



■ Point Lonsdale, Victoria  
Photo by Michael Boniwell

# Coasts



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# Key findings

Variations in climate, and changes in the size and composition of the population around Australia's coasts, have been major drivers of pressure on the coasts—for both the natural and the built environment—over the past decade.

Concerns about how to deal with the pressures caused by these drivers and how to prepare for future climate change have been the catalysts for adaptation responses.

The major pressures on natural and cultural heritage, marine and terrestrial biodiversity, and ecosystem processes along Australian coasts are similar to those in previous reports on the state of the environment.

They include urban expansion in capital cities and major regional coastal cities; modification of coastal habitats by urban and commercial developments, and nearshore mining and dredging; changed flows of rivers into estuaries and coastal environments; disturbance of acid sulfate soils; loss and fragmentation of native vegetation; increasing use of coastal areas for food production (aquaculture); fishing and intertidal harvesting; rapidly growing numbers of invasive species and pathogens; tension between the potential economic value of land, including areas that are suitable for intensive agriculture, and its conservation; modest budgets for management of reserved lands; degrading conditions that affect buildings (e.g. wind, salt, inundation); low levels of recognition and understanding of what is culturally significant; and decline in connections between Indigenous people and coastal places.

Some trends in land use and management practices have reduced some pressures.


These include expansion of conservation and Indigenous areas, decline in the extent of native forest managed for wood production and a corresponding increase in the extent managed for conservation, and improvements in land-management practices that have reduced the flows of sediments and chemicals to the coast during major rainfall events.

The greatest reductions in native vegetation extent have been in eastern, south-eastern and south-western Australia.

Impacts on the coastal strip are highly variable around Australia's coastline. The extent of native vegetation ranges from very heavily cleared, with less than 10% remaining, in parts of Victoria and South Australia, through 31–50% remaining in large parts of the south-western and north-eastern coastal areas, to 71–100% remaining for most of northern Australia. Many species of plants and animals are threatened by activities associated with Australia's coast-based population.

All chapters of this report cite examples of promising responses to coastal challenges by governments, working individually and together, but outcomes for some major issues are still far from ideal.

There is significant uncertainty about how species and ecological systems will be affected by climate change. Local governments are expressing concern about the lack of guidelines, standards and national strategic approaches to address coastal development, growing populations and environmental impacts. The recent Hawke report, reviewing the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act),



*You can tell all you  
need to about a society  
from how it treats  
animals and beaches.*

Frank Deford (1938–)

recommended a range of changes to the Act that would allow it to be applied more strategically and at ecosystem and landscape scales. Many of these recommendations have been accepted by the Australian Government. It remains to be seen whether action is sufficient and soon enough to allow assessment and successful management of the cumulative effects of small developments along the coastal strip.

■ Debate about coastal governance and management took an important step forward with a 2009 report from the House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts.

The report, *Managing our coastal zone in a changing climate: the time to act is now*, noted that there is limited national collaboration and cooperation to achieve consistencies, efficiencies and agreements on issues such as variation in planning laws, capacities of local councils, monitoring coastal habitat change and legal liabilities. The report made 47 recommendations to address these issues. Most of these recommendations have been noted or accepted in principle by the Australian Government. As with the responses to the review of the EPBC Act, the quality and timeliness of actions will be critical if existing challenges to coastal sustainability are to be addressed and looming ones prepared for.

■ Recent research comparing Australian coastal governance with examples elsewhere in the world concluded that the ability to adapt to emerging pressures, especially climate change, is low and declining in many parts of Australia.

Recommended remedies include allocating authority and resources between levels of governance according to their effectiveness at each level (rather than trying to manage everything centrally);

strengthening development rules and incentives to encourage relocation before irreversible problems arise; allowing for uncertainties by building flexibility into rules and incentives so that they can be adjusted when knowledge and circumstances change; transferring public and private benefits, costs, risks, uncertainties and responsibilities from governments to beneficiaries of development; and viewing catastrophes as opportunities for learning and change, not signals to automatically rebuild. There is potential for these issues to be addressed in the responses to the key reports mentioned above, but this will require strong leadership from both government and other sectors.

■ The major emerging risks that remain incompletely addressed for Australia's coasts are those relating to climate change, especially sea level rise, and demographic change. The future of coastal Australia will depend largely on how rapidly these changes occur, how extreme they are, and how Australians prepare for and respond to them.

Although coastal environments are facing major pressures, awareness is growing that ecological, social, economic and cultural issues are interlinked and cannot be addressed separately. The future of our coasts depends on whether government and governance arrangements can be developed that allow a much more strategic approach to managing coastal resources, over spatial scales that match the scale of the challenges. Desirable futures are most likely if major reform of coastal governance is achieved in the next decade or sooner, which is possible, but not guaranteed.

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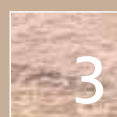
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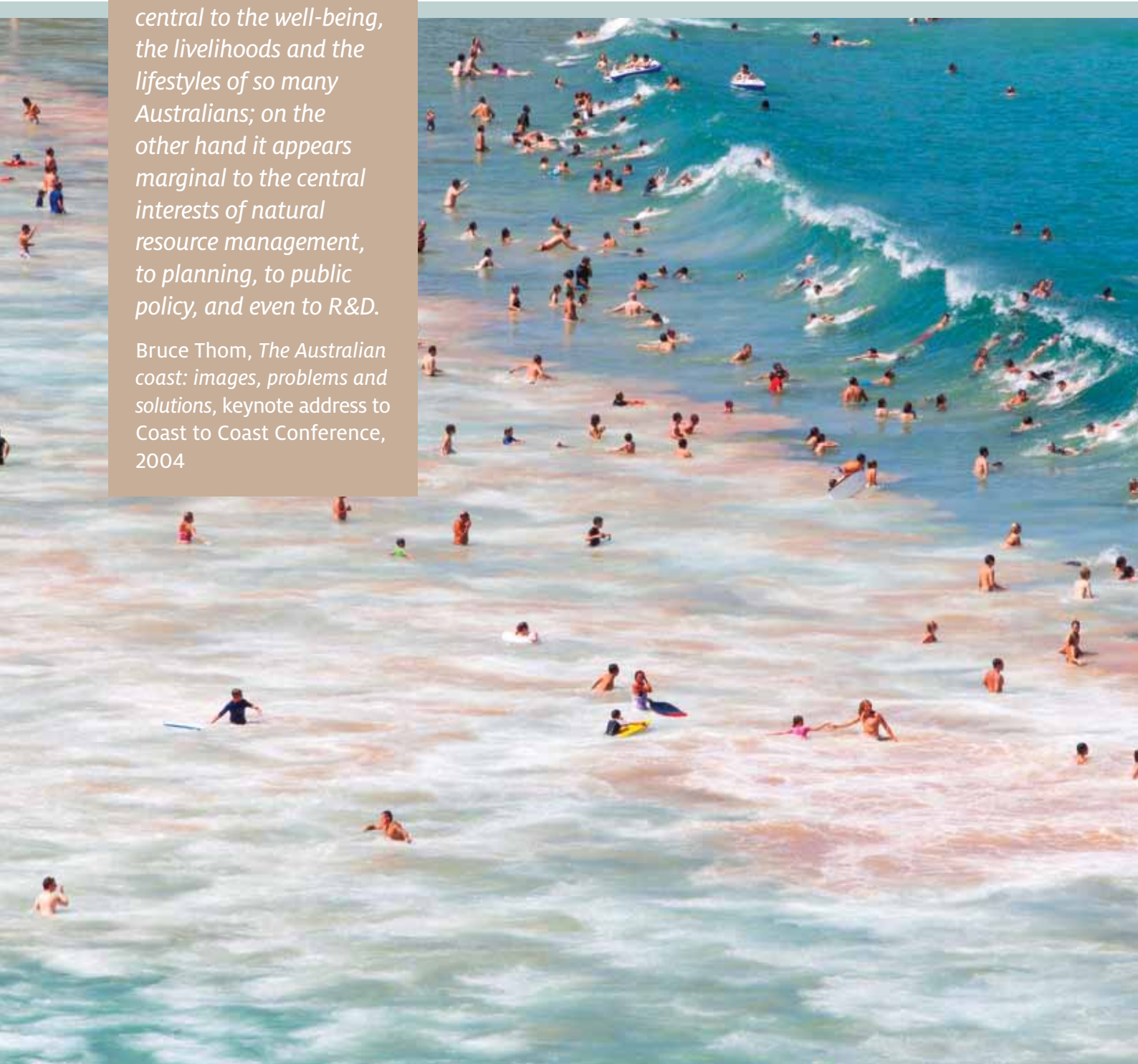
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*There is something about coastal management which is quite paradoxical: on the one hand it is central to the well-being, the livelihoods and the lifestyles of so many Australians; on the other hand it appears marginal to the central interests of natural resource management, to planning, to public policy, and even to R&D.*

