Saving the past from the future

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Abstract

Australian archaeologists and cultural heritage managers have shown limited interest in the impact of human induced global warming on cultural heritage. The issue has also failed to find a significant place on government and non-government climate change agendas. This is not surprising since archaeologists are aware that past climates have varied on natural cycles that range from 100,000 years to decades and also that humans have adapted to such changes. Cultural heritage managers are also called on to give priority to a range of other natural and human impacts on cultural heritage. Principal threats to heritage places are the same as those endangering biodiversity and we should therefore become involved on a multidisciplinary basis with scientists and planners dealing with these issues. One approach is to develop geindicators to monitor changes that take account of a range of human and natural impacts, including potential global warming, and develop risk maps and a strategic approach to management. Aspects of this approach are briefly demonstrated by reference to the Keppel Islands off the central Queensland coast.

Introduction

Future climate change scenarios all suffer from considerable uncertainties but climate change, as it has done in the past, will continue to impact on cultural heritage places. There are also many other potential impacts on cultural heritage places and a much greater emphasis needs to be placed on long-term monitoring of both human and naturally induced changes. Geindicators can be developed that measure the extent and direction of such changes across a range of environments. These are cost-effective, easy to measure and can be applied at appropriate time scales. A brief outline of their relevance is demonstrated by reference to the Queensland coast.

Getting heritage issues on the global warming agenda

The issue of the impact of global climate change and its likely impact on cultural heritage sites (including archaeological sites) has had intermittent attention in Australia. In 1990 the Australian Archaeological Association Annual Conference in Townsville included a session ‘Coasts, Islands and the Greenhouse Effect’, although only two papers (Rowland 1990; Sullivan & Hughes 1990) specifically addressed the issue of climate impacts on cultural heritage. In May 1991 a workshop was held in Canberra on the ‘Effects of Climate Change on Australia’s Cultural Heritage’. Papers from the workshop were published and a number of recommendations made but they have not been implemented (Department of the Arts, Sport, the Environment and Territories 1992: 82–84; but see also Rowland 1992). A special issue of Tempus published in 1996 on issues in management archaeology (Smith & Clarke 1996) contained two papers under the header ‘The Greenhouse Effect’ (Pearson & Williams 1996; Rowland 1996). A paper by the author (Rowland 1999a) published in the Australian Journal of Environmental Management was an attempt to raise the issues among a broader audience. Despite these discussions there appeared to be little uptake of these issues by heritage managers and practitioners. For example, Australia ICOMOS reported that the Canberra workshop covered an ‘important issue’ (Brooks 1991) but it was not raised in Australia ICOMOS Cultural Heritage Places Policy (1998), nor discussed in standard textson cultural heritage management in Australia (e.g. Pearson & Sullivan 1995). A National Heritage Convention in Canberra in 1998 produced a publication of key outcomes but did not include reference to the possible impacts of climate change (Australian Heritage Commission 1998a). A comprehensive Australian Heritage Commission publication on protecting local heritage places, also failed to mention climate impacts (Australian Heritage Commission 1999b). Enhanced greenhouse impacts were discussed in Chapter 5 of Australia State of the Environment 1996 report, but potential impacts on cultural heritage were not mentioned in the chapter on Natural and Cultural Heritage (Purdie et al. 1996: Chapter 9).

Australia ratified the Framework Convention on Climate Change on 30 December 1992. Australian initiatives from the Kyoto Conference included the establishment of the Australian Greenhouse Office and drafting of the National Greenhouse Strategy 1998. The draft made no mention of cultural heritage. A response to the draft from the then Queensland Department of Environment and Heritage (dated March 1998), via the Department of Premier and Cabinet, did include a recommendation that cultural heritage be included in the priority areas for impact assessment in Module 8. Unfortunately, this did not translate into The National Greenhouse Strategy (1998), While natural heritage is identified in a general way (1998: 90) cultural heritage is not mentioned.

