Australia's Marine Life

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Richardson A.J., Hobday, A.J. and Poloczanska E.S. (2009) Australia's Marine Life. In *Report Card of Marine Climate Change for Australia 2009* Eds. E.S. Poloczanska, A.J. Hobday and A.J. Richardson, NCCARF Publication 05/09, ISBN 978-1-921609-03-9.

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Summary: Australia has highly diverse and unique marine flora and fauna, ranging from spectacular coral reefs in the tropics to giant kelp forests in Tasmanian waters. The species diversity in Australia's northern waters is very high because it is a continuation of the Indo-Pacific biodiversity hot spot. Although Australian temperate waters have lower species diversity than northern tropical waters, they harbour more endemic species due to their long history of geographic isolation (over geological time) from other temperate regions. Australian waters contain ecosystems that are of international importance, The best-known example internationally being the Great Barrier Reef.

Australia's marine biodiversity underpins considerable economic wealth, for fisheries and aquaculture amounting to a gross value of $A2.2 billion (2007-08) annually. Marine life also provides invaluable ecosystem services including coastal defence against damaging waves and storms, processing of pollution, oxygen production and greenhouse gas regulation.

Climate variability and change are likely to cause several fundamental changes to plant and animal life in our oceans: (i) changes in distribution and abundance; (ii) faster physiology, earlier timing of life history events such as breeding, and some species moving beyond their thermal tolerances; and (iii) changes in community structure and function (including general productivity). Of particular concern is that impacts of climate change, in conjunction with other human stresses such as fishing, eutrophication and species introductions, could shift coastal ecosystems beyond tipping points and thrust them into entirely new states that no longer function in the same way, and may not provide the ecosystem goods and services that we have become accustomed to.

Australia's marine life

Australia harbours a vast marine biodiversity ranging from spectacular coral reefs in the warm tropical waters of the north to giant kelp forests in the cool waters of southern Australia. Australia has the largest extension of seagrass beds (96,371km^2) and second largest extension of coral reefs (48,960km^2), after Indonesia, of any countries globally and ranks among the top five countries for mangrove extension (9,553km^2; Martinez et al. 2007). The biodiversity in tropical Australia is very high because it is a continuation of the Indo-Pacific biodiversity hot spot, and much of this biodiversity is threatened by overharvesting and unregulated development in countries to the north of Australia (Hoegh-Guldberg et al. 2009). The species diversity of Australian seagrasses and mangroves is among the world's highest, particularly in tropical Australia (Walker et al. 1999, see Marine Report Card *Seagrass* – Connolly 2009; *Tidal Wetlands* – Lovelock et al. 2009).

Australian temperate waters may have lower species diversity than the northern tropical waters, but they harbour much higher numbers of endemic species. Approximately 85% of fish species, 90% of echinoderm species and 95% of mollusc species in these southern waters are unique to Australia (Poore 2001). This high endemism is also apparent in Australia's temperate macroalgae (Phillips 2001). There are over 3500 fish species in a huge range of families in our southern coastal waters and many of these are the focus of our commercial and recreational fishing industries (worth $600 million annually to Australia) (see Marine Report Card *Temperate coastal fish* – Booth et al. 2009).

Australian waters contain ecosystems that are of international importance. The best-known example internationally is the Great Barrier Reef, which is the world's largest World Heritage Area and extends some 2100 km along the coast of northeast Australia. Other world heritage sites in Australia which include extensive marine or intertidal area are the Kakadu National Park, NT and Shark Bay, WA. All three of these areas were classified for criteria which include "*To contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation*". These regions are at risk from considerable loss of biodiversity and/or declines in key species due to climate change over the coming decades (Australian National University 2009).