Bruce Thom, *The Australian coast: images, problems and solutions*, keynote address to Coast to Coast Conference, 2004



■ Freshwater Beach, Sydney, New South Wales  
Photo by Matt Lauder



## Introduction

Australia is a land of diverse geographical and biological features. The natural features of our coasts are some of the most iconic in Australia—many of the ‘jewels in the crown’ of Australia’s World Heritage properties are in the coastal zone. ‘Coastal zone’ has been defined in various ways in the past. In this chapter, coasts are considered loosely to be the zone of interface between terrestrial, aquatic and marine environments. The size of that interface is different for different issues and processes.

### 1.1 Coastal features and issues

Biologically, coasts are an interface between the biota of the oceans and the land, including biota of freshwater systems that mingle with salt water in estuaries. The transition between terrestrial and marine environments represents one of the sharpest changes in habitat for living organisms found on Earth. It produces unique flora and fauna adapted to deal with unique environmental challenges. One of those challenges is that the border between terrestrial and marine systems is constantly changing; it is set to become even more variable with the effects of climate change in coming decades. Geomorphology is also unique and dynamic.

Australian coastal environments include a range of ecosystems that contain habitat for a variety of species. Habitats include mangroves, saltmarshes, saltflats, seagrass beds, beaches, dunes, estuaries, intertidal mudflats, gulfs, bays and coastal wetlands.

Nearshore and offshore marine habitats are potentially impacted by human coastal settlements and activities. Coasts, especially the mouths of rivers, are where valuable resources such as high-quality soils accumulate, and where people practise agriculture and a range of other resource-based industries, as well as enjoying the amenity of these places.

Australia’s population is focused strongly around its coastline, especially around the estuaries of major river systems. These areas include good shipping and boating facilities, as well as prime agricultural land. Australians have been concentrated on the coast since the beginning of European settlement. Before then, coastal Aboriginal people had lifestyles that differed from those of Aboriginal people living inland, although goods, stories and practices were exchanged between coastal and inland people.

Concentration of people around the coasts puts pressure on coastal ecosystems. It also complicates the management of these systems because several major demands on the land come into potential conflict with each other: demand for urban development at the waterline; demand for agricultural production on fertile floodplains; increasing demand for inshore areas for food production (aquaculture); increasing recreational use, including fishing and boating; and demand for conservation of nature for both its intrinsic values and the benefits it provides for humans through water filtration, regulation of river flows, provision of food and provision of cultural values. Coastal ports are also prime sites for entry of invasive pests and diseases.



Governance issues are highly complex in coastal areas. The importance of coastal assets means that many interest groups place demands on local, state and national governments. The responsibilities and authorities of these three levels of government overlap at times, which can lead to conflict if objectives differ between levels of government. Issues can be inadequately addressed if it is unclear where responsibilities lie, with one level of government expecting another to take responsibility and action. Resourcing can often be a major issue at all levels, especially when the desires of coastal residents outstrip funding, including land rates.

Coastal environments are where the dynamics of future change will be writ large on the landscape and ecosystems. Many aspects of climate change will directly affect the coast: sea level rise; changing wind patterns; changes in the frequency and magnitude of cyclones, storms, tidal surges and rainfall events; changes in erosion and sediment transport; and changes in nearshore ocean currents. The effects of changes in the nature and amount of trade with other countries will be felt in coastal ports, with flow-on effects on local economies and lifestyles. All these will drive change in ecosystems and human values at the waterline, where even small changes in sea level and the quality of water can have major effects on the species that live where the sea and the land overlap.

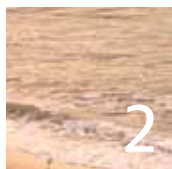
## 1.2 In this chapter

Many state of the environment reports around Australia and the world do not include a chapter on coasts, considering them under the topics of land, water and the marine environment. The State of the Environment Committee preparing this report considered that the unique characteristics of coastal environments, the strong focus on coasts in Australian culture and settlement patterns, and the growing concern about the convergence of social, economic and environmental issues around our coasts warranted a chapter discussing the key issues.

Like other chapters in this report, this chapter is structured loosely around a framework of drivers, pressures, state, impact and response (DPSIR). However, the committee considered that there are insufficient data specifically relating to coasts to support the detailed assessment used in other chapters. Conclusions about the condition of coastal environments, factors affecting condition and the effectiveness of management responses are therefore drawn primarily from other chapters of the report. We have considered ongoing risks, resilience and outlook together in a general discussion section, drawing on both insights from other chapters and additional information that is specific to coasts.



■ Tacking Point Lighthouse, Port Macquarie, New South Wales  
Photo by Matt Lauder



## Major issues for coastal environments

### At a glance

The three drivers of environmental change—climate change, population growth and economic growth—result in a range of pressures on our coastal environment. Events associated with variations in climate have been major pressures on Australian coasts over the past decade, and concern about preparing for possible future impacts of climate change and variability has been a strong driver of adaptation responses. Concern about changes in the size and composition of coastal populations has also been growing for several decades. Urbanisation and coastal development for farming and industry are a major pressure on terrestrial and marine biodiversity and environmental quality, water resources, air quality, and cultural and natural heritage. The 2006 State of the Environment report concluded that ‘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’.

Our coastal regions bring together many of the issues identified for other environmental themes.

For inland waters, issues relevant to coasts include coastal river and estuary pollution, desalination, seawater intrusion, and impacts of water abstraction (removal) on flora and fauna. Overall, the management of coastal waters has improved greatly in Australia in the past decade, including some high-profile programs to ensure river and estuary health in metropolitan areas (e.g. Hobart and Brisbane). Widespread drought has increased tensions over water use, including in coastal areas, and this is likely to be an important consideration for coastal management in the future.

For land, major trends in land use that have both negative and positive impacts on coastal Australia include urban expansion in capital cities and major regional coastal cities, changed flow in rivers that influences freshwater and nutrient flows to estuaries and coastal environments, expansion of conservation and Indigenous areas, declines in the extent of native forest managed for wood production and increases in the extent managed for conservation, and improvements in land-management practices that have reduced the flows of sediments and chemicals to the coast during major rainfall events. Disturbance of acid sulfate soils remains a major consequence of coastal development, with significant environmental, economic and social costs to coastal communities.

For vegetation, impacts on the coastal strip are highly variable around Australia’s coastline. Native vegetation ranges from very heavily cleared, with less than 10% remaining, in parts of Victoria and South Australia, through 31–50% remaining in large parts of the south-western and north-eastern coastal areas, to 71–100% remaining for most of northern Australia. The greatest reductions in native vegetation extent have been in eastern, south-eastern and south-western Australia.

For biodiversity in general, many species of plants and animals are threatened by activities associated with Australia’s coast-based population. The introduction of weeds and pest species to our coasts has also contributed to national reductions in biodiversity, and to marine, estuarine and coastal productivity.

For the marine environment, issues relevant to coasts include modification of coastal habitats by processes such as coastal urban development, catchment development, marinas, breakwaters, island reclamation projects, coastal and nearshore mining and dredging, harbours and shipping channels; and a continued increase in impacts of invasive species, including threats from pathogens and viruses. A particular concern is the incremental nature of coastal development, which reduces the abundance of native vegetation and breaks down connectivity among remnant habitat patches. The cumulative effects of coastal development are rarely considered.

