Coasts and oceans

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Introduction

Australia is the largest island continent, and controls the world's third-largest area of ocean. Our marine jurisdiction extends from the shoreline of the estuaries, bays and beaches, out to the edge of the Exclusive Economic Zone (EEZ), about 200 M (nautical miles) from the coastline of the continent and the islands. This covers an area of about 9.1 million square kilometres, with about a further two million square kilometres in Australia's Antarctic Territory). In addition to the EEZ, under the United Nations Convention on the Law of the Sea, Australia also claims control of an additional 3.4 million square kilometres of extended continental shelf in ten places around the mainland, the islands and Antarctica. So in total, Australia is responsible for a marine area of about 14.7 million square kilometres. This is greater than all the Australian land area combined—the mainland, islands and Antarctic Territory are about 13.6 million square kilometres.

The mainland EEZ has a coastline of about 36 000 kilometres, and spans more than 5000 kilometres from the tropics (9 ^{o}S) to temperate latitudes (47 ^{o}S). This extensive continuous coastline, together with about 12 000 islands from the tropics to the polar region, including a number of major oceanic offshore island groups (such as Cocos Keeling in the Indian Ocean, Lord Howe Island in the South Pacific and Macquarie Island in the Southern Ocean) creates a vast array of tropical to sub-Antarctic shallow water conditions and habitats. Together with the deepwater areas of the continental shelf and the slope, and the overlying water column, this complement of ocean and coastal systems provides Australia with a vast array of highly diverse marine habitats and ocean features.

These diverse ocean and coastal habitats are colonised by an equally vast biodiversity, which includes large proportions of endemic temperate species of flora and fauna, part of the tropical Indo-West Pacific world centre of species richness, extensive tropical–temperate transition areas, and large areas of Antarctic and sub-Antarctic territory and islands. As a result of the long history of geological separation, Australia's location at the junction of three of the world's major oceans, and the span from tropics to the Antarctic, Australia probably is the world's most important single jurisdiction for marine biodiversity.

Australia is one of 12 nations who together are responsible for more than 70 per cent of the world's biodiversity—known as 'megadiverse'. It is known that that Australia is biologically rich, but much (and possibly most) of Australia's marine biodiversity still remains to be discovered (see for example Ponder et al. 2002), especially the species of the outlying islands, continental shelves, shelf edge canyons, and the continental slopes and their overlying waters, all of which are difficult to sample and study. But even though there are many important species inhabiting Australian waters, for most of them we do not understand how their populations are maintained, or what environmental features are critical for their long-term survival. Despite this, the existing knowledge is sufficient to indicate that the marine biodiversity of Australia's waters has outstanding and universal global importance, as is evident in virtually any group of marine plants or animals that have been studied well enough to be able to make an informed judgement.

Just some examples of the outstanding importance of our marine biodiversity are as follows:

- Australia has the highest number of species of mangroves in the world—39 of the world's 68 species (Spalding et al. 1997)
- Australia hosts 34 species of seagrasses in the shallow tropical and temperate inshore waters (more than half of the world's 60 species) and 11 of the world's 12 genera of seagrasses (Short and Coles 2001), as well as the world's largest seagrass bed (in Shark Bay in WA).

The temperate waters of Australia's south-east region (NOO 2002) hold:

- the world's highest levels of species richness and endemism (distribution restricted to the region) for marine flora—about 1200 species of marine macro-algae, which is about 20 per cent of the world's species, with levels of endemism of about 70 per cent
- about 600 fish species with about 80 per cent endemism
- many hundreds of molluscs and echinoderm species, of which more than 90 per cent are endemic.

Although little explored, Australia's deeper waters also appear to have high diversity and endemism when compared to similar systems elsewhere (for example, Richer de Forges et al. 2000).

Australia's marine biodiversity is the basis for many important tourism and recreation activities, as well as commercial, recreational, traditional and subsistence fishing. The overall value of biodiversity in the world's oceans is estimated to be about US $21 trillion per year (Costanza et al. 1997), and the value of Australia's marine industry is around $22.4 billion (NOO 2001). While Australia's fisheries are limited compared to some other countries (because of the generally low nutrient status of our oceans), they nonetheless provide for an important source of wealth and recreation in most coastal areas of Australia. The commercial fisheries are concentrated on high-value but low-tonnage benthic species and products. In 2003–04, Australia's commercial fisheries (including aquaculture) produced about 267 000 tonnes of seafood valued at about $2.2 billion (ABARE 2005). In addition, recreational and subsistence fisheries form an important part of Australia's unique coastally-focused culture, and make a major contribution to the Australian way of life. This is reflected in the economic value of coastal recreation and in the recreational catches of fish, which, for some species, are now thought to be larger than those of the commercial catch.

Australia's rich marine biodiversity also offers the prospect of new chemicals that may be active in fighting diseases that afflict modern society. About 80 per cent of the world's population relies upon natural medicinal products. Of the top 150 prescription drugs used in the US, 118 originate from natural sources: 74 per cent from plants, 18 per cent from fungi, five per cent from bacteria, and three per cent from one vertebrate (a snake species) (Daily et al. 1997). Globally, there is considerable current interest in the potential for deep-sea bacteria to provide new bio-active molecules that may ultimately be developed as new pharmaceutical products. Bio-prospecting for such new compounds has become an important part of the effort to explore and better understand the diversity and natural function of Australia's marine biodiversity.

The ocean has a major climatic influence on all coastal regions. Sea breezes and temperature moderation generated by the ocean environment make many otherwise less tolerable coastal areas highly liveable. The oceans are also dynamic, and their impacts on shorelines and coastal systems can be extreme at times, particularly during storms and cyclones. This variability is a dynamic feature of ocean and coastal environments, but the variability and rate of change are increasing as a result of global changes in climate. In particular, changes to the patterns in ocean currents are affecting coastal and ocean ecosystems, and beginning to affect the distribution of marine biodiversity. At the shoreline, changes in wave and current patterns are altering the shape of the beaches and dunes, and there are likely to be greater changes as extreme events (storms and cyclones) become more frequent and more intense.

The vastness and the remoteness of Australia's oceans belies their vulnerability. Offshore and deepwater activities are increasing, and no longer is it appropriate simply to ignore remote areas of the ocean, or the deep waters, on the basis that they are too difficult to assess and manage, or that they are far from land and can look after themselves. Policy decisions about such matters as the amount of fishing effort permitted in an area, the zoning and management of coastal land, and management of the ballast water of ships, amongst many others, all have

the potential to have a big effect on ocean ecosystems. But perhaps even more importantly, many of the pressures related to such policies can be cumulative, and they may interact with natural stresses and variability to have even more profound effects.

While there have been many programmes committed to reducing marine impacts and pressures, and despite all the best intentions of managing within a complex world, we may still be facing the decline of important assets and features of ocean and coastal ecosystems. To guard against this happening without our knowledge, it is necessary to rely on monitoring systems that can detect the most important changes and provide alerts to generate a suitable management response. Australia has, however, few systematic national integrated monitoring systems in place. For example, there are sites in some coastal locations where long-term monitoring of some features is conducted (such as on the Great Barrier Reef) but there are no systematic, long-term national programmes that monitor key features such as coral reefs, seagrasses, or water quality to provide information about their condition. So precious little is known about their condition, or their trends.

In the sections that follow, some of the important features of the oceans and coasts are discussed, and, although there are very little data or knowledge on most of them, the key issues and trends are highlighted. Where they are available, specific examples of trends in the condition of the ocean and coastal ecosystems and pressures upon them are also provided to illustrate what are presumed to be the more general trends in conditions, pressures and responses.

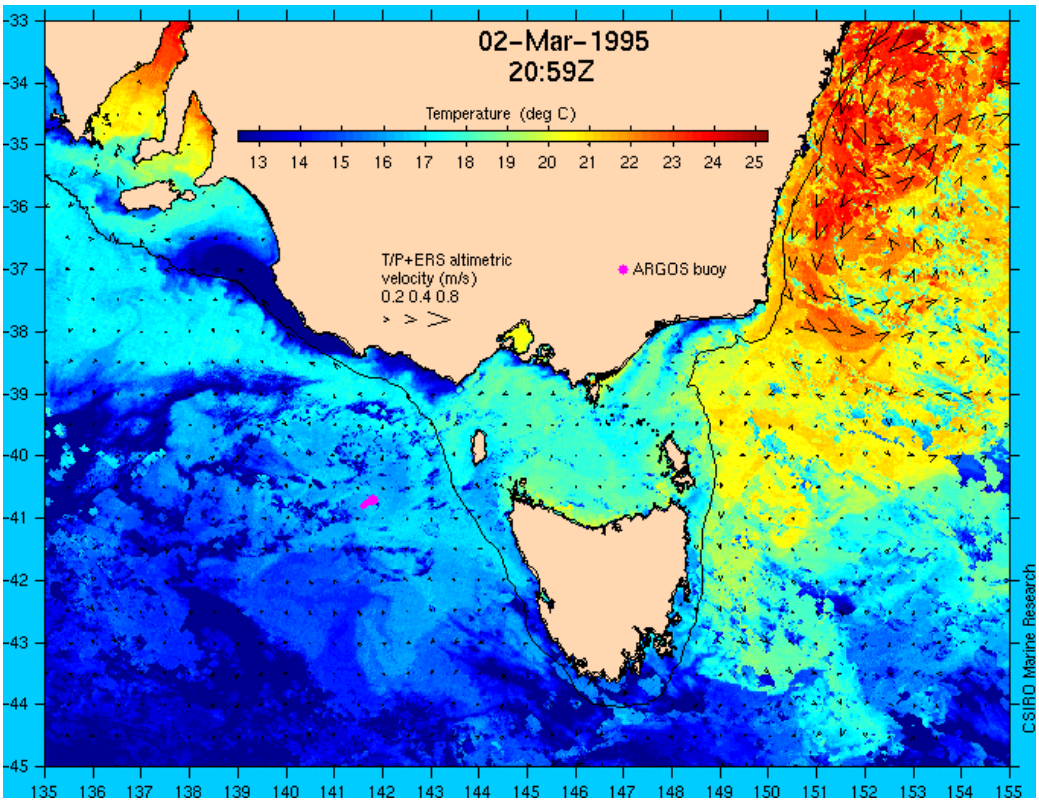
Ecosystem conditions

Ocean ecosystems

Australia has oceanic ecosystem features of great international interest and of great importance for fisheries, biodiversity and control of our climate, such as the East Australia Current and the Leeuwin Current. For example, one of Australia's most prominent and predictable upwelling systems occurs along the Bonney Coast (Robe in South Australia to Portland in Victoria), between November–December and March–April each year. The waters are highly productive as a result, producing a discrete sediment type, with a distinctive colder-water flora and rich assemblages of sessile filter feeders such as sponges, bryozoans and corals. It is also a productive fishing ground, in particular for rock lobster, sustaining a relatively large fishing industry. It is one of the 12 global feeding areas where Blue Whales aggregate in relatively high numbers (Butler et al. 2002) (Figure 1).

The patterns of variability in Australia's upwellings, and their relationship with large-scale climate features, such as currents and wind patterns, are unclear. It is likely that changes in climate and ocean currents will affect the location, extent and duration of upwellings, and this has direct implications for biodiversity conservation and fisheries production in Australian waters.

