

Introduction

Our diverse environment

Environmental indicators reported in this section:

Environmental Indicator	
CO 8.1	Sea level
CO 8.2	Sea surface temperature variability

As an island continent, Australia has a coastal and marine area that borders three great oceans: the Pacific Ocean in the east, the Indian Ocean in the west, and the Southern Ocean. In the north, Australia is separated from Indonesia, East Timor and Papua New Guinea by the shallow waters of the Timor Sea, Arafura Sea and Torres Strait.

Australia's marine area is one of the largest in the world, extending over about 16 million square kilometres. This is more than double the continent's land area. Australia's ocean domain includes all ocean temperature zones (based on sea surface temperature), from tropical to polar.

Australia's very diverse marine and estuarine habitats range from small estuaries to the extended continental shelf, and from the tropics to the Antarctic and to the island ecosystems of Australia's external territories. The familiar coastal habitats of beaches, dunes, rocky shores, seagrass beds, algae-covered reefs and even mangrove swamps occur in most of the mainland states. These habitats are the home of a wealth of fauna and flora, most of which is found only in Australia. For example, Australia has:

- the world's largest areas and highest species diversity of tropical and temperate seagrasses,
- one of the largest areas of coral reefs,
- the highest mangrove species diversity, and
- the highest levels of biodiversity for a number of types of marine invertebrates.

Indigenous peoples have been custodians and users of Australia's marine environments for thousands of years, and cultural associations remain strong. From an Indigenous perspective, the sea is not additional to but part of their traditional territory. With some 150 groups whose country abuts the coast and includes the sea, the cultural associations of coasts and oceans are thus of very high significance to Indigenous Australians.

In many respects Australia is established around the coastal rim of the continent, and the coastal and marine environment is important to the culture and lifestyle of Australians and visitors. In 1996 around four out of five Australians lived within 50 kilometres of the coast, in cities and towns on the coastal fringe. The coastal zone is used for activities such as settlement, industry, agriculture and mariculture. The ocean environment supports a number of activities, including petroleum mining and commercial fishing.

Some Australians appreciate where this environment is fragile and where it is resistant to human influence, but relatively few know of the importance to our economy of the shipping and port industries, and of the economic value added to Australia by marine tourism and the seafood industry.

Marine resources have considerable economic value and contribute to Australia's economy. The gross value of fisheries production in 1999–2000 was \$2.3 billion (ABARE 2001). The size of economic activity of the major marine industries is estimated to be more than \$30 billion annually (Greiner et al. 1997). Marine tourism and recreation is estimated to contribute 50% to the economic activity; oil, gas and engineering 27%; shipping, transport and ship building 13%; and commercial fishing and aquaculture 5%.

Our marine environment also has an important role in the provision of ecosystem services. The concept of ecosystem services is a way of describing the functions (or services) that come from the ecosystems that sustain or fulfil human life and that cannot be replicated in any other way. Some examples of ecosystem services are purification of air and water, biological breakdown of wastes, and recycling of wastes.

Interest in valuing ecosystem services has increased following a global study that estimated the economic value of 17 ecosystem services across 16 biological zones to be

between US\$16–54 trillion per year (10^{12}), with an average of US\$33 trillion per year (Costanza et al. 1997). This valuation was in turn used to estimate an average value in 1997 for Australian marine ecosystems of US\$640 billion per year (Jones and Pittock 1997).

Australia's marine and coastal systems depend on and influence global climatic and other systems. Changes in global systems like sea temperature or the major global ocean currents may have potentially unwelcome effects.

The marine environment differs in some crucial aspects from our terrestrial environment, in that most of the marine environment can be regarded as a common resource, to be used and enjoyed by people who do not possess an exclusive right to own or use the resource. This aspect of a common heritage is reflected in one of the principles for ecologically sustainable ocean use in Australia's Oceans Policy (Commonwealth of Australia 1998a):

'the benefits from the use of Australia's common ocean resources, and the responsibilities, for their continuing health and productivity should be shared by all Australians'.



Figure 1: The Australian coastline.

Source: Environment Australia (2000).

