmott et al. 2008; Rowland and Ulm 2011). Other stone-built structures found in the Northern Territory include large ceremonial stone arrangements (Gunn and Whear 2007; Gunn et al. 2012; Sim and Wallis 2008) as well as smaller hawk hunting hides (Lewis 1988), with some evidence of possible stone-built structures found within rock shelters (David et al. 2012; Delannoy et al. 2013; Wallis and Matthews 2016).

Burials are also potentially present within the submerged area and are well attested from submerged contexts internationally, including Denmark (Bailey et al. 2020), Norway (Glørstad et al. 2020; Nymoen and Skar 2011), Sweden (Nilsson et al. 2020), Italy (Antonioli et al. 1996), Israel (Hershkovitz and Galili 1990) and the USA (Sturt et al. 2018). In the Northern Territory, burial practices include cremation, excarnation, tree burial, log coffins, and primary and secondary burials in rockshelters, sand dunes and middens (Allen and Barton 1989; Lowe et al. 2014; Meehan 1971; Schrire 1982). Below-ground burials in graves or middens, either through inhumation or deposited cremation, are more likely to have survived marine inundation.

Recommendations and future research

This study collates regional data relevant to submerged landscapes in the Northern Territory, highlighting evidence for their existence in this area from both scientific and oral traditions. We have reviewed their extent, landscape history, and the probable nature of archaeological material in them.

The next step is sub-regional studies to characterise the geomorphological character and more localised prospection, which should be undertaken in partnership with Traditional Owner and custodian communities to identify ground-truthing locations using methods such as targeted diving.

At the regional-scale it is possible to begin to narrow down where these studies should be targeted. The least prospective zones in the study area are within the low-lying basins where marine and terrigenous sediments are likely to have accumulated over palaeolandsurfaces to a significant depth, and also within areas of high erosion, such as narrow tidal channels between islands and the mainland and areas scoured by prolonged exposure to high energy coasts. The most prospective areas are likely to be those where accumulation of protective sediments is balanced by erosion to expose part of the palaeolandscape at the seabed surface, around landforms such as archipelagos, submerged caves, rocky headlands or beach ridges and at the margins of submerged palaeochannels (Bailey et al. 2020). Given the large scale of the region and the remote nature of parts of it, the logistics of maritime archaeological fieldwork must also be considered.

Taking these key factors into consideration, the areas around Darwin and Bynoe Harbours provide varied and partially sheltered environments with maximum availability of facilities to support fieldwork. Shorelines in Darwin Harbour are generally prograding, while Bynoe Harbour shows a more attractive mix of prograding and retrograding coasts. More remote areas attractive for prospection include the Tiwi Islands, the Wessel Islands, the Gulf of Carpentaria, Groote Eylandt and the Sir Edward Pellew Islands, where the focused energy of currents and tides may provide windows of opportunity through erosion of sediments. Areas where substantial baseline data on traditional knowledge have been published are also attractive for fieldwork. The Sir Edward Pellew Islands in Yanyuwa Country are one such example. Anthropologist John Bradley has been working with the Yanyuwa for over 40 years, and compiled an extensive record of Yanyuwa knowledge concerning the complexity of relationships between people and Sea Country (e.g. Yanyuwa Families et al. 2003). In addition, the *Barni Wardi-mantha Awara Yanyuwa Sea Country Plan* (Bradley and Yanyuwa Families 2007), is one of five pilot plans funded by the Australian Government to support engagement of coastal Indigenous groups in marine planning. To the north, at Groote Eylandt (Figure 8), there has been sustained effort to record Anindilyakwa oral traditions (Clarke 2002; Clarke and Frederick 2006) while traditional knowledge of the coastal and underwater ecological environment around the island has recently been mapped in detail (Davies et al. 2020), making this an ideal location to merge multiple perspectives in the search for submerged archaeology.