Figure 1: Sea surface temperature satellite image from March 1995, showing strong cold water upwelling along the Bonney Coast, and cool water near Eyre Peninsula, Kangaroo Island, and eastern Victoria



Source: CSIRO Marine Laboratories Remote Sensing Facility; (a related image, slightly further west, is published in Griffin et al. 1997)

Climate change and sea level

The world's climate is coupled to the oceans at three important spatial levels: ocean basins, regional areas (such as the eastern coast of Australia), and the local shores, estuaries and bays. Changes in the coupling of the global ocean–climate systems are already having substantial and important ramifications for the world's coasts and oceans (Hays et al. 2005). Increases in the acidity of seawater as the ocean absorbs carbon dioxide from the atmosphere will make it more difficult for coral and other calcareous organisms in the sea to build new skeletons (The Royal Society 2005). In Australian waters, perhaps the most visible impact of changes in climate is the bleaching of coral reefs as a result of increased water temperatures. Changes in the oceanic water column—in the plankton—may have more far-reaching effects (Hays et al. 2005) and there are many other changes that are related to changes in the climate, and they are becoming more evident in Australian marine ecosystems.

The sea level is rising around the Australian coastline at about 1.2 millimetres per year (Sea Level Survey 2003; Church et al. 2004). The Intergovernmental Panel on Climate Change (IPCC) concluded that sea level has risen globally by between 0.1 and 0.2 metres during the twentieth century. The IPCC predicts, for the period 1990 to 2100, a further rise of between

0.09 and 0.88 metres globally, an increase in the frequency of extreme sea-level events, and a resulting significant increase in storm damage.

These changes in climate are likely to have negative effects on Australia's coral reefs, seagrasses, reef systems and other nearshore marine habitats, and cause complex readjustments in the physical structure of beaches, estuaries and sheltered foreshores. Benthic species that are able to colonise new territory may be able to adjust, but those that cannot might become locally eliminated or even extinct. For example, increased sea level is likely to reduce the species diversity of corals because of from the indirect effect of water depth on coastal erosion, nutrients and suspended solids (Wilkinson 1999).

In south-eastern Tasmania, there are changes in the distribution of kelps, changes in the distribution of sea urchins, and problems with the salmon culture industry that can be related to climate change and, potentially, to other human influences (Edgar et al. 2005, Pittock 2003). These may be associated with the warm East Australia Current moving further south more frequently (Thresher et al. 2004). For example, the dominant mainland sea urchin (*Centrostephanus rodgersii*) has extended its range southward along the east coast of Tasmania. Concomitantly, macro-algal (kelp) communities have declined.

The aquaculture industry is also at risk. Water temperature shifts of just a few degrees may mean the difference between successful and unsuccessful aquaculture of a number of species. For example, warmer waters (and higher rainfall leading to reduced salinity) can increase the incidence of amoebic gill disease in Atlantic Salmon (*Salmo salar*) (Clark and Nowak 1999).

Responses so far to the issues of climate change in coastal and ocean ecosystems have been very limited, such as the *National Biodiversity and Climate Change Action Plan 2004–2007* (Natural Resource Management Ministerial Council 2004). Few marine industries have established precautionary climate change adaptation strategies, and there is no specific set of national responses that are designed to ensure that biodiversity issues driven by climate change are properly identified, or to provide a suitable planning base to respond to the pressures created by climate change. If management and conservation strategies do not urgently begin to take climate-driven variability and the likely long-term shifts into account, it may be difficult to effectively mitigate or manage impacts.

Coastal ecosystems

Coral ecosystems

Australia's coral reef ecosystems are unique. The Great Barrier Reef (in Queensland) and Ningaloo Reef (in Western Australia) are Australia's coral reef icons, but there are many other coral reef ecosystems with unique species assemblages, including deep-water corals, the low to high latitude transitional reefs in New South Wales and Western Australian waters, and coral atolls in the Indian Ocean and South Pacific Ocean. Each of these types of coral ecosystems supports a broad array of fish and invertebrates, many of which are endemic.

They also support a range of species that are important for recreational, commercial and traditional fisheries.

The Australian Government, the Great Barrier Reef Marine Park Authority (GBRMPA), and the state and territory governments each have a different system for protecting and managing coral reef ecosystems. Despite the overwhelming global and national importance of these ecosystems, there is no national system for assessing or reporting on the condition of Australia's coral ecosystems, and so, overall, the condition of Australia's coral reef ecosystems remains unclear.

The Great Barrier Reef is managed under one of the best-developed and most effective coral reef management systems in the world. The major responses to the identified pressures on the Great Barrier Reef are the development of new fisheries management plans, a water quality protection plan to reduce the impacts of land-derived nutrients, sediments and pesticides, and a new zoning plan for GBRMPA to protect more than 30 per cent of the Great Barrier Reef within 'no-take' sanctuaries. Western Australia is developing management arrangements for Ningaloo Reef, but there appear to have been few initiatives developed in the Northern Territory to protect coral reef systems.

Many coral ecosystems are probably in good condition, but the limited monitoring conducted on the Great Barrier Reef and in Western Australia shows that there is considerable local damage at some places caused by cyclones, bleaching, invasive species, fishing, sedimentation and pollution. It is unlikely that there will be any major reductions in these key pressures on coral reef ecosystems in the short to medium term outside the Great Barrier Reef; therefore, despite considerable management efforts, the future for Australia's coral reef ecosystems is uncertain.

More information is available at:

- Environmental status of corals on the Great Barrier Reef <http://www.gbrmpa.gov.au/corp_site/info_services/publications/sotr/corals/>
- The state of the Great Barrier Reef online <http://www.gbrmpa.gov.au/corp_site/info_services/publications/sotr/>
- Ningaloo reef website <http://www.naturebase.net/national_parks/marine/ningaloo/ >

Seagrass

Australia has the world's most diverse array of tropical and temperate seagrasses, including 34 species, which is more than half of the world's 60 species, and 11 of the world's 12 genera of seagrasses (Short and Coles 2001). Australia has about 51 000 square kilometres of seagrass meadows, with major areas in the Gulf of Carpentaria, Shark Bay (the world's largest seagrass bed), the southern coast of Western Australia, and in Spencer Gulf and St Vincents Gulf in South Australia.

There is no systematic national assessment and reporting system for seagrasses, but where there have been studies, major seagrass losses have been documented in the past—in Queensland, Victoria, South Australia and Western Australia. These have been caused by changes in estuarine hydrology, rainfall and flooding patterns; elevated nutrients from factories, sewage and agricultural runoff; increased turbidity and siltation; and the destruction of seagrass beds by sand mining (Butler and Jernakoff 1999). For example, seagrass beds declined in St Vincent Gulf by 720 hectares between 1995 and 2002. Some of these losses are continuing (such as losses caused by sand mining in Cockburn Sound, Western Australia) although many agricultural sources of nutrients and sediments are being reduced through improved catchment management programmes.

Since replanting and transplanting of seagrasses is not a viable option for mitigating degraded seagrass beds, it is most prudent to avoid as much damage as possible, by ensuring that activities such as trawling and dredging, sand mining, and water pollution from local catchments do not have any negative effects on Australia's remaining seagrass beds.

Birds

Many of Australia's birds live on the coasts and islands, and depend on both coastal and inland wetlands. Monitoring of many of the wetland species indicates that their populations are generally stable, although some are highly variable. In particular, extreme storms and extended droughts and floods have major impacts on the size of bird populations (Olsen et al. 2003.

An estimated two million migratory waders from 69 species enter Australia each year. There is no systematic national monitoring of waders, but data from the Coorong in South Australia—one of the most important Australian sites for waders—show there has been a steady decline in wader abundance. In the 1980s there were 50 000 to 60 000 waders using this wetland system, but in the last five or so years there have been consistently only about 5000 to 15 000 waders. Curlew sandpipers (*Calidris ferruginea*) and fairy terns (*Sterna nereis*) seem to be in continuing decline in the Coorong, while numbers of some of the other species (red-necked stint (*Calidris ruficollis*), sharp-tailed sandpiper (*Calidris acuminata*), red-capped plover (*Charadrius ruficapillus*) appear to have stabilised. The populations of many waders have declined over the past few decades, and, because many of the threats occur in overseas countries, a number of international agreements (such as Japan–Australia Migratory Bird Agreement, JAMBA) have been developed to attempt to prevent the decline in these highly migratory species and promote their recovery.

Of the 142 species of seabird that occur in Australian waters, 76 breed and spend their lives in the region, and 34 are regular or occasional visitors. Several species are threatened by incidental capture during fishing operations. The Wandering Albatross (*Diomedea exulans*) came close to extinction in the 1980s as a result of longline fisheries bycatch, but with the introduction of mitigation measures in 1994, the population has remained stable at the very low level of about 19 breeding pairs. Considerable reductions in the fisheries bycatch of many

other seabirds has apparently been achieved in the last five years, but tuna fisheries may still pose a serious threat so some bird species, particularly the Flesh-footed Shearwater (*Olsen et al. 2003, page 19*).

The main pressures on shorebirds and migratory waders are loss of habitat, disturbance of feeding, nesting and roosting areas, predation, especially by introduced pests, and droughts and floods. Also, the once rich feeding grounds of many urban estuaries have been degraded by pollution and the increasing mobility of tourists now places many formerly secluded bird feeding and roosting areas within easy reach, increasing levels of stress on individuals and populations.

Mammals

Australia hosts eight (62 per cent) of the world's 13 cetacean families, 27 (68 per cent) of the 40 genera, and 43 (54 per cent) of the 80 or so currently recognised species of cetacean. This includes about 29 species of whales, 13 dolphins and one porpoise.

All cetaceans are fully protected in Australia, and from acts by Australian citizens globally, under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Even so, cetaceans everywhere are subject to a number of significant pressures from both human activities and from long-term climate change. The main issues in Australian waters are boat-strike, entanglement in fishing gear (nets, ropes) or shark protection nets, marine debris (plastics, ropes), oil spills, acoustic survey impacts, tourism and whale-watching activities, and viruses and diseases from terrestrial mammals. For example, a recent university study in Shark Bay found that the mean abundance and reproductive output of dolphins was lower in an area subject to commercial tourism interactions than that of dolphins in a control area (Bejder 2005).

The ingestion of foreign matter such as plastic bags can lead to serious gastrointestinal blockages in cetaceans, potentially causing the animal to starve. In 2000, a Bryde's whale with almost six square metres of ingested supermarket bags, food packaging, two-metre long plastic sheets and fragments of garbage bags was found stranded on a beach in Cairns.

There are also many global-scale pressures on cetacean populations. These include hunting and commercial fishing (practiced by a number of countries), the impacts of changing ocean currents and production, the depletion of krill (an important whale food) by commercial fisheries, climate change factors, and the accumulation of persistent organic pesticides and other long-lived chemicals.

Australia has declared a Whale Sanctuary over all Commonwealth-managed waters for all whales, dolphins and porpoises. All the states and territories also protect these species in their waters. Five whale species are currently listed as nationally threatened under the EPBC Act, and recovery plans have been developed for each species (DEH 2005).

The Dugong (*Dugong dugon*) is the only herbivorous mammal that is strictly marine, and in Australia, ranges from the New South Wales – Queensland border to Shark Bay in Western Australia. Torres Strait and the northern waters of the Great Barrier Reef support the largest known populations of Dugong in the world. The largely undisturbed population of Dugong in Shark Bay is the largest intact population of Dugong in the Indian Ocean. In all parts of their range, Dugong populations are under pressure, and in some places they have already been eliminated.

