THE CHANGING COAST – PROVIDING ROOM FOR NATURAL ADJUSTMENTS

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Abstract

Much attention is focussed on protecting built development and infrastructure in coastal areas as a result of climate change and sea-level rise. In some cases, allowance for the coast to adjust naturally to sea-level rise can provide substantial benefits in reduced protection costs and preservation of natural features that underpin the appeal and value of the coast to residents and visitors. Natural foredunes provide substantial protection for inland areas from storm surges. They provide a buffer to reduce the immediate rate of erosion after a severe storm or series of lesser storm events. Given adequate room to form and reform as sea levels change, they provide these services at a minimal cost. Where the natural rate of adjustment may be slow and leave some hind areas at risk, these processes may be assisted by augmentation/nourishment and revegetation undertaken in a way to mimic or reinforce natural processes. All this may be at substantially lower cost than man-made structures of rock, concrete or other responses, and often with greater appeal to many in the community. Some other shoreline types are also prone to flooding, erosion and slumping. In these cases too, provision of an unoccupied buffer zone between the shoreline and development serves as a low cost form of protection from these coastal hazards while also providing a coastal strip giving the social benefit of public access to the shore along with the conservation benefits of retaining a natural coastal reserve. High value coastal ecosystems may also make a claim on space to adjust. Areas that host shore feeding birds, wetlands that provide habitat for migratory birds (RAMSAR sites) and other coastal habitat that host ecological communities such as salt marsh which have declining areas available may have high ecological value. If there were no coastal development, many of these ecosystems could migrate inland with rising sea levels. Where landscape fragmentation due to roads or other forms of development block this inland movement, or where natural landforms prevent this, these natural coastal communities will be lost. Inventories of high value ecosystems that still have potential to move inland are needed, so as to identify priority sites where allowance for inland migration over time can be ensured.

Key Words: climate change, coastal, adaptation, policy, planning, natural areas, saltmarsh, dunes, erosion, flooding

Introduction

Much attention is focussed on protecting built development and infrastructure in coastal areas as a result of climate change and sea level rise. In some cases, allowance for the coast to adjust 'naturally' to sea level rise can provide substantial benefits in reduced protection costs and preservation of natural features such as beaches and dunes that underpin the appeal and value to coastal residents and visitors. It may have the added benefit of maintaining community access to foreshores that otherwise would be lost.

This paper explores how allowing natural adjustment of coastal areas may provide benefits in cost savings for property protection and enhanced coastal values, both for human use and protection of ecosystem values.

The ideas presented in this paper were in part developed as part of a project undertaken in the Clarence City Council area in Tasmania, and also in part derive from a variety of projects previously undertaken by several of the authors for the Tasmanian Department of Primary Industries & Water and the Break O'Day local government council in Tasmania. The issues discussed

here reflect the conditions prevailing in those situations, and while we consider these to provide insights and approaches with merit in many other coastal areas, we recognise that the range of coastal risks arising from climate change in other locations may not be fully addressed by them.

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The character of the coast

Australians value the coast, with a high proportion of the Australian population living within 100 km of the coast line. The coast plays a major role in Australia's identity, lifestyle and character.

The natural character of the coast is varied, including a wide range of geological and ecological conditions: beaches, lagoons, wetlands, reefs, rocky shores, mangroves and cliffs, to name a few. The natural character of the coast line has been a major attractor to Australians.

Natural coastlines are generally dynamic environments. They are subject to erosion, sediment deposition from long shore transport and fluvial deposits, growing and eroding sand dunes from wind and wave action and active river outlets that often meander widely in response to the dynamics of longshore drift (blocking outlets) and flood events that break through in different locations.

Where there is no development, these adjustments occur in response to seasonal and storm events, with changes over periods of days, weeks, years and centuries.

