Enhancing Species Adaptation to Climate Change

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Introduction

Climate change impacting our marine life is one of several pressures on the marine system. These pressures include coastal development, fisheries, tourism, marine pollution, and increased terrestrial pollutant runoff. Climate change will exacerbate the effects of many of these uses and society will need to adjust conventional management and governance practices to accommodate those greater effects. Responding to climate change requires two platforms: mitigation of impact, through reduction of greenhouse gas emissions; and adaptation to climate change while mitigation gradually occurs. Some of the considerations regarding adaptation options for the natural marine environment are described here. While a range of stakeholders must also adapt to these changes, the focus of this report card is on adaptation options to assist species to cope with climate change.

What is adaptation?

Adaptation in the context of marine species is a term that refers to a species changing to be suited to a new environment, or to be better suited to the same environment. True adaptation is genetic and generally requires many generations (evolutionary adaptation). Over shorter time periods, species can persist by a change in their adaptive capacity, or coping range, which does not require evolution.

Substantial changes to marine biodiversity and resources are unavoidable in a changing climate. Natural systems are likely to have limited capacity to adjust to the *rate* of climate change and its consequences. Increasing the adaptive capacity of species and biological systems increases the coping range before major change occurs (Figure 1).

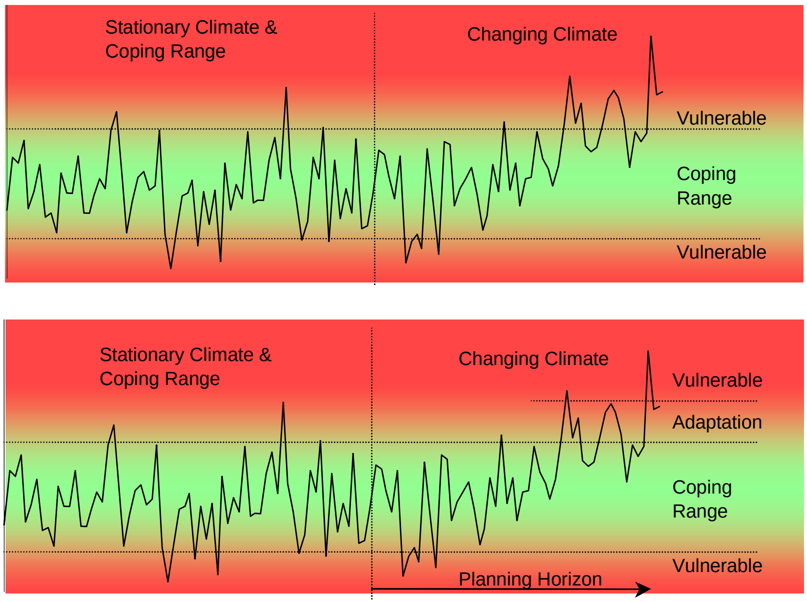

Figure 1. Adaptation strategies aim to increase the coping range before species or ecosystems become vulnerable (source: Jones and Mearns 2005).

Ecological adaptation

Response to climate change within the marine ecosystem may occur autonomously, through natural physical and biological processes, or it may be engineered by human interventions (planned adaptation). Both autonomous and planned adaptation can be facilitated publicly or privately, by individuals or groups. Autonomous responses include movement, acclimatisation, genetic changes through selective mortality (biological evolution) and shifts in species' distributions or composition of communities. Autonomous responses can also be facilitated by human actions at a range of levels. For example, networks of protected areas facilitate species re-distribution, protecting and restoring habitats essential for important life stages (e.g. nursery grounds), and might preserve biological robustness to climate variability and change. More direct action may take the form of translocation of mature (breeding) animals, or human-engineered strategies designed to increase the ability of species or other ecosystem components to cope with or be resilient to climate change. Examples of these might include genetic engineering for heat tolerant fish and assisted dispersal of larvae or seeds (e.g. mangroves and seagrasses). There is considerable uncertainty about the effectiveness of such direct interventions and experience shows that they come with significant risk of unintended or unanticipated consequences. Australians must learn to incorporate risk and change into natural resource management strategies, preferably using a formal adaptive management approach that is informed by a proper evaluation of risks.