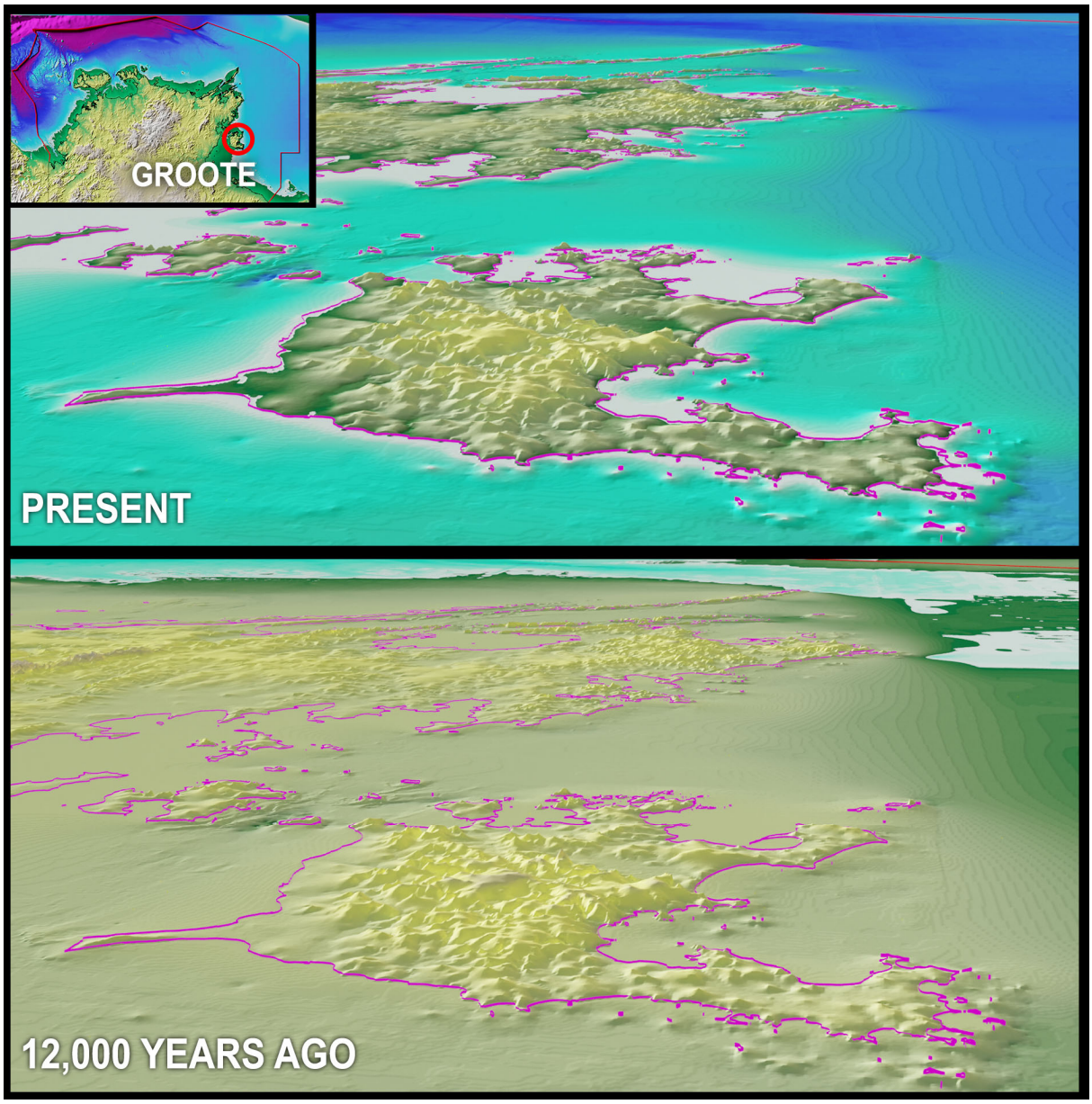

Figure 8. A perspective view of Groote Eylandt's topography as it appears now and at 12,000 years ago. Contains GEBCO 15 ArcSecond raster data (Public Domain).

Elsewhere in the world, in areas such as the Baltic, the North Sea and North America, where submerged landscape research is highly active, the management of submerged landscapes has become fully integrated into the marine planning regime, taking a place alongside related environmental disciplines such as marine ecology (Bailey and Flemming 2008; Bailey et al. 2020; Harff et al. 2016). The nature of submerged landscapes is such that archaeological potential must be considered iteratively at the macro-, meso-, and micro-scale (Wiseman et al. 2021). At the meso-scale, regional desk-based studies have been key tools for management and research into submerged landscapes.

These studies can be undertaken through strategic marine planning studies, academic research or through Archaeological Research Frameworks, as implemented in the United Kingdom. Regardless of the mechanism, the regional-scale study provides a key link between national-scale analysis of sea-level change undertaken by climatologists and geoscientists, and site-level investigations carried out by archaeologists.

In Australia, this study presents the first baseline study for submerged landscape archaeology at a regional or territorial-scale. This scale of assessment provides a crucial step for management of submerged landscapes, and the development of high potential target areas for diver-based survey. The prioritisation of similar regional scale studies to those in the UK and USA allows for a focus on submerged Indigenous archaeology that is not otherwise evident at a state-scale, with significance for marine planning and offshore industry.

Conclusions

This study has shown how regionally-specific evidence for material culture and oral traditions can be related to sea-level change and demonstrates some of the insights that can be gained from regional synthetical studies to provide a regional perspective that has been generally lacking in Australia. There is clear potential in northern Australia to find former Pleistocene landscapes and Indigenous occupation sites, and to gain insight into early colonisation, internal migration, land use and occupation.

Australia should follow examples of best practice from other parts of the world and take a coordinated and consistent nationwide approach, commissioning a series of regional studies of submerged archaeological landscapes, either through strategic planning (perhaps as supplementary studies for the marine bioregional studies), through Archaeological Research Frameworks or through other governmental or academic studies. Whatever the mechanism, a coordinated and consistent approach is likely to give the greatest benefit and will support greater awareness of and protection for inundated archaeological landscapes.

Acknowledgements

This article arises from research funded by the Northern Territory Government and we would like to acknowledge the support of the NT Heritage Branch and funding provided through the *Underwater Cultural Heritage Act 2018* (Cwlth).

Disclosure statement

DS is employed by the NT Heritage Branch who funded the initial study represented in this article; however, he was on leave during the time of application, funding and initial development of this project. The authors declare no other conflict of interest.

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