In contrast, some areas are intensely developed – in particular the waterfronts of the major capital cities and larger coastal towns are often highly modified with sea walls, port developments, groins and other coastal works. These have generally been developed:

- to stabilise otherwise mobile coastal landforms, (dune areas, river mouths)
- to provide economic services, e.g. ports, coastal roads and other infrastructure
- to extend and reclaim otherwise 'unusable' land (filling wetlands and other reclamation)
- to provide additional amenity – coastal footpaths, promenades, etc.
- or as low cost repositories of fill and other wastes including at times waste landfills

These modified coastlines in many cases are now committed to being managed as developed areas, with natural coastal processes heavily modified. In some cases this leads to ongoing maintenance costs as erosion and sediment transport processes act to degrade the coastal modifications.

These modified coastlines may also be highly valued, both for economic services delivered and as social, outdoor meeting places that benefit from the modified coast – e.g. Bondi Beach

Many coastal areas with significant nearby populations fall in-between a fully natural and a highly modified character. This is the case for much of the coastline in the south east of the continent (except where bounded by national parks), as well as populated areas of WA and the Northern Territory. Here development has intruded on natural processes but is far from over-riding or dominating them and much of the original coastal character is still evident.

With climate change, a new set of forces is unleashed to which the dynamic coast will respond. Rising sea levels are more likely to cause erosion than deposition along shorelines. They will inundate areas previously high and dry and will reactivate some areas that have had relatively long term stability through changed storm and erosion dynamics.

Highly modified coastal areas are generally committed to a developed and modified coastline but will face new challenges in

addition to those faced already. Areas that are partly developed will need to assess to what extent they wish to or are able to work against the expected changes or to allow coastal processes room to unfold unmodified.

The discussion in this paper is most relevant to these partly developed coastal areas, where natural coastal processes currently remain active but not fully free to adjust to climate driven changes.

Adjustment to climate change in partly developed coastal areas

Where coastlines remain more or less undeveloped, highly mobile coastal landforms and ecosystems such as beaches, dune systems, wetlands, mangroves and saltmarsh have the potential to adjust to rising sea levels, changing groundwater levels and increased frequencies of inundation by migrating landwards, at least in situations where the present shoreline is backed by low-lying soft-sediment environments that allow such migration.

However, where coasts are already partly occupied by development, this potential may be already wholly or partly forgone. Moreover, where the response to sea-level rise is to defend the coast with hard structures such as sea walls, existing potential for natural shoreline adjustment to the changing conditions will be reduced further, resulting in less natural shoreline and more artificial shorelines with high attendant ongoing maintenance costs. Ultimately, the resulting degradation of natural coastal values will impact significantly on the integrity and enjoyment of the coast, which is the very reason why coastal residential development is widely considered desirable in the first place.

In this paper, we suggest that an approach to coastal management and adaptation to sea-level rise which emphasises the value of leaving undeveloped coastal buffers where-ever this remains feasible can have numerous benefits, both in maintaining the amenity and ecological value of coastal environments, and also in reducing the ongoing costs of sea-level rise adaptation in the long term.

Undeveloped coastal buffer zones in areas of significant coastal development can serve at least four key functions which are valuable irrespective of sea-level rise, but will become increasingly important as sea-level rise places greater pressures on the coast:

- Provide a hazard buffer zone in which coastal flooding and erosion can occur without impacting on infrastructure & assets further inland
- Provide public access to the recreational and aesthetic amenity of the coast.
- Serve a conservation function by allowing maintenance of natural coastal processes in the coastal strip, which is the “active” transitional zone between land and sea where such processes are typically most active and rates of change are highest.
- Serve as an ecological buffer providing space for ecosystems such as coastal dunes, wetlands, saltmarsh and mangroves to persist and migrate landwards as shoreline conditions change.

Given that sea level rise will result in an increased rate of coastal change – with faster shoreline erosion & recession, more extensive flooding, and migration inland of ecosystems such as saltmarsh & dunes – these functions are all the more important as a means of minimising the impacts of sea-level rise by allowing a space in which coasts can adjust without requiring expensive artificial measures to protect assets further inland.