The coastline and beyond

The shores include open coasts with rocky headlands, cliffs and sandy beaches, and sheltered coasts, bays and estuaries with muddy and sandy tidal flats. The predominant substrates around the coastline are sand, mud and rock. Dunes and sandy beaches feature most commonly, with tidal mud flats more evident in the tropical north. Rocky shorelines are limited, but are common along the southern margins of the continent.

The coastline encompasses some 61 700 kilometres (including nearby islands) with variable physical characteristics around the country, as shown in Figure 1.

Much of the Australian mainland is surrounded by a relatively narrow continental shelf, with the exception of the Great Australian Bight and the tropics. The continental shelf extends to depths of about 150–200 metres and varies from between 15 and 400 kilometres in width.

At the edge of the continental shelf, the continental slope drops from a depth of about 150–200 metres to 4000 metres. Only a little light can penetrate beyond about 1000 metres. There is complete darkness in this zone, although the deep oceans support a great variety of species and habitats.

Ocean currents around Australia

There are several major ocean currents that affect our marine environment (Figure 2) including:

- The East Australian Current, which brings warm, high-salinity water from the tropics through the Great Barrier Reef along the east coast, reaching south to Tasmania. It carries about 30 million cubic metres of water per second, and as it progresses down the continental margin it generates eddies that spin off and return into the surface waters of the Pacific Ocean.
- The Leeuwin Current, which begins off the North West Shelf and flows down the west coast in winter, extending across the Great Australian Bight to Bass Strait. This current carries about five million cubic metres of water per second.
- The South Equatorial Current, which passes through the Indonesian archipelago from the Pacific Ocean and carries about seven million cubic metres of water per second.
- The predominant current around the Australian Antarctic Territory in the Southern Ocean flows west to east—the Antarctic Circumpolar Current. This current has a major influence on the Earth's climate. Close to the Antarctic shore, the current flows east to west—the East Wind Drift, driven by the polar easterlies.

These water masses and ocean currents have a significant influence upon both the global and Australian climate and the productivity of coastal waters. The strength, seasonality and southward extension of the first three major currents are highly variable, and their flow

influences coastal conditions and larval fish distribution. The Cooperative Research Centre for Antarctica and the Southern Ocean is researching the links between the Southern Ocean currents and the global climate system.

The productivity of Australia's fishery resource is influenced by the absence of upwelling conditions that brings nutrients to the upper layers of the oceans. The productivity of coastal waters is influenced more by land use and the export of nutrients in the catchments draining to the coast.

Australia's marine responsibilities

Under the United Nations Convention on the Law of the Sea (UNCLOS) 1982, Australia has sovereign rights to explore and exploit, conserve and manage, the living and non-living natural resources within its Exclusive Economic Zone (EEZ). UNCLOS sanctions the declaration of 200 nautical mile (nm) EEZs, enabling a significant area of ocean to be brought within the jurisdiction of maritime nations. In Australia's case, this amounts to some 11 million square kilometres of ocean beyond the territorial sea. In addition, UNCLOS requires a Coastal State to define the limits of its continental shelf within ten years of the entry into force of the Convention for that State. In Australia's case, this is November 2004. Considerable mapping of the proposed areas is required for this.

There are a range of international agreements to which Australia is party and which influence marine management. Some of these are listed in the marine management section of this chapter. Australia has international obligations in Antarctica. Fisheries in the Southern Ocean are subject to the requirements of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR).

The Australian Antarctic Territory comprises 5 896 500 square kilometres, equal to 77% of the land area of Australia and 42% of Antarctica. It is the coldest, driest, windiest, and most remote continent on Earth. Antarctica is also the continent least affected by human activity, making it an ideal location for studying human impacts and global background levels of anthropogenic agents such as polychlorinated biphenyls (PCBs).

Australia's marine area includes about 12 000 islands. Some of these islands are important in extending Australia's EEZ, and hence our marine responsibilities. For example, Heard Island, the McDonald Islands and Macquarie Island in the Southern Ocean; Christmas Island, the Cocos (Keeling) Islands, Ashmore Island and Cartier Islet in the Indian Ocean; the Coral Sea Islands and Torres Strait Islands; and Lord Howe and Norfolk Islands in the South Pacific Ocean (Figure 2).

