**Submission 017**
**Date received: 28/07/2011**

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The Secretary,
Standing Committee on Climate Change, Environment and the Arts,
House of Representatives,
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Dear Sir/Madam,

**Re: SUBMISSION FOR THE INQUIRY INTO AUSTRALIA'S BIODIVERSITY IN A CHANGING CLIMATE**

The Australian Marine Sciences Association welcomes the opportunity to provide input to the Inquiry into Australia's biodiversity in a changing climate. We provide the attached submission in relation to the effects of climate change on marine biodiversity for your consideration.

AMSA is Australia's largest professional association of marine scientists and actively promotes the advancement of marine science in Australia. Membership comprises about 1000 professional scientists and students located throughout all Australian states and territories and working in the private sector, government departments, research agencies and universities.

AMSA would be happy to provide further information associated with this submission if required. As we represent Australia's marine science community, we feel we are well placed to make a significant contribution to the inquiry on biodiversity in a changing climate.

Yours sincerely,

Dr Karen Miller
Secretary, AMSA

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**SUBMISSION FOR THE INQUIRY INTO AUSTRALIA'S BIODIVERSITY IN A CHANGING CLIMATE**

Marine ecosystems, and the biodiversity contained within them, are a fundamental component of Australia's social, cultural and economic future. Scientific evidence is showing that marine species and ecosystems are likely to be dramatically affected by changing climate, and that management actions are required to minimise both the environmental and economic consequences of climate change effects. The oceans are the earth's main buffer to climate change, absorbing up to 80% of the heat and 50% of the atmospheric carbon emitted (Sabine et al. 2004, Levitus et al. 2005, Domingues et al. 2008) and thus suffer the double effect of warming and ocean acidification (Cao & Caldeira 2008, Lough 2008). Changes in sea temperatures, rainfall, ocean acidification, sea level, and wind patterns are all contributing to modifications in productivity, distribution and phenology of marine species, affecting ecosystem processes and altering food webs (Poloczanska et al. 2007, Brierly & Kingsford 2009, Brown et al. 2010).

***Marine biodiversity in Australia and its territories***

There are millions of marine species in the world, and because Australia has one of the largest marine jurisdictions globally, we have an incredible diversity of marine species and ecosystems - from shallow intertidal to abyssal depths - in our care. However our ability to predict what will happen to marine biodiversity as climate changes is confounded by our limited knowledge of the actual biodiversity of much of Australia's marine environment. This is especially true of Northern Australia and in deeper waters, and is exacerbated by our declining taxonomic resources. Increasingly we are finding that suites of cryptic species are present particularly for many marine benthic invertebrates, so there is a serious underestimate of our known marine biodiversity (Ponder et al. 2002).

The effects of changing climate will have important consequences for marine biodiversity at three levels; extinction of species, extirpation of populations and changes in species distributions (range shifts). Extinction risk is highest for endemic species and those that have narrow distributional ranges. The Australian temperate marine environment, in particular, has a very high proportion of species that are endemic (i.e. they occur nowhere else). As the ocean warms, these species will increasingly be restricted to a smaller portion of Australian waters, and range shifts will be limited by the southern extent of our coastline. The same is true of marine species within Australia's Antarctic Territory that are living close to their physiological limits (Peck et al. 2010) and for which habitats are disappearing. Many Australian endemic marine species are predicted to become endangered and some will become extinct, including many species of commercial and recreational importance. This represents a major challenge for Australia in the area of biodiversity conservation.

Changing climate will alter the nature and frequency of key physical processes in the marine environment and these will have consequences for biodiversity and persistence of marine populations. For example, the increased frequency and severity of catastrophic events such as cyclones will damage marine coastal habitats impairing their function and, in turn, impacting biodiversity. These habitats will be among the first and most severely affected by sea level rise (Dale et al 2010). Rising sea levels will affect the distribution of wetlands and seagrasses and drown intertidal habitats which are critical to biodiversity because of their nursery ground value and their role in translocation of nutrients to offshore habitats. In some cases these communities will migrate to follow rising sea levels, but in many situations this movement will be blocked by human structures such as training walls and roadways.

One of the least well understood aspects of changing climate on biodiversity is the synergistic effects of environmental changes. A recent paper by Przeslawski et al. (2008) reviews the effects of climate change on reef invertebrates (excluding corals), and emphasises that impacts are likely to be cumulative and that there may be severe non-lethal effects; for example, reduced reproduction, changes in timing of reproduction and reduced rates of calcification. Such physiological stresses of environmental change may also influence inter-specific interactions; an example of this is the breakdown in the symbiosis between corals and zooxanthellae associated with rising water temperature (Hoegh-Guldberg 1999). These are tropical reef examples, but similar trends are seen everywhere and highlight that one of the key challenges in managing marine biodiversity in a changing climate is that the effects on species will not exist in isolation. Management or conservation measures will therefore need to recognise ecological relationships among species that are all responding to and dealing with environmental change. The need to address community responses to change is a challenging endeavour in the marine environment, and is confounded by our poor understanding of the ecology of many of our marine ecosystems.