However there is also high demand for development (including roads and housing) in the near-shore zones that could serve as buffers. As sea-level rise progresses, such development may require costly protection against coastal hazards. If on the other hand appropriate buffer zones to accommodate coastal hazards – with sea-level rise taken into account – are identified and maintained, these can serve as a no-cost protection zones while at the same time providing public

amenity, conservation and ecological benefits.

Since a lot of coastal buffer land has already been alienated – and will require costly adaptation decisions in future – it will be advantageous to give priority to identifying coastal locations where it still remains possible to minimise the costs and hazards associated with sea-level rise by maintaining suitable coastal buffer zones.

The following sections describe a number of examples of coastal buffer zone types whose maintenance where-ever still possible would have positive benefits for both society and ecosystems in the process of adaptation to sea-level rise.

Example one – Ecological buffer zones – lagoons and saltmarsh

Coastal salt marshes occur in estuaries, bays and lagoons that are sheltered from strong wave action. They are vegetated by halophytic (salt tolerant) herbs, grasses or low shrubs, which tend to trap and stabilise fine sediment from rivers or longshore drift, to build low gradient silt banks.

Owing to the inundation tolerances of salt marsh species, elevations are restricted to the upper part of the inter-tidal range, from mean sea level to high water levels. Species diversity tends to increase towards upper levels within this. Tasmania has a tidal range of approximately 2-4 metres; hence salt marshes are restricted to less than 2 metres vertical range on open shorelines. They tend to be more extensive consequently where tidal ranges are greater.

Salt marsh vegetation is habitat for a wide range of bioturbating infaunal and epifaunal invertebrates, as well as low-tide and high-tide visitors (such as fish and water birds). The vegetation traps sediment and so improves water clarity off shore to the benefit of benthic communities, and can through accretion keep pace with slowly rising sea level. Through sediment-building, marshes can provide a buffer for landward areas from sea-level inundation and wave damage.

The majority of Tasmania's RAMSAR sites are coastal lagoons, incorporating some salt marsh habitats. The largest of these is Moulting Lagoon. These coastal lagoons are currently sheltered behind recent sand deposits. The salt marsh vegetation as part of these RAMSAR sites provides some buffering from the impacts of rising sea-level.

Figure 1: On low-gradient shores, salt marsh (closest to water) may have the capacity to adapt to sea-level rise by progressively converting the slightly higher foreground areas. Photo: J. Ellison.

Figure 2: In situations such as this, the narrow coastal salt marsh is blocked from inland migration by an aquaculture facility. Photo: J. Ellison.

However, with salt marshes occurring on sheltered accreting shorelines, the low gradient land behind is frequently converted to coastal roads, and associated developments (Figure 2). Along with reduced river discharge, this has reduced the sediment supply to salt marshes, critical for their ability to accrete to keep pace with slow sea-level rise. Development has also blocked access to potential migration areas inland should salt marshes need to retreat with

rising sea-level. This indicates a gap in coastal planning, with the coastal buffer of salt marshes along with its many values, needing longer term consideration for its continued existence.

Areas of salt marsh that do not have near-shore developments blocking salt marsh connection with higher ground inland (to approximately 1 m above High Water Mark), need identification and protection, as these are likely to be the only remaining areas of salt marsh in the future (e.g., see Figure 1). Protection would increase their resilience to combat the stresses of rising sea-level.

Example two - Foredunes as coastal buffers

Foredunes provide protection and buffer space from coastal hazards including storm surges and erosion. They also function as public coastal access space and have a conservation function by allowing natural coastal change to continue in the immediate backshore zone where coastal rates of natural change are typically high.

The value of these functions is recognised in many planning instruments which endeavour to restrict development on foredunes or "frontal dunes" (for example, the current Tasmanian State Coastal policy and most coastal Tasmanian Council planning schemes).