There are no national surveys of Dugong in Australia's waters, but the populations in waters off Western Australia, the Northern Territory and the Torres Strait are thought to be reasonably stable despite a number of pressures, including impacts on seagrass habitats and hunting. In contrast, south of Cooktown on the Queensland coast, surveys and catches of Dugong in beach protection shark nets indicate that there has been a major reduction in Dugong population in this region since the 1960s. In response to this, 16 Dugong Protection Areas were declared in 1997.

Turtles

There are seven species of marine turtles in the world, and six of them occur in Australian waters—the Flatback (*Natator depressus*), Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*), Leatherback (*Dermochelys coriacea*), Loggerhead (*Caretta caretta*) and Olive Ridley (*Lepidochelys olivacea)* turtles. The Flatback Turtle nests only on Australian beaches from Exmouth (Western Australia) to the Great Barrier Reef, and is endemic to the Australia-New Guinea continental shelf. More than two-thirds of the world population of this species breeds in Australian waters.

All the turtle species are migratory, with some travelling vast ocean distances; hunting of turtles in overseas waters is of major concern to the populations of all turtle species. Human impacts in Australian waters are also important, including boat strikes; bycatch in trawl fisheries; entanglement in lost fishing nets and ropes (see Figure 2); predation on eggs by other animals; the loss and pollution of habitats; the encroachment of vehicles, coastal development and light pollution onto nesting beaches; turtle hunting for traditional food; and ingestion of marine debris. In Queensland in 2002, 69 turtles were found stranded and dead, most after entanglement with marine debris from various sources.

Figure 2: Green Turtle drowned by entanglement in lost or discarded net (ghost net)

Source: Limpus and Chatto (2004)

The number of female Loggerhead Turtles breeding annually on the east coast of Australia has declined by about 86 per cent from an annual nesting population of about 3500 females in the 1970s to the present level of less than 500 females breeding. This decline means the Loggerhead Turtles of the South Pacific Ocean are critically endangered. Data on trends in other marine turtle species are not available.

All six marine turtle species in Australia are listed as threatened under the EPBC Act, under CITES, and some are also protected under state and territory legislation. A recovery plan for marine turtles has been prepared in accordance with the EPBC Act to promote the recovery in the wild of all Australia's turtle populations. Trawl fisheries are now expected to take major steps to reduce their bycatch (and the mortality) of turtles. For example, in the Northern Prawn Fishery, through the use of bycatch reduction devices, the annual bycatch of turtles has been reduced by 99 per cent since 1999. Less than 100 turtles were caught as bycatch in the Northern Prawn Fishery in 2001, and actual turtle drownings are considered to be less than 20 per year (Brewer et al. in press).

Other systems

The condition of Australia's coastal and ocean ecosystems can be understood and assessed only in the light of data and knowledge about their features and values. It is important to understand and, where necessary, mitigate pressures that might tend to degrade these ecosystems, but knowledge of pressures alone cannot provide a solid indication of the condition of the ecosystems. This is because it is not always clear how the various pressures affect the ecosystem conditions, nor how different pressures can interact with each other to create greater impacts.

There are few measurement or reporting programmes across much of Australia's coastal and ocean ecosystems. The lack of an integrated and national analysis and reporting system creates the situation where 'sliding baselines' can occur without our knowledge. Here managers and scientists only assess and report on the significance of changes that are within their own personal experience, and not against a documented set of benchmark conditions that would more properly reflect historic conditions, the expectations of the community, conditions in other regions, or changes over more than a decade or two. For example, recent evidence suggests that there has been a major loss of shell (mollusc) species over the past 150 years in shallow, sheltered estuarine waters of south-eastern Tasmania (Edgar and Samson 2004). These losses were previously undetected, and this example highlights the risk of the 'sliding baseline syndrome', where changes that occur over generations are not noticed and the new environmental conditions become considered to be 'normal' (Dayton et al. 1998).

There is a broad appreciation of some of the important features and values of Australia's coastal and ocean ecosystems (Ward et al. 1998), but there is neither nationally consistent data nor knowledge about their condition. The lack of a systematic and national approach to documenting the conditions in Australia's ecosystems means there is very little reliable knowledge that can be assessed to report on changes in their condition.

While it is clearly expensive to design, establish and implement long-term monitoring, assessment and reporting systems, the eventual benefits are much greater than the short-term costs. Critical insights about the way in which ecosystems operate, the way in which they respond to major stresses, and patterns of natural change have all been secured through long term monitoring studies of ecological systems both in Australia and in other countries. It is only with long-term knowledge of the condition of ecosystems and how they respond to pressures that effective response strategies can be designed and tested.

Given the inevitable climate-driven changes in the oceans, and with these changes already being recognised today in marine systems, more systematic and strategic planning will be required for the coastal zone to allow for a gradual transition and systematic adaptation of regional and urban communities to new coastal and ocean conditions of the future. Without a systematic and planned transition, both biodiversity and the existing basis for wealth-generation from coastal ecosystems will be disrupted in an unpredictable way, and this will undermine the security of resources for coastal industries and the systematic protection and management of coastal biodiversity into the future.

Contributions and pressures

Ecosystem services

Ecosystem services are the processes through which ocean ecosystems produce resources that are often taken for granted, such as clean and healthy beaches for surfing, productive habitats for fisheries, moderation of the extremes of coastal temperatures that make coastal areas more habitable, and the recycling and relocation of nutrients derived from land runoff. These

services are maintained by retention of the natural structure and function of the ecosystems, such as the natural functioning and diversity of seagrasses, primary production in benthic and pelagic systems, and clear waters allowing light penetration into the water column (Daily et al. 1997).

There have been no documented, large-scale failures in Australia's ecosystem services, but there are many locally important problems in Australian coastal and ocean ecosystems. The lack of evidence of large-scale changes may well be related more to a lack of knowledge than to a lack of change. The examples highlighted in this report serve as early warning indicators for Australia that better monitoring of conditions and more effective responses to emerging issues in coastal and ocean ecosystems need to be urgently implemented. *Australia's Oceans Policy* is the main policy response to these broad scale ecosystem issues, but the policy is having only limited success, and so far provides no system for national (or regional) monitoring and assessment of ocean ecosystem services.

Water quality

The discharge of sewage and stormwater, land runoff, groundwater and river inputs of nutrients and sediments to estuaries and the coastal waters is arguably Australia's greatest coastal management challenge (NLWRA 2002). All capital cities discharge sewage and stormwater to estuarine and marine waters, and much of this receives only minimal treatment—stripped only of solids and rubbish, but not of nutrients, hormones, disinfectant breakdown products, nor of a range of resistant viruses. Stormwater from urban areas is discharged after minimal treatment to reduce large solids (such as plastics and industrial rubbish), but otherwise contains untreated road and garden runoff, with oils, rubber particles, fertiliser, nutrients and sediments. River catchments are major sources of nutrients, sediments and a range of agricultural and veterinary chemicals, all of which affect estuarine flora and fauna; where river inputs are large, coastal ecosystems are adversely affected. Unfortunately, there are no national-level data on the impacts of these non-point source discharges on the coastal and marine ecosystems and biodiversity.

There is growing concern globally about the range of chemicals that enter sewage treatment plants—from human waste or from industrial wastes. These chemicals are not routinely monitored in treatment processes. Sewage discharges of these chemical and nutrients can be highly significant at local scales because they have a chronic daily delivery concentrated at a point source. For example, although water-industry monitoring found no evidence of sewage impacts in the exposed coastal waters of metropolitan Perth, scientific studies found that Perth's sewage discharge leads to algal blooms, reduction of light penetration by one-third, increase in nitrogen by three to five times natural backgrounds, and more than a doubling of phytoplankton biomass (Thompson and Waite 2003). Furthermore, in NSW waters, it is estimated that 30 to 50 per cent of nitrogen in one species of reef fish is derived from nitrogen discharged in sewage (Gaston et al. 2004).

Industrial facilities discharge nitrogen, ammonia, phosphorus and sulphuric acid to coastal waters, and volatile organic compounds and hydrogen sulphide to offshore waters. In coastal waters, the metal refining industry has created intense pollution problems around several Australian smelters. For example, in the Northern Territory, the ongoing discharges from the major alumina refinery at Gove have created a 70 hectare marine 'dead zone' in the adjacent harbour (Alcan Grove Alumina Refinery 2004), and pollutant impacts may extend further into adjacent bays and seafood (Figure 3.1).

Various forms of responses have been developed to deal with these issues. To protect the biodiversity structure and function of the inshore reefs of the Great Barrier Reef, the *Reef Water Quality Protection Plan* is intended to reduce inputs of sediments, nutrients and pesticides (GBRMPA 2001). In South Australia, sewage and stormwater programs to reduce the load of nutrients have been initiated to improve the water quality of St Vincent Gulf near Adelaide (South Australian Government 2006).

The most visible indicator of coastal eutrophication is excess blooms of phytoplankton and benthic macroalgae; extensive mortality of seagrass beds has been one of the most commonly documented features of Australian coastal eutrophication (Price 1995). There is no systematic monitoring and reporting of algal blooms in Australia's estuaries and coastal waters, so there is no way of knowing if eutrophication is increasing or decreasing as a national problem.

Figure 3: Hot water refinery discharge, creating biological 'dead zone' in Gove Harbour, Northern Territory

Photo: Patrick O'Leary

Fisheries

Fishing is the most widespread activity in marine ecosystems. Australia's commercial fisheries exploit more than 300 species of fish and invertebrates, and operate in all areas of inshore and offshore waters, including the Antarctic region. While the productivity of Australia's fisheries is limited compared to those of some other countries (because of the generally low nutrient status of Australia's oceans), they nonetheless provide for an important source of wealth and recreation in most coastal areas of Australia.

The commercial fisheries are concentrated on high-value but low-tonnage benthic species. In 2003–04, the commercial wild-catch fisheries produced about 228 000 tons of seafood, valued at about $1.56 billion (ABARE 2005). The main component of this is generated by state and territory-managed coastal fisheries (151 000 tons, $1.15 billion), with Commonwealth-managed fisheries generating about half of that (77 000 tons, $0.34 billion). The value of Western Australia's fisheries alone in 2003–04 ($396 million), mostly due to the Western Rock Lobster fishery, exceeds the combined value of the Commonwealth-managed fisheries.

It is difficult to find consistent data to demonstrate changes over time in the condition of stocks (see Table 1 and Table 2). While many of the state-managed fisheries appear to be stable, some appear to be overfished (see, for example, NSW Department of Primary Industries 2004). However, for many of Australia's state-managed fisheries, there are no biomass reference points to determine the condition of the stocks, few reliable data, and no fully independent assessment of fish stocks or the fisheries (other than the Marine Stewardship Council's assessment of the Western Rock Lobster fishery in Western Australia).