Changes in the distributions of species (range shifts) are also predicted to occur as a consequence of climate change. As physical factors are altered in the marine environment, species distributions will change through the contraction and/or expansion of their current ranges as species seek favourable conditions (e.g. Johnson et al. 2011), and there is good evidence that marine pest species may increase with increasing water temperatures (Stachowicz et al. 2002, Agius 2007, Saunders & Metaxas 2007). Such range shifts will alter species interactions and ecological processes with subsequent effects on biodiversity including both changes in the relative abundance of species and local extinctions. While there will be winners and losers with climate change, our ability to predict how range changes will either manifest or the subsequent consequences for biodiversity is hindered by lack of basic understandings of the biology and ecology of the vast majority of our marine species. For example for most marine species we have very limited data even on the temperature tolerance of individual species.

The effects of changing climate on marine biodiversity will not be uniform across ecosystems or along our coastline and so it will be important not to over generalise about the likely effects of change in the marine environment. Modelling studies by the CSIRO certainly suggest that some areas will be more impacted than others, and this is also illustrated by the patterns of coral bleaching along the Great Barrier Reef which are not uniform. For example, during any bleaching event some reefs are impacted, while others are not.

***Connectivity between ecosystems and across landscapes that may contribute to biodiversity conservation***

The maintenance of connections among populations, habitats and ecosystems is essential for maintaining healthy marine ecosystems that can continue to provide goods and services for Australia. In the context of changing climate, ensuring connectivity among marine populations and regions will be critical to facilitate range shifts of species. Similarly, because extinction risk is highest in those species and populations that are both isolated and have low genetic diversity, ensuring gene flow can continue through migration will help mitigate the impact of climate change and maintain the resilience of marine communities.

Connectivity remains one of the least understood ecological and evolutionary processes in the marine environment. This is because many marine species disperse as tiny larvae or juveniles that are difficult to track across ocean expanses. New technologies and genetic tools are becoming increasingly important to understand the scale and directionality over which dispersal occurs in the sea and we are gradually learning that dispersal varies tremendously among species. Nonetheless, predicting the effects of a changing climate on marine connectivity is hindered by limited knowledge of dispersal in most species, although there is consensus across the scientific community that dispersal processes will be affected by climate change, linked to changes in the strength and direction of oceanographic currents but also due to biological effects.

Changed environmental conditions will affect biological processes in marine species including fertilisation success (especially for species that release gametes into the water column) and the survival of larvae and juveniles. This will in turn affect their dispersal capacity, and the patterns of settlement and recruitment (or replenishment) into populations. For example, increased ocean temperatures will increase metabolic rates of cold-blooded animals (most marine species). Increased metabolism will decrease the duration of larval stages, and will likely decrease the geographic scale of population connectivity of marine species. Increased metabolism will also increase the requirement for food per unit time: food may become limiting, and vulnerable life history stages may starve or lose condition making them more vulnerable to disease and predation and less likely to disperse successfully. Coupled with biological impacts on dispersal, changing ocean currents may also carry larvae to habitats that are unsuitable for settlement. These effects will have an important effect on the sustainability of fisheries and conservation management (Munday et al. 2009).

Connectivity among ecosystems will also need to be considered. For example, altered rainfall patterns (both intensity and seasonality) will affect connectivity between freshwater and marine ecosystems, mostly via estuaries. This is particularly important for the tropics where we do not understand coastal and freshwater systems and the links between them, but we know that coastal habitat mosaic structure is important and maintaining connections between components vital. There will be shifts of wet tropics towards dry tropics, and increases in the likelihood of wetlands failing as nurseries i.e. flooding is crucial to connect coastal nurseries to the marine environment. Increasing duration between flood events means that many coastal wetland nurseries can dry out before they are reconnected and juveniles have the chance to move to back to adult habitats.

Connectivity, through migration and range shifts, is understood to provide a means by which marine species can seek refugia as their existing habitats become uninhabitable. However this assumes that migration to new habitats is possible, which may not always be so. For example, shallow seamount habitats had been considered as refugia for deeper populations as deep waters become uninhabitable due to the negative effects of ocean acidification, but recent studies have shown that there is limited connectivity between deep and shallow seamount coral populations (Miller et al. 2011) and so deep water coral populations, and their associated fauna may well be lost as climate changes. Although the ocean is often seen as a vast, interconnected system, there are in fact many barriers to connectivity in the ocean and understanding these and how they are likely to change with climate will be an integral part of future management.

