Marine Climate Change in Australia
Impacts and Adaptation Responses 2009 REPORT CARD

Australia's Oceans

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Summary: Australian ocean territory is huge, with a coastline of almost 60,000 km from tropical waters of northern Australia to cool temperate waters of Tasmania. Australia has sovereign rights over around 8.1 million km^2 of ocean (excluding Australian Antarctic Territory) and greater than its land area. The Australian mainland is bounded by East Australian Current on the east coast and the Leeuwin Current on the west. These major currents carry warm-water into southern regions and have considerable influence on our marine flora and fauna. To the south, the southern ocean flows from west to east, and connects the Indian, Pacific and Atlantic Oceans. Relatively small regions of upwelling occur around the continent, and are locally important for bringing nutrients from the depths to the surface. Australia's oceans provide valuable services such as nutrient cycling, processing of pollution, greenhouse gas regulation, coastal protection and support diverse and unique marine life. Australia's oceans generate considerable economic wealth through industries such as fisheries, tourism, and shipping and port industries.

Australian marine waters

Australia claims the third largest exclusive economic zone in the world, with sovereign rights over around 8.1 million km^2 of ocean (excluding the Australian Antarctic Territory), greater than its land area of around 7.7 million km^2. Australia has a coastline of almost 60,000 km that spans from the tropical waters of northern Australia to the cool-temperate waters of Tasmania.

The Australia region is particularly complex oceanographically because it is bordered by the Indian, Pacific and Southern Oceans. The west and east coasts are bounded by major warm, nutrient-poor, poleward-flowing currents (Figure 1), which exert considerable influence on marine flora and fauna, as well as the Australian climate more generally.

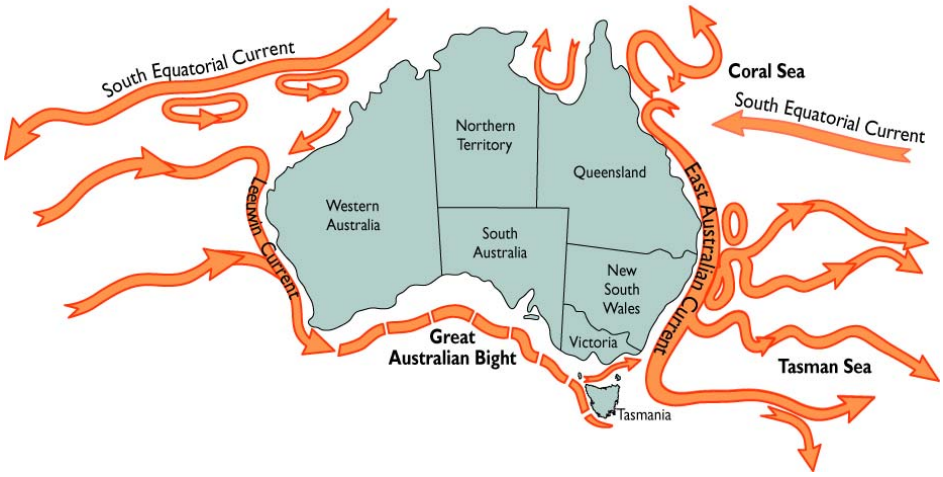

Figure 1. Major currents and circulation patterns around Australia. The continent is bounded by the Pacific Ocean to the east, the Indian Ocean to the west and the Southern Ocean to the south. Figure courtesy of S. Condie/CSIRO.

The largest ocean current off the Australian coast is the East Australian Current (EAC). It is a complex and energetic western boundary system off the east coast (see Marine Report Card *East Australian Current* - Ridgway and Hill 2009). It originates in the Coral Sea, where the northern arm of the South Pacific anticyclonic (anticlockwise) gyre, the South Equatorial Current, flows west and approaches the Australian coast between 14º-20ºS. Here it bifurcates, with a smaller northward flow and a larger southward flow that forms the EAC. As the EAC flows south, it accelerates along the coastal boundary, and then separates into northeastward (Subtropical Counter Current), eastward (Tasman Front) and residual southward (EAC Extension) components at around 31°S Rather than being an intense, coherent current, the EAC is dominated by large mesoscale cyclonic (clockwise) and anticyclonic eddies. Many of the eddies originate immediately south of the Great Barrier Reef and eddy activity increases as the current moves south. Eddies spawned by the EAC continue southward into the Tasman Sea, bringing episodic incursions of warm water to temperate eastern Australia and Tasmanian waters (Ridgway and Godfrey 1997). The EAC is strongest and penetrates furthest south during summer and is weakest in winter. The EAC is an important influence on marine biodiversity and fisheries productivity in south-eastern Australian waters.

The second largest current in Australia is the Leeuwin Current (LC), off the west coast (see Marine Report Card *Leeuwin Current* - Feng et al. 2009). The LC is much weaker than the EAC, with mean flow about 20% of the strength of the EAC. The LC originates from both the Indian Ocean in the west and the Pacific Ocean in the east (through the Indonesian Throughflow). The LC rounds Cape Leeuwin and continues eastward into the Great Australian Bight where it becomes the South Australia Current that finally flows into the Zeehan Current, which can reach Tasmania during the winter (Ridgway and Condie 2004). The strength of the LC varies seasonally, being greatest in the autumn and winter when southerly winds are weakest. The LC is influenced by El Niño, with the current weakening under El Niño and strengthening under La Niña conditions (see Marine Report Card *El Niño-Southern Oscillation* – Holbrook et al. 2009).