Table 1: Australia's fisheries catch and value: the ten-year trend in the 18 main species reported in SOE (1996) (Table 8.11)

Rank (by value in 93–94)	Fishery/ *species*	Catch 93–94 tonnes	Catch 03–04 tonnes	Value 93–94 $million	Value 03–04 $million	Trends 93–94	Trends 03–04
1	Western Rock Lobster (*Panulirus cygnus*)	11 045	NA	287.12	NA	Stable, fully exploited	NA
2	Abalone: all species	4 723	5 585	177.50	189 413	Stable, declining in some areas	NA
3	Tiger prawns:	6 062	2 193	147.23	32.1	Stable	Not

	brown tiger (*Penaeus esculentus*), grooved tiger (*P. semisulcatus*)					overall; Fully exploited;	overfished
4	Southern Rock Lobster(*Jasus edwardsii*)	5 060	4 605 (excludes WA)	119.50	124.2 (excludes WA)	Stable; Fully exploited	NA
5	Southern bluefin tuna (*Thunnus maccoyii*)	6 080	5 080	116.35	38.15	Stable; recovery uncertain from earlier overexploitation	Overfished
6	Pearl oystera[(a)]	-	-	96.50	150	Stable; depressed in Torres Strait; Fully exploited	NA
7	King prawns (species not reported)	6 056	U	68 44	U	Stable Fully exploited	U
8	Northern scallops (two species)	13 445	4 286	51.31	17.64	Variable; Some over exploited	NA
9	Oysters (aquaculture: two species)[(b)]	2 280	7 625	48.85	71.82	Increasing; Space limitations	NA
10	Banana prawns (two species)	3 348	3 516	36.54	36.04	Variable; Fully exploited	Not overfished
11	Endeavour prawns (two species)	3 056	418 (NPF only)	31.36	4.39 (NPF only)	Stable; Fully exploited	Uncertain
12	Crabs (species not reported)	3 551	-	17.55	-	Variable; Fully exploited	U
13	Southern scallops	9 006	6 029	16.60	7.36	Variable; Fully	NA

						exploited	
14	School and gummy shark	5 152	2 875 (Commonwealth fisheries only)	15.54	14.16 (Commonwealth fisheries only)	Stable; some signs of recovery; School shark overexploited in 1980s;	School Shark Overfished; Gummy Shark Not overfished
15	Coral trout	1 101	1 605 (Qld only)	13.21	24.08 (Qld only)	Stable; Some overexploited	NA
16	Barramundi	861	1 624 (excludes WA and hatchery)	8.44	10.03 (excludes WA and hatchery)	Stable; Fully exploited	NA
17	Mullet and sea mullet	4 464	5 433	8.23	12.91	Stable; Uncertain	NA
18	Blue grenadier	3 111	8 819	7.08	11.2	Stable; quota not reached; Possibly under exploited;	Not overfished

Source: 03–04 data from ABARE (2005); BRS (2004)

NA = not available; U = unknown
Notes: (a) The value given is the value of the cultivated pearls produced. b) The value given is that of the cultured product of oysters. The catch is the weight of cultured product.

Table 2: Commonwealth, NSW & WA Fisheries status - not referred to in the text

Jurisdiction	Fishery Name	EPBC Ministerial Decision	Status (from BRS, 2004)
Commonwealth	Bass Strait Central Zone Scallop Fishery	WTO	NA
	Heard Islands and McDonald Islands	Exempt	Patagonian toothfish, mackerel icefish: not overfished
	Northern Prawn Fishery	Exempt	Banana, brown tiger, grooved tiger prawns: not overfished; endeavour, king prawns: uncertain
	Southern and Eastern Scalefish and Shark Fishery	WTO	Status reported as the component fisheries below: the South East Fishery trawl sector and South East Fishery non-trawl sector (which have many quota species in common); the Great Australian Bight Trawl
	Southern Shark Fishery		School shark overfished; gummy shark not overfished, current catch probably sustainable; sawshark and elephant fish uncertain
	South East Fishery – trawl and non-trawl fishery		Five species—blue warehou, eastern gemfish, orange roughy [except Cascade Plateau], redfish and silver trevally—classified overfished; and overfishing continues. Five species—blue-eye trevalla, blue grenadier, pink ling, spotted warehou and tiger flathead—classified not overfished; recent blue grenadier and flathead catch levels probably unsustainable in the long term; pink ling possibly nearing overfished, with catches declining and overfishing east of Bass Strait. Seven species—eastern school whiting, Jackass morwong, John dory, mirror dory, ocean perch, royal red prawn and western gemfish—uncertain. Of the 14 species or species-groups for which the Australian Fisheries Management Authority has set a catch-rate reference level, nine

			did not meet the criterion during 2003: blue-eye trevalla, blue warehou, jackass morwong, John dory, ocean perch,pink ling, redfish, spotted warehou and western gemfish
	Great Australian Bight Trawl fishery		Shelf: All species uncertainSlope: Uncertain; (orange roughy have quickly become overfished in other fisheries)
	Southern Squid Jig	Exempt	Uncertain in western Bass Strait; probably not overfished in other areas
	Coral Sea	WTO	NA
	Western Trawl Fisheries	WTO	NA
	Western Australian Southern DemersalGillnet and Longline Fishery (SDF)		Dusky shark and whiskery shark—overfished; gummy shark—not overfished; school shark overfished.
	Torres Strait Tropical Rock Lobster	WTO	Overfished; lack of reliable post-2000 catch data prevented review of the previous overfished classification; similarly, although effort has intensified, it is not possible to determine whether or not overfishing is occurring due to increased stock abundance
	TS Prawn Fishery		Tiger prawn not overfished; endeavour prawn uncertain but probably not overfished; king prawn uncertain
	Eastern Tuna and Billfish Fishery		Overfishing of Pacific bigeye but stock not yet overfished; yellowfin in the Western and Central Pacific Ocean (WCPO) not overfished and overfishing not occurring; status of marlins and south-western Pacific swordfish uncertain, but localised depletion of swordfish apparent; South Pacific albacore not overfished and overfishing is not occurring
	Southern & Western Tuna and billfish fishery		Bigeye tuna not overfished; yellowfin tuna and broadbill swordfish uncertain; overfishing of bigeye tuna is occurring in the broader Indian Ocean

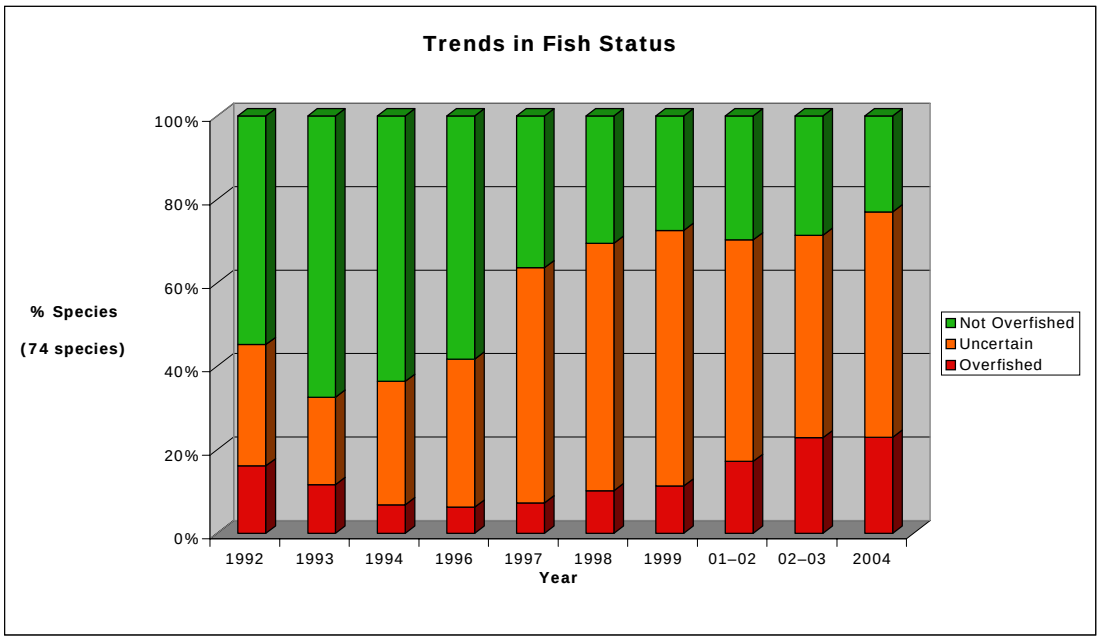
	Western Tuna and Billfish	Exempt	NA
	Southern Bluefin Tuna	WTO	Overfished, and overfishing is occurring; spawning stock severely depleted and current catches severely limit probability of rebuilding
	Small Pelagics Fishery	Temp WTO	NA
New South Wales	Estuary General Fishery	Exempt	Target species fully fished except squid, which has not been assessed (NSW Fisheries. 2003. Status of fisheries resources 2001/2002. Cronulla Fisheries Centre, NSW Fisheries,Cronulla, NSW, 293pp.)
	Estuary Prawn Trawl Fishery	WTO	Target species fully fished except squid which has not been assessed
	Ocean Hauling Fishery	Exempt	Fully exploited – garfish & silver trevally slightly overexploited
Western Australia	Exmouth Gulf Prawn Fishery	Exempt	Fully exploited Breeding Stock Levels (BSL): Adequate
	Pearl Oyster Fishery	Exempt	Fully exploited BSL: Adequate
	Rock Lobster Fishery	Exempt	Fully exploited BSL: Adequate
	Shark Bay Prawn Fishery	Exempt	Fully exploited BSL: Adequate
	Shark Bay Snapper Fishery	Exempt	Over-exploited BSL: Inadequate
	Shark Bay Scallop Fishery	Exempt	Fully exploited BSL: Adequate
	West Coast Deep Sea Crab Fishery	WTO	Not assessed BSL: Adequate
	Abalone Managed Fishery	Exempt	Fully exploited BSL: Adequate
	Broome Prawn Managed Fishery	Exempt	Under-exploited BSL: Adequate
	South Coast Crustacean	WTO	Fully exploited BSL: Adequate

	Fishery		
	Salmon Fishery	Exempt	Fully exploited BSL: Adequate
	Mackerel Fishery	Exempt	Fully exploited BSL: Adequate
	Pilbara Trap Fishery	WTO	Fully exploited BSL: Adequate
	Kimberley Prawn Fishery	Exempt	Fully exploited BSL: Adequate
	Shark Bay Experimental Crab Fishery	WTO	NA
	Onslow/Nickol Bay Prawn Fishery	Exempt	Fully exploited BSL: Adequate
	Specimen Shell Managed Fishery	Exempt	Not assessed BSL: Adequate
	Pilbara Fish Trawl Fishery	WTO	Fully exploited BSL: Adequate

In contrast, there are much more accessible and verifiable data for Commonwealth-managed fisheries, and they show an alarming trend in stock conditions. Over the past 12 years, amongst the 74 species that are Commonwealth-managed, there has been an increase in the number of stocks that are overfished, or have inadequate knowledge to make a decision (Figure 4). Some 23 per cent (17 species) of fish stocks are currently overfished (or inadequately known)—this is an all-time record high (BRS 2004). This current trend of increasing numbers of overfished species is not consistent with sustainable management of Australia's fisheries and, as for global fisheries (FAO 2004), urgent conservation action is now required in Australia to restore commercial fish stocks.

In November 2005, the Australian Government announced a $220 million national fisheries structural adjustment programme to deal with this problem. The package aims for a major reduction in permitted catches across a number of Commonwealth-managed fisheries. It also includes considerable structural adjustment to compensate fishers for the catch reductions and business disruption. This response is designed to take a large fraction of the fishing effort permanently out of these fisheries, and allow stocks to recover from their currently overfished conditions.

Figure 4: Increase in overfished target species in Commonwealth-managed fisheries over the past 12 years



Source: BRS, 2004

The EPBC Act requires that all Commonwealth-managed fisheries undergo strategic environmental impact assessment, and that all fisheries with an export component undergo assessment to determine their sustainability. Fisheries assessed under the Act may be permitted to export products or they may be prohibited. Up to April 2005, 11 Commonwealth-managed and 69 state-managed fisheries held approvals to export products, and no fisheries have been classified as Prohibited. A further 31 fisheries were in various stages of the assessment process (DEH 2005).