A key question in predicting the ecological effects of climate change is whether species will be able to adapt fast enough to keep up with their changing environment. For example, the maximum rate of adaptation will set an upper limit to the rate at which temperatures can increase without loss of biodiversity. Research is in its infancy with respect to enhancing biological responses to climate change. Potential strategies that have been proposed seek to reduce stress and enhance resilience. These approaches are expected to increase the period of time over which biological response (e.g. evolution to increased temperature tolerance) can occur. Examples include habitat restoration, provision of shade for turtle-nesting beaches, assisted translocation of heat tolerant coral genotypes from warmer waters, inoculation of bleached corals following bleaching, disease suppression, stocking of genetically modified animals, and establishment of new populations or habitat structure. Many concepts and ideas have been borrowed from the terrestrial sphere but the scale at which these intervention strategies can be applied in the ocean is limited. The application of intervention strategies is likely to be limited to high conservation value species and locations. Finally, the ethical issues around so-called ecosystem engineering have yet to be considered, but may become relevant in future years.

Adaptation action

Projections of climate change become increasingly uncertain, however, as the spatial scale becomes finer, and hence it is likely that there will be direct and indirect effects in places we have not anticipated. It is difficult to prepare specifically for unexpected or unknown effects. Rather than contemplating all possibilities and attempting to design a myriad of targeted adaptation strategies, a more effective action may be to enhance the resilience and flexibility of social and ecological systems, providing them with the capacity to autonomously adapt or respond as likely changes become more clearly understood. Building general resilience by promoting diversity, flexibility and responsiveness within human systems is usually advocated in preference to individual, prescribed adaptation measures targeting specific impacts of unknown likelihood.

Reducing vulnerability to the challenges of climate change requires proactive management and rapid institutional learning. Governance and management strategies and practices need to be regularly tested and adjusted. Adaptive management uses information derived from targeted interventions to revise successive interventions and improve policy. Adaptive management has been advocated for several decades as an approach to natural resource management that maximises the rate of learning and progressive improvement in management responses to problems. ‘Whole of system’ strategies such as catchment-scale management and ecosystem-based management are likely to increase the prospect that marine systems will build increased resilience to unexpected ‘shocks’ or cumulative impacts of multiple stresses.

Adaptation options are highly dependent on specific geographical, biological and climatic risk factors, and are subject to institutional, political and financial constraints. Improvement of coastal development and planning regimes with specific attention to likely climate change impacts on marine biodiversity is likely to help with conservation of coastal wetland habitats under changing climate. The provision of buffer zones between development and coastal habitats and set-back provisions to allow for retreat and re-establishment of coastal habitats as sea level rises are two options for revision of planning guidelines. However, there is little evidence that such measures are being implemented except to protect built infrastructure or to diminish legal liability of local governments for damage to built environments. Recognition of the need for more consistent, integrated and ecologically sensitive coastal planning and development rules may result in protection of coastal habitats or accommodation of their retreat as sea level rises. The development of more consistent and proactive development and planning instruments is at an early stage and many surviving coastal ecosystems are already either compromised or constrained by surrounding development.

Natural resource management in Australia is moving to an ecosystem-based approach, requiring joint consideration of the biological systems and all their uses to provide a holistic management response. It is important to include climate change as another driver of change in the marine environment that will need to be considered in ecosystem-based management. Adaptation strategies within an ecosystem approach will have to be location-, user group-, and time-specific. Gradual changes can be identified and monitored, and adaptation can be proactive, progressive, or reactive. In contrast, step or threshold changes may not be foreseen, and in the absence of any prediction, adaptation in these cases will often be reactive. One of the key challenges in developing climate change adaptation strategies is how to deal with the uncertainty over the precise nature, scope, and timing of impacts. Climate change projections and associated ecological impacts are inherently uncertain and policy-makers, resource managers and users will have to learn to make adaptation decisions in the face of unavoidable uncertainty.

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