Foredunes backing sandy shores are likely to show high rates of change (by scarping and receding) as the effects of sea-level rise on coasts begin to become more obvious over the next few decades. A significant increase in foredune erosion and recession at particular beaches will be a key trigger alerting planners to the need to start considering adaptation measures for infrastructure behind those beaches. Thus, the presence of an undeveloped foredune which can clearly show the onset and acceleration of the effects of sea-level rise, while still providing an erosional buffer to give time for adaptation measures to be planned for built-up back-dune areas, can be a valuable asset to coastal communities.

However, foredunes are also widely regarded as perhaps the most desirable of all coastal real estate. Social research during the current Clarence Coastal Climate Impacts Study (Tasmania) has shown that, not only do many people want to live as close to the shoreline as possible, but they more particularly want to live as close as possible to *sandy beaches* (as opposed to the less erosion- and flood-prone rocky shores). As the closest feasible building location above the High Water Mark on a beach, foredunes are clearly prized as coastal residential locations with excellent beach views and access.

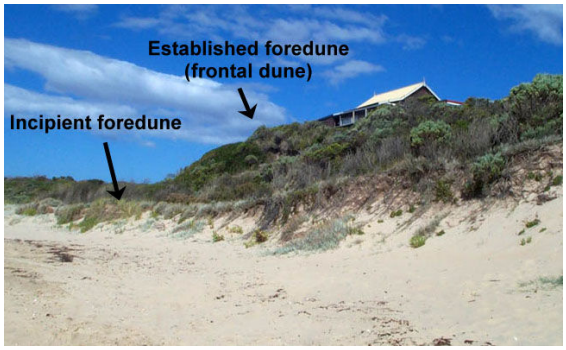

Figure 3: During a dispute over this shack near Bellingham, northern Tasmania, two geologists engaged by would-be purchasers of this crown land dune argued that the incipient foredune shown is the "frontal dune", and that the large established foredune on whose crest the shack sits is a "hind dune" and not a frontal dune in the sense of the State Coastal Policy. Ploys such as this have commonly been used to bypass State and Local Government planning provisions so as to develop on coveted but hazardous locations such as foredunes. Photo: C. Sharples.

So strong is the desire to build on foredunes that, where planning authorities in Tasmania have endeavoured to restrict development on foredunes, a common ploy used to bypass such planning provisions in planning appeal tribunals has been to argue that the (generally small and ephemeral) incipient foredune at the back of the beach is the 'true' foredune or 'frontal dune', and that the (larger, more exposed) established foredune rising above and behind it is actually a "hind-dune" and therefore not subject to planning restrictions (for an example see Sharples 2004). This terminology does not accord with widely accepted geomorphological definitions

(see Hesp 2002), but has been a popular method of attempting to bypass planning instruments such as the Tasmanian State Coastal Policy (1996).

Where development on foredunes has occurred, not only does this compromise the value of foredunes as a coastal conservation and public access resource, but it also implies that available options for adaptation to sea-level rise will be more restricted and costly. Impacts on foredune buildings – due to increased erosional scarping of the dunes during storms attacking the coast from a higher sea-level base than previously – may occur relatively quickly and with comparatively little forewarning. Hence where infrastructure already exists on foredunes there are likely to be strong demands for immediate building of extensive coastal defence structures, with their attendant costs and effects on natural coastal processes and amenity. In contrast, where foredunes remain unoccupied as hazard buffers for housing further inland, a longer period of forewarning will be available for discussion and consideration of a broader range of adaptation options.

It seems clear that some of the most difficult and expensive issues for adapting to sea-level rise will occur where residential and other development already exists on foredunes. On the other hand, where foredunes remain unoccupied to sea-wards of residential and other developments the opportunity remains to maximise the hazard-buffering and other benefits of these landforms in the face of sea-level rise by ensuring that they remain unoccupied.