Public and government interest in climate change issues have grown exponentially since the late 1990s. For example, in Queensland the Environmental Protection Agency convened a Climate Change Workshop in August 2001. A discussion document (Queensland Environmental Protection Agency 2001: 34) produced for the workshop included a brief section on cultural heritage referring to several published papers on the subject (Rowland 1990, 1992, 1996, 1999a). Submissions were also tabled from a limited number of traditional owner groups. Subsequently, the Queensland Government produced a public discussion paper but cultural heritage was not mentioned (The State of Queensland, Department of Natural Resources and Mines 2005). Later the government produced a document which aimed to shape the development of a Queensland Climate Change Adaptation Action Plan (Adaptation Action Plan) (The State of Queensland 2006). This report noted ‘climate change impacts on indigenous communities’ as a theme to be developed but did not mention cultural heritage. The National Climate Change Adaptation Framework (Commonwealth of Australia 2004) does not identify cultural heritage as an issue.

The 2003 Queensland State of the Environment report pays only passing attention to the impact of climate change on cultural heritage (State of the Environment Queensland 2003:9.23) and the Australia State of the Environment 2006...
report does not link climate change and cultural heritage, nor are they linked in an independent report (Australian State of the Environment Committee, 2006 Chapter 9 ‘Natural and Cultural Heritage’; Beeton et al. 2006: 77). Cultural heritage is not mentioned in a proposed national approach to coastal zone management (Natural Resource Management Council 2006). The Queensland State Coastal Management Plan prescribes the inclusion of climate and related sea-level issues into local planning but while environmental impact studies now address greenhouse issues, none of the archaeological reports that form a component of these studies has done likewise (Rowland 1992: ‘31–32). A Queensland Climate Change Centre of Excellence was established in March 2007 as a specialist unit within the Department of Natural Resources and Water. It has so far produced – ClimateSmart Adaptation 2007-2012 – in which there is a recommendation to produce by 2008 an online “Best Practice Sustainable Tourism” package that involves advice for businesses on ‘best practice in environmental tourism and cultural heritage management’ (Queensland Government 2007: 27). The Queensland Government has also produced ClimateSmart 2050 (The State of Queensland 2007) but this does not mention cultural heritage.

It is reasonable to conclude from the above discussion that archaeologists and cultural heritage managers in Australia have not shown a significant interest in the impact of climate change on cultural heritage (for exceptions see Spennemann and Look 1998; Spennemann 2005; Pearson and Williams 1996). Equally the issues have not been considered by government and non-government agencies.

Some reasons for an apparent lack of interest in climate change impacts on cultural heritage

That humans contribute to global climate change is not a new idea. Theophrastus (c. 370–285 BC) a pupil of Aristotle, for example, raised the possibility that the clearing of woodlands might lead to warmer climates (Rowland 1996). More recently, Ruddiman (2005) proposed that from 8000 years ago humans began adding carbon dioxide and methane to the atmosphere through forest clearing, rice farming, and raising domesticated animals. An alternative view is that we have escaped the ‘reign of chaos’ of the Pleistocene in which climate controlled us, to arrive at a more stable Holocene allowing for human control over the environment (Burroughs 2005). However, because of the enormous complexities involved in climate change processes, abrupt and unexpected surprises will always be a feature of climate systems (Schneider 2003). An awareness that climate can change abruptly is relatively recent (e.g. Alley 2000; National Research Council 2002). In the late 1960s/1970s debate centred on the question of whether or not the world was heading toward a new ice age (Pearman 1988). Since the 1970s/80s however global warming has become a dominant issue, with the media reproducing scenarios that range from tales of impending doom through to a hoax perpetrated by scientists to obtain jobs and funding (Rowland 1996: 128).

In an analysis of the impact on the public of the movie The Day After Tomorrow Lowe et al. (2006) found them frustrated and confused by mixed messages from academics and politicians concerning climate change. Public perception was that there was little agreement among the experts and a majority expressed greater concern for other issues including personal income, crime reduction and education. Lowe et al. also identified a perception that climate is already changing and a recognition of the adaptive capacities of humans.