Globally significant populations of many diverse species occur in Australia including marine turtles (see Marine Report Card *Marine Reptiles* – Fuentes et al. 2009), seabirds (see Marine Report Card *Seabirds* – Chambers et al. 2009). For example, six of the seven living species of marine turtle forage and breed in Australian tropical waters. Large rookeries used by tens to hundreds of thousands of turtles occur along the northern Australian coastline and the southern Great Barrier Reef area (Marsh et al. 2001). Australia, and its external territories, has a diverse seabird fauna of 110 species, covering 12 families (Ross et al. 2000). The majority of these (69%) breed in the region; with the remaining species being either regular or occasional foraging visitors during the non-breeding season (Ross et al. 2000).

Ecosystems are valued on a number of levels such as for their aesthetic value, for the rarity or the diversity of their species, or for their economic value. Marine life and ecosystems also provide invaluable services to human society and the functioning of Earth's life support system including nutrient recycling, and greenhouse gas regulation (Costanza et al. 1997, Martinez et al. 2007). The ecosystem services product (estimated commercial value of ecosystem services) of Australian coastal marine waters have been valued at US$222,762 million (roughly equivalent to Aus$205,000 million) (Martinez et al. 2007).

Australia's marine biodiversity underpins considerable economic wealth. Fisheries and aquaculture are important industries in Australia, both economically (gross value over $A2.2 billion 2007-08, ABARE 2009) and socially while tourism to the Great Barrier Reef generates over $6 billion annually (Wachenfeld et al. 2007). Pelagic fish found in Australian offshore waters include iconic species such as tuna, billfish (swordfish and marlin) and sharks, often the focus of recreational and commercial fisheries (see Marine Report Card *Pelagic Fish and Sharks* – Hobday et al. 2009). Continental shelf waters off southern Queensland have been identified as a biodiversity hot-spot for large pelagic fishes (Worm et al. 2003). Valuable fisheries exist in Australian coastal and offshore waters including the Northern Prawn Fishery, the Southern Bluefin Tuna Fishery, the Eastern Tuna and Billfish Fishery and the Western Rock Lobster Fishery. Small pelagic species, such as sardines, jack mackerel, redbait and squid are captured in lower-value but higher volume coastal fisheries operating from a number of Australian ports.

Australia is unique among continents in that both the west and east coasts are bounded by major poleward-flowing warm currents, the East Australian Current (EAC) on the east coast and The Leeuwin Current on the west coast, which have considerable influence on marine flora and fauna (see Marine Report Card *Australia's Oceans* – Richardson and Poloczanska 2009). Tropical species can be much far south at latitudes inhabited by wholly temperate species on other coastlines of the world (Maxwell and Cresswell 1981, Wells 1985, Dunlop and Wooller 1990, O'Hara and Poore 2000, Griffiths 2003).The importance of these major currents in structuring marine communities can be seen in the biogeographic distributions of many species, functional groups and communities. For example, there is broad agreement between phytoplankton community distributions and water masses (Figure 1).