For natural and cultural heritage, our coastal areas include many important wetlands, places of importance in the traditional culture and practices of Indigenous people, buildings associated with areas of early European colonisation, historically important shipwrecks, threatened species and communities, and other places of natural heritage significance. Issues relevant to coasts include degrading conditions (e.g. wind, salt, inundation), low levels of recognition and understanding of what is significant, a decline in connections between Indigenous people and coastal places, the rapidly increasing number of invasive species and pathogens, progressive loss of habitat, tension between the potential economic value of land and its dedication for conservation purposes, and modest budgets for the management of reserved lands.

In this section, we draw on the other chapters of this report, as well as some key literature specific to coasts, to consider in an integrated way the major drivers and pressures affecting Australia's coasts, the impacts of these drivers and pressures on the state of coastal environments, and the responses that have been made to manage coasts as a national asset.

## 2.1 Atmosphere (including climate change)

For further information, see Chapter 3: Atmosphere.

### 2.1.1 Air quality

Australia's coasts are where most of the nation's people live, where the major cities and urban areas exist and, therefore, where the effects of human activities on local air quality are most felt.

Air quality in Australia's major urban centres is generally good. This is due to the progressive tightening of national vehicle emission and fuel standards over the past 20 years and actions by state and territory environment protection agencies to substantially control industrial, commercial and domestic sources of air pollution. Maintenance of past gains in air quality, especially with respect to peak levels of particles and ozone, will be influenced by technological advances (such as improvements in propulsion systems for motor vehicles and clean forms of production), changes in climate and planning issues (such as transport and urban sprawl). Coastal councils around Australia are concerned about how they can manage these issues when demands on their land-rates base are rising but per capita rates are falling.

National health-based standards are rarely exceeded for prolonged periods, and very high levels of pollution are usually associated with short-lived extreme events such as bushfires and dust storms that generate very high levels of particle pollution.

### 2.1.2 Climate change and variability

Climate change is emerging as a major driver of change for Australian coasts and marine areas in the next few decades and beyond (see also Section 4 of this chapter and Chapter 6: Marine environment).

Although the extent to which long-term climate change has driven pressures on coasts over the past decade is still being debated, the variability of climate (whatever its cause) has led to many incidents of inundation, erosion of coastline and damage to human lives and property. Of particular significance are sea temperature increases in the south-west, east and south-east regions, which are among the largest in the world (see Section 2.4.2). This is likely to affect commercial and recreational fishing and aquaculture, and could potentially have wider impacts on a range of coastal activities that are part of the social and economic fabric of coastal communities.

Sea level rise is emerging as a major future impact of climate change (see Section 4), but the processes affecting it have been active for some time (Figure 11.1). Over the past 25 years, the rate of sea level rise has been an order of magnitude greater than the average for several previous decades—an average rise of 3.1 millimetres per year occurred between 1993 and 2003, compared with 1.8 millimetres per year between 1961 and 2003, and 1.2 millimetres per year during the 20th century as a whole.<sup>1</sup>

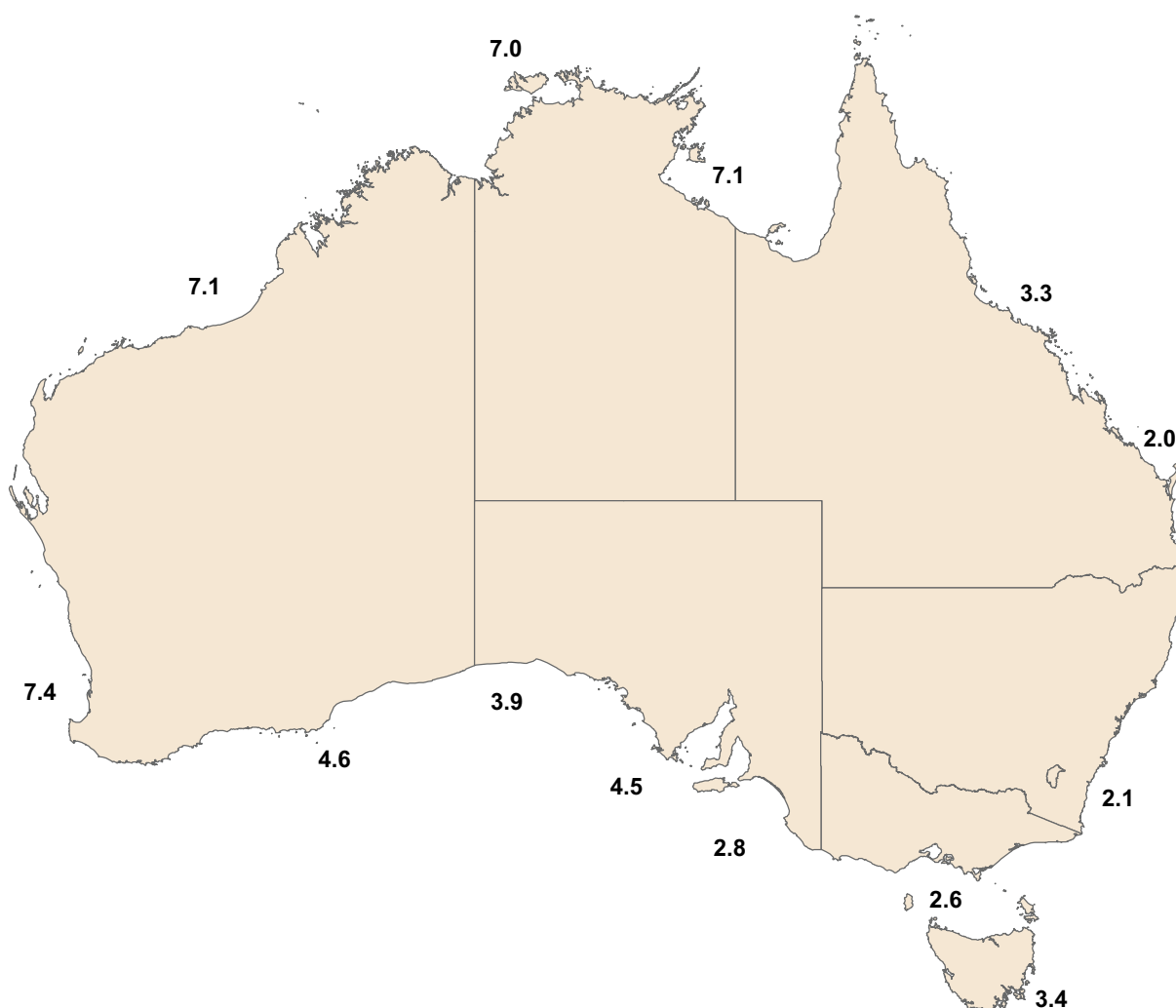
Future direct and indirect impacts of climatic events and climate variability on Australia's coasts are discussed in Section 4.

Many of the management responses to pressures on Australian coasts, especially in the past six years, have been in response to concerns about future impacts of climate in combination with other drivers and pressures (see Section 3).

### 2.1.3 Responses

Roles for governments in adapting to climate change include:

- supporting scientific studies that are unlikely to be undertaken by the private sector (particularly relevant at the national government level) and providing information to the private sector and the community to encourage and assist adaptation (relevant to all tiers of government, but especially state and local governments)
- adopting policies that facilitate adaptation and a regulatory framework that supports, rather than distorts, effective market signals (a critical role for the national government, but one that state governments can significantly reinforce)



Source: National Tidal Centre, reported in Australian Government Department of Climate Change and Energy Efficiency<sup>1</sup>

**Figure 11.1** Local sea level rise (millimetres per year) from the early 1990s to June 2010

- using policy mechanisms such as land-use planning, building codes and product standards to deal with situations where short-term market responses may act to restrict longer term adaptive action (mainly relevant to state governments, but local government also plays an important role in on-ground implementation)
- fully factoring climate change into planning, resourcing and managing the provision of public goods and services, such as public health and safety; emergency services; flood and coastal protection; water supply, drainage and sewerage services; protection of public lands, parks and

reserves; fisheries; and other natural resources (relevant to all tiers of government, but especially state and local governments).