The Stern Review raised the issues of climate change to a new political level in Australia but questions have been raised concerning both the scientific basis and the derived economic implications of the review (Stern 2006, see also Carter 2007). The release in February 2007 of the Intergovernmental Panel on Climate Change (IPPC) report might have been expected to have removed any doubt about the influence of humans in the process of climate warming. However, uncertainty remains. It would seem both inappropriate and unhelpful, for example, for the editor of the prestigious journal Nature to claim that the evidence from the IPCC report should remove ‘the last ground from under the climate-change sceptics’ feet, leaving them ‘looking marooned and ridiculous’ (Editor Nature 445 2007: 567: emphasis added) – since subsequent papers in the volume do demonstrate the degree of uncertainty and disagreement. Schiermeier (2007), for example, refers to the ‘wissy wissy’ language of the report suggesting this is understandable ‘in a field that is still, in some areas, shot through with uncertainty’. It is also noted that while the IPCC report is considered a consensus report this does not mean that everyone agrees. John Christy, a climatologist at the University of Alabama, for example, notes ‘I am one of the 2000 with their names on [the assessment], but don’t sign me up for the catastrophic view of climate change’ (Anon 2007: 582). A further paper by Pielke et al. (2007: 597) makes the important point that vulnerability to climate-related impacts are increasing for reasons that relate more to rapid population growth, an issue discussed further below. An increasing number of scholars predict global catastrophe (e.g. Diamond 2005; Linden 2006) resulting from human impacts on the environment. Archaeologists in particular however are aware that the desire to improve the conditions of life is one that has driven humanity from the earliest times. In relation to climate, humans for example, adapted to the massive changes of the Last Ice Age, the Younger Dryas, and the lesser changes of the Medieval Warm Period, the Little Ice Age and particularly in Australia to the El Nino-Southern Oscillation. Another archaeologist who has recently reviewed the evidence comments that ‘on the basis of what I know about the past, I remain optimistic that people will manage. In the end, the best advice this archaeologist has to offer … [is] … DON’T PANIC!’ (Lilley 2006 no pagination, see also Redman 1999: 214-15).

In sum, archaeologists are aware that humans have had a significant impact on the environment over a long period of time. They are also aware that climate change of different intensities and time scales is a natural process that has impacted both gradually and abruptly on humans. Cultural heritage places are also subject to a multitude of diverse threats which range from pollution and natural disasters to economic pressure, development projects and uncontrolled tourism (Hassler 2006). Significantly, in his popular and somewhat alarmist book on climate change it takes Flannery (2005) until page 294 to recognise that a root cause of human induced climate change is the total number of people on the planet. By the year 2030 a key date for climate predictions, there will be for example 11–15 million extra Australians located in the coastal zone, as are 85% of the present population (Department of Immigration, Local Government and Ethnic
therefore clear that there are numerous factors that impact on cultural heritage places and that there is a need to be cautious in getting side-tracked by the current high profile of the global warming debate. This is not to deny that human induced climate change is occurring, indeed it has probably been occurring for over 10,000 years.

How should archaeologists / cultural heritage managers respond?

Archaeologists/cultural heritage managers need to develop a rational, tempered response to change which incorporates potential natural and human induced global warming effects along with a host of other potential long- and short-term environmental changes. This will require ongoing research, monitoring and assessment of cultural heritage places. It also requires the cultural heritage profession to assess their expertise, and the extent and quality of resources available to deal with change. In particular there is a need to address an ability to cope with large scale salvage projects as total loss of sites may be more common. Strategies for responding to change need to be framed in terms of the uncertainty of potential global warming, the extent of normal variability in environmental factors, the impact of other perhaps more dominant human-induced changes and the concerns of heritage owners or users. Environmental changes and increasing human development will continue to impact on heritage resources and the global warming debate should therefore re-emphasise the need to continue to define and refine the processes involved in cultural resource management. The principal threats to heritage sites are the same as those endangering biodiversity and we should therefore become more involved on a multi-disciplinary basis with scientists and planners dealing with these issues (Rowland 1996: 131–133). Indigenous people have a significant role in observing change, developing adaptive models to cope with change and of course it will be their cultural heritage that will be impacted so that they must be involved in all decision making processes (Rowland 1996; 1999a). Some of these issues are discussed below in the context of the coastal zone.

The coastal zone

Australia’s coastal zone includes the coastline, nearshore reefs, nearshore islands, nearshore parts of the continental shelf, estuaries, tidal flats, coastal sand dunes and the coastal land margin (Voice, Harvey & Walsh 2006: 1). It therefore incorporates among other things: over 80% of Australia’s population, many top tourist destinations (including World Heritage and National Heritage sites), around 1000 estuaries, seven capital cities, globally significant ecosystems including coral reefs, mangroves and seagrasses, many ‘sea change’ shires, the conduit to our export economy and a significant percentage of Australia’s water resources. The impact of climate change on coastal systems is therefore likely to be significant but difficult to predict (e.g. Cowell et al. 2006). Causes of sea-level variation, that are independent of global warming, may be overlooked. For example, ongoing vertical crustal adjustment to changes in ice and water loading is an important factor in many regions so that in some places relative sea level is still falling (Forbes & Liverman 1996: 179). This may account for the fact that from 1950 to 2000 Australia had a slightly lower (1.2mm) rate of sea-level rise than the global average of 1.8±0.3mm per year (Church & White 2006).

