Standing Committee on Climate Change, Water, Environment and the Arts

Inquiry into climate change and environmental impacts on coastal communities

– Submission –

Authors: Professor Bruce Mapstone, Dr John Hunter

Organisation: Antarctic Climate & Ecosystems CRC (ACE CRC)

Organisation Type & Role: Unincorporated Joint Venture R&D Provider

Statement of Interest

The ACE CRC is a 3rd generation Cooperative Research Centre funded from July 1, 2003 to June 30, 2010. One of the Centre's four science programs is dedicated to research on sea level rise and its implications for the coastal regions of Australia and neighbouring regions. In addition, the centre does research on Australia's interests in Antarctica and the Southern Ocean, the roles of Antarctica & the Southern Ocean in climate change, and climate change impacts on Southern Ocean ecosystems.

Summary

This submission relates primarily to the third term of reference of the inquiry, *the impact of climate change on coastal areas and strategies to deal with climate change adaptation, particularly in response to projected sea level rise*. We focus almost entirely on the implications of sea level rise, as one facet of climate change, for Australian coastal regions and the communities living near our coasts. The following points are expanded in the submission.

- Sea level rise will affect our coasts progressively over coming decades more than is generally inferred from the rise in mean sea level because of significant and accelerating changes in the frequency of extremes of sea level.
- Existing coastal infrastructure was generally built with expected asset lives of several to many decades and designed to withstand extremes of sea level expected from past experience. Past experience is not a satisfactory indicator of future risk, however, and coastal infrastructure is likely to be subject to sea level extreme phenomena outside the original design standards.
- Sea level rise will have significant effects on the shape and position of 'soft' (sandy, muddy) shorelines around Australia, most likely resulting in shoreline recession, although some shoreline accretion might be expected in some areas.
- Planning and development guidelines and regulations for most coastal regions relate to expected return periods for 'unusual' sea level extremes (e.g., the 1 in 100 year event) which implicitly are based on the assumption of static sea level. These guidelines are inadequate to deal properly with planning and development when sea level is continuously rising, with attendant increases in coastal inundation frequencies and changes in shoreline.
- Rising sea level will result in increased frequency and duration of inundation of low-lying coastal habitats, including wetlands, leading to increased salinity and likely changes in species composition of affected coastal habitats.
- The presence of coastal infrastructure will exacerbate habitat loss by preventing the inland migration of habitat which would often occur naturally as a result of sea-level rise.

- Australian coastal communities are also at economic risk from secondary effects of climate change on the marine environment, with processes such as ocean warming and ocean acidification potentially resulting in changes in species distributions (e.g., fishery or mariculture species) and economically and aesthetically important ecosystems (e.g., the Great Barrier Reef).
- There is an urgent need to nationally coordinate and increase research on the impacts of sea level rise to improve our capacity to devise and apply appropriate, robust and cost-efficient adaptations strategies for the 21st century.

The Nature or Sea Level Rise Effects

The Intergovernmental Panel on Climate Change (IPCC) has routinely reported projected changes in globally averaged mean sea levels. The 3rd (2001) and 4th (2007) Assessment Reports contain slightly different estimates of sea level rise during this century but if adjustments are made for the slightly different methods of deriving those estimates, they are found to be very similar, at least for the projected upper limits of sea level rise. IPCC projections indicate that global average sea level might be up to about 80 cm higher by the end of the 21st century than at the end of the 20th century. Observations of the world oceans since 1990 indicate that sea level is currently rising along the uppermost – most severe – trajectory projected by the modelling done for the IPCC reports. Further, work completed since the IPCC 4th Assessment has lead some researchers to suggest that the IPCC projections might significantly underestimated sea level rise this century, which some recent estimates put at up to 140cm. The amount by which sea level rises also may vary regionally because of atmospheric and oceanographic conditions, and interactions with ocean and land topography, but the details of this variation are not well understood at this stage.