Recreational fishing is responsible for substantial catches of fish and invertebrates that are taken mostly from nearshore waters in the most populous states, but increasingly also in remote areas of the mainland and the offshore islands. A national survey of recreational fishing estimated that between May 1999 and May 2000, 3.36 million people participated in recreational fishing, catching about 136 million individual animals. This included more than 12 500 tonnes of the most popular species, and where there are comparable data, it has been estimated that for some of these species, the recreational catch exceeds the commercial catch. In 2004, domestic and international visitors alone are estimated to have spent 40 million trip-nights, and at least $3.4 billion on various aspects of recreational fishing.

Few recreational fisheries are fully managed, in the sense that stocks are assessed and fishing effort is controlled appropriately to ensure adequate levels of breeding populations are maintained. The lack of effective control mechanisms over recreational fishing pressures increases the risks of overfishing and degradation of the fish populations. As Australia's

population increases and more people fish, the pressures on fish stocks will increase. At present there is almost no systematic collection of recreational fishing data, and so trends in recreational effort, including possible effects on sensitive species that are highly targeted by recreational fishers, such as Mulloway (*Argyrosomus hololepidotus*), and the resulting impacts on fish stocks are virtually unknown. These issues are well recognised by fishery managers in all states and territories, and there is an increasing focus on improving the management of recreational fishing for highly sensitive species.

All fisheries (commercial, recreational, subsistence and Indigenous) have direct impacts on non-target species and habitats, and indirect impacts on species that are ecologically linked to the species being caught. The effects of target catch, bycatch, and possibly habitat degradation, in Commonwealth and state-managed fisheries, have had a major impact on sharks, rays and sawfish, and there is a high level of concern over the illegal catch of sharks from tropical waters for finning.

The tuna fisheries set more than 70 million baited hooks on longlines in Australian waters in the five years from 1998 to 2002. Of the 21 species of albatross that occur in Australian waters, 13 have been caught as bycatch on longlines (AFFA 2003), and all these species have been observed caught on longline hooks elsewhere in their geographic range. Thirteen other species of seabirds have also been observed killed on longlines in Australian waters, including petrels, gannets and skuas.

Australia's Northern Prawn Fishery extends across about 6000 kilometres of the northern Australian coastline, through Queensland, the Northern Territory and Western Australia, and catches about 8500 tonnes of penaeid prawns each year. In addition, catches are dominated by a wide range of unwanted (and ultimately discarded) bycatch species, including at least 330 species of fish, 56 species of sharks, stingrays and sawfish, 13 species of sea snakes, five species of turtles, and hundreds of species of benthic invertebrates (Stobutzki et al. 2001b, Pender et al. 1992, Brewer et al. 1998)

In response to these concerns, the Northern Prawn Fishery has implemented a number of bycatch reduction initiatives which have substantially reduced the annual catch of turtle, sharks and rays. Fishing reduces the abundance of target stocks and, if fishing intensity is high enough, the numbers of fish available for natural predators may become highly depleted. The history of Australia's Southern & Eastern Scalefish and Shark shows that, since the fishery commenced in 1915, fishing has greatly altered the biodiversity of the continental shelf and deeper water ecosystems. While flathead (*Platycephalus*) remains the main target species in the fishery, the mix of other exploited species has changed substantially. The spawning biomass of tiger flathead (*Neoplatycephalus richardsoni)* in this area, for example, has been reduced from about 27 000 tons in 1915 to about 7000 tonnes in 2004; and leatherjackets and Latchet (*Pterygotrigla polyommata*) have now almost disappeared from catches in the fishery (Klaer 2001). Since the 1970s, the catch rates of sharks and rays in the

fishery have also declined dramatically, and populations of most of these species are now at very low levels (Graham et al. 2001).

A qualitative analysis of the ecological risks from fishing in 14 Commonwealth-managed fisheries identified sharks and rays as a group that has a higher level of risk from the impacts of fishing than the other groups considered (Hobday et al. 2004). These species are mainly predators and, although climate change and habitat destruction may also have important impacts, fishing impacts are likely to be very important.

Commonwealth-managed fisheries are developing bycatch action plans. Also, ecological indicators to report on impacts are being developed for Commonwealth-managed fisheries (Fulton et al. 2004). Without a comprehensive reporting system for bycatch and ecological impacts that parallels a system for commercial stocks for all Australian (state, territory and Commonwealth-managed) fisheries, there can be no comprehensive national analysis of the condition of fish stocks and the impact of fishing.

Aquaculture

Australia's main aquaculture products are pearls, Atlantic Salmon (*Salmo salar*), Southern Bluefin Tuna (*Thunnus maccoyii*), oysters (two species), and a range of other mollusc and finfish species. Production has increased during the past decade, from $494 million in 1994–95 (in 2003–04 dollars) to $732 million in 2003–04. The relative value of aquaculture also continues to increase, contributing 34 per cent of the gross value of production of all fisheries in 2003–04 (ABARE 2005).

While land-based aquaculture is increasing, most of Australia's production is still sourced from in-water aquaculture activities. These activities tend to be concentrated in coastal regions of high water quality, which are usually also areas of high conservation value. The allocation of highly sensitive inshore sites for aquaculture operations in all states and the Northern Territory has generated widespread concern about the biodiversity and ecosystem impacts of these activities. The main ongoing pressures related to in-water aquaculture ventures are:

- water and sediment pollution (nutrients, biocides, antibiotics, diseases) around installations
- alienation of highly environmentally sensitive inshore habitats for sea-cages and supporting shore-based infrastructure
- the overharvesting of pelagic species to provide feed for farmed species
- the wild catch of immature fish that would otherwise contribute to maintenance of a natural wild breeding population of that species
- the escape of cultured species into the wild and their consequent impact on local populations of prey species and the gene pool of native species

- attraction of predators and entraining of birds and mammals on facility wastes or escapes
- the introduction of diseases into the local region
- the risk of catastrophic failure of installations under storm and cyclone extremes.

Perhaps the worst ever fish kill from human causes is the massive series of pilchard kills that repeatedly occurred across temperate Australian waters (from Western Australia to New South Wales) in 1995 and again in 1998–99 (reported in *SoE2001*). The fish kill episodes were observed across more than 4000 kilometres of temperate Australian coastline and, although there has been no attempt to estimate the total mortality of pilchards, mass fish mortalities of this scale are of national and probably global importance. It is unlikely that the precise cause of these fish kills will ever be known, but the most likely source of the virus thought to be responsible is the frozen, but otherwise unprocessed, food used for aquaculture sea-cages in South Australia (Griffin et al. 1997, Gaughan et al. 2000). Food for aquaculture purposes is now more systematically managed to reduce the risk of such disease importations re-occurring, but the virus that affected the pilchards is probably now well established in Australian marine ecosystems and likely to have ongoing impacts on the pilchard population and species that depend on this fish (such as penguins).

In New South Wales, the stick and tray aquaculture industry produces about 100 million Sydney Rock Oysters (*Saccostrea glomerata*) a year, valued at about $35 million in 2003–04. In June 2004, an outbreak of the 'QX' parasite *Martelia sydneyi* was detected in oysters in the major growing area, the Hawkesbury River near Sydney. This disease has been known in oysters for more than 20 years, but this recent outbreak has resulted in the closure of the Hawkesbury to commercial oyster production.

The Australian aquaculture industry is small by global standards, contributing less than 0.1 per cent of global production by volume (ABARE 2005). The industry is expected to continue to grow at a rapid rate (Love and Langenkamp 2003). It is likely that, at least in some areas of Australia, growth in the industry will be heavily based on sea-cage and other in-water operations, and will place an increasing stress on coastal planning and management as the economic pressure for multiple uses of protected shallow coastal sites of high water quality intensifies. With some exceptions, local, state and national planning processes are presently inadequate to cope responsibly with the demands for aquaculture sites and operations. Better planning and management will be needed to avoid irreversible environmental impacts

Oil and gas

Australia's oil and gas industry is based around three major production areas: the North West Shelf, Gippsland and Bass Strait, and the Cooper Basin (APPEA, 2003). Australian production is valued at about $15 billion per year.

Each year the industry has several hundred minor incidents (APPEA 2003), but there is also an increased risk of pollution from drilling muds or formation water, from shipping accidents,

and the possibility of oil rig or wellhead failure that could result in major spills of oil or gas. At least three areas of importance to whales, in Victoria and Western Australia, are shared with oil and gas wells; increasing the risk of collision, entanglement, and exposure to low levels of contaminants. Most of Australia's oil and gas wells occur in areas where there are high numbers of threatened species, especially in the north and central west, eastern South Australia and the Bass Strait.

The most important environmental risk is from the shipping of oil and gas products, and the potential for shipping accidents, or accidents related to floating production systems. Where facilities are located in shallow waters, or near sensitive habitats such as coral reefs or seagrass beds, or near habitats of protected species, there are always concerns about possible impacts from accidents. These risks are increasing because of the increased frequency and severity of storms and extreme ocean conditions, which increase the risk of equipment failure and other forms of accidents. The industry has developed extensive environmental programmes to avoid potential impacts. These programmes are supported by a range of research projects that are designed to better understand the current levels of impact and the levels of environmental risk (APPEA 2003).

Shipping

In 2002–03, almost 9000 voyages by ships transported 592 million tonnes of cargo from overseas to Australian ports over the main Coral Sea and west coast shipping lanes. There is also considerable coastal transport of cargo, although only three ports have facilities to handle contaminated ballast water. The increasing number of shipping movements is increasing the risk of collision with cetaceans and other large marine species in estuaries, coastal and ocean waters. In Queensland in 2002, 65 turtles and seven dugongs are considered to have been killed by vessel strikes. There have been no major shipping accidents in Australian waters that have resulted in major oil spills since 1999, when the Laura D'Amato released 250 tonnes of oil in Sydney. In contrast, there have been many small spills and discharges from ships (129 in 2003–04), and a large number (135) of unknown origin (but many likely to be from shipping). Oil spills from any source are dealt with under the provisions of a national plan that provides detailed guidance and methods for coordination in the event of a major spill, training, oil spill cleanup procedures, and equipment that is available at all major ports. Individual ports across Australia also have a range of equipment and local procedures in place in the event of oil spills in their area.

Antifouling paints have previously been a major issue in Australian waters. The most toxic forms (tributyly tin-based paints) have been progressively phased out of use for small vessels. The remaining use of tributyl tin paints is restricted to large commercial vessels, and the main issues of antifouling now are constrained to commercial shipyards and anchorages where there is a high density of these large commercial vessels.

Invasive species

At any given moment, about 10 000 different species are being moved between various regions around the world in the ballast water tanks of the world's vessels (Carlton 1999). Travel times between Australian and overseas ports are reducing, and there is a greater range of ports that trade directly with Australia. Also, there is an accelerating increase in small vessels (semi-commercial and recreational) travelling between Australia and adjacent countries. Between 150 and 200 million tonnes of ballast water from overseas locations are discharged inside Australia's territorial seas each year.

More than 250 introduced marine species, and possibly up to about 500 species (Hayes et al 2005), are now established in Australian waters. Such exotic species can have major impacts, and their effects are probably irreversible. For example, the introduced seaweed *Undaria pinnatifida*, can invade large areas of native, subtidal kelp forests to establish populations at the expense of native species (Valentine and Johnson 2004). Detailed surveys of benthic fauna have discovered that introduced species can be the dominant species (for example, Hutchings et al. 1993), and even in World Heritage Areas, there are substantial populations of introduced marine invertebrates (Wyatt et al. 2005). There are 58 species of marine invaders in Tasmanian waters and, as a result, ballast water from Tasmania is not allowed to be discharged in New Zealand, or in the Port of Hastings (Victoria) (*Tasmanian Government, 2003*). In response to these issues, Australia has been a leader in the drafting and support for the International Convention for the Control and Management of Ships' Ballast Water and Sediments, and it is the first country to notify its intention to sign the Convention. Compliance with Australia's mandatory ballast water management requirements by arriving vessels is better than 99 per cent, and it is expected that this reduces the risk of further marine species introductions.