Complex changes will therefore occur in the coastal zone, whether caused by normal climate variation or anthropogenic induced warming, and will impact on both Aboriginal and European places (Rowland 1996: 131). To date however little has been done to monitor these potential changes and impacts. In the following discussion I refer firstly to changes that have impacted on sites on the Keppel Islands located in the coastal zone.
long term environmental trends and secondly on personal observations made over a period of 30 years. I then propose the need to establish some measures (geoindicators) that can be used to identify the nature and direction of changes in the coastal zone in the future.

The Keppel Islands

The Keppel Islands lie at 23°11’S 150°05’E off the coast of central Queensland, offshore from Rockhampton (Figure 1). Archaeological investigations on the Keppel Islands commenced in 1978 and have continued to the present (see Rowland 2007 for details). The biogeography of the islands is discussed by Creighton (1984).

Aboriginal people occupied the Keppel Islands from prior to 4000 years ago, probably soon after they became islands. The first European residence on South Keppel Island was established by 1883. At times, as many as 3000 sheep were grazing on the islands and goats and possums were also introduced. Tourism developed on the islands from the late 1960s. Thus apart from natural impacts the presence of sheep, possums, goats, tourists and tourism infrastructure developments has impacted substantially on the islands (Rowland 2007).

The Keppel’s are continental islands, cut off by submergence from the mainland by the Post Pleistocene Marine Transgression. They are only partially sheltered from the influences of oceanic swells by the Swains Reefs to the north, and the Capricorn Group to the south. Pleistocene remnant sands are present on high dune areas at Long Beach, Wreck Beach and Red Beach on South Keppel Island. Holocene dune formation is variable. For example, at Considine Bay on North Keppel and Putney’s Beach on South Keppel a series of Holocene sandridges extends landward up to 1.5km. At Putney’s Beach, at least six accretion cycles can be observed with the start of each cycle indicated by an erosion scarp in to a previous accretion zone, followed by a further accretion ridge to seaward with the two ridges separated by a slight depression. Both of these areas are orientated towards the northwest with similar local onshore and offshore topography. Wreck Beach and Little Wreck Beach on South Keppel Island are by comparison exposed to easterly swells and winds, resulting in foredunes, of up to 5 metres in height. Landward of these foredunes, particularly in the case of Wreck Beach, previously active blowouts occur (Figure 2).

Sea Levels

The timing and magnitude of Holocene sea-levels on the east coast of Australia are still uncertain. Chappell’s (1983) smoothly falling sea level from 6000 years ago has long remained the paradigm. More recently Baker, Haworth & Flood (2001) have suggested the sea level oscillated up to three times over the last 6000 years. More recently still, Lewis et al. (2008) have proposed a high stand of +1.0-1.5m was reached approximately 7000 cal yrs BP and that sea level fell to its present position after 2000 years. In between this there were then two distinct periods (4800-4500 and 3300-2700 yrs BP) of possibly lower sea level of +0.5m. This is consistent with a hiatus in dune development at Mazie Bay at 3500 years ago related to a change in sea level (see Rowland 1999b). Evidence from the Capricorn Coast also suggests a fall in sea level of approximately 1 metre prior to 1500 years and a fall of 0.5 after 1500 years (Brooke et al. 2006a and b; Delvin et al. 2001). Over the last 200 years sediments have accreted to form a beachridge plain approximately 3km wide that extends from Cattle Point north to Keppel Sands on the Capricorn coast. Catchment derived sediments and nutrient discharges have increased four fold since European settlement, primarily as a result of the clearance of native vegetation for agriculture (Bostock et al. 2006a and b).