***How climate change impacts on biodiversity may flow on to affect human communities and the economy***

Australians rely on marine ecosystems for a range of goods and services including food, livelihoods, and recreational activities. Any changes in the marine environment associated with climate change are also likely to have downstream effects on human communities and the economy. For example, many marine species of commercial and recreational importance will undergo range shifts; some of these will be range reductions, and some will become extinct. The scale of population connectivity will decrease, which will have a strong impact on viability of populations, and upon management of living marine resources (including fisheries and marine protected areas).

Repeated bleaching events on reefs will lead to death of corals and associated invertebrates (Stella et al. 2011), leading to increased rates of bioerosion, loss of reef substrate, and replacement of coral reefs with algal dominated reefs. This will reduce the ability of fringing reefs to protect low lying coastal communities and will reduce the value of those reefs both in terms of loss of fisheries but also tourism, as algal dominated reefs have less appeal to tourists.

Nursery and spawning ground impacts and connectivity issues will retard commercial and recreational fisheries. There will be a particularly large impact on food security in the Pacific region where Australia is the largest aid donor, and where rapid population growth is already stressing resources.

Climate change has the potential to impact on the development of new industries such as biodiscovery. Australia is one of only 17 recognised mega-biodiverse countries based on its highly biodiverse and endemic terrestrial flora and fauna (Mittermeier et al. 1999, UNEP-WCMC 2011), and this trend is also mirrored in the sea. Hence Australia is exceptionally well positioned to participate and prosper in the field of marine biodiscovery because it combines a world-class scientific base with immense raw materials within its biodiversity. Climate-mediated species extinctions will impact on the biodiscovery potential within Australia's marine environment, and the future development of such industry.

In light of even the most conservative future climate change projections, coupled with the available evidence that climate change is likely to be responsible for shifts in many species' biogeographic ranges and for species extinctions, more research is needed to understand the full extent of climate mediated changes in the marine environment. Because range shifts and extinctions affect the distribution and abundance of harvested marine resources, as well as the dynamics of the ecosystems that underpin the productivity of marine resources, examining the diverse consequences of climate change-induced changes is critical.

***Strategies to enhance climate change adaptation, including promoting resilience in ecosystems and human communities***

Adaptation to the effects of predicted warming will be a complex, difficult and multi-dimensional undertaking, but one that is necessary for lessening the impacts of climate change in a warming world. Our understanding of climate change impacts in the ocean has lagged behind that of terrestrial systems. Likewise, adaptation efforts to date have focused on terrestrial systems, with the options for adaptation in ocean systems largely neglected. As the global climate continues to change, range shifts driven by this globally ubiquitous process will likely broaden in both number and geographic extent. Considering the ecological, socio-economic, and management implications of these changes before they occur is essential to mitigating their negative effects and developing effective adaptive response strategies.

Resilience of marine ecosystems can be promoted by reducing other impacts, such as pollution, habitat destruction and over-exploitation, recognising that the effects of environmental change will be synergistic and potentially greater in populations that are already stressed. Certainly the Great Barrier Reef Marine Park Authority has already been employing management strategies that improve water quality and reduce overfishing, in order to minimise impacts of climate change. For example, bleached reefs are more likely to recover if other impacts are low. The Great Barrier Reef Outlook Report (2009) promotes this view; maximising resilience of reefs by reducing fishing pressure, increasing green zones and improving water quality to give the reef the best chance of coping with climate change. Marine protected areas (including extensive no-take zones) are recognised as a major means by which resilience can be enhanced and are also of critical importance in providing a benchmark against which anthropogenic impacts may be disentangled from other drivers and stressors. AMSA's Position Statement on Marine

Protected Areas (https://www.amsa.asn.au/statements/index.php) represents the Marine Science community's perspective on the importance of MPAs in functioning to protect biodiversity, maintain ecosystem services and protect marine communities from disturbance (including climate change).

***Mechanisms to promote the sustainable use of natural resources and ecosystem services in a changing climate***

Australia has had very limited investment in large-scale and long-term monitoring of its marine living resources, and as such our baseline knowledge of the distribution of many species is poor or unknown. Sustainable use of biodiversity under a changing climate will depend upon improving this level of knowledge by developing and maintaining appropriate large-scale and long-term monitoring programs along with continued investment in fundamental research in marine biodiversity, connectivity and the biological effects (incorporating life-history and ecology) of change. Improved knowledge will enable us to better understand the way populations of marine animals function, and therefore to manage them more effectively for sustainability and climate change impact.

In line with this, a recent review on the distributions of marine invertebrates was undertaken to determine changes in distribution associated with climate change and also if museum records could support changes in distribution patterns (Falkner et al. in review). Limited support was found from existing data and it was recommend that some sites along the coast are selected (especially intertidal and shallow subtidal) for ongoing monitoring of suites of common marine species to better document what shifts are occurring. Invertebrates are considered good candidates as they cannot move easily if temperatures rise, whereas fish can migrate more readily.