The rise in mean sea level will have significant effects on Australian coasts, especially in the long-term redistribution of coastal sediments. Redistribution of sediments occurs at short intervals because of storms etc, but the average position and shape of our sandy or muddy shores reflects the balance between average sea level and coastal sediment transport processes. It is expected that rising average sea level will result in erosion of our coasts in most areas. An oft-cited rule of thumb is the "Bruun rule" which states that each 1 cm of rise in sea level results in about 1m of coastal recession. The actual amount of coastal recession because of sea level rise is variable, however, depending on the wind and wave environment in a region, the longshore currents, the nearshore topography and the nature of the sediments on the coast. Hence, each cm of sea level rise will likely result in considerable more than 1m of coastal recession in some places and less that 1 m in others. These effects are most likely to be relatively gradual.

Mean sea level, however, is not usually the source of greatest concern for effects of the sea on coastal environments, communities and infrastructure. It is the 'extreme sea levels' that cause greatest concern, especially the high extremes associated with large tides, storm surges, severe waves and low pressure systems. Most coastal planning and development guidelines are based on assessing the risks of such extremes occurring at potential development sites and then setting approvals and construction codes to standards that control developments in areas where risks are unacceptably high. A common point of reference is the height above mean sea level that might

be exceeded, on average, by extreme sea levels only once in one hundred years (the "1 in 100 year event").

As mean sea level rises, even slightly, these points of reference change. For example, a given site on a coast that was likely to be inundated by extreme sea levels once in a hundred years in 1990 will be subject to increasingly frequent inundation as the underlying mean sea level rises. Recent estimates of this effect indicate that a rise in mean sea level in the mid-range of that projected by the IPCC (~50cm by 2100) will mean that 1 in 100 year events (at 1990 sea levels) at sites around Australia may recur as often as 1 in 10 years by 2050, 1 in 3 years by 2070, and annually or more frequently by 2100. If mean sea level continues to track the uppermost IPCC projections (leading to ~80cm rise by 2100), then the same 1 in 100 year events will become annual events in some Australian locations by 2050.

Sea Level Rise and Existing Infrastructure

Most of Australia's existing coastal infrastructure and built assets were designed to tolerate or at least survive occasional effects from extreme sea levels (e.g., 1 in 100 or 1in 1,000 year prospects of inundation with seawater). As sea level rises, however, those designed tolerances will be exceeded increasingly frequently. A corollary is that assets that were built to be above the height that extreme sea levels might reach, and so perhaps considered intolerant of inundation, will increasingly be within the range of extreme sea levels as mean sea level rises. The consequences of these increasingly frequent effects are generally not well understood or thoroughly researched for most types of assets. This issue will affect low lying coastal residential and communities but also is likely to affect major coastal assets like airport runways, port facilities, coastal roads and water and sewage infrastructure, among other assets. In general, there is little quantitative information or awareness about these effects and so there is a dearth of guidance for the community about risks expected from rising sea levels, making it difficult or impossible to plan robust and cost-effective adaptation strategies.

Sea Level Rise and Sandy Shores

The effects of rising sea level on erosion of soft shorelines also presents risks for coastal communities and infrastructure, especially where assets have been built on the beach front on what was formerly coastal dunes or wetlands. Those assets are at significant risk of undercutting through coastal erosion as sea level rises, with considerable economic and social consequences. There is also likely to be increasing attrition in some regions of natural coastal assets of aesthetic (recreational) and economic (e.g., for tourism) importance, such as beaches and estuarine foreshores. It is important to note that these effects are likely even without any increase in storminess or storm intensity associate with climate change. In most cases, climate change effects on storm frequency or intensity will tend to exacerbate rather than diminish other effects of rising sea level.

Planning and Development Guidelines

A key implicit assumption of most of Australia's planning and development guidelines for coastal regions is that prior experience of extreme sea levels is a good indicator of future risk.

This assumption is probably fine provided that: a) the mean sea level remains fairly static; and b) the magnitude and frequency of drivers of extreme sea levels (e.g., tides, storms, floods, etc) also remain fairly constant. If either of these conditions fails, then the assumption on which planning guidelines are based is no longer legitimate. We now know that mean sea level is rising, violating the first condition, and modelling suggests that storm frequency and intensity may also change with climate change, violating the second condition. These changes mean that the conditions for which planning development guidelines were written no longer apply and those guidelines will become increasingly inadequate as sea level continues to rise. We have discussed above what will be some of the consequences for existing infrastructure.