Climate

The climate of Keppel Bay is sub-tropical, sub-humid with a
concentration of rainfall in summer and a fairly high degree of rainfall variability. The most significant dynamic climatic feature of the area is the incidence of tropical cyclones and associated storm surges. On average the region suffers the effects of tropical cyclones once every two years, although occurrence of widespread cyclonic destruction in the area is a much rarer event. The frequency of cyclone occurrence in each decade since 1909 is shown in Table 1.

<table>
<thead>
<tr>
<th>Period</th>
<th>Number of Cyclones</th>
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<tbody>
<tr>
<td>1909-1920</td>
<td>5</td>
</tr>
<tr>
<td>1921-1930</td>
<td>4</td>
</tr>
<tr>
<td>1931-1940</td>
<td>6</td>
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<tr>
<td>1941-1950</td>
<td>13</td>
</tr>
<tr>
<td>1951-1960</td>
<td>4</td>
</tr>
<tr>
<td>1961-1970</td>
<td>5</td>
</tr>
<tr>
<td>1971-1979</td>
<td>4</td>
</tr>
<tr>
<td>1981-1989</td>
<td>6</td>
</tr>
<tr>
<td>1991-1999</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1: Frequency of cyclones passing within 320km of Keppel Bay (Beach Protection Authority, 1979-73, figures for 1981-89, 1991-1999 provided by Greg Stuart, Coasts, Wetlands and Waterways Branch, Environmental Protection Agency, Brisbane)

Cyclones have produced short periods of shoreline erosion in Keppel Bay. For example, beaches of the Capricorn Coast receded by at least 4 metres during cyclone David in 1976. The eroded sand was moved into the near shore zone and subsequently, within a few months, transported back onshore under normal wind, wave and tidal conditions. Over the last 1500 years, approximately every 500–200 years there have been rapid episodes of beach ridge formation that lasted a few decades or less followed by relatively quiescent periods. It is argued that this periodicity is related to major flood discharge events of the Fitzroy River induced by the onshore passage of high-magnitude cyclones. The decline in rate of ridge formation may be related to phases of global climatic cycles that have a roughly 1500 year periodicity (Bond events). Also noted was a general decline in the rate at which sediment accumulated during the last 1500 years that likely reflects a long-term decline in major rainfall events in the Fitzroy River catchment. More recent events in the area include coral bleaching recognised around the Keppel’s (Elvidge et al. 2004; Wettle, Dekker & Blondeau-Patissier 2006) and based on historical records from 1941–1999 evidence of mangrove gains and substantial loss of saltmarsh. While these changes are attributed to human factors there are also indications that climate change was involved (Duke 2003). Predictive modelling for cyclones and storm surges for parts of the Capricorn coast has been undertaken but they did not incorporate impacts from greenhouse warming and make no major reference to the Keppel Islands (Connell Wagner 2003).

Archaeological investigations

Initial archaeological research on the Keppel Islands did not incorporate systematic recording of the condition and extent of sites recorded and time was not available to undertake systematic mapping of individual sites, with the exception of Maza Bay and Stockyards Beach on North Keppel Island. Nevertheless, in the process of achieving certain research goals, most of the islands were systematically surveyed and issues of site location, preservation and erosion became a major focus of interest (e.g. Rowland 1989 and 2007). Therefore over a period of thirty years some general observations have been made, photographic data and notes maintained and anecdotal information collected which allows for some general impressions of site disturbance and management issues to be identified.

Discussion

The major cause of damage to coastal sites on the Keppel Island Group over the last 5000 years has been the long-term impact of wind and wave climates. This ‘normal’ process of wind and water erosion is exacerbated by natural and human induced vegetation removal. Introduced sheep, goats and possums have also been a major source of vegetation destruction on the islands. Contrary to expectations tourists have probably had a limited impact on most sites.

‘Normal’ weather conditions have had a significant impact on sites by causing damage to vegetation, resulting in substantial erosion over short time-spans. Stochastic events such as cyclones and flood discharges from the Fitzroy River have also had significant impacts. For example, Cyclone Fran which passed within the vicinity of the islands in March 1992 had significant impacts on Wreck Beach, Monkey Point, Little Peninsula and Fisherman’s Beach. More than 1 metre of sand was lost from Fisherman’s Beach during the cyclone though it is important to note that this has now largely been replaced and revegetated. On South Keppel Island, local fishermen have reported erosion of at least 15 metres over a 40-year period at Putney Beach and Fisherman’s Beach and these beaches, not surprisingly, produced no evidence of Aboriginal occupation (see Rowland 2007 for details).