Australia has declared a range of maritime zones (Figure 3). The outer limits of all of these zones are measured from the territorial sea baseline, located for the most part at the low-water mark along the coast. However, it also consists of bay and river closing lines, and some straight baselines between the mainland and adjacent islands and across parts of the coast that are deeply indented. The 12 nm boundary may be, in places, much further than 12 nm from the continent. The zones include:

- The territorial sea: the outer limit of the territorial sea is 12 nautical miles seaward of the baseline. Australia has sovereignty over the territorial waters but must respect the right of innocent passage of foreign vessels.
- The Exclusive Economic Zone: the area between the lines 12 nautical miles and 200 nautical miles seaward of the territorial sea baselines.
- The continental shelf: the area between 12 nm and 200 nm seaward of the territorial sea baseline (i.e. it covers much the same area as the EEZ) and any area of physical continental shelf beyond 200 nautical miles.
- The Australian Fishing Zone: declared in 1979, and now managed under the *Fisheries Management Act 1991*. The zone is the area of waters between 3 nm and 200 nm seaward of the baselines.

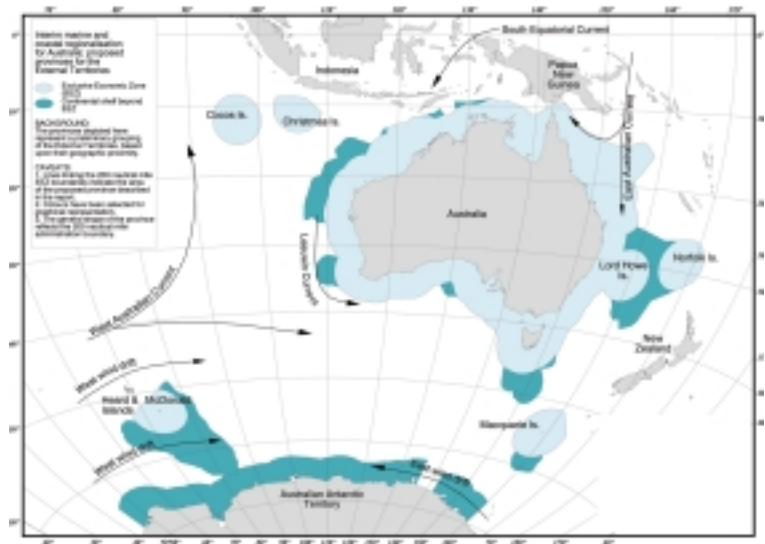


Figure 2: Major global ocean currents that affect Australia.

Source: Environment Australia (2000).

Within Australia, the responsibilities of different levels of government with respect to the sea are complex (Symonds et al. 1998), and the multiplicity of legislation relating to the coast and to marine resources has long been a matter of concern because of the potential for overlap and duplication.

In general, the States and Territories have jurisdiction over marine areas to 3 nm from the baseline, and the Commonwealth has jurisdiction beyond those waters to the outer boundaries of the EEZ. The Offshore Constitutional Settlement established jurisdictions between the Commonwealth and the States over marine areas in 1983. The great majority of Australia's marine area is under sole Commonwealth jurisdiction. Issues (such as pollution incidents) which straddle the 3 nm boundary can be complex. These may depend upon the precise wording of the legislation concerned, or require the cooperation of the Commonwealth and States.

Our knowledge of the habitats and species within the EEZ is limited as only 1 to 2% of the EEZ has been surveyed to describe these different marine habitats. Seabed habitat mapping of varying detail has been produced for areas such as the Torres Strait (50 000 km²), Great Barrier Reef (347 800 km²) and the south-east Australian continental shelf (30 000 km²). Scientists from CSIRO Marine Research, the Australian Institute of Marine Science (AIMS) and the CRC for the Great Barrier Reef World Heritage Area have developed and used acoustic tools, together with other equipment, to survey both seabed to a depth of 200 metres and deeper habitats to 2000 metres. A research voyage by CSIRO Marine Research in April–May 2001 was part of an investigation of marine life in waters off Tasmania and Victoria. The voyage made the deepest sampling trawls so far conducted in Australian waters. Innovative use of deepwater video identified environmental conditions and associated marine life, revealing fish and invertebrates new to science as well as reefs and unique canyons.

