Navigating from climate change impacts to adaptation in Australia's coastal zone

Project team

Wade Hadwen, Sam Capon, Daijiro Kobashi, Elvira Poloczanska, Wayne Rochester, Tara Martin, Line Bay, Morgan Pratchett, Jo Green, Ben Cook, Ashton Berry, Amy Lalone, Aimee Hall, Shireen Fahey

Timeframe

2014 - ongoing

Project description

Climate change represents a major threat to coastal ecosystems and communities. In many areas around the Australian coast, the combined projected threats of sea level rise, increased temperatures and reduced rainfall will place unprecedented stress on species and ecosystems as well as human settlements and industries. Given that even the strictest climate change mitigation policies are unlikely to halt or reduce the threat that climate change currently poses to coastal ecosystems, consideration is needed as to how species, ecosystems and human communities might be able to adapt to anticipated changes.

The Coastal Ecosystems Responses to Climate Change Synthesis (CERCCS) Project represents a major Synthesis and Integration project commissioned by the National Climate Change Adaptation Research Facility (NCCARF) and undertaken by staff at Griffith University, the University of the Sunshine Coast, James Cook University and CSIRO.

The CERCCS project was developed "to synthesise knowledge of climate change impacts on Australian coastal ecosystems and integrate understanding of potential adaptive pathways, both ecological and human, to identify priorities for management and future research".

To achieve this goal, the project's major objectives were to:

- integrate knowledge of historical and projected climatic changes in Australian coastal ecosystems.
- synthesise knowledge of historical and predicted ecological impacts of climate change in Australian coastal ecosystems.
- identify ecological and socio-economic pathways for adaptation to climate change in Australian coastal ecosystems, and
- identify priorities for management and future research.

Outcomes

Climate change impacts in Australian coastal ecosystems

Climate change will have wide ranging impacts in Australian coastal ecosystems, including reduced population sizes, shifts in species' ranges and changes in the composition, structure and dynamics of biological communities. Rising

temperatures are generally expected to drive species' distributions southwards as well as affecting physiological and behavioural responses in some species and altering ecological processes including primary production. Coral reefs are particularly sensitive to temperature and extreme ocean temperatures lead to bleaching events which can result in mass coral mortality and significant shifts in community composition, including the replacement of corals by algae.

Sea level rise will redistribute shallow marine and intertidal habitats around the coastal zone, lead to saltwater intrusion into estuarine and freshwater coastal ecosystems and result in a loss of area of some habitats, particularly those experiencing coastal 'squeeze' as a result of human developments. Dominant coastal processes including wind, waves, tides, currents and hydrology are also likely to change and drive ecological impacts in all coastal ecosystems by altering the distribution, movement and processing of water, materials (i.e. sediments and nutrients) and biota.

Changes in the frequency and intensity of extreme events will further affect coastal ecosystems in all realms both directly, e.g. via mechanical damage to organisms or effects on sediment dynamics, and indirectly, e.g. by influencing the quantity and quality of terrestrial runoff entering coastal ecosystems. Increased levels of coastal erosion are also widely predicted.

In the coastal marine environment and intertidal and subtidal coastal habitats, ocean acidification is likely to result in further ecological impacts by reducing the growth and survival of the many organisms which rely on dissolved carbonate to build their shells or skeletons, with significant ramifications for the food webs which rely on them. Ocean acidification may also directly affect the development and metabolism of non-calcifying marine organisms.

With respect to intertidal species of rocky shores, considerable range expansions of warm water species and range contractions of cold water species have been recorded in the northern hemisphere. Furthermore, Australian arrival and departure dates of migratory birds, including shorebirds, have already shifted in line with temperature changes.

In terrestrial coastal ecosystems, e.g. dunes and headlands, CO_2 fertilisation may lead to vegetation thickening and encroachment of grasslands by shrubs. Altered fire regimes resulting from rising temperatures and reduced precipitation are also likely to affect vegetation communities in these coastal ecosystems and the habitat they provide to fauna. Some fauna, e.g. penguins, may be affected directly by changed burning patterns as well.

Certainty surrounding predictions of ecological impacts of climate change varies considerably between ecosystems and regions. Specific studies of climate change impacts in Australian coastal ecosystems are relatively limited with most work having been conducted on coral reefs, particularly the Great Barrier Reef, and mangroves. Climate change studies on sandy beach and coastal dune ecosystems, as well as freshwater coastal habitats, appear to be particularly lacking.

Adaptation pathways

Pathways for climate change adaptation can be autonomous (ecological or human responses), or managed (strategic adaptation, in human systems only). Autonomous ecological adaptation at a species level may occur via:

- acclimatisation: changes in physiology or life history toward phenotypes which can persist under changed conditions;
- adaptation: natural selection of genotypes which can persist under changed conditions;
- epigenetic interactions: changes in the function and expression of genes that are not explained at the level of DNA but which enable organisms to persist under changed conditions; or
- geographic range shifts: migration into areas with appropriate conditions

Shifts in community composition towards hardier species that are more tolerant of changed conditions may also be perceived as autonomous ecological adaptation at the community level.