Management and monitoring – a case for using geindicators

The management and monitoring of coastal sites has not been widely discussed in Australia (but see Aboriginal Affairs, Victoria 2000; Bonhomme & Buzer 1994; Cane 1997; Smith 1998; Snelson, Sullivan & Preece 1986; Watson 1993; Zaltar 1978). The management of coastal sites is inherently difficult and problematic including critical issues of scale and cost (for a brief but useful overall review see Sullivan 1989). It is therefore proposed that geindicators be used as a measure of change as discussed below.

Geindicators are measures (magnitudes, frequencies, rates, and trends) in geological processes and phenomena occurring at or near the Earth’s surface which are subject to changes that are significant in understanding environmental change over periods of 100 years or less. They measure both catastrophic events and those that are more gradual, but evident within a human lifespan. A range of geindicators have been developed during a three-year international project by the Commission on Geological Sciences for Environmental Planning (International Union of Geological Sciences). They are designed for use in environmental and ecological monitoring, state of the environment reporting, and general assessments of environmental sustainability on local, national and international scales. They measure what is happening in the environment, why it is happening and what impacts it is having (see Berger 1996: 384–385; Cogeoenvironment (IUGS) working group on...
Geoindicators 1996; see also Young, Bush and Pilkey 1996: 194: Table 1 who have developed further geoindicators that can be used for the qualitative assessment of shoreline erosion or accretion). Geoindicators apply to a number of land systems but here space allows for reference only to coastal systems. Three coastal geoindicators – dune formation and reactivation, relative sea level rise and shoreline position – are described below and their relevance to monitoring change on the Keppel Islands and Queensland coast is briefly outlined (Table 2).

Wreck Beach
The use of geoindicators is demonstrated very briefly by reference to one site complex – Wreck Beach on South Keppel Island using air photos from 1962, 1992 and 2001 and the personal observations of Carl Svendsen and myself. Archaeological remains were first recorded at Wreck Beach in 1979 (JF:A99 and JF:B08). The site was further inspected in November 1979 and excavations were undertaken in 1980 (see Rowland 2007: 59 – 62 for details). The Wreck Beach unit extends the length of Wreck Beach and landward about 0.5km and extends through to Big Sandhill’s Beach. Holocene sands in the area frequently overlap Pleistocene sands in landward areas and this is particularly marked at the southern end of the beach. In 1980 the beach dune scarp was 4 metres to HWMS (High Water Mean Spring) with no incipient foredune. The area from Wreck Beach to Big Sandhills Beach is an active dune

Table 2: Three coastal indicators applied to the Keppel Islands (see Berger 1996).