Example three – Alienation of coastal hazard buffers on shores prone to flooding and erosion

Many non-dune coasts are also subject to natural (ongoing) erosion and flooding, and are likely to become increasingly subject to these hazards with sea-level rise.

In the same way that retaining undeveloped foredunes provides multiple benefits including hazard buffering, so too retaining an undeveloped crown coastal reserve strip along non-dune hazard-prone coasts is an effective way of protecting infrastructure further inland from erosion and flooding, while avoiding the costs and amenity losses associated with needing to protect these shores by artificial means.

Unfortunately, a number of instances can be cited in Tasmania (and undoubtedly elsewhere) of cases where the potential hazard buffer value of a crown coastal reserve has been lost as a result of planning decisions which arguably failed to give sufficient weight to the implications of future sea-level rises for those coasts. One such example with which two of the authors (Stephenson & Sharples) have had professional involvement occurred at Anson's Bay in north-eastern Tasmania.

The bay is a bar-built estuary at the end of Anson's River. With the exception of the sandy Holocene barrier, much of the northern shoreline is dominated by soft Quaternary alluvium emplaced over granitic bedrock during lower sea levels, although the southern shoreline is composed mostly of hard lithified rocks. Sea level rise since the last glacial maximum has flooded the alluvial deposits and resulting in an erosive shore line along the north-western shore within the bay (see Figure 4). This erosion is driven by storm waves generated from south-easterly winds blowing across a 2 km fetch. The erosion is a natural ongoing geomorphic process whereby the shoreline attempts to widen enough to dissipate wave energy. As a consequence of these processes the north-western shoreline of the bay is now dominated by a low actively eroding cliff that undulates in elevation along the shore from 0.5 to 3 or 4 metres high. Where the cliff is only about 0.5 m high the back-shore is low and flat and prone to flooding during storms coincident with high river inflows to the estuary (see Figure 5). Both flooding and erosion are expected to continue if not worsen under both current sea levels and predicted accelerated sea level rise scenarios.

Over top of this geomorphic setting is a history of European land tenure that has entrenched coastal hazards and has recently resulted in costly litigation. The shoreline of Anson's Bay was originally zoned as a crown

coastal reserve several tens of metres wide, and along the northwest shore this strip provided a buffer for freehold property and houses further inland against erosion and flooding. However this "vacant" reserve strip to shore-wards of the freehold blocks was occupied by "squatters" who built "shacks" there as holiday homes. From at least the mid-1940s this practice was widespread across Tasmania with approximately 1300 shacks occupying crown reserves along waterways, lake shores, coasts and elsewhere. In response the state government partially legitimised these squatters by charging a lease. The shack "owners" pressured the Government to provide a more secure tenure, arguing that without secure tenure they could not invest in improvements to their buildings, many of which did not comply with building codes. During the 1990's a process known as the Shack Site Project was began under the Tasmanian Resource Management and Planning System to determine if shacks could be given freehold tenure, but complaints from shack owners that the process was too difficult resulted in the Crown Lands (Shack Sites) Act 1997 being passed. This Act hastened the process of assessment and wherever possible created freehold tenure for the shack owner. The basic criteria of the assessment were environmental sustainability, Aboriginal heritage and social concerns. Shacks could be sold to the occupier, leased for a period up to 30 years or relocated or removed. Across Tasmania approximately 90% of shacks were converted to freehold and 6% to leasehold. Just 53 shacks were identified as requiring removal. At Anson's Bay many of the shoreline shacks were converted to freehold title.