The role of governments is particularly challenging for coastal communities and environments because of the complex interactions and divided responsibilities between the different levels of government and the currently limited mechanisms for coordinated and strategic action (see Section 3).

## 2.2 Inland water flows and use

For further information, see Chapter 4: Inland water.

### 2.2.1 Coastal river and estuary pollution

River pollution often arises from upstream development and land use. However, it has particular impacts on the environment where it enters estuaries and the nearshore coastal environment. Some of the most significant of these estuaries and coastal lagoons are near our major cities (Sydney, Melbourne, Brisbane, Adelaide, Perth) or significant environmental assets (the Great Barrier Reef).

The land is a major source of coastal and marine pollution. Considerable progress has been made in addressing point-source pollution, although some problems still arise from these sources. Current diffuse pollution to catchments often results from historical land clearing and land-use changes. Urban stormwater is a major non-point source. Although extensive land clearing for agriculture has been considerably reduced in Australia, the legacy of sedimentation and salinisation of rivers continues. The millennium drought (lasting from 2000 to 2010 throughout southern Australia, but starting in 1997 in some areas) slowed some of these degrading processes in places, but it is likely that subsequent flooding will bring these issues back to the fore among environmental concerns.

Chapter 4: Inland water gives examples of major short-term increases in sedimentation after bushfires in south-eastern Australia (due to reduced vegetation cover and exposure of soil) and major longer term (25–30 years post-fire) reductions in water yield (due to regrowth of vegetation).

### 2.2.2 Desalination

Most Australians live in metropolitan areas, most of which are located on the coast. Although many of these cities draw water from inland areas, pressure is increasing for them to be able to replace or supplement these inputs by collecting the water that falls as rain in their metropolitan areas and/or by desalinating sea water, as a hedge against climate change. This would reduce further pressure on local freshwater resources. However, it entails a potential risk to coastal waters if salt is disposed of into these waters, and will increase the overall energy use in our cities.

The amount of desalination undertaken by Australian cities increased sharply during 2005–10, largely in response to drought, climate uncertainty, population increase and a new understanding of the need to provide water flows to the environment. Desalination plants were commissioned in Sydney and at Tugun in south-east Queensland in 2010; others are under construction in Melbourne (completion 2011), Perth (completion 2011) and Adelaide (completion 2013). However, desalination is not a universal strategy, as many local governments have sought to manage demand for water and improve water saving at municipal and household levels, often avoiding the need for major new water infrastructure.

### 2.2.3 Seawater intrusion

Development of groundwater resources to meet growing demands at the coast can put local aquifers at risk of seawater intrusion. Before development, groundwater gradients are naturally towards the sea and maintain an interface between fresh and salt water. If aquifers are exploited too heavily, this gradient can reverse and draw sea water into previously fresh aquifers. Rising sea levels also have the potential to reverse this gradient.

A number of locations around Australia have already been identified where seawater intrusion is a concern, including coastal locations in Queensland (Lower Burdekin, Bribie Island and the Pioneer Valley), South Australia (Eyre Peninsula, Port McDonnell and metropolitan Adelaide), Victoria (Port Phillip, Westernport and Werribee) and Western Australia (Swan Coastal Plain, Carnarvon, Esperance, Cottesloe and Cape Range).

Coastal development leading to increased groundwater use, potentially exacerbated by sea level rise, poses a risk to fresh groundwater resources and the people and natural environments they support.

### 2.2.4 Impacts of water abstraction on flora and fauna

Coastal environments and the species that inhabit them are particularly vulnerable to the effects of drought, because the impacts of drought are exacerbated by withdrawal (abstraction) of water for human use along rivers before they reach the coast. Impacts on waterbird and shorebird populations due to abstractions and extended drought were evident

by 2008. The annual survey of waterbird communities at the Living Murray icon sites found a 48% decrease in bird numbers from the previous year. No waterbird breeding was recorded at the Lower Lakes, Coorong and Murray mouth, and only minimal breeding of white ibis and black swans was recorded at Chowilla Floodplain and Lindsay–Wallpolla islands. The decline of inland wetlands was identified as a significant contributor to the drastic decline in shorebirds (73% and 81% declines for migratory and resident shorebirds, respectively) between 1983 and 2006.

### 2.2.5 Responses

Management of coastal waters has improved greatly in Australia during the past decade, including some high-profile programs to ensure river and estuary health in metropolitan areas (e.g. Hobart and Brisbane). These programs have developed and tested cost-effective approaches to monitoring, modelling, reporting, innovation, communication, strategic interventions and effective partnerships between researchers and managers. Another successful approach to the management of coastal waters is described in Box 11.1.

#### Box 11.1 The Lower Lakes, Coorong and Murray mouth—Ngarrindjeri ruwe

The Lower Lakes, Coorong and Murray mouth in South Australia extend over approximately 140 000 hectares, covering 23 different wetland types, from very fresh to saltier than the sea. This area, where the Murray River meets the sea, is one of 10 major havens for large concentrations of wading birds in Australia, and is recognised internationally as a breeding ground for many species of waterbirds and native fish. The area was designated as a Ramsar Wetland of International Importance in recognition of its diverse range of wetland ecosystems, habitats and species of birds, fish and plants (more than 30% of the migratory wading birds that fly to Australia spend summer there). It is also of high cultural, economic, spiritual and social value to the Ngarrindjeri people, the traditional owners of the region, who maintain a continuous, strong relationship with their land and waters (ruwe).

Cultural flows are essential for the continued breeding and health of Ngarrindjeri ngartjis (totems), which determine the health of the Ngarrindjeri nation. Cultural flows are also essential to maintain the health of Ngarrindjeri cultural heritage sites. Some of these are areas of high cultural significance but have not been identified as being environmentally significant.

Years of water overallocation and the severe drought of 2001–10 led to significant impacts on the Coorong, Lower Lakes and Murray mouth. Due to the barrages holding back sea water, water levels in the lakes dropped to unprecedented lows—more than one metre below sea level in Lake Alexandrina in April 2009. As the water levels fell, serious land and water management issues emerged, with the drying of wetlands, exposure of previously submerged sulfidic soils and disconnection of different elements of the system. The water quality of the system declined markedly due to insufficient freshwater flows through the barrages.

The Lower Lakes, Coorong and Murray mouth icon site environmental management plan commits to protect and restore natural habitats, restore viable populations of native species, improve water quality and increase flows through the wetlands, as well as recognising the Ngarrindjeri association with the area. The short-term emergency response included the pumping of water from Lake Alexandrina to Lake Albert to prevent acidification; preparatory work towards the ponding of fresh water within the Finniss River and Currency Creek area to help manage acidification, as well as trials to assess the effectiveness of revegetation and bioremediation techniques to manage acid sulfate soils; and the purchase of water on the temporary water market to provide flows to the lakes.

Throughout the crisis, Ngarrindjeri elders worked closely with the South Australian Department of Environment and Natural Resources to put in place the emergency works and plan for the future of the Coorong, Lower Lakes and Murray mouth, and actively participated in the bioremediation and revegetation around the Lower Lakes. In recognition of their contributions, the Ngarrindjeri elders were awarded the 2010 South Australian Environment Award.



## 2.3 Coastal land

For further information, see Chapter 5: Land.

Urban settlements and our population are concentrated along the eastern, south-eastern and south-western coastal fringes of Australia. This area overlaps, and sometimes conflicts, with the areas most suitable for intensive agriculture (i.e. higher rainfall zones within 200 kilometres of the coast and where the floodplains of major rivers provide the most fertile soil). Land managed for nature conservation is located primarily in central and northern Australia, and in the forested ranges of the east and south-west of both mainland Australia and Tasmania.