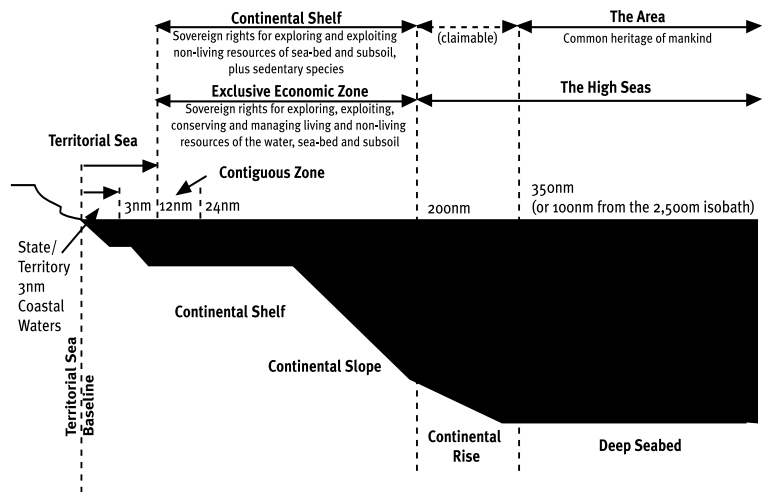


Figure 3: Australia's marine zones.

Source: Environment Australia (2000).

Climate variability and change—the global context

Antarctica and the Southern Ocean play a critical role in the global environmental system. Processes of interaction between the atmosphere, oceans, ice, and biota affect the entire global system through feedbacks, biogeochemical cycles, circulation patterns, transport of energy and pollutants, and changes in ice mass balance.

Global climate variability may have serious repercussions for Australia's coasts and oceans in the future. The two aspects that could affect Australia's coastal and marine environments are rises in sea surface temperature and sea level change. Climate variability may in the future result in extreme events in different parts of the country and drought in other places. (This is further discussed in the Atmosphere Theme Report.) Floods associated with the increasing trend in extreme rainfall events could result in increased sedimentation and nutrient levels in estuaries and coastal ecosystems and harsher erosion events, threatening coastline stability and coastal infrastructure. Any increase in the frequency of cyclones or storms in tropical areas could also result in increased resuspension of sediments.

Sea surface temperature [CO Indicator 8.2]

Changes in the sea surface temperature are closely linked to climate variability. If sea surface temperatures rise significantly in the future, there is the potential for effects on marine life.

Information from recent studies on Heard Island by scientists from the Australian Antarctic Division, University of Tasmania and Macquarie University has found an increase in many marine species. For example, Fur Seals and King Penguins have multiplied. This may be the result of the rapid decline in the area of Antarctic sea ice that occurred between 1950 and 1973, which appears to be the result of a small rise in sea temperature.

Rising sea surface temperatures in the tropics are considered responsible for widespread bleaching of corals, including on the Great Barrier Reef (Wilkinson 2000). The bleaching was caused by the combination of extremely calm conditions during the 1997–98 El Niño event,

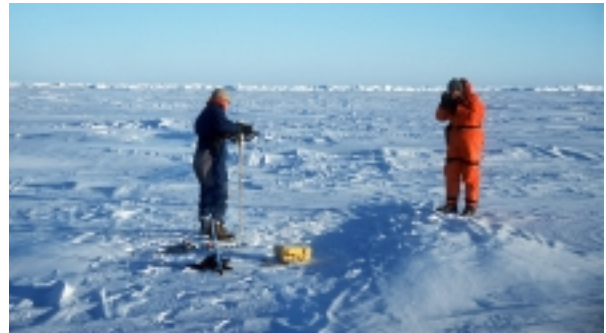
Antarctic sea ice

Antarctica, the ‘frozen continent’, is blanketed with ice in a layer on average over two kilometres thick. Antarctica is also surrounded by a vast band of ice derived mainly from direct freezing of ocean water. This sea ice forms the Antarctic pack ice zone with innumerable ice floes about 0.5 metres thick, separated by open water.

This sea ice undergoes a dramatic annual change in area, from a minimum of 4 million km² in February to a maximum of 19 million km² in September. Climatologists consider this cycle to be crucial in the regulation of the Earth’s climate. The ice also has a major influence on the Southern Ocean ecosystem, as a wide variety of organisms, from unicellular algae to penguins and seals, depend on its presence.