Within Australia, an Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions (DAFF, 2005) is being developed to implement a national system for management of ballast water issues and all other vectors, and to provide for emergency response and long-term control and management of species of concern. Emergency response arrangements are in place to deal with major outbreaks of marine invaders (*DAFF, 2006*). The National Strategy does not yet incorporate a comprehensive system for monitoring of ports or adjacent areas to detect introduced species that may have important ecological consequences (as opposed to commercial consequences), and this may allow invasive species to pass unnoticed until they are well entrenched into local ecosystems, possibly with irreversible ecological impacts. Nonetheless, the high level of cooperation between state, territory and Commonwealth agencies demonstrates the importance of the issue of marine invasive species, and the commitment of governments to identify and address such a key issue for Australia's marine industries and biodiversity.

Tourism and recreation

Australians and visitors to Australia admire the high quality of coastal and ocean ecosystems across much of the continent, especially away from the urban centres. The diversity and naturalness of coastal and marine recreational attractions is, to some extent, taken for granted by Australians, however well established and enshrined it is into the national culture. In 2004, domestic and international visitors spent about $20 billion purely on recreational and tourist activities directly involving coastal and ocean ecosystems.

The popularity of all nature-based tourism, including whale watching, diving, snorkelling, glass-bottom boat tours and sea kayaking, is rapidly increasing in Australia. In the Ningaloo Marine Park (Western Australia), swimming with whale sharks has grown into a $12 million a year industry in little more than a decade, attracting visitors from around the world (DCLM 2005). .

The success of tourism and recreation, in both monetary and visitor enjoyment terms, is dependent on the availability of the resource and there being appropriate infrastructure and facilities. Maintaining the naturalness of the ecosystems, including their biodiversity, is clearly an essential objective of planning for recreation and tourism; but there is no national, integrated system for assessing or reporting on the performance of tourism ventures in relation to their ecosystem resource base.

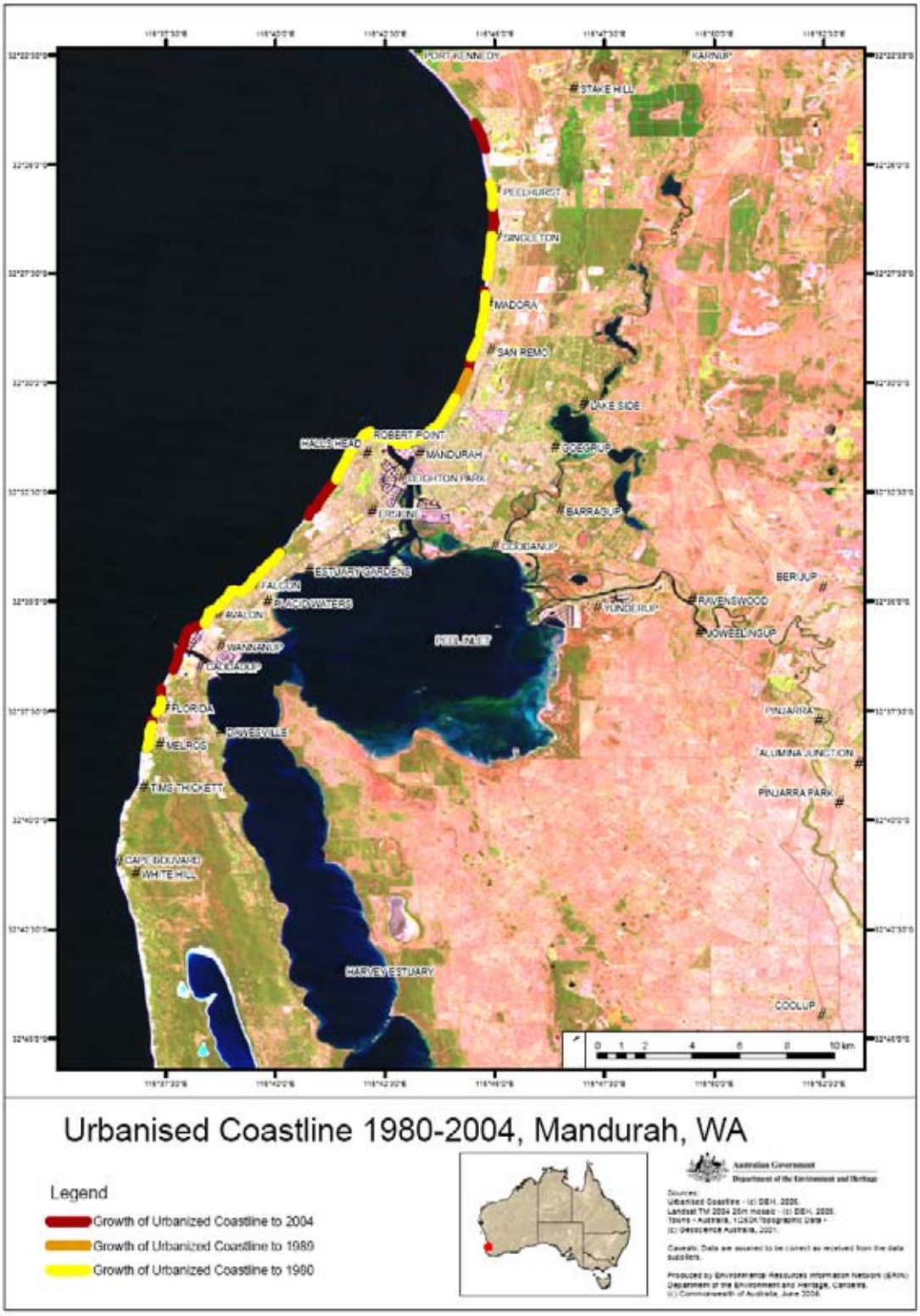
Coastal development

Coastal strip development through incremental extension of most of Australia's existing urban areas threatens much of the temperate coast and tropical systems near existing centres of population. This leads to pressure for opening and dredging of estuary and lagoon channels, construction of marinas, beach groynes, and coastal stabilisation projects, all of which gradually degrade coastal habitats and ecosystem functions. These pressures are accelerating because of the increasing coastal focus of Australia's population, the increasing vehicle mobility and access to coastal areas and coastal waters, exposure of acid-sulphate soils during development and the ongoing demand for tourism and recreation facilities to cater for non-consumptive uses of coastal and marine ecosystems.

The cumulative outcomes of such ongoing coastal alienation of habitat, the alteration in natural dynamics and hydrological cycles in coastal wetlands, and the pressure on fish and coastal invertebrates, results in an ongoing series of complex changes to coastal ecosystems. For example, foreshore lands are rapidly being developed for urban dwellings near Mandurah, Western Australia (Figure 5). This urban expansion is linked with the unsuccessful attempt to resolve the eutrophication problem of the Peel Harvey estuary in the late 1990s, in which a canal was dredged in an attempt to flush nutrients from the estuary, and to reduce algal blooms that resulted from the high levels of nutrients in agricultural runoff. Associated with this has been development of surrounding housing estates, recreation areas and coastal access roads. The direct and indirect impact of this $50 million engineering initiative extends along

the coast north and south of the canal, including changes to local groundwater and wetland systems. In 2003, a $2 million Commonwealth-State water quality improvement programme was announced, with the aim of improving water quality in the estuary. Although there are now indications of improvements in water quality near the canal from the increased flushing by marine water, elsewhere in the estuary there are apparent increases in harmful algal blooms, bank erosion, low oxygen events and large ‘dead zones’ (DEH, 2003).

Figure 5: The increase of urban areas along the Western Australian coastline. The yellow line shows the extent of urban areas in 1980, the blue line shows the expansion of the urban area to 1989, and the red line shows the expansion urban areas in 2004



Management systems

Integrated Oceans Management

Australia's Oceans Policy is the single most important policy instrument in Australian history. It is designed to improve the processes and outcomes of marine management in estuaries, coastal, and offshore waters. The policy was developed through substantial national consultation between government and industries, and with Indigenous, community and conservation groups in the mid to late 1990s. The primary expression of the policy is the process of regional marine planning, which is being conducted sequentially in each of the major marine regions of Australia by the National Oceans Office. To provide the spatial framework for the regional marine planning process, a National Marine Bioregionalisation has been produced to define, amongst others, the boundaries of 41 marine provinces within the EEZ. The first regional marine plan has been completed for the south-east region, and subsequent plans are in the process of development for the northern and south-west regions (NOO, 2003).

The primary objective of the regional marine planning process, and each regional plan, is to identify and agree on a set of management arrangements for each use and user of ocean resources so that, collectively, their impacts on the environment, biodiversity and natural resources are minimised and constrained to acceptable levels. There is a substantial Australian Government commitment to implement regional marine planning, but the process has not achieved wide recognition and acceptance in the states and territories, although all states recognise the importance of bioregional planning and integration of management arrangements. In November 2005, it was announced by the Commonwealth Minister for Environment and Heritage that the preparation of regional marine planning under *Australia's Oceans Policy* would thenceforth be considered to fall within section 176 of the EPBC Act, which deals with the development of bioregional plans. This declaration recognises the primary role of regional marine planning as a Commonwealth planning instrument, and makes it clear that complementary arrangements will need to be negotiated with each state and territory in regard to the integration and coordination of ecosystem-based management arrangements for inshore waters.

The issue of management integration within and between state, territory and Commonwealth waters is crucial. All the states and the Northern Territory have vast coastal marine regions with exceptional biodiversity values. For example, Western Australia's marine jurisdiction comprises 18 bioregions covering about 126 000 square kilometres of mainly shallow coastal waters along 13 000 kilometres of coastline, spanning a range of more than 20^{o} of latitude (14^{o} to 35^{o}) and, in places, extending out to 100 kilometres from the coast. This Western Australian area hosts marine biodiversity components of extreme global biodiversity value, including about 20 000 square kilometres of the worlds most diverse seagrass beds, about 2500 square kilometres of mangrove forests, one of the worlds largest fringing coral reef

ecosystems (Ningaloo Reef is 290 kilometres long) and one of the world's most southerly high diversity coral reef systems (Abrolhos Islands, 28°S, comprising 122 islands).

The Natural Resources Management Ministerial Council (NRMMC) oversees the delivery of the Natural Resources Management programmes: the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust (NHT) (Australian Government, 2006). These programmes are cooperatively implemented by the Commonwealth, state and territory governments to improve catchment management and land use, and the NRMMC has endorsed a framework for a national cooperative approach to integrated coastal zone management (DEH 2003). Despite the obvious implications for water quality and resources of estuaries and coastal waters across all of Australia, there are only minor marine or coastal aspects in either programme, and there appears to be only limited coordination with the regional marine planning process under *Australia's Oceans Policy*.

Protected areas

It is widely argued that networks of formally protected areas are the only way that the structure and function of marine ecosystems and biodiversity can be reliably managed to ensure their long term and low risk protection (for example, Lubchenco et al. 2003). In 1998 the Commonwealth and state governments committed to developing a National Representative System of Marine Protected Areas (NRSMPA). The primary goal of the NRSMPA is to establish and manage a Comprehensive, Adequate and Representative (CAR) system of marine protected areas to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels.