### 2.3.1 Major trends

Some major trends in land use that are relevant to coastal Australia include:

- continuing urban expansion in both capital cities and major regional coastal cities (see also Chapter 10: Built environment)
- continuing expansion of the conservation and Indigenous estates (see also Chapter 6: Marine environment, and Chapter 8: Biodiversity)
- continuing decline in the area of native forest managed for wood production and a corresponding increase in the extent of native forest managed for conservation, much of which is found in coastal ranges (see Chapter 5: Land)
- changes in flows from rivers into estuaries and coastal environments, due to increased extraction of water for agricultural and urban use, and to drought over the past decade in many areas (see Chapter 4: Inland water)
- growth of mining developments in the north-west of Australia (see Chapter 6: Marine environment), which is increasing the number of people accessing coastal environments for recreation, warranting monitoring of its impacts
- improvements in land-management practices in many (but not all) areas, which have reduced the flows of sediments and chemicals to the coast that were characteristic of major rainfall events in the past (see Chapter 4: Inland water).

■ Surfers Paradise in morning light, Queensland  
Photo by Ilya Genkin

### 2.3.2 Factors affecting coastal land-use change

Growing Australian and global populations will demand more food and fibre, and expanding settlements and infrastructure will continue to impact on the environment. Economic growth places more demands on natural resources, as well as generating financial resources and new technologies for environmental management. The changed climate regimes and sea level rise associated with global warming are expected to place new pressures on both the natural environment and primary production systems. All of these factors will affect coastal ecosystems, but particular pressure will come from the interaction between sea level rise and human settlements.

### 2.3.3 Acid sulfate soils

Acid sulfate soils occur naturally in both coastal (tidal) and inland or upland (freshwater) settings. When disturbed, sulfides within the soil react with oxygen in the air, forming sulfuric acid.<sup>2</sup> Coastal development for tourism, towns and agriculture has disturbed large areas of acid sulfate soils, with significant environmental, economic and social costs to coastal communities. Adverse impacts of acid sulfate soils in coastal lowlands include:

- poor water quality (e.g. dissolved metal contaminants, low pH, reduced oxygen levels)
- direct killing of fish, or fish becoming more vulnerable to pathogens
- loss of critical habitat areas, aquaculture production, fish stocks, wetland biodiversity and amenity
- acid erosion of infrastructure
- the need for rehabilitation of disturbed areas.<sup>3</sup>

The public health implications of disturbing acid sulfate soils are not well understood. However, acidified coastal wetlands may provide predator-free habitat for species of mosquito that transmit arboviruses (e.g. Ross River virus). Acid dust mobilised during ploughing and construction activities may cause dermatitis and eye irritation.<sup>3</sup>

Risk mapping in various locations around Australia has lacked consistency and contained many large gaps. In collaboration with the National Committee for Acid Sulfate Soils, the Commonwealth Scientific



and Industrial Research Organisation (CSIRO) developed the Atlas of Australian Acid Sulfate Soils, which has now been incorporated into the Australian Soil Resource Information System.<sup>a</sup>

Local and state governments around Australia have produced policies, plans and guidelines for managing the risks of acid sulfate soils. At a national scale, the National Water Quality Management Strategy<sup>4</sup> provides guidelines on water management, including management of acid sulfate soils; the National Strategy for the Management of Coastal Acid Sulfate Soils<sup>5</sup> assists in coordinated management; and the handbook *Managing acid and metalliferous drainage*<sup>6</sup> provides guidance on best-practice management for an Australian context.

### 2.3.4 Changes in native vegetation and habitat

Chapter 5: Land, and Chapter 8: Biodiversity discuss data on declines in native vegetation around Australia and its significance for biodiversity conservation. The greatest reductions in native vegetation extent have been in eastern, south-eastern and south-western Australia (Figure 11.2). Impacts on the coastal strip are highly variable around Australia's coastline, ranging from very heavily cleared, with less than 10% remaining, in parts of Victoria and South Australia, through 31–50% remaining in large parts of the south-western and north-eastern coastal areas, to 71–100% remaining for most of northern Australia.

Natural coastal habitat systems, including the coastal swamp systems (such as those dominated by *Melaleuca*, *Casuarina*, saltmarsh and mangrove species) and the submerged wetlands (such as mudflats, seagrasses and algal beds), play a major ecological role in the lives of marine fish and invertebrates. These habitat systems provide breeding, feeding and nursery grounds for many species of fish and invertebrates, as well as rich feeding grounds for migratory waders and other shorebirds.<sup>7</sup>

Coastal urban development (especially canals), catchment development, marinas, breakwaters, island reclamation projects, coastal and nearshore mining and dredging, harbours and shipping channels all have impacts on the ecology of coastal habitats. For example, coastal dune vegetation and natural beaches may be replaced by housing, hard surfaces

and beach groynes. In places, entirely new forms of habitat may be created, such as low-energy harbours with surrounding rock walls, which attract a different suite of marine species.

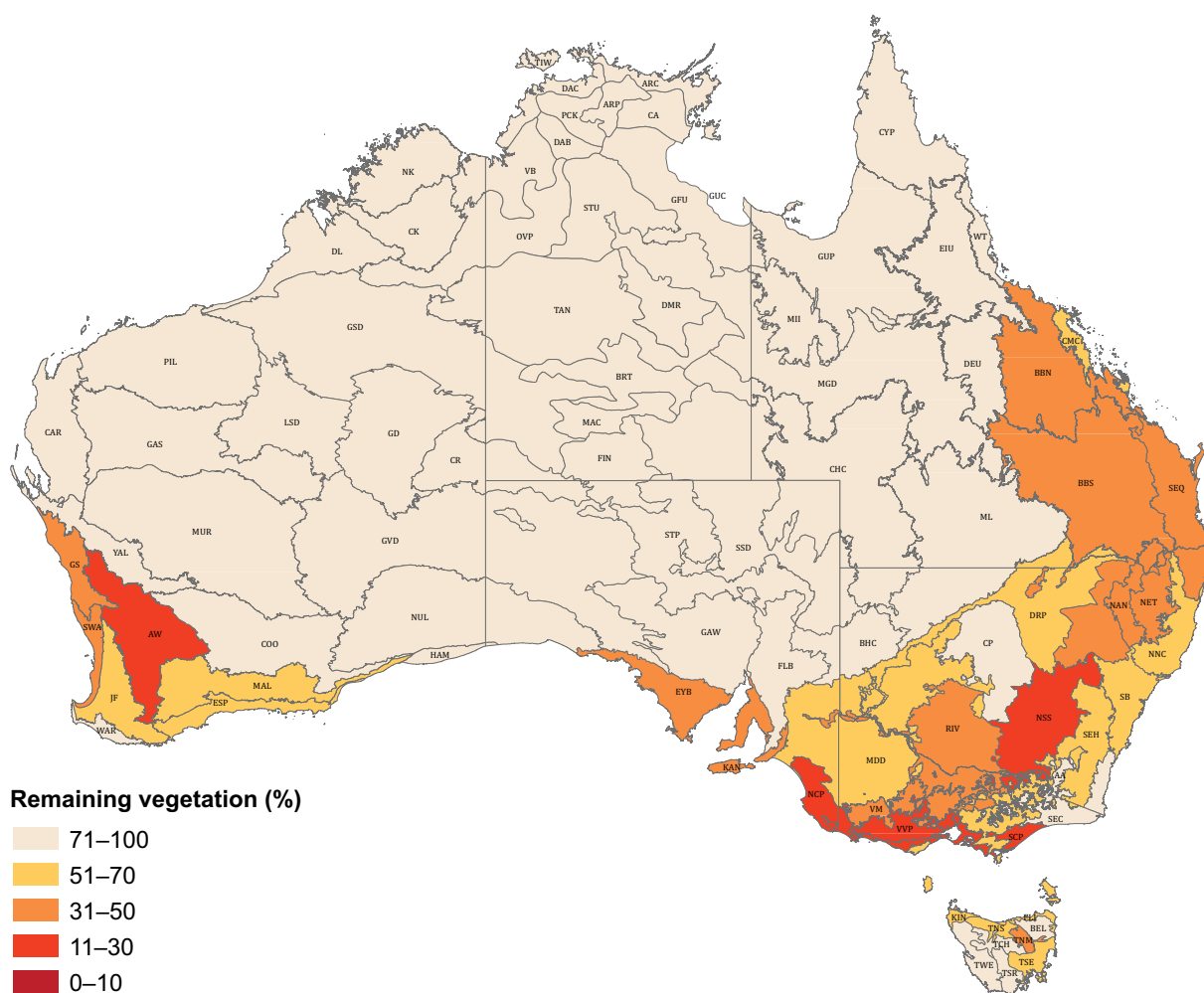
Coastal development happens in an incremental way, making it difficult for local or state planning authorities to assess the cumulative impact of specific development proposals. One consequence of coastal development is a reduction in the abundance of native vegetation and the breakdown of connectivity among remnant habitat patches.