Most sea ice is formed close to the Antarctic continent and is then transported northwards by winds and currents. The ice provides an efficient insulating layer that reduces heat loss from the relatively warm ocean to the atmosphere. The presence of ice also increases the amount of energy reflected back into space. The balance between these processes—one which retains heat in the ocean, and the other which reduces solar heating—is of prime importance.

The Southern Ocean and the Antarctic pack ice zone play an important role in global climate variability and change. Climate models predict that increased global temperatures will affect the Antarctic sea ice zone, leading to a decrease in its extent. Satellite-based measurements of



Gathering information on the sea ice.

Source: B Wienecke, Australian Antarctic Division.

the extent of sea ice are relatively recent (post-1973), and indicate no major change in its winter extent over the last 25 years. However, this method does not give any information on changes in the thickness of the ice. Also, there is evidence of some regional decrease in ice cover during summer.

Historical shipping records of the position of the edge of the pack ice zone suggest that there was a major decrease in the extent of the pack ice between 1950 and 1970. The relationship between this apparent decrease and global warming is uncertain, but it is clear that a major change has occurred. The influence of this change on the physics of the Southern Ocean and its biota are unclear.

(one of the strongest on record) and a steadily rising baseline of sea surface temperatures in the tropics. This is a matter of major concern in the context of climate variability.

Sea level rise [CO Indicator 8.1]

Rises in sea level could be catastrophic for low-lying coasts, islands and cays, and coral reefs. However, on present information, it is not possible to demonstrate consistent increases in sea level arising from global warming, as distinct from other causes.

Sea level changes are calculated from data gathered from tide gauges installed along the coastline of Australia for port operations by the National Tidal Facility at 23 sites for periods ranging from 25 to 100 years (Mitchell et al. 2000).

A number of these gauges are affected by very local processes, such as subsidence, that reflect changes in local land level rather than sea level. All gauge heights are also affected by slower geological processes, whose contribution can be estimated using various techniques. Researchers believe that at least 30 years of good-quality data are required to estimate trends from tide records. Fremantle has some 100 years of data, and Port Denison has data for 85 years. After correction for geological effects, data from these two stations suggest a sea level rise of 12–16 cm during the past century (Lambeck 2001). A slight rise in overall sea level may be accompanied by much larger impacts of extreme events, such as storm surges.

People cause environmental change

The movement of people to live near the coast, identified in the 1996 SoE Report, has continued during the past five years. Although most people live in urban centres, the density of people and their mobility and activities are affecting particular coastal environments and urban localities.

Population pressures are a major driver of environmental change in the estuaries and coastal waters of Australia. This has effects as diverse as loss of important coastal and nearshore

habitat, loss of open space and natural landscape, increased nutrient loads to estuaries, and increased stormwater runoff into coastal waters. The provision of infrastructure to support industrial activities, shipping, tourism ventures and expanding human settlements has both environmental and physical effects. As the predictions of population growth in coastal areas of Australia are for an increasing trend, the quality of our coastal and marine environments will continue to be placed under pressure.

Risks to the marine environment

One of the risks to our coastal environment arises from our dependence on international and coastal shipping to transport goods to and around the country. As the countries with whom we trade change, constant vigilance is needed to reduce the chances of introduced species establishing in either our tropical or temperate waters. Such species could become new pests that could have devastating consequences for our environment and for sectors of the economy. The discovery of the Black Striped Mussel in Darwin Harbour in early 1999 was a salutary reminder of the potential for harm that exists.

Other shipping-related risks are the risks of at-sea collisions or groundings (as happened on the Great Barrier Reef in 2001), loss of containers overboard, and spillage of hazardous cargo at sea or in ports or handling facilities.

Risks to estuarine and coastal waters arise from agriculture and catchment management practices, especially where high sediment loads are transported into coastal and estuarine waters. The effects on habitats and species include those on juvenile stages of commercially important species as well as the potential loss of habitat for endangered species. There are also risks to the coastal and marine environments from fishing of some fish species where the ecosystems of which the fish are part, can be affected by heavy fishing pressure. Aquaculture activities can also pose risks to the coastal and marine environment.