The marine research community has been innovative in addressing the challenges associated with a paucity of funding for monitoring through programs such as Reef Life Survey (RLS). RLS aims to improve biodiversity conservation and the sustainable management of marine resources through the production of high-quality survey information at spatial and temporal scales beyond those possible by scientific dive teams (which have to work with increasingly limited resources). It does this through the skills of experienced and motivated recreational SCUBA divers, as well as through partnerships with management agencies and a steering committee comprising managers, scientists and recreational divers. Funding towards programs like RLS, and other appropriate monitoring mechanisms such as IMOS reference sites, needs to be improved if we are to have the capacity to generate the knowledge required to manage biodiversity effectively under a changing climate.

Marine protected areas (including extensive no-take zones) are also a major means by which resilience and sustainability can be enhanced. However Marine Protected Areas (MPAs) are only part of the solution. We also need to change the way areas outside of MPAs are used, for example areas used for food security need to be managed but increasing population pressures mean that even then they cannot produce sufficient food. In these cases we need to develop strategies for non-extractive use of marine resources such as aquaculture and ecotourism, and manage the associated impacts.

***Are current governance arrangements well placed to deal with the challenges of conserving biodiversity in a changing climate***

There will be many challenges to be met in conserving marine biodiversity under changing climate. Adequate resources need to be provided to those institutions which can actually document biodiversity (remembering much still remains to be described). State Natural History Museums are increasingly being subjected to funding cuts. Furthermore, because our knowledge of many marine ecosystems and the species that inhabit them is rudimentary, conservation measures will need to be adaptive as new information becomes available. For example, boundaries of existing marine protected areas may need to be flexible to accommodate changing habitats and species assemblages (Hobday 2011). Options for adaptive management and governance will also be integral for range-shifting species or for identifying alternatives to support communities as their resource base changes.

In the marine environment it is critical to record changes in the lower levels of the food chain such as the invertebrates, and not just concentrate on the "charismatic megafauna". Conserving biodiversity involves more than just protecting whales, dugongs and seabirds – we need to conserve all functional levels if we are to have functioning ecosystems.

***Mechanisms to enhance community engagement.***

Limited information about marine biodiversity in most of Australia’s marine territory has been a significant barrier to developing a strategic approach to the sustainable management of our oceans. Another, and equally challenging, component is effectively communicating marine issues - especially climate change impacts to marine users and stakeholders. Much stronger community engagement and involvement is needed. Most people who are using the ocean know little about it and they have few opportunities to participate in management. Evidence also suggests the majority of commercial fishers (at least in some Australian states) either do not accept that climate change is occurring at all, or acknowledge that it is a concern for the marine sector. If marine users do not understand the issues and help develop solutions it increases the challenge of managing impacts and realising the full benefits of our ocean estate. However, citizen science programs like the successful Redmap (Range Extension Database and Mapping project, www.Redmap.org.au) pilot are able to some extent fill the gaps in marine monitoring whilst also engaging the marine community on issues of marine sustainability and climate change. Australia has 3.5 million recreational fishers, thousands of commercial fishers, tens of thousands of divers and a coastline of 60,000 km for ‘citizen scientists’ to explore, and through participation in citizen science, develop a deeper appreciation of marine issues. Community engagement should also be encouraged through museums and through global initiatives such as the Census of Marine Life.

***Nationally important ecosystems:***

While all marine ecosystems are important and rarely exist in isolation from other ecosystems, some areas are considered especially vulnerable to the effects of climate change and in this context warrant greater attention. Shallow coastal areas, where Australia's population is the greatest (i.e. the Eastern seaboard) are especially vulnerable. In these areas, climate changes will be enhanced by other anthropogenic impacts including reduced water quality, increased water extraction, loss of coastal habitats (seagrasses, salt marsh and mangroves), increasing use of estuaries, aquaculture and increased fishing. Coastal ecosystems perform a pivotal role in the lives of many species and so are considered critical to biodiversity of many other ecosystems and are areas where management and adaptation can have real effects.

The deep sea is also an area that warrants attention. Still one of Australia's least understood marine ecosystems, the deep sea is now the location of many of our commercial fisheries and is increasingly under threat from the effects of mining and mining exploration. It also represents a great untapped resource of biodiversity and biodiscovery, as well as harbouring a wealth of climate records and acting as a carbon sink. The deep sea will be one of the first ecosystems to be affected by climate change. Ocean acidification will have the greatest affects in deep water where pressures are highest and temperatures lowest: this will affect the persistence of calcifying organisms that form both an integral part of the food chain (e.g. diatoms) as well as important ecosystem engineers (e.g. deep sea corals) that provide habitat for other species.

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