By 2002, Australia had declared 188 marine and estuarine protected areas with the primary objective of protection of biodiversity, encompassing a total area of 646 400 square kilometres (DEH, 2002). This includes the world's largest marine reserve, 65 000 square kilometres, in the waters surrounding Heard Island and McDonald Islands. In 2004, protection of the Great Barrier Reef was substantially increased through a major rezoning in the Great Barrier Reef Marine Park, which resulted in an increase in the most highly protected 'green zones' from about 17 000 square kilometres to about 114 530 square kilometres (about 33 per cent of the total area of the Great Barrier Reef Marine Park). In Western Australia, the Ningaloo Marine Park was extended to 2354 square kilometres, and 34 per cent of this is dedicated to high-level protection (marine reserve). These protected areas contain some of the world's most important areas of marine biodiversity, and result from an accelerating programme of protected area establishment in all state, territory and Commonwealth jurisdictions.

The formal NRSMPA programme does not recognise marine areas that are protected for other purposes, such as fisheries closures. While only areas dedicated under conservation legislation are likely to be fully effective as marine reserves, the areas set aside for, say,

fishery protection purposes also make a contribution to the protection of marine biodiversity. The extent of this contribution, and the effectiveness of the management controls in such areas, have not been assessed, although it is clear that areas such as fishery closures do make a significant additional contribution beyond the NRSMPA to the conservation of marine biodiversity, even though they may be dedicated for protection of production values rather than conservation values.

While many of Australia's marine protected areas have zones that are dedicated for high levels of protection, some have large areas where a range of activities are permitted, including fishing, mining, oil and gas exploration. By 2002 less than 160 000 square kilometres was classified for highest level of protection, limiting the effectiveness for conservation. For example, of Western Australia's 18 bioregions, 12 have no marine protected areas. While 12 per cent of the Western Australian marine jurisdiction is within some form of marine protected area, only about 2.5 per cent is contained within highly protected zones, and the existing system of Western Australian marine protected areas is neither fully comprehensive nor representative (Figure 6). Nonetheless, for the existing marine protected areas, Western Australia has a strong programme of management, and well-designed management plans with elements of research and monitoring are either now in place or are under development. Other states have varying policies, for example:

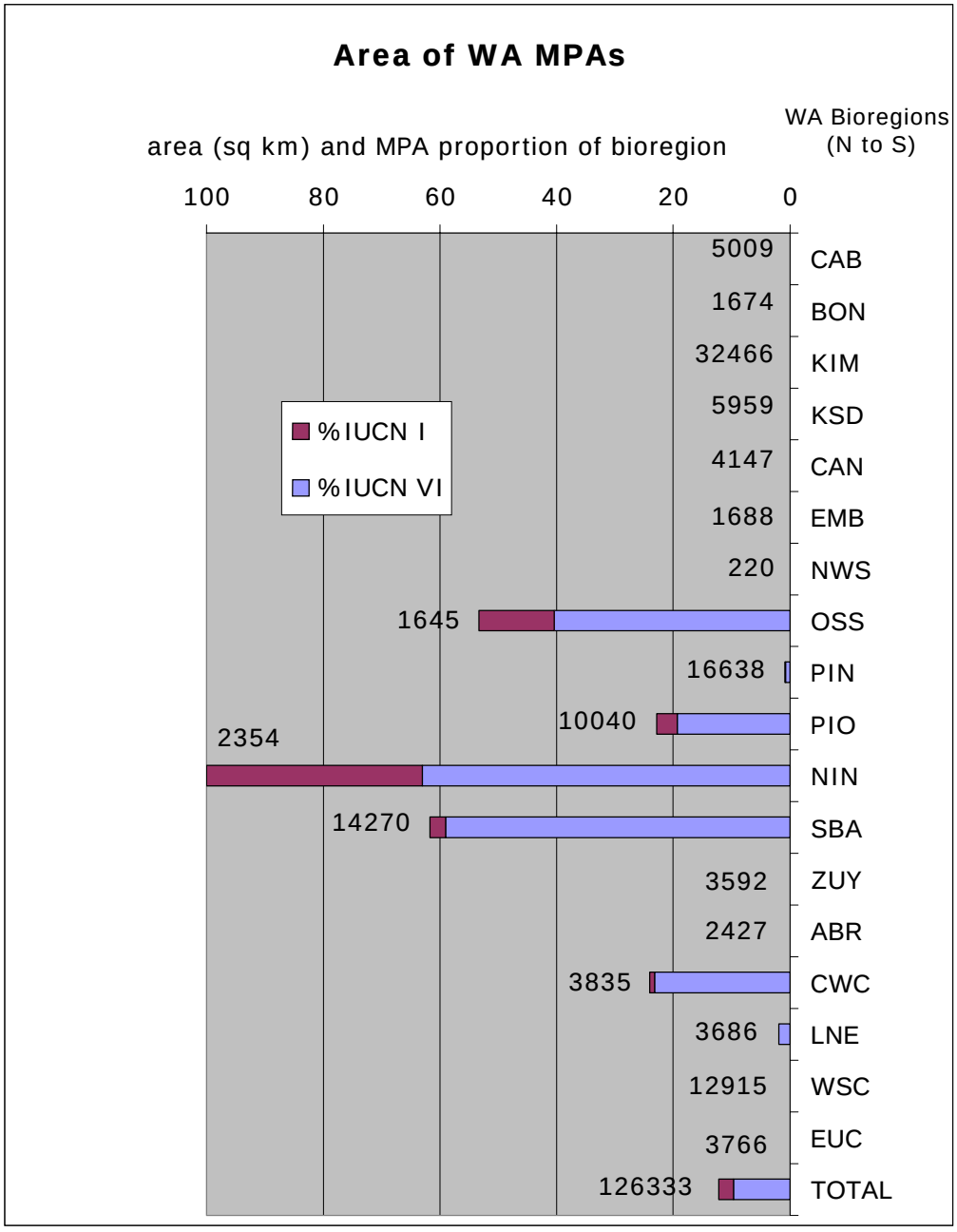
- Tasmania - <http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/BHAN-54983Z?open>
- Queensland - <http://www.epa.qld.gov.au/publications/p00541aa.pdf/Marine_protected_areas_in_Queensland_a_draft_planning_framework.pdf>
- New South Wales - <http://www.fisheries.nsw.gov.au/marine_protected_areas>
- Victoria - <http://www.parkweb.vic.gov.au/1process_content.cfm?section=94&page=28>
- South Australia - <http://www.environment.sa.gov.au/coasts/marine_paps.html>
- Northern Territory - <http://www.ipe.nt.gov.au/whatwedo/inrm/report/coastalmarine/current.html>.

The explicit intention of the NRSMPA is to protect samples of all the types and levels of Australia's marine biodiversity within a system of protected areas that span the full marine jurisdiction, including the offshore waters and islands, coasts and shores, estuaries, lagoons and bays, reef systems, benthic systems, and pelagic systems. But as yet no nationally consistent system of planning and management, or assessment and reporting, has been developed that will deliver outcomes capable of meeting the expressed intention of the NRSMPA in either CAR or IUCN terms. Each state and territory and the Commonwealth have adopted a different approach to the planning, consultation, identification and selection of marine protected areas, and each of these is different to that of the Great Barrier Reef Marine Park Authority, the recognised international benchmark in such matters. A systematic monitoring of the performance of the NRSMPA against a nationally-agreed set of

performance criteria is urgently needed to enable an evaluation of the effectiveness of the NRSMPA as a national response to the critical issues of the conservation of marine biodiversity in on-reserve situations. To enable an unbiased assessment of conservation achievements, this will also need to be supported by an analysis of the biodiversity conservation contribution made by the various forms of fishery closures in Australian waters.

Overall, Australia's NRSMPA is an important policy platform for securing conservation of biodiversity and protection of ecosystem functions within Australian waters, but has not yet been proven to provide a major contribution to biodiversity conservation. Certainly some important marine protected areas have been declared, and some very important elements of biodiversity have been protected (such as the Great Barrier Reef, Ningaloo and the Heard and McDonald islands, but these have been achieved in their own right, not because of a systematic application of the NRSMPA.

Figure 6: Marine Protected Areas in Western Australian waters



Source: Bioregions from IMCRA 3.3, Data provided courtesy of the Marine Conservation Branch of Western Australian Department of Conservation and Land Management.

Protected species

The Commonwealth's EPBC Act promotes the conservation of biodiversity by providing strong protection for threatened species and ecological communities. These are species and communities that may be threatened for a variety of reasons, such as loss of critical habitat, or the adverse effects of fishing. The Act also provides a list of species that must be considered

in the conduct of any activity by any Commonwealth agency, or within fisheries that are submitted for approval under the Act, to ensure that impacts on such species are at an acceptable level.

The Act provides for identification of key threatening processes, protection of critical habitat, preparation of management plans, issuing of conservation orders and regulation of wildlife import and export. Species and ecological communities that meet specific criteria may be declared as threatened under the Act, and processes may be formally declared as key threatening processes. Species may be found to be Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable or Conservation Dependent.

Up to mid-2005, the populations of 18 marine species have been declared as threatened under the Act— five birds, five sharks, two seals, the Australian Sea Lion (*Neophoca cinerea*), four species of handfish, and the Port Davey Skate (or Maugean Skate (*Raja sp.L*)). Some 12 recovery plans were in place at mid-2005. No marine communities have been declared as threatened. Two marine Key Threatening Processes have been declared—'Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South', and 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris'.

The number of populations of threatened marine species listed under the Act has increased in recent years, but this probably is more a reflection of improving knowledge than declining species conditions. The number is likely to continue to increase as better information accrues. In particular, as information about invertebrates and marine plants increases, more of these groups are likely to become formally recognised as threatened.

Conclusions and key issues

The overall conclusion that can be drawn from this analysis is that in 2006, most, if not all, of the issues identified and assessed in both the 1996 and the 2001 national State of the Environment reports still remain to be resolved. Some issues have changed in importance, but all have been foreshadowed in earlier state of the environment reports.

This calls into question the effectiveness of Australia's responses to identified key national problems that afflict coastal and marine ecosystems, and particularly the reforms in governance that are required to enable a move away from short-term and sectoral management towards a more systematic, integrated and planned approach to managing coast and ocean issues. Such reform would not only deliver better solutions (hence increasing the effectiveness of governance) but would also increase efficiency through reducing the large amount of existing duplication and redundancy in governance systems, and ultimately achieve reduced monetary costs to governments, communities and the private sector for management of ocean and coastal issues.

The most all-pervading systemic problem that underpins almost all the issues of managing Australia's coasts and oceans is the lack of any systematic and strategic policy or operational framework that provides for the national-level monitoring and assessment of the condition of the ocean features, biodiversity or key resources. Only for commercial fisheries that are Commonwealth-managed is there an acceptable basic level of analysis and public reporting that can inform national management, and establish the trends in commercial fish stocks of national importance. Although the Commonwealth fisheries reporting does not extend to bycatch or other associated environmental issues, the improving fisheries reporting and public accountability has provided the basis for identifying the issues, and now corrective responses (such as the fisheries restructure package announced in November 2005, and requirements imposed under the EPBC Act) can be implemented with appropriate urgency.