Integrated management

The sheer extent and diversity of coastal environments around Australia, together with the large number of agencies and bodies with an interest in coastal and marine management, has led to a lack of integration and consistent management in the past.

The Resource Assessment Commission (1993) laid down a challenge that still remains: to further enhance consistent, strategic and integrated management of this important environment.

In 1995, the State of the Marine Environment Report (SOMER) (Zann 1995) provided the first comprehensive scientific description of our marine environment, its uses and values, the issues and threats affecting it, and its management. The top five concerns were:

- declining marine and coastal water /sediment quality, particularly as a result of inappropriate land use practices,
- loss of marine and coastal habitats,
- unsustainable use of marine and coastal resources,
- lack of marine science policy and lack of long-term research and monitoring, and
- lack of strategic and integrated planning in the marine and coastal environments.

This Theme Report outlines where progress on some of these issues has been made and where progress is still required, but it is not a repeat of SOMER.

The major element of progress towards integrated management is the development of Australia's Oceans Policy (AOP) in 1998 which sets out a framework for the integrated planning and management of our ocean environment. The AOP is supported by the *Wildlife Protection Act* 1982 and the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) to encourage the sustainable use of marine natural resources.

The need for integrated management is nowhere clearer than in the link between activities on the land and the effects on coastal resources and environments. In the past, management has often been compartmentalised, with various government agencies focusing on separate issues in accordance with their responsibility. The challenge for management is to deal with the whole catchment, from watershed to coast, as a single system, and to integrate action across the many agencies involved in coastal management. Management of ocean resources also requires integration.

State of the Environment reporting

State of the Environment reporting is a tool for providing timely and accessible information to decision makers, the public, industry, non-government organisations and all levels of government about the condition and prospects of the Australian environment. It allows regular reports of trends in environmental conditions and their implications for maintaining ecological processes and systems. The approach to national State of the Environment reporting in Australia is to use a modified version of the OECD's 'pressure–condition–response' model to include an examination of the implications for the environment of the condition, pressures and responses.

A suite of national-scale environmental indicators has been developed (Ward et al. 1998), but so far there has been little progress on compiling the data for these indicators at the national scale. Data for each indicator are generally available for small areas, or for only some jurisdictions, and in many cases have been derived to deal with specific management issues of local concern. The scientific models needed to derive national-scale information from such patchy and non-coherent data are in their infancy, and considerable further development is needed in order to be able to compile and fully utilise (for SoE purposes) the large amounts of existing data held by the various jurisdictions, the private sector, and in the community, NGO and Indigenous groups.

The data used for this report has been synthesised from the best available sources, but nonetheless there are large gaps. This has greatly constrained the nature of the assessment and limited the ability to determine with any certainty the nature and extent of any possible changes in the condition of the environment. Maps and other data presented in this report must be considered to be indicative of the best knowledge that could be compiled.

Key findings of the 1996 report

- **The knowledge base** was inadequate for most areas of the estuarine and marine environments.
- **Habitat loss and degradation** Increasing coastal development, industry and urbanisation had reduced or degraded water quality and habitat elements (e.g. vegetation, beaches) particularly in the south-east and south-west.
- **Nutrient runoff** Excessive nitrates and phosphates flowing into estuaries and bays were causing algal blooms, deteriorating water quality and may have affected inshore corals.
- **Poor water quality** caused by high nutrient and sediment loads was a feature of many Australian estuaries.
- **Coastal pollution** There were localised 'hot spots' off urban and industrial coasts, mostly land-based sources, there was a need for national strategic planning.
- **Coastal vegetation** There was an extensive clearing or serious decline in area, particularly of seagrasses, mangroves and saltmarshes. Seagrass decline was especially serious as there was little regeneration.
- **Fisheries stocks** Most were fully exploited, with little room for further development; management regimes were partially effective and improving; the effects of fishing on habitat and non-target species were largely unknown.
- **Seafood quality** was generally very high around Australia.
- **Introduced pests** threatened most natural ecosystems and mariculture.
- **Integrated management** There was a need for catchment/large marine ecosystem approach. Only the Great Barrier Reef Marine Park had integrated management.
- **Marine reserves** A national representative system was under way.