Most research into autonomous ecological adaptation in coastal ecosystems has been conducted in the marine realm, particularly in relation to coral reefs. There is limited evidence to suggest that some coral species have the potential to acclimatise, adapt and migrate in response to climate change and those changes in communities composition may also occur.

With respect to estuarine ecosystems, mangroves are considered to be particularly plastic with a high ability to adapt to changed conditions and migrate landward with sea level rise, provided appropriate habitats are not already occupied by human developments.

The adaptive capacity of coastal terrestrial and freshwater species and ecosystems is largely unknown although it is likely some species will tolerate changed conditions *in situ*, some will adapt their life histories or behaviours, e.g. altered microhabitats for egg-laying amongst turtles, and other, more mobile or easily dispersed organisms, will migrate, e.g. shorebirds.

Significantly, in all coastal ecosystems, the potential for autonomous ecological adaptation pathways to 'keep up' with the current and projected rates of climate change is largely unknown and a cause of considerable concern.

With respect to managed human adaptation pathways in the coastal zone, four broad responses to climate change, particularly the threat of sea level rise, can be identified:

- managed retreat,
- limited intervention or accommodation,
- hold the line, and
- do nothing.

Each of these approaches can entail a range of on-ground adaptation options which may include:

- minimisation of existing non-climatic threats, e.g. invasive species;
- hard-engineering approaches, e.g. sea walls, groynes, armouring etc.;
- soft-engineering approaches, e.g. removing hard-engineering structures, revegetation, beach nourishment and drainage;
- ecological engineering, i.e. retrofitting hard engineering structures or introducing new structures to create artificial habitats; and
- ecosystem engineering, i.e. introduction of species which play a key role in shaping ecosystems structure and function, e.g. oysters, corals and dune grasses.

All of these approaches are likely to incur a range of unintended consequences, both ecological, e.g. effects on food webs, and socio-economic or cultural, e.g. impacts on human activities or loss of income, which, given the high level of connectivity amongst coastal ecosystems, can be far-reaching. Furthermore, these adaptation options entail varying costs, both in terms of time and resources involved in their implementation and maintenance as well as with respect to the risks involved. Selection of adaptation action is likely to be further limited by socio-economic and cultural context, e.g. recognition of high value of ecosystem services.

Many existing strategies of relevance to climate change adaptation for Australian coastal ecosystems can be identified amongst global, national, state and local conventions, legislation and policy. For the most part, these strategies do not address climate change specifically but, by addressing non-climatic threats, can be perceived as adaptation strategies since they aim to enhance ecosystem resilience. With respect to specific climate change adaptation strategies, those at state and local levels tend to offer the greatest degree of practical advice concerning on-ground adaptation options, though these tend to be quite limited. Local strategies are also significantly constrained by state and federal legislation.

Common themes emerging from consideration of current approaches to climate change adaptation for Australian coastal ecosystems, particularly with respect to the three case study areas examined here (i.e. Kakadu National Park, the Hunter River estuary and the Cairns region) include:

- climate change impacts tend to be common amongst coastal regions but issues associated with their impacts may differ;
- current management strategies share an overarching aim to build resilience in threatened ecosystems by targeting non-climatic threats;
- current on-ground climate change adaptation actions are limited;
- adaptation decision-making is hampered by a lack of certainty and availability of information and funding;
- adaptation is also impeded by existing legislation and the timeframes involved;
- unintended consequences of adaptation actions require greater consideration.

Recommendations for policy and management
Seven Principles for Climate Change Adaptation

Climate change adaptation approaches and actions require clearly stated (and debated) goals and objectives to reduce the risk of establishing unrealistic expectations and implementing maladaptive strategies. Climate change adaptation planning should therefore include the setting of broad goals, e.g. 'keeping the system as it is' versus 'moving the system

to a new state' as well specific, targeted objectives concerning the desired ecological consequences of adaptation actions, e.g. conserving species, ecosystem function or ecosystem services.

Climate change adaptation planning and decision-making requires involvement from a wide range of stakeholders across environmental, social, economic and cultural sectors. Such integration is critical to developing appropriate goals and objectives for adaptation as well as identifying strategies which are likely to be successfully implemented and maintained and that involve minimal risks across sectors.

Climate change adaptation planning requires information to be made easily available and shared. This includes information regarding climate projections, physical, chemical and ecological parameters and social, economic and cultural components of the area of concern. Issues of data availability also highlight the need for monitoring across all sectors to provide information to underpin adaptation decision making. Improved mechanisms of data collation, storage and delivery are also urgently required.

Climate change adaptation for the Australian coastal zone requires more integrated, flexible and dynamic legislative, policy and institutional frameworks which adequately reflect the temporal and spatial scales required by adaptation decision-making as well as allowing for adaptive management cycles.