The key issues

There are nine key issues identified in this report. None of these is new, but each has increased in profile and importance since 2001:

1. The effects of existing changes in the climate on biodiversity and fisheries resources

We now know that there are many changes underway that are measurable and will have an important ecological and economic impact on the oceans and their values; we know that the risk of major regime shift is increasing; but as yet almost no attention is paid to the preparation of management systems for the inevitable effects of these changes.

2. The continuing decline of a number of our commercial fish stocks

The planned major reductions in total allowable catch (quotas) and consequent reduction in fishing effort is expected to make a significant improvement to Commonwealth-managed fish stocks, and similar responses may be needed for some state-managed fisheries; but there is still limited reporting of bycatch and other ecological interactions of fisheries, so the environmental sustainability of fishing cannot be assessed on a national scale.

3. The extreme vulnerability of sharks, rays and sawfish as a group

It is now recognised that this group of species is highly vulnerable to the combined effects of fishing, coastal habitat changes and climate impacts, and requires urgent management attention.

4. The need for a systematic national approach to management of recreational fishing

Recreational fishing may affect some fish stocks more than commercial fishing does. The impacts are likely to be increasing and, despite increasing management efforts, it is only weakly managed; a national response is now required.

5. The need to develop an integrated national framework, including environmental standards, for management and auditing of the aquaculture industry

The likely growth of the aquaculture industry will depend on the availability of high quality sites, but given the history of pollution and habitat impacts there will be an inevitable increase in environmental issues as the industry expands.

6. The limited success in implementing the National Representative System of Marine Protected Areas (NRSMPA)

This important policy continues to be implemented piecemeal by the Australia Government and each of the states and territory governments in different ways, and it is not demonstrably leading towards achievement of its aims—that is, towards a system that includes a representative sample of all Australia's marine ecosystems, of adequate size and design, and with adequate monitoring and integrated management, to protect them against likely threats. The lack of a systematic performance assessment and reporting system prevents an informed analysis of the achievements of the NRSMPA;

7. The limited effectiveness of regional marine planning as a solution to the problem of a lack of integrated management of ocean and coastal ecosystems and resources

While *Australia's Oceans Policy* established the appropriate policy platform, it has not been able to be translated into an operational national (states, territories and commonwealth together) system that provides integrated outcomes in relation to ecosystem-based management, security for resource-based industries, and biodiversity protection; now that regional marine planning has been clearly identified as a Commonwealth planning instrument, there is an enhanced and urgent need to develop effective procedures to secure highly coordinated arrangements with the states and territories for the integrated and ecosystem-based management of inshore waters that complements the developing Commonwealth system.

8. The predominance in all governments of a reactive rather than proactive approach to managing environmental issues in coastal ecosystems

The lack of a systematic national approach to coastal issues of pollution and habitat loss, coordinated across the three levels of government, prevents systematic capture of appropriate information and knowledge that would be able to underpin high quality and strategic management decisions that provide for sustainable development of Australia's coastal and ocean resources and for orderly adaptation to inevitable changes.

9. The need for national assessment of coastal and ocean conditions

Throughout this commentary, we have reported limited, indicative data but remark that there is no national monitoring. Despite more than a decade of work to establish indicators, the

practical issues of capturing data on these coast and ocean indicators have not been resolved, and there are no systems in place that will routinely compile environmental statistics on key indicators of condition. Effective State of the Environment reporting should be based firstly on national status and trends in key indicators, and secondly on comparison with established 'benchmark' values for those indicators (like those that are used to decide whether a fishery is 'overfished'); neither is currently available. Based on a national coordinated system of monitoring (including reference sites), a national audit of status and trends for coastal and ocean ecosystems needs to be developed and implemented with urgency to establish an appropriate set of benchmarks, to underpin policy implementation in the major government programmes, and to report to Australians about the real effectiveness of the many large investments of government funds in coastal and ocean management in recent years.

The conditions

Much of Australia's ocean appears to be in good condition, particularly the offshore waters, and the biodiversity and many of the resources of our coastal and ocean ecosystems appear to be in reasonably good shape. There is a risk that Australians remain complacent simply because the appropriate observation systems are not in place. There are some important danger signs that, elsewhere in the world, have led to major environmental problems, and can only be ignored at our peril. The coasts, estuaries and some nearshore waters adjacent to urban areas are degraded—'dead zones' appear to be increasing, not decreasing. Also, some of the areas that are remote from the cities are degraded. For example, while the estuaries of tropical Australia are remote, most are heavily fished, some are affected by sediment and agricultural chemical transport from the hinterlands, some of their species are threatened, and their associated wetlands are increasingly being altered by changing rainfall regimes and seawater incursions. As a result, few of these estuaries are in pristine condition. Nationally, a number of Australia's fish stocks are at alarmingly low levels. While Australia's natural systems have great appeal for tourism and recreation, because they are still in good shape compared with those of other countries, taken together, there are a number of early warning signals that should be alerting us to the need to take corrective action, before degradation becomes irreversible.

The pressures

As previously reported in 1996 and in 2001, the major pressures are estuarine and coastal—involving nutrients, sediments, pollution from agriculture and industry; sewage discharges; the urban sprawl of cities; the colonisation by invasive species; and the use of coastal land for tourism and industry. In addition to this, fishing is everywhere. Recreational fishing is concentrated in coastal areas and the islands, while commercial fishing operates in all waters, and increasingly in the most remote areas and depths. Illegal fishing is a major issue in the offshore waters and remote island groups. The combined fishing effort puts pressure on fish stocks, and on the associated species, habitats and ecosystems. Changes in climate, including rainfall patterns, storm frequency and sea level are likely to have an increasingly important

impact on the biodiversity and infrastructure of coastal systems, and on the fisheries in estuaries, coastal and ocean ecosystems.

Our responses

Broadly, the main pressures on Australia's coastal and ocean ecosystems are now well recognised. Although there are many appropriate programmes in place at all levels of government and in the private sector to reduce these pressures, as yet they seem only weakly coordinated or integrated, and the national-level effectiveness of many of them has not been assessed to determine if they have been wise investments.

There are many *local* initiatives to reduce pressures on the coast, often in partnership between local community, local government, non-government organisations, state and territory governments and the Australian Government. These responses are generally effective in focusing on specific threats, and can reduce short-term impacts, but most lack a strategic approach to threat identification, analysis, mitigation or intervention.

At the *State and Territory* level, there are many relevant Acts and consultative processes, but some of the responses appear to be short term and reactive, without an obvious systematic approach to resolving the fundamentals of the environmental issues. There is a risk that such responses are tackling the symptoms and not dealing with the causes, particularly for coastal issues.

At the *Commonwealth* level, the main responses dealing with environment issues have been through regional marine planning, through the EPBC Act, the Fisheries Management Act, and programmes implemented through the natural resources management system. For coastal and marine systems, these collective responses lack effective integration, both within the Commonwealth and with other levels of government. The lack of a pro-active integrated and national approach, the lack of well-substantiated models for prediction of impacts, and little measurement or verification of environmental outcomes, leaves a considerable gap in Australia's knowledge base. It may be leaving the ecosystems, particularly the coastal ecosystems and their resources, at risk.

Glossary

Australia's Marine Area: The area of sea or seabed for which Australia has jurisdiction and rights under the Law of the Sea Convention. It includes the Exclusive Economic Zone and extended continental shelf off the Australian mainland

benthic: Referring to the organisms or environment of the seabed, for example plants and animals living on or in the sub-sea sediment

biocide: A chemical that kills animals and plants

biodiversity: The variety of all life-forms: the different plants, animals and microorganisms, the genes they contain, the ecosystems they form and the processes that maintain them; often considered at three levels: genetic diversity, species diversity and ecosystem diversity

biomass: The quantity of biological material, generally in weight

bio-prospecting: Searching for free-living animals or plants that have properties of value for deriving drugs to treat human diseases, or other values and human uses

bioregion: A large area of the ocean that is classified as having similar types of plants, animals and ocean conditions, compared to other similarly-sized areas

bloom: The uncontrolled and rapid growth and multiplication, usually of plants, in response to freely available nutrients in waterways, and forming a nuisance or toxic biomass

bryozoans: Marine animals commonly known as moss animals, sea mats or (for some forms) lace coral. The majority of living byrozoans are encrusting, forming flat sheets that spread out over the substrate but others grow upwards into the water column

bycatch (or incidental capture): The catch, by a fishery, of species other than those targeted; generally discarded because they have low commercial or recreational value

cetaceans: Members of the mammalian group Cetacea, including whales, dolphins and porpoises

crustacea A class of arthropods, which have gills and bodies covered by a hard shell (e.g. crabs, lobsters, shrimps).

dead zone: A condition of the ocean where all or most marine life is unable to survive because of extreme pollution

demersal: Living on or near the bottom of the sea

ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit

ecosystem services: The role played by organisms and environmental processes in creating a healthy environment for human beings, from production of oxygen to soil formation and maintenance of water quality

endemism: species found only in a particular region; for example, a species endemic to South Australia is not found anywhere else

entraining: a form of behaviour exhibited by animals when they become habituated to fishing vessels or aquaculture facilities, and rely on the supply of food these may inadvertently supply as operational wastes, discards, or accidental releases

erosion: The removal of sediment from the seabed by the action of wind, waves, or tidal currents

eutrophication: Excessive nutrients which causes high levels of plant growth. Often resulting in nuisance algal blooms, turbid waters and subsequent decay and decomposition of the plants

fishing effort: The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time, for example, the number of hauls of a beach seine net per day

genera: The plural of genus, the scientific grouping of plants and animals immediately above the species level; when combined with species provides a unique identifier of a type of plant or animal in scientific nomenclature

infrastructure: The built systems of, for example, water supply, wastewater treatment, drainage, airports, roads and ports

invertebrates: Animals without internal skeletal structure

macro-algae: The algae are a major group of ‘plants’; they are plants without a vascular or ‘vein’ system, living in fresh or marine waters. Macro-algae are the large, visible algae or ‘seaweeds’, such as kelps, as opposed to micro-algae, the microscopic algae that form phytoplankton

marine protected area: Any area of intertidal or subtidal terrain, together with its overlying water and associated plants, animals, historical, or cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment

marine reserve: A marine protected area that is highly protected, and is effective as a complete sanctuary; no extractive uses are permitted, and very few (or no) other human uses (including scientific research) are permitted

non-target species: Fish or invertebrates taken in a fishery that is targeting other species; they may be either retained and sold as a product, or discarded as bycatch

nutrients: Substances required for the growth of plants; for example, nitrogen and phosphorus

overfished: The condition of a fish stock where the rate of fish extraction will lead soon to too many fish taken, or where the breeding stock is so low that the population may not be able to adequately produce young fish to replenish the population

pelagic: Associated with the surface or middle depths of the water column, for example, fish swimming freely in the open sea

phytoplankton: Small plants, mostly microscopic, that are suspended in water and free-drifting

plankton: Small plants or animals and the reproductive stages of larger ones, mostly microscopic, that are suspended in water and free-drifting

sessile: Organisms fixed in one position to the seabed

subsistence fishing: Fishing for food (consumed by the local group of people who do the fishing), not for commercial sale

substrate: A surface of the seabed on which organisms live

threatened species: A species of plant or animal threatened with extinction either locally or globally, without defining its formal status as to the degree of threat

turbidity: The cloudiness in water that is caused by particles, usually of fine sediment or microscopic particles of biological material

upwelling: The phenomenon of deep ocean water rising to the surface, usually bringing nutrients which can increase productivity

vulnerable species: A species of plant or animal vulnerable to extinction, but carrying a lower level of concern than 'endangered'

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