<table>
<thead>
<tr>
<th>Geoindicator</th>
<th>Type of Change and Impact</th>
<th>Measurement</th>
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<tr>
<td>Dune formation and reactivation</td>
<td>Changes in dune morphology and movement can result from variations in aridity, changes in wind patterns and human disturbance, such as alteration of beach processes and sediment budgets, destruction of vegetation cover by trampling or vehicle use, overgrazing, and the introduction of exotic species.</td>
<td>These changes can be measured by changes in size, shape and position of sand sheets and dune fields can be monitored by repeated ground surveys and measurement of active and dormant/relic dunes, by air photos, or by satellite images (Berger 1996:400-402).</td>
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<tr>
<td>Relative Sea Level</td>
<td>Numerous mechanisms can raise or lower sea-levels (Stewart et al 1990), a number of which such as subsidence, tectonic emergence or submergence and/or post-glacial rebound are not directly related to climate change, while the IPPC projects that thermal expansion will be the main component of sea-level change in the 21st century. All are difficult to measure. Changes in RSL may alter the position and morphology of coastlines, causing coastal flooding, waterlogging of soils and a loss or gain of land. They may also create or destroy coastal wetlands and salt marshes, inundate coastal settlements, and induce salt-water intrusion into aquifers, leading to salinisation of groundwater. Modelling has predicted that inundation would cause sandy beaches on the Australian coastline to recede by an order of 100 times the vertical sea-level rise.</td>
<td>RSL can be measured by tide gauges, GPS techniques and levelling surveys to identify changes in coastal land elevation. Holocene RSLs are commonly documented by locating a feature associated with a former sea level and determining its present elevation and age. In general, coastal lagoons, barrier coral reefs, and flooded river mouths imply submergence. More specific indicators include raised strandlines and marine shell deposits. Distinguishing land subsidence or uplift from submergence or recession due to other sources of sea-level change is difficult (Berger 1996:419-421).</td>
</tr>
<tr>
<td>Shoreline position</td>
<td>Shoreline position varies over a broad spectrum of time scales in response to shoreline erosion (retract) or accretion (advance), changes in water level, and land uplift or subsidence. Erosion and sediment accretion are on-going natural processes along all coasts. Human activities (e.g. dredging, beach mining, river modification, installation of protective structures such as breakwaters, removal of backshore vegetation, reclamation of nearshore areas) can profoundly alter shoreline processes, position and morphology, in particular by affecting sediment supply (Berger 1996: 426-429). It has been estimated that seventy percent of the worlds’ coastlines have retreated over the past few decades, less that 10% have shown substantial progradation and only 20-30% have shown no change or been stable though these changes cannot be attributed entirely to climate change (Bird 1985, Rowland 1996:130).</td>
<td>Using conventional ground survey and other methods (simple rod and tape profiles, levelling, electronic total-station surveys, air photos, GPS, analysis of old maps and charts) a number of parameters can be measured such as width of dry beach, changes in position of foreshore and backshore vegetation (Berger 1996:426-429).</td>
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field. Wreck Beach is protected from major wind and wave action at its southern end. However a creek exits at this point and goats have removed vegetation, resulting in exposure of archaeological material. It is possible that occupational deposits extend the length of the beach, but as one proceeds from the sheltered end overlying deposits of recent wind blown sand are substantial which may have covered cultural deposits.

Big Sandhills Beach (JF:B04) was located in 1978 and revisited in 1979 when vegetation had been reduced by fire. Excavations at the site were undertaken in 1980. Big Sandhills Beach is above HWMS extending some 5 metres landward at which a scarp of some 15 metres is reached, being the toe of a presently active transgressive dune. A slight incipient foredune is present but no creeks are associated with the unit.

There is no doubt that detailed, long-term monitoring is the ideal way to obtain information about the current state of the global environment, rates of change, and the appropriate management techniques required to deal with the changes. However, such monitoring is not currently happening and is unlikely to happen widely in the future. Detailed monitoring is expensive and suffers from the reality that it is in fact long term. Predictive modelling is also rare due to uncertainty of many variables (e.g. Bernier et al. 2007; McInnes et al. 2003); however, the broad level of monitoring outlined in this paper should be sufficient to indicate general trends. Because of the expense and time consuming nature of such monitoring it may be necessary to concentrate on areas of known significance and also to focus on digitising geindicators so that long term assessment and comparisons can be facilitated.

Wreck Beach – big sandhills beach.
Deductions from 1962, 1992, 2001 air photos using geindicators

Dune formation and reactivation

The long elongated transgressive dune (A) has continued to move forward from Big Sandhills Beach through the years 1962 to 2001. The surface of the dunes in 1992 and 2001 would appear to be less well vegetated than in 1962. The dunes at Big Sandhills Beach (B) appear in 2001 to be more completely vegetated than in 1992. The air photo for 1992 was taken in October, Cyclone Fran passed over the island in March 1992 and this cyclone had a significant impact on the island (Carl Svendsen pers. comm.) (see Table 2 for geindicator details and Figure 3 for reference to Wreck Beach and Big Sandhills Beach).

By 2001 the transgressive dune (A) had extended on to the dunes at Big Sandhills Beach. However the dunes at this beach appear to be better vegetated than in 1962 and 1992. There are indications that the dunes at Wreck Beach (C) are beginning to erode in 1992 and this erosion is clearly more marked by 2001. The area (D) at the end of Wreck Beach appears to be relatively more exposed in 1992 than in 2001. The ‘wreck’ (E) in 1992 is not apparent in 1962 or 2001. Carl Svendsen is of the view that the wreck was there in 1962 and 2001 but was exposed by cyclone Fran in 1992.