To obtain a coarse assessment of changes in vegetation, the Environmental Resources Information Network unit in the Australian Government Department of Sustainability, Environment, Water, Population and Communities compared the current mapped extent of major (native) vegetation groups (MVGs) around Australia's mainland coast with their modelled extent before European settlement (i.e. pre-1750) (Figure 11.3). In this analysis, the 'coastal strip' was defined in three different ways: 10 kilometres, 50 kilometres or 100 kilometres inland from the high water line. To examine impacts on lowland vegetation separately from impacts on mountains, separate analyses were run for map components lying below 20 metres above sea level, components below 50 metres above sea level and components regardless of elevation. Figure 11.3 shows the data for vegetation below 50 metres elevation and for two widths of coastal strip. The broad conclusions hold for the other combinations, which are available on the State of the Environment website.<sup>b</sup>

In the 10-kilometre coastal strip (where most coastal settlements fall), most MVGs, apart from *Acacia* shrublands and *Callitrus* open woodlands, occur at more than 50% of their pre-1750 extent; several are above 80% (Figure 11.3). This conclusion should be regarded with caution as MVGs are very broad groupings and may include ecosystems that are far more reduced than the average for the MVG. Furthermore, these figures are for the nation's coastline overall, much of which (especially in northern Australia) has not been affected by urban development. Therefore, the decline of two MVGs to less than 50% of their pre-1750 level and of five MVGs to below 60% suggests that major clearing has occurred around coastal settlements. This is supported by the state of the environment reports by the states and territories.

a [www.asris.csiro.au](http://www.asris.csiro.au)

b [www.environment.gov.au/soe](http://www.environment.gov.au/soe)



**Remaining vegetation (%)**

- 71–100
- 51–70
- 31–50
- 11–30
- 0–10

**IBRA abbreviation key**

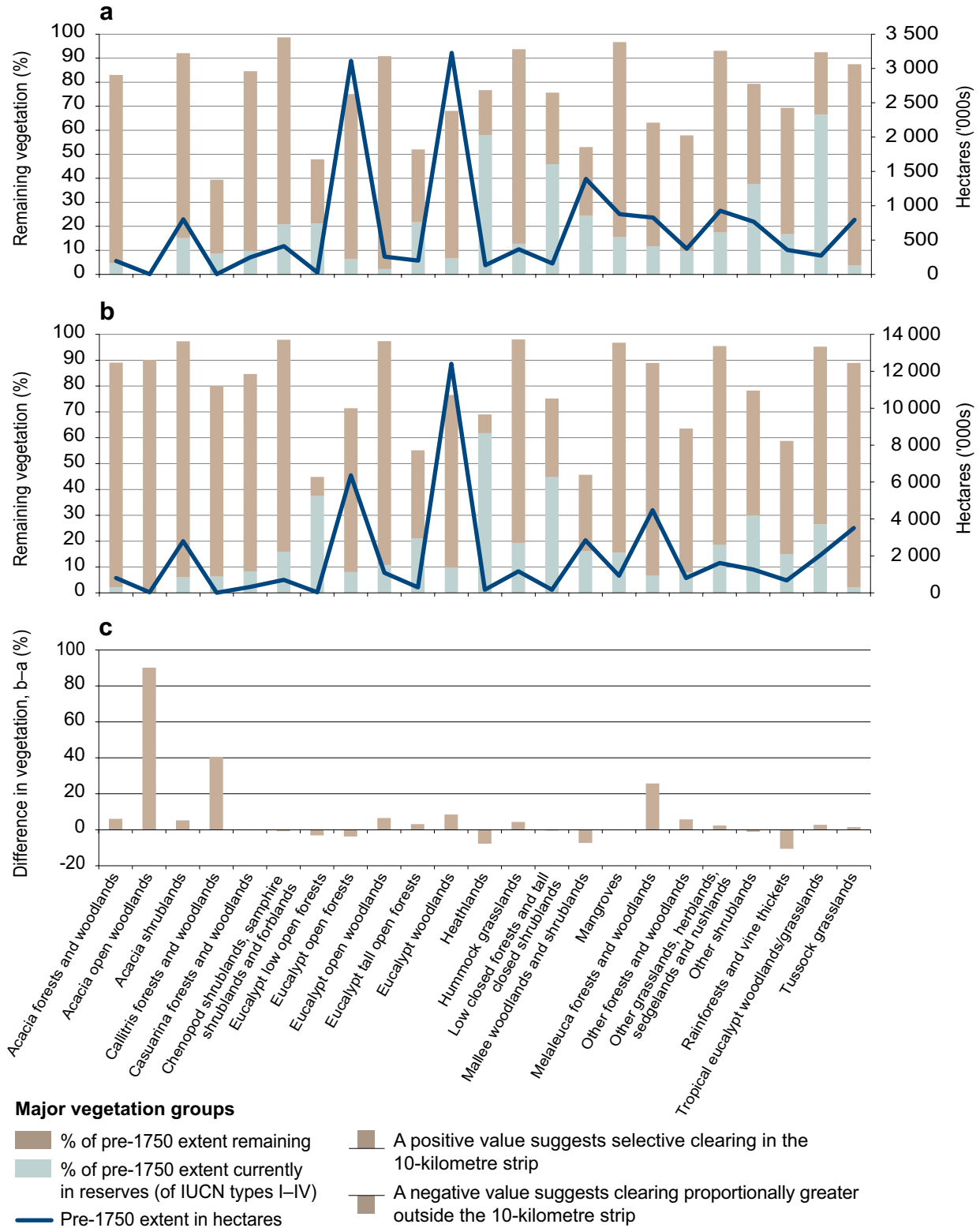
AA, Australian Alps	COO, Coolgardie	FLI, Flinders	MAC, MacDonnell Ranges	PCK, Pine Creek	TNM, Tasmanian Northern Midlands
ARC, Arnhem Coast	CP, Cobar Peneplain	GAS, Gascoyne	MAL, Mallee	PIL, Pilbara	TNS, Tasmanian Northern Slopes
ARP, Arnhem Plateau	CR, Central Ranges	GAW, Gawler	MDD, Murray Darling Depression	RIV, Riverina	TSE, Tasmanian South East
AW, Avon Wheatbelt	DAB, Daly Basin	GD, Gibson Desert	MGD, Mitchell Grass Downs	SB, Sydney Basin	TSR, Tasmanian Southern Ranges
BBN, Brigalow Belt North	DAC, Darwin Coastal	GFU, Gulf Fall and Uplands	MII, Mount Isa Inlier	SCP, South East Coastal Plain	TWE, Tasmanian West
BBS, Brigalow Belt South	DEU, Desert Uplands	GS, Geraldton Sandplains	ML, Mulga Lands	SEC, South East Coastal Plain	VB, Victoria Bonaparte
BEL, Ben Lomond	DL, Dampierland	GSD, Great Sandy Desert	MUR, Murchison	SEH, South Eastern Highlands	VM, Victorian Midlands
BHC, Broken Hill Complex	DMR, Davenport Murchison Ranges	GUC, Gulf Coastal	NAN, Nandewar	SEQ, South Eastern Queensland	VVP, Victorian Volcanic Plain
BRT, Burt Plain	DRP, Darling Riverine Plains	GUP, Gulf Plains	NCP, Naracoorte Coastal Plain	SSD, Simpson Strzelecki Dunefields	WAR, Warren
CA, Central Arnhem	EIU, Einasleigh Uplands	GVD, Great Victoria Desert	NET, New England Tablelands	STP, Stony Plains	WT, Wet Tropics
CAR, Carnarvon	ESP, Esperance Plains	HAM, Hampton	NK, Northern Kimberley	STU, Sturt Plateau	YAL, Yalgoo
CHC, Channel Country	EYB, Eyre Yorke Block	JF, Jarrah Forest	NNC, NSW North Coast	SWA, Swan Coastal Plain	
CK, Central Kimberley	FIN, Finke	KAN, Kanmantoo	NSS, NSW South Western Slopes	TAN, Tanami	
CMC, Central Mackay Coast	FLB, Flinders Lofty Block	KIN, King	NUL, Nullarbor	TCH, Tasmanian Central Highlands	
		LSD, Little Sandy Desert	OVP, Ord Victoria Plain	TIW, Tiwi Cobourgs	