The influence of these two large, warm, poleward-flowing currents, the EAC and LC, is evident from the occurrence of tropical fauna and flora in southern Australian waters at normally temperate latitudes (Maxwell and Cresswell 1981, Wells 1985, Dunlop and Wooller 1990, O'Hara and Poore 2000, Griffiths 2003). For example, the LC is responsible for the

transport of tropical marine species down the west coast and across into the Great Australian Bight, and enables reef-building corals to exist at the Abrolhos Islands, the highest latitude for any true corals.

Australia's shallow continental shelf is wide in the north (>200 km in places), extending to the New Guinea islands and is narrow in the south (<10 km in places; Figure 2). Extreme climate conditions (intense rainfall, large waves, storm surges) from topical cyclones impact northern Australia, while swell generated in the Southern Ocean and severe storms impact the southern Australian coastline. Biodiversity is generally much higher in continental shelf waters then in the deeper waters away from the continental shelf.

Figure 2. Australia showing continental shelf in little blue (Source: Google Earth).

Australian waters are generally nutrient poor (oligotrophic), particularly with respect to nitrate and phosphate, so have low productivity. This nutrient-poor water originates in the tropics and subtropics and is carried southwards by both boundary currents. Australian soil is generally low in nutrients and this, together with the low but variable rainfall, results in little terrestrial nutrient input into surrounding seas. The generally oligotrophic status of Australian marine waters contrasts with many mid-latitude coastal areas around the world that are extremely productive. It is common for eastern sides of continents to have warm, nutrient-poor, poleward flowing currents, but it is unique to have such a current on the western margin of a continent, as there is with the LC. This current replaces the highly productive upwelling systems produced by the eastern boundary currents characteristic of all other major ocean basins. The impact of changing productivity on marine oligotrophic systems is largely unknown; they may not be as resilient to stress and disturbance, including climate change, as more productive regions.

Value and services of Australia's oceans

Key goods and services provided by Australian and global marine systems include coastal protection, food supply, and life-support functions including gas regulation (e.g., oxygen production), disturbance regulation, waste treatment and nutrient cycling, as well as many intangible aesthetic and cultural benefits (Daily 1997). Australia's oceans generate considerable economic wealth through industries such as fisheries, tourism, and shipping and port industries. For example, fisheries and aquaculture are important industries in Australia,

both economically (gross value over $2.2 billon, ABARE 2009) and socially. Rock lobster, prawns, abalone, tuna and pearls are the most valuable fisheries and aquaculture, accounting for 86% of Australia's gross value of fisheries production in 2007-08. Recreational fishing is also important economically and socially in Australia, with estimates of over 500,000 boats worth $3.3 billion used for recreational fishing (Henry and Lyle 2003). The Port of Fremantle, one of Australia's largest bulk cargo ports, is responsible for 8% of employment in Western Australia (1998-99) and port-related activities generate considerable economic wealth (BTE 2000).

Over 80% of the Australian population lives close to the coast and 'beach culture' forms an integral part of the Australian identity. Tourism from both within Australia and overseas generates considerable income. For example, the Gold Coast, with a resident population of around 500,000, receives over 9 million visitors a year; surfing tourism alone generates in an estimated annual income of $126-233 million (Lazarow 2009). Tourism is one of the major activities associated with the Great Barrier Reef, and in 2005, some 1.9 million people used tourism services, and another 6 million undertook recreational visits, contributing over $6 billion annually (Wachenfeld et al. 2007). The tourism industry is a major regional employer, with some 63,000 jobs linked to the Great Barrier Reef. Tourists come to Australia to experience our unique coastal and oceanic systems, and adverse effects of climate change will reduce the economic wealth they generate.

Australia's oceans also provide important ecosystem services. For example, coastal habitats such as coral reefs, mangroves and kelp forests protect shorelines by dampening waves and storm surges. Marine biodiversity also provides the potential for new scientific discoveries that will directly benefit society through bio-prospecting for new pharmaceuticals, and the development of new environmental protection strategies (e.g., microorganisms to aid the degradation of toxic waste).

Observing Australia's Oceans

Australia is now in the fortunate position of building a world-class program observing our oceans. The Australian Integrated Marine Observing System (funded by the Commonwealth Government with some support from State Governments) is monitoring our boundary currents and our shelf waters for changes in their physical (temperature, salinity, currents), chemical (nutrients) and biological (plankton, top predators) characteristics. This is achieved by using state-of-the-art technology such as ocean gliders, moorings, floats, and satellite imagery (Figure 3), integrated with high resolution models of Australia's oceans. This unprecedented observing capacity is increasing our understanding of how our oceans respond to climate variability and change, expanding our knowledge of the importance of oceans to the Australian economy, and is providing an early warning system for major changes that might occur.

Figure 3. The Australian Integrated Marine Observing System (IMOS) comprising facilities (numbered 1-9) and nodes (in red) (see www.imos.org.au for more information).

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