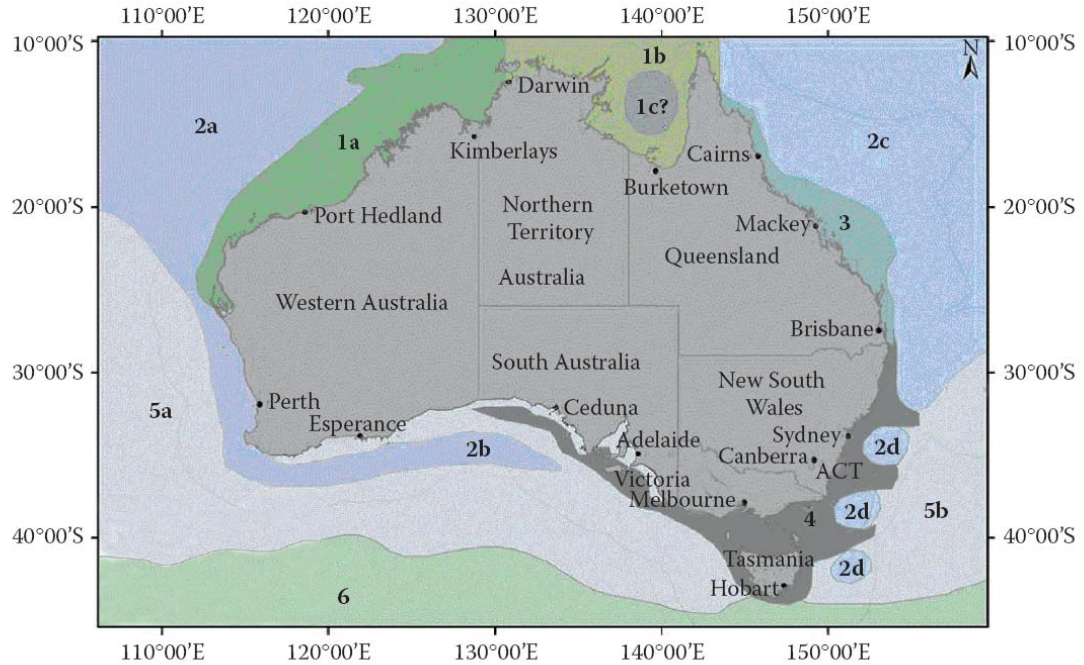

Figure 1. Phytoplankton provinces around Australia. In northern shelf waters tropical diatom species dominate, with slight regional differences in relative abundances and absolute biomass (1a-c). Shallow waters of the Great Barrier Reef (3) are dominated by fast-growing nano-sized diatoms. Deeper waters of the Indian Ocean and the Coral Sea are characterised by a tropical oceanic flora (2a and 2c, respectively) dominated by dinoflagellates and follows the Leeuwin Current (2b) and the East Australia Current and its eddies (2d). South-eastern coastal waters harbour a temperate phytoplankton flora (4), with seasonal succession of different diatom and dinoflagellate communities. Waters south of the tropical and temperate phytoplankton provinces have an oceanic transition flora (5a,b) that communicates with the subantarctic phytoplankton province (6) and is highly variable in extent. Phytoplankton provinces are associated with surface water masses and the zooplankton fauna likely show a similar pattern (Source: Gustaaf Hallegraeff).

Climate change impacts

Several studies of the impact of climate change on biodiversity, harvestable resources and aquaculture have consolidated the knowledge of historical and predicted changes for Australian marine systems (e.g., Hughes 2003, Chambers 2006, Hobday et al. 2007, Johnson and Marshall 2007, Poloczanska et al. 2007, the present Report Card of Marine Climate Change for Australia). Climate change is likely to cause several fundamental changes to plant and animal life in our oceans: (i) changes in distribution and abundance; (ii) faster physiology, earlier timing of life history events such as breeding, and some species moving beyond their thermal tolerances; and (iii) changes in community structure and function (including general productivity). Not all species will be affected negatively by climate change, as some will be able to better adapt that others, and some will enter new environments where they might outcompete other species.

The impact of climate change on a species will depend on many factors including the life stage (e.g., reproducing adult, larvae, seed), the habitat in which it is found, resource availability (e.g., food, space), and other the presence of other stressors such as pollutants and exploitation. Many marine animals and plants have complex life cycles and use different habitats during different life stages. For example, some fish species use mangroves and seagrass beds during juvenile stages and move further offshore as adults. Climate change in coastal waters and impacts on mangroves and seagrass beds will affect these young life stages with knock-on effects for adult populations. Almost all marine animals have a dispersive stage when the eggs and larvae form part of the zooplankton community in offshore waters (see Marine Report Card *Zooplankton* – Richardson et al. 2009). Ocean currents provide an ideal mechanism for organisms to disperse. Climate change impacts on the lower trophic levels, the phytoplankton and zooplankton, will resonate through marine food webs and marine ecosystems.

Risk of flipping ecosystems to alternate states

One concern is that impacts of climate change, in conjunction with other stresses, could shift coastal ecosystems beyond tipping points and thrust them into entirely new states that no longer function in the same way. This change into an alternative state can happen abruptly in a discontinuous, non-linear fashion when a threshold is crossed and can be permanent. For example, the combined effects of eutrophication (i.e. nutrient enrichment of water which reduces dissolved oxygen and may stimulate algal blooms), removal of grazing fish, global warming and ocean acidification can reach a threshold beyond which corals rapidly decline and algae growth accelerates. Algae can then smother corals, preventing photosynthesis by their symbiotic zooxanthellae (the small organisms that live within the coral).