Source: Environmental Resources Information Network, Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2011

**Figure 11.2** Remaining native vegetation (percentage of pre-1750 extent) for Interim Biogeographic Regionalisation of Australia (IBRA) regions

The extents of reservation for 9 of the 23 MVGs are below 10% of pre-1750 extent, and a further 4 are at or below 15% (see Chapter 8: Biodiversity for a discussion of targets for the National Reserve System). This represents a large risk to the ecosystems within these MVGs, given the pressure on Australia’s coasts.

For several MVGs, a greater proportion of pre-1750 extent remains in the 100-kilometre coastal strip than in the 10-kilometre strip (Figure 11.3). This indicates that clearing of these MVGs (e.g. *Acacia* open woodlands) has been more intense near the coast than further inland. For most other MVGs,



Source: Environmental Resources Information Network, Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2011

**Figure 11.3** Proportion of major vegetation groups (MVGs) below 50 metres altitude remaining around Australia's coasts showing (a) data from a 10-kilometre strip inland from the high tide line, (b) data for a 100-kilometre strip and (c) the difference in percentage of MVGs remaining between the 100-kilometre strip and the 10-kilometre strip

In a and b, the darker parts of the columns are the percentage of pre-1750 vegetation remaining, and the lighter parts of the columns are the percentage of pre-1750 vegetation currently in International Union for Conservation of Nature reserve categories I-IV (i.e. strict nature reserves and wilderness areas, national parks, natural monuments or features, or habitat/species management areas). A positive value suggests that there has been selective clearing in the 10-kilometre strip, and a negative value suggests that clearing has been proportionally greater outside the 10-kilometre strip.

the differences are small; for three, there is 5–10% less remaining in the 100-kilometre strip, suggesting that a little more clearing has occurred inland.

Although many mangrove swamps have been lost to coastal development, particularly as a result of land reclamation near urban areas and estuarine flood mitigation programs, at the national level we still retain around 96% of mangrove area. Most of this is in pristine areas of the Northern Territory, Cape York and the Kimberley. However, even though large coherent areas of such ecosystems remain and are highly valued, many small areas of fringing mangroves have been lost from estuaries (particularly on the east coast). This will have significant ecological impacts on locally dependent species and ecological functions, such as connectivity, that contribute strongly to the resilience of coastal ecosystems. Some loss of fringing mangroves occurs across all regions. For example, substantial areas of mangroves fringing the water's edge have declined along the Pilbara coast of Western Australia, probably as a result of local developments, changes in hydrodynamics and climate change impacts. These losses are hard to detect—trends in area coverage shown in the coarse-scale national statistics may significantly underestimate the extent of the ecological impact from the loss of fringing mangroves.

Change in area of vegetation is only one type of measure; more information is needed on how ecological processes have changed and little such information is currently available.

### 2.3.5 Invasive species

We deal with invasive species only briefly here, as most of the invasive species associated with coasts have invaded marine environments and are discussed in detail in Chapter 6: Marine environment (see also Section 2.4.3).

Introduced weeds and pest species have contributed to national reductions in biodiversity and marine, estuarine and coastal productivity. Many of the weeds that threaten native species and ecosystems across Australia have impacts on coastal areas. Two weeds that have particular impacts on coastal dune systems are bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) and boneseed (*C. monilifera* ssp. *monilifera*). These species displace native vegetation, are highly invasive and have potentially high economic and

environmental impacts.<sup>8-9</sup> Weeds are a particular problem in peri-urban areas (between the outer fringes of urban centres and rural areas) as they are easily transported by high rates of traffic and people who are unaware of necessary precautions; as well, some inexperienced or temporary residents in coastal areas may practise poor weed control (see Section 2.7.3).<sup>10</sup>

Feral animals like foxes and cats are particularly active around human settlements because of the ready abundance of food.

Native species can have similar effects to invasive species when they move rapidly outside their usual range, threatening species that normally live in a particular environment. Such movements occur when native species are spread by birds, other animals or people, all of which are very active along Australia's coastal strip, both on the land and in the water. Unusual movements of native species also occur as habitat changes (e.g. with increasing sea temperature). An example in south-east Australia is the expansion of the range of the sea urchin *Centrostephanus*, which is denuding coastal reefs in Victoria and Tasmania with subsequent impacts on biodiversity and recreational and commercial fishing.<sup>11</sup>

## 2.4 Coastal marine waters

For further information, see Chapter 6: Marine environment.

### 2.4.1 Fishing and aquaculture

Pressures from commercial and recreational fishing are important outcomes of coastal urban development, growth in the Australian and global populations, and a range of economic drivers. Aquaculture in coastal waters is one of the fastest growing commercial sectors in Australia.

Pressures from fishing are decreasing overall. However, in some areas of the south-east, east and south-west regions, pressures are widespread and causing serious degradation. Pressures from the development of aquaculture continue to increase in the south-east region, where the worst areas are already suffering serious degradation.

### 2.4.2 Impacts of rising sea temperatures

Sea surface temperatures have increased since the early 20th century—by 0.7 °C from 1910–29 to 1989–2008. As mentioned in Section 2.1.2, increases in sea surface temperature, which are particularly marked in the south-west, east and south-east regions, are likely to affect commercial and recreational fishing, aquaculture and a wide range of coastal activities that are part of the social and economic fabric of coastal communities.

Changing ocean temperature directly affects the distribution and abundance of many species and habitats, including seagrasses, macroalgae, phytoplankton, coral reefs, tropical and temperate fish, pelagic fish, marine reptiles and seabirds. The general trend is that habitats and distributions of species are moving southward. Further declines in seagrass meadows and algal beds, due to storms, turbidity and warmer water, are expected in the future. A loss of diversity in coral fish and other coral-dependent organisms is also expected.

For species that require shallow and cool coastal waters, such as for breeding or nursery grounds, this southward forcing by the changing temperature will eventually result in major population reductions as habitats become less available, and finally become unavailable south of the mainland and Tasmania. Changing temperature is likely to create the greatest set of ecological changes in shallow-water marine ecosystems in the coming decades.

### 2.4.3 Invasive species

An emerging concern in the marine environment is the threat from pathogens and viruses, which are spread by people, cargo, fishing gear and boats, and are difficult to detect. Introduced marine pests can enter Australia by a variety of routes, including ships' ballast water, biofouling on ships' hulls and equipment, and the aquarium trade and aquaculture. Around 97% of the volume of Australia's trade is moved through the network of ports. In 2008–09, approximately 800 million tonnes of cargo were moved through Australian wharves by 4200 vessels that made 26 700 port calls. Further introductions of marine pests in coastal waters represent a significant economic and environmental threat.

Translocation of introduced marine pests within Australian waters occurs through the same means,

as well as through natural processes. More than 100 introduced species and marine pests have been identified in Australian coastal waters.

Governments are working together to develop and implement a national system to prevent and manage marine pest incursions.<sup>c</sup>

## 2.5 Biodiversity

For further information, see Chapter 8: Biodiversity.