Climate change adaptation in the Australian coastal zone requires a greater understanding and appreciation of connectivity within and amongst coastal ecosystems as well as between ecological and human systems, e.g. the high value of ecosystem services provided to human communities by coastal ecosystems.

Climate change adaptation actions will be implemented at local or regional scales, since these will determine which adaptation approaches are appropriate to address adaptation goals and objectives and possible given the physical, ecological, social, economic and cultural features of the area of concern. However, larger scales require consideration since adaptation actions may have consequences for connectivity with ecological and human systems beyond this area, e.g. migrating species.

Climate change adaptation in the Australian coastal zone cannot be considered in isolation of existing non-climatic threats. Climate change adaptation should focus on coastal zone sustainability so explicit consideration of non-climatic threats is essential, particularly as the impacts of many are likely to be exacerbated by climate change. As with other adaptation approaches, management of non-climatic threats should take into account the risks associated with their cost, efficacy and unintended ecological and human consequences.

Recommendations for future research

Improved projections of future climate change for the Australian coastal zone would be aided by the development of a coastal climate model which integrates existing terrestrial, marine and sea level models and considers the interactions amongst these. In particular, improved information is required with respect to climate change impacts on winds and hydrodynamics (i.e. waves, tides and currents) around the Australian coastline.

There is a need for more basic ecological information for many Australian coastal ecosystems to contribute to an improved understanding of ecosystem structure, function and connectivity. In particular, research is needed on sandy beach and dune ecosystems and coastal forested wetlands around the country as well as most of the coastal ecosystems in northern Australia.

Ecological monitoring is lacking for many Australian coastal ecosystems and regions. Research is needed to identify robust indicators and appropriate methods for collecting and analysing ecological data with respect to assessing climate change impacts and the efficacy of adaptation actions in the Australian coastal zone.

Research is needed to assess the efficacy and potential unintended ecological consequences of different proposed adaptation actions. This work needs to be done at the regional scale, as it is likely that consequences will vary according to the local setting and in response to interactions with each other and regional non-climatic stressors.

Research is needed to support the development of robust decision-making approaches which can integrate ecological, social, economic and cultural objectives and information. This should include an assessment of information needs across stakeholder groups as well as an examination of constraints and barriers to adaptation and how these might be overcome.

Coastal Australia represents a hotspot for climate change threats, impacts and adaptation opportunities. Strategic and systems-level thinking, capturing all of our knowledge of climate change and adaptation consequences, offers the greatest opportunity for generating support for sustainable adaptation that will benefit people, communities and the diverse species and ecosystems that inhabit the extensive coastal habitats around the continent.

Funding

Funded by the National Climate Change Adaptation Research Facility (NCCARF)

Partners

- Research team members from: CSIRO (Commonwealth Scientific and Industrial Research Organisation), Sunshine Coast University, James Cook University (ARC Centre of Excellence for Coral Reef Studies)
- Project Steering Committee members from: Griffith University (Australian Rivers Insititute), University of Tasmania, Great Barrier Reef Marine Park Authority, University of Sunshine Coast, University of Queensland, Griffith University (Griffith Centre for Coastal Management), James Cook University, Griffith University (NCCARF)
- Expert panel workshop participants from: Macquarie University, Adelaide University (Water Research Centre), Bureau of Meteorology, James Cook University, Griffith University, University of Western Australia, Deakin University, Griffith University, Southern Cross University, Victoria University
- Stakeholder Reference Group members from: Great Barrier Reef Marine Park Authority, WWF Australia, Sunshine Coast Regional Council, DHI Group, Local Government Association of Queensland, Griffith University (Indigenous Research Network), Fisheries Research and Development Corporation, Department of Environment and Resource Management (Qld), Department of Climate Change and Energy Efficiency (Australia), Caring for our Country (Environment).
- CERCCs app developers: Kintek Pty Ltd

For more information, contact

Dr Wade Hadwen

Email: w.hadwen@griffith.edu.au

Research outputs

Final Report - https://www.nccarf.edu.au/publications/coastal-ecosystems-responses-climate-change-synthesis-report

Managed Adaptation Options fact sheet: https://www.nccarf.edu.au/publications/managed-adaptation-options

Seven Principles for Adaptation factsheet: https://www.nccarf.edu.au/publications/seven-principles-cerccs

Book Chapter - Hadwen, W. L. and Capon, S. J. (2015) Navigating from climate change impacts to adaptation actions in coastal ecosystems. Pp 190-199. In Palutikof, J.P., Boulter, S.L., Barnett, J. & Rissik, D. (eds.) (2015) Applied Studies in Climate Adaptation: Australian Experiences. Wiley, Oxford.

CERCCs app - A guide to climate change and adaptation in Australia's coastal zone: https://itunes.apple.com/au/app/cerccs-guide-to-climate-change/id672962077?mt=8