A number of the shacks at Anson's Bay are at risk from flooding and many are threatened by erosion as the low cliff recedes. These hazards were identified during the shack site assessment process and were well known to the shack owners. Over the history of the shacks, owners had taken various unsuccessful measures to stop erosion (see Figure 4). Despite this knowledge shack owners were given freehold title because the Act did not require freehold to be refused under such circumstances (the only coastal landform category prohibited freehold under Shack Sites Act were "mobile dunes" – freehold on other hazard types was permitted). Instead the Shack Sites Act indemnified the crown against claims by shack owners for damages resulting from natural hazards such as flooding and erosion. As a consequence of much of the former crown coastal reserve being converted to freehold, the coastal reserve strip was reduced to a few metres width.

Figure 4: An eroding shoreline at Anson's Bay (Tas.) in 2002. The wall built to protect the adjacent shacks from erosion has subsequently collapsed and been removed. Photo: C. Sharples

Figure 5: A storm surge at Anson's Bay during 1993. Several floods of this magnitude or greater have occurred during the last few decades, impacting on shacks built on the former crown coastal reserve strip. However freehold blocks to landwards have had little or no flood impact, implying that the crown reserve would have provided adequate flood buffering for residences if it had been permitted to perform this function. Photo: Richard Mason, Break O'Day council.

The new freehold title owners not surprisingly want artificial erosion and flooding protection, however this is not provided by state or local governments. As a consequence some

shack owners have taken unilateral action to prevent erosion. Most recently (2008) this has resulted in a planning tribunal case following the illegal construction of a revetment because the local government (Break O'Day Council) planning scheme does not permit development in erosion/flood hazard zones. The council sought an order to remove the wall; this order was granted by the Tasmanian Resource Management and Planning Appeal Tribunal.

Anson's Bay is a case where the "traditional rights" of crown land shack owners were considered paramount, thus they were given freehold on a coastal buffer subject to hazards. As a result, the value of the coastal reserve in providing a low cost erosion and flooding buffer has been lost and the pressure on the local government Council to permit new development and redevelopment in a known hazard zone has been increased. Given that flood and erosion hazards will undoubtedly increase at these sites with sea-level rise, a major planning and hazard management problem has been created for the future on what could have instead served as an ideal low-cost coastal hazard buffer.

Given that sea-level rise will generally increase rather than decrease coastal erosion and flooding hazards, there needs to be a higher priority given to maintaining functional coastal hazard buffers like this, and lower priority to some putative "traditional rights" – such as those of crown land squatters - where these will exacerbate community problems and costs arising from sea-level rise.

Conclusions

This paper has explored a number of coastal situations where maintaining undeveloped coastal strips between the shoreline and backshore infrastructure development may greatly reduce the future costs of adaptation to sea-level rise while providing additional amenity and ecological benefits.

Where major investment has already occurred in the shoreline strip and the coast has been heavily modified, these benefits have typically already been foregone and it is likely that expensive coastal defences will need to be maintained and expanded as required.

However, where there is a lower intensity of shoreline development, a broader range of options remains available. Coastal buffer strips which are still unoccupied can be seen as an economic as well as an ecological asset in their undeveloped state, in that they can play a valuable hazard buffer role at little or no cost.

Shorelines with some development, yet which still retain substantial natural values including partly unoccupied buffer zones, may be best managed by undertaking less intensive responses that permit coastal processes to proceed until the end of the useful life of the investments, and then withdrawing, allowing the coast to respond to changes.

The coast is a mix of public and private ownership. Public ownership typically retains rights of access to the coast to the public. Exceptions include working port areas, public institutions use of the foreshore (naval, research of other activities with restricted access). However, both extensive areas of national parks, crown land and reserves held by different tiers of government allow relatively free access to many coastal areas.

Where private land is held inland of these public reserves and the reserves are relatively narrow, erosion and inundation may eventually eliminate the publicly owned area, resulting in a long term loss of public access to the foreshore.[1] However, by allowing adequate room for coastal processes to respond to the impacts of climate change where-ever possible, public access can be maintained much longer or indefinitely, adding to the wider community's access and benefit from the coast.

[1] While in principle the opposite may also occur, private ownership of the foreshore backed by public land is relatively less common.

References

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