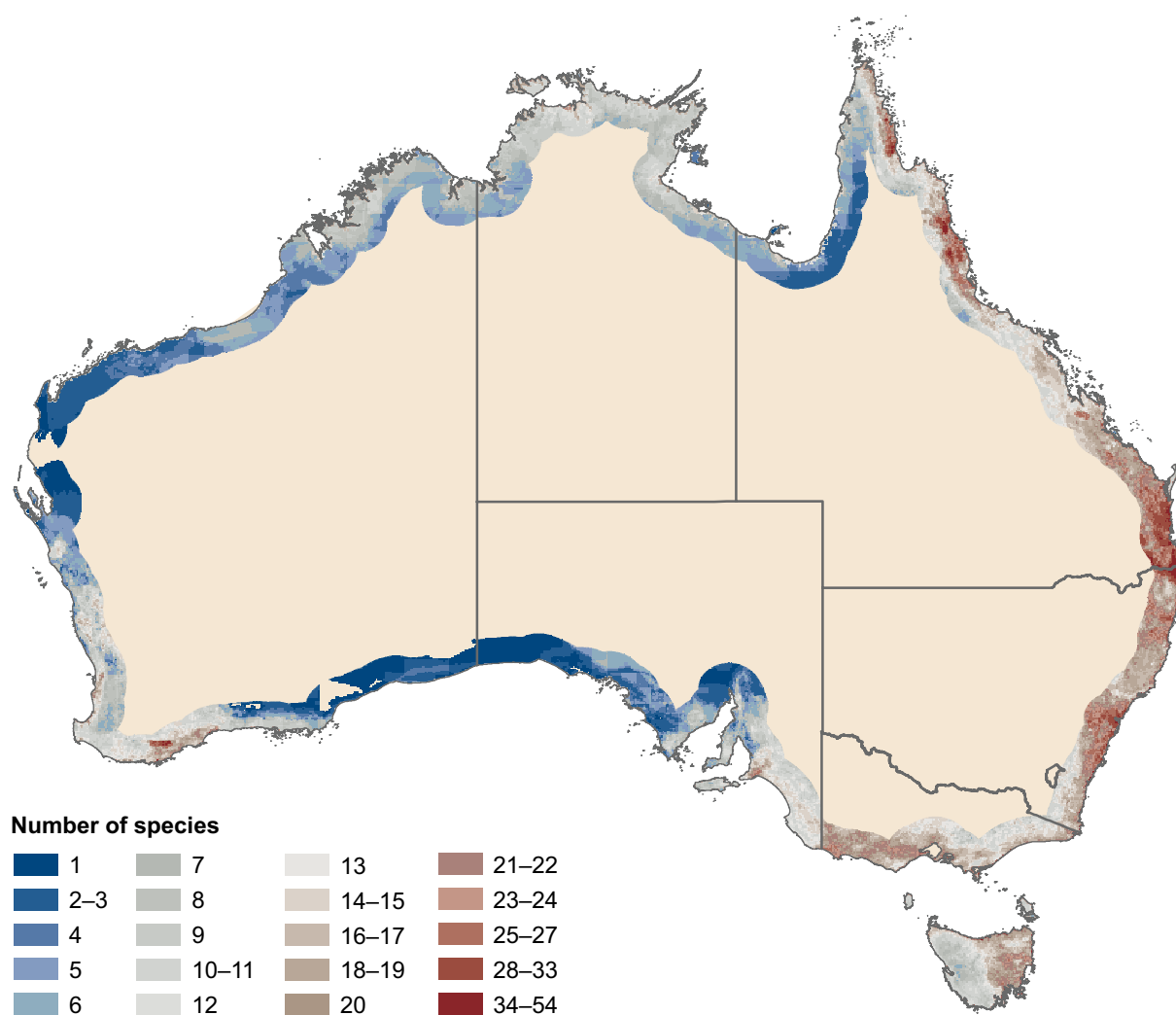
### 2.5.1 Threatened species

Australia's population is heavily concentrated in coastal regions, and so are impacts on our biodiversity. Figure 11.4 shows a coarse assessment of the location of threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in a 100-kilometre band around Australia. Such data are difficult to interpret. For example, the concentration of threatened species around the northern coast contradicts other data in this report showing that these coastlines are relatively undisturbed. This could partly reflect the larger number of species in tropical parts of Australia. As well, a range of small mammals, birds and reptiles, whose ranges include coastal areas, are currently of concern in the north. Events outside Australia potentially affect migratory species like birds. More consistent with expectations is the high concentration of threatened species around the areas of high population growth in south-east Queensland and northern and central New South Wales (Figure 11.4).

### 2.5.2 Concerns from previous State of the Environment reports

The past three national State of the Environment reports have expressed concern about impacts on most coastal habitats or about lack of information on which to base assessments of impacts. They noted that, while there are continued efforts to improve coastal management responses, coastal zone condition is not significantly improving and continues to decline against a number of criteria. Pressures on coastal resources are increasing at a rate that exceeds the ability of damaged environments to stabilise and be repaired.

<sup>c</sup> [www.environment.gov.au/coasts/imps](http://www.environment.gov.au/coasts/imps)



Source: Environmental Resources Information Network, Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2011

**Figure 11.4** Threatened species that occur within 100 kilometres of the coast

This map uses the 1698 threatened (critically endangered, endangered or vulnerable) species listed as at June 2011 under the *Environment Protection and Biodiversity Conservation Act 1999*. Each species distribution was intersected with a 5-kilometre grid of the coastal region (100 kilometres inland), and a count for each grid cell was calculated.

The increasing cost of addressing these issues as coastal populations grow and the need for specialised knowledge are major challenges for coastal management.<sup>12</sup>

### 2.5.3 Impacts of climate change

Potential impacts of climate change on terrestrial and marine biodiversity are dealt with in detail in Chapter 8: Biodiversity and Chapter 6: Marine environment, respectively. There is significant uncertainty about how species and ecological

systems will be affected by climate change. Current regional climate models suggest that impacts will be widespread and that a 'business as usual' greenhouse gas emissions scenario over the next few decades will result in global mass extinctions on a scale previously unseen in human history.<sup>13</sup> Evidence is mounting that, even with a concerted mitigation effort, it may not be possible to avoid impacts such as the loss of large components of biodiversity, including freshwater systems, coral reefs and coastal mangroves.<sup>14</sup> Northern Australian wetlands and the Great Barrier Reef are among the threatened assets.

## 2.6 Coastal heritage

For further information, see Chapter 9: Heritage.

### 2.6.1 The nature of coastal heritage

Many Australian natural heritage places are in coastal areas. Many important wetlands, for example, occur on coastal plains, which are especially vulnerable to degradation both because they are often accessible and close to population centres and because they are at the end of river systems that have had water extracted for various uses before it reaches the coast (see also Chapter 4: Inland water).

Because Australia was initially settled around its coasts, coastal areas have many buildings of heritage significance and historically important shipwrecks. Conditions that degrade buildings and natural structures (e.g. wind, salt, inundation) are often more extreme in coastal areas, requiring particular attention to the preservation of heritage assets.

Indigenous places of cultural significance in the coastal zone are potentially under threat from the same forces that affect natural heritage. As well, many Australians lack recognition and understanding of what is significant, and connections between Indigenous people and coastal places have declined. In Chapter 9: Heritage, the Tjilbruke dreaming trails are described. This dreaming links features of coastal environments together in an explanation of the creation of seven freshwater springs along the coast of the Fleurieu Peninsula, between Crystal Brook in the north, through the Adelaide Plains, to Parewarangga (Cape Jervis) in the south. This example illustrates the challenges for managing such heritage values, since the dreaming trails spread across large areas of public and private land and require management by several local councils.

### 2.6.2 Pressures

Pressures specific to natural heritage include rapid increases in the number of invasive species and pathogens; progressive loss of habitat; conflict in land use, including tension between the potential economic value of land and its dedication for conservation purposes; and the relatively modest budgets made available to those charged with the care, control and management of reserved lands.

Coastal Indigenous heritage in Australia faces pressures in two major areas. Firstly, knowledge and tradition have been lost