Relative sea level

The IPCC Working Group (1) ‘Summary for Policymakers’ of the Fourth Assessment Report anticipates a rise in sea level of between 18 and 59 cm by the year 2100. It also indicates an average rate of 1.9 mm per year has occurred from 1961 to 2003, with a faster rate from 1993 to 2003 of about 3.1 mm per year. Oppenheimer et al. (2007: 1505) propose that the Greenland and West Antarctic ice sheets ‘have already had a significant effect on sea level over the past 15 years and could eventually raise sea level by many meters’. In other locations (the Maldives) it is argued that sea levels have in fact fallen over the last 30 years (Mörner, Tooley & Possnert 2004).

There is nothing in the air photos from Wreck Beach/Big Sandhills Beach to support a view that sea level change has impacted on the coastline in this area although more recent air photos and ongoing assessment might reveal such changes.

Figure 3a,b,c: Wreck Beach, South Keppel Island. Comparison of air photos 1962 and 1992, 1962 and 2001, 1992 and 2001.
All that can be indicated at this stage is that some areas appear to have stabilised while others have not.

**Shoreline position**

This variable is difficult to measure without further ground survey and without knowing the time of day (i.e., tide times and when the air photos were taken). Nevertheless, there is no evidence of major changes in this variable. In fact the area of dry beach at Wreck Beach would appear broader and more stable in 2001 than in 1992.

**Conclusions**

The limited evidence from Wreck Beach and Big Sandhills Beach using air photos and anecdotal information over a period of 30 years cannot be used to draw specific conclusions. However, it could be concluded that most of the changes identified can be attributed to ‘normal’ changes in climate patterns and increasing human impacts. At present none of the changes could be attributed to the impact of accelerated global warming. However, the application of basic geoindicators such as those used above should in the future provide clearer trends. Coastal dunes are fragile systems impacted by the dynamic nature of weather and wave climates and a host of human related impacts that occur on a number of time-scales. The magnitude of these changes may also be highly variable and they may be substantially random and unpredictable. Given the range of potential impacts as outlined above it is critical that broad scale long-term monitoring is undertaken and trends identified.

From the moment of their formation, heritage places are subject to processes that modify and may eventually destroy them. In the past the response was to excavate those sites threatened with immediate destruction – to salvage as much information as possible. However, with increasing awareness throughout the 1970s that archaeological resources are ‘non-renewable’, emphasis shifted from this exploitative model to a conservation one and the rise of an extensive literature on Cultural Resource Management (e.g., Schiffer and Gumerman 1977, Sullivan and Bowdler 1984). However with increasing development and the potential impact of human induced warming salting may become more of an issue (Rowland 1992, 1996, 1999a). If worst case scenarios of climate change occur, heritage sites will have a relatively low priority and it is unlikely that funds would be available to preserve sites in situ. Thus there is a need to discuss with heritage owners the potential impact of climate change on sites. This will be particularly important since as noted above the major emphasis in management will of necessity be on salting. The current global warming debate is controversial and there is still uncertainty. There is no uncertainty however that population will increase and demand more space and resources. The climate debate must therefore heighten our awareness of all possible impacts in developing cultural resources management strategies and of the importance of undertaking monitoring programmes that can measure the causes and direction of change.

**Future directions**

It would be costly, time consuming and probably impossible to maintain a comprehensive and sophisticated monitoring system for all coastal sites. Nevertheless two approaches to the monitoring of coastal sites are highlighted which are relevant to the Queensland coast in general. First, anecdotal information could be collected and occasional observations made (as for example was undertaken on the Keppel Islands) which would provide general trends. Such an approach could be supplemented by establishing photo points at some sites, along with marker pegs to determine trends in sand movement. Observations should be undertaken on an annual basis, but in the case of major climate events observations should follow as soon as practical after the event. Second, a major project could be developed to focus on the Queensland coast in general. This would require a risk management analysis of the coast involving mapping landform type, vegetation coverage, climate factors, storm surge, and predicted global sea level rise. It would also involve mapping past and present impacts such as past urban development, present and future development, other coastal works, including mining, tourism, agricultural and industrial developments. At the broadest scale the geoindicators discussed above – dune formation and reaction, relative sea level and shoreline position – could be mapped as indicators of trends in respect to potential global warming and other natural and human induced changes. A series of risk assessment maps could then be produced for the coastline. Digital models of the coastline could also be developed that could be rapidly updated as new data becomes available.


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