Recent evidence suggests that other coastal and open-water systems can rapidly flip from being dominated by fish (that keep jellyfish in check through competition or predation) to a less desirable 'gelatinous' state (Richardson et al. 2009). This new ecosystem state is resistant to returning to its original state because jellyfish are voracious predators of fish eggs and larvae, and effectively prevent fish from returning. This flip to a jellyfish-dominated system once a critical threshold is reached has been termed 'the jellyfish joyride'. Thus natural ecosystems can be slowly degraded by the combination of continued overfishing, eutrophication and climate change to one where there are few fish, marine mammals and seabirds (Figure 2). This change to jellyfish is consistent with the 'rise of slime' (Pandolfi et al. 2005).

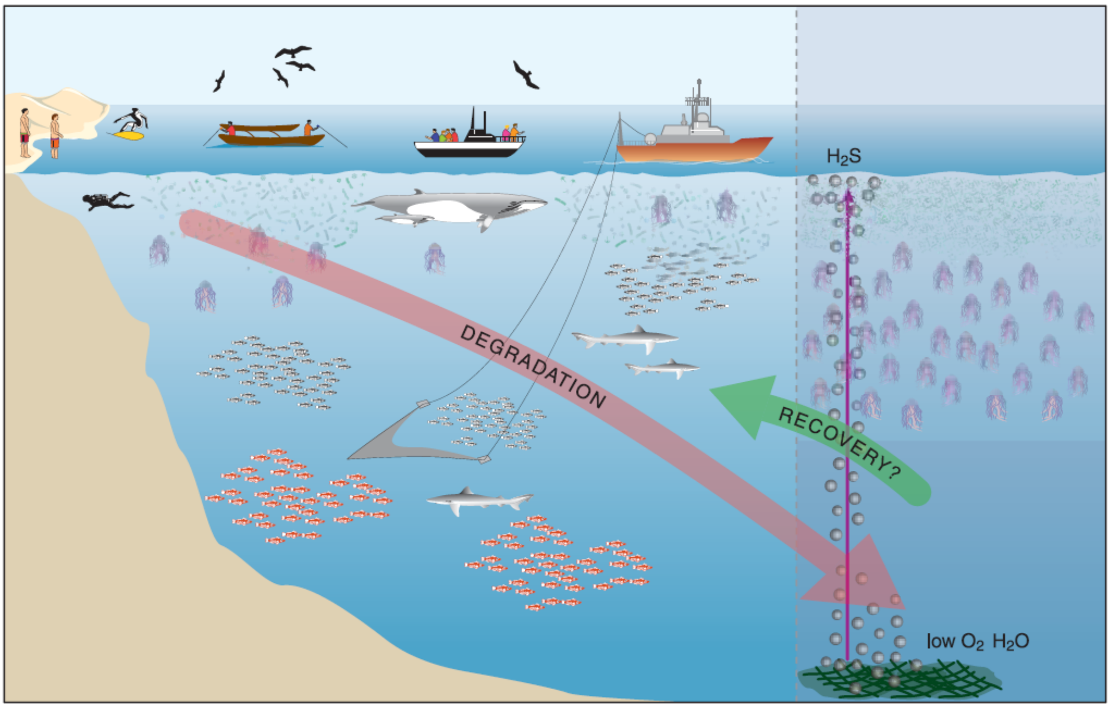

Figure 2. Human stresses such as climate change, overfishing and eutrophication can flip marine ecosystems from being dominated by one group (here fish, left hand side) to being dominated by another group (jellyfish on the right side). These tipping points for ecosystems are generally unknown and the new ecosystem state is resistant to returning to its original state (from Richardson et al. 2009).

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