There is pressing need to reconsider how we plan for coastal development, the criteria we apply to approve or reject development applications and the building regulations imposed for new structures to safeguard against risks of sea effects on coastal assets. These revisions will not be simple recasting of existing instruments but will need to be dynamic in nature to take into account the fact that the points of reference for planning (e.g., height above sea level, frequency of extreme sea levels) are now constantly changing and will continue to change for the foreseeable future. It is likely that appropriate guidelines, approval criteria and building regulations will necessarily be more complex than the existing, familiar, standards. Development of these tools for practical application will require close cooperation between researchers familiar with the details of sea level rise and associated extreme events and policy authorities, planners, engineers and regulators responsible for developing and applying planning instruments.

Effects on Coastal Natural Resources

Increasing sea levels and the associated more frequent effects of extremes will mean more frequent and longer periods of intrusion of sea water into low lying coastal habitats, including wetlands, marshlands and coastal flood plains. These intrusions will change the physical and chemical environments in which the associated biological communities have developed over the last several thousand years, when sea levels have been relatively stable. It is to be expected that there will be some changes in species composition and distribution and, in places, loss of existing ecosystems without local replacement. The specific nature of these effects locally, or even regionally, is generally not well researched or understood.

In the absence of coastal infrastructure, coastal habitat would often be able to simply migrate inland under conditions of rising sea level. Much of the Australian shoreline is now backed by infrastructure, however, making such migration impossible and habitat loss an inevitable outcome. Consideration should to be given to which forms of infrastructure may be more easily moved (for example, roads) to at least accommodate some habitat migration.

Other Effects of Climate Change on Marine Systems

Climate change is expected to have several effects on the oceans around our coasts and some of these effects will have consequences for coastal communities. Anthropogenic emissions of carbon dioxide into the atmosphere are driving an imbalance in the exchange of carbon dioxide between the atmosphere and oceans, resulting in increased carbon dioxide absorption by the oceans, changes in ocean carbonate chemistry and, ultimately, acidification of the ocean. The

change ocean chemistry is expected to make it increasingly difficult for organisms that form carbonate shells or skeletons to deposit those structures. Organisms that will be affected range from microscopic marine plants and animals to corals, bivalves (e.g., oysters), crustaceans and fish. Many of the affected animals are likely to be affected most during the larval stages of reproduction, but effects will also be increasingly evident throughout the life cycles. These effects pose uncertain risks for marine species and ecosystems, including those on which coastal communities depend for fisheries, tourism, recreation and aesthetics. The potential economic and social implications have not been well researched and nor have the likely implications for biodiversity conservation.

Global warming will also cause warming of the oceans and, potentially, changes in ocean currents. Changes in ocean temperatures will likely drive changes in the distributions of some species and cause stress or mortality of others (e.g., coral bleaching). Some of these changes may result in local or regional reduction or loss of nearshore habitats (e,g., cold water kelp forests) or fishery species or comprise the mariculture of some species (e.g. Atlantic Salmon off Tasmania), with consequential economic effects on coastal communities. Changes in ocean currents have the potential to significantly change the distribution of heat and nutrients around the global oceans with local consequences where nutrient rich upwelling, that support coastal ore pelagic ecosystems and fisheries, is diminished or warm ocean currents slow and cause local changes in coastal climate. These effects have been prediction by global climate models but are only just beginning to be seen in field observations.

Conclusion

Research on the specific and local effects of sea level rise and changes in ocean properties is in its infancy and being done in a relatively fragmented way around Australia. Understanding of the consequences of these effects by policy makers, decision makers, regulators, investors and the broader community lags significantly behind the knowledge in the research community, meaning that proposed adaptation responses are often poorly informed, inadequate or even dangerous. There is an urgent need to nationally coordinate and increase research on the impacts of sea level rise to improve our capacity to devise and apply appropriate, robust and cost-efficient adaptations strategies for the 21st century.