Climate Change – Impacts on Australia's Coast and Oceans

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Climate Change Challenge

There is now broad scientific consensus that climate change is occurring, and that the early impacts of this change can already be observed[1]. The term *climate change* refers to a directional change in climate, beyond natural bounds of variability, that is attributed to human activity and alters the composition of the atmosphere. Over the past 100 years or so, the levels of carbon dioxide (CO_2) and other greenhouse gases have increased dramatically in the Earth's atmosphere – primarily from the burning of fossil fuels. The main concern with climate change is the projected rapidity of change, with current estimates suggesting a global average warming of around 1.4 to 5.8° C in a mere 100 years, compared with thousands of years for similar change in the historical record[1]. It appears likely that a substantial proportion of organisms and many natural systems may not have time to adapt to this rapid change given the evolutionary timescales at which they normally adapt to change.

Impacts of Climate Change

The impacts of climate change are likely to subject the marine environment and the coasts to major change and damage. Generally, ocean waters are warming, sea level is rising at an increasing rate, and importantly, the sea is becoming more acidic. As stated by a recent report[2], "*the causes are clear: elevated greenhouse gases in the atmosphere have led to a global warming that has also increased temperatures in the surface waters of the oceans. This leads to rising sea levels due to thermal expansion of the water and due to melting ice masses. At the same time, the continuously rising carbon dioxide concentration in the air causes CO_2 to be absorbed by the sea, where, through chemical reactions, the seawater acidifies*". For coastal and marine environments the threat of climate change is also compounded by other pressures such as pollution, invasive species, or extractive activities.

A range of the likely impacts of climate change on Australia's coasts and oceans are shown in *Table 1* and there is emerging evidence that a number of these changes already may be occurring. Importantly, major Australian fisheries have historically shown change as a consequence of climate variations – so fisheries (and aquaculture operations) are likely to be sensitive to climate change[3]. Specifically, changes to water temperature, pH and ocean currents may affect the survival, distribution and recruitment of larval fish and their food sources[4]. Australia's iconic coral reefs and major tourist attractions, the Great Barrier Reef in the east and Ningaloo Reef in the west, are highly vulnerable to coral bleaching from increased sea surface temperature. It is currently predicted that a warming of 1 to 2° C will lead to annual bleaching events and large-scale mortality.[4]

Vulnerable Coast

The high vulnerability of Australia's coastal zone to the impacts of climate change is due to the large proportion of Australia's population that lives on the coast, the large number of assets in the region (human and natural), and to the extent of likely biophysical change at the land/sea interface. The coast also supports important activities and features such as: tourism, agriculture, fisheries, aquaculture, residential and industry infrastructure, coastal wetlands and estuaries, mangroves and other coastal vegetation, coral or rocky reefs, heritage areas, and threatened species or habitats. At present, some 85% of Australia's population lives near the coast and this

proportion is increasing, with many coastal communities based on local industries such as fisheries or tourism. The coast is also the conduit to Australia's export industry, with over 70 onshore and offshore trading ports. Estimates suggest that some one third of all ship losses are due to weather related problems, so this raises further concern regarding the impact on shipping and the marine environment from likely increases to severe weather events. Climate change will undoubtedly increase the challenge of sustainable management of the coastal zone and it is likely that Australia's current coastal development patterns are further increasing vulnerability to climate change.

Marine Biodiversity and Climate Change

Many consider biodiversity loss a minor issue for marine species. However, it is estimated that less than 5% of marine biodiversity has been discovered or described to date for the entire Australian marine jurisdiction[5], and natural and anthropogenic pressures could potentially lead to local extinctions. While marine species are considered to typically possess large ranges and good dispersal capabilities that insulate them against extinction[6] (see ref. p1294) as seen by *Table 1* these capacities may be severely limited by the impacts and consequences of climate change in the Australian region. Climate change may also affect biodiversity by modifying biogenic habitats[4] like those formed by foundation species such as mangroves, seagrasses, corals and kelp – leading to major changes in the composition of ecological communities. Impacts of climate change on critical producer groups such as phytoplankton and zooplankton may have significant repercussions throughout marine foodwebs[4]. This may also lead to shifts in community structure and composition, and affect productivity levels.

The Thin Blue Line

Notable impacts of climate change on marine biodiversity have already been observed throughout the world – principally due to the existence of long-term data series[4]. For example, northern hemisphere data show that the distribution of plankton, fish and rocky shore intertidal species are all shifting polewards in the North Atlantic[4] (see refs p.11). Such poleward shifts are becoming known as reaching the '*thin blue line*', that is, where suitable habitat ends – often due to depth restrictions. Australia is unique among maritime nations in that both the west and east coasts are bounded by major poleward-flowing warm currents - which have considerable influence on marine flora and fauna, as well as implications for distributional shifts under climate change[4].

Unfortunately, evidence of climate change impacts from Australian marine waters is sparse to date, mainly due to a lack of historical long-term data collection and dedicated research[4]. We do know that climate change is already moving tropical and temperate phytoplankton southwards off eastern Australia and that warming of tropical waters has led to several mass coral bleaching events, not observed globally before 1979[4] (see refs. p.12*)*. Also, range expansions have been observed in seabird species along the west coast of Australia[4] (see refs. p.12). Mean sea surface temperature off the Tasmanian east coast has increased by more than 1° C since the 1940s and this change has coincided with the transformation of habitat types – resulting in population gains for warm-temperate biota such as barren forming sea urchins, and population loss for cool-temperate species such as the infamous giant kelp[6]. Suites of cool-temperate organisms are likely to disappear from southeast Australian waters, an area particularly renowned for high proportions of endemic species. Tasmanian ecosystems are particularly susceptible to temperature rise because the southward range extension of species is prevented by a deepwater

barrier[6] – the *thin blue line* in action! By contrast, species with ranges currently centered on mainland Australia are potentially able to migrate south to maintain residence in preferred temperature bands and avoid competition with species better adapted to warmer conditions[6].

Implications

As concluded by a recent, seminal CSIRO report on the impacts of climate change on Australia's marine life[4]: "*climate change is expected to have considerable impacts on marine life and marine ecosystems. There will inevitably be flow-on implications for human societies and economies, particularly those in regional Australia highly dependent on the marine environment and its resources*". These sentiments are consistent with Northern hemisphere findings, such as those from a recent report by the German Advisory Council on Global Change (WBGU)[2], which suggest that the effects of climate change in the oceans are without precedent in the past several million years. WBGU state that: *'Due to the considerable geophysical time lags, these processes will determine the state of the world's oceans for millennia to come*". WGBU go on to recommend that resolute and forward-looking action is needed to ensure that the oceans do not overstep critical system boundaries.

Climate Change Action and Adaptation

At our current stage of limited knowledge, it is unclear to what extent Australia's marine and coastal zones will be impacted by climate change and what form the flow-on socio-economic ramifications may take. Natural disasters already cost the Australian community around $1 billion per year, and it is expected that climate change will reduce the return period or increase the intensity of some climate-driven weather extremes. Shifts in major ocean currents and key ecological species have already been documented in southeast Australia, with concerns about other important fauna reaching the limits of the '*thin blue line'*. Recent observations suggest that, globally, we have been tracking the upper limits of climate change projection models[1] (e.g. sea level rise) – so greater change than first thought may be in order.

What is clear, however, is the need to improve our knowledge, data and modelling capacities to help better predict and prepare for the likely challenges of climate change on Australia's coasts and oceans. Two major Government programmes in the Department of the Environment and Heritage, Australian Greenhouse Office are working towards addressing this need (www.greenhouse.gov.au). The *Australian Climate Change Science Programme* works with major science provides to address priority research to increase knowledge and understanding of climate change and its potential impacts in the Australian context – many projects involve marine-based studies[7]. The *National Climate Change Adaptation Programme* is developing targeted information and tools that will help the community and industry to understand climate change impacts, assess the risks and decide on adaptation options. A major component of this programme is a cross-jurisdictional, national assessment of Australia's coastal vulnerability to climate change – outcomes of a first pass assessment are due in mid-2008.

Table 1: Some likely impacts of climate change on Australia's coasts and oceans, as exemplified by some biophysical change from climate drivers (sources CSIRO Marine and Atmospheric Research; Bureau of Meteorology; Australian Greenhouse Office).

Likely bio-physical change from climate change drivers	
Sea level rise and storms	• a rise in sea-level from thermal expansion of the ocean and glacial melt, and increased frequency or intensity of extreme storms - leading to higher risk of inundation and flooding. • shoreline erosion and realignment leading to loss of amenity or damage to assets (natural and human).
Warmer ocean temperatures	• leading to increased frequency of coral bleaching events (present models project the Great Barrier Reef will warm by 2 to 5° C by 2100). • potential impacts on biodiversity by affecting the distribution and reproductive patterns of marine organisms, and consequently food web dynamics (productivity).
Ocean acidification	• increased CO_2 concentration in sea water is altering ocean chemistry, making it more difficult for calcitic organisms such as coccolithophores, corals and molluscs to grow and function.
Tropical cyclones and storm surges	• combined with higher sea levels, the projected increase in frequency and intensity of tropical cyclones would cause more frequent and intense coastal flooding. • tropical cyclones may occur further south than they do at present. • there are likely to be shifts in prevailing wind and wave climates.
Decreased rainfall and drought	• warmer temperatures will cause greater evaporation, increasing the severity of drought for a given decrease in rainfall.
Run-off changes	• changes in climate over land will cause changes in run-off reaching coastal and marine systems and alter the availability and quality of freshwater – this has implications for productivity and ecosystem function of coastal and estuarine environments. • related changes in riverine flooding frequency and intensity.
Ocean stability and currents	• changes to wind and water temperature affect water column stratification and stability – leading to changes in upwelling of nutrient rich deeper waters and productivity of surface waters. • Changes to ocean currents may affect dispersal and distribution patterns of marine organisms, and therefore affect biodiversity.
ENSO	• some models suggest global warming may lead to an increase in the frequency or intensity of El Nino events – if so, Australia may have more intense droughts and La Nina floods, particularly in the eastern part of the country.
Increased fire and wind	• increased frequency and/or intensity of aeolian dust and fire-born particulates can affect coastal productivity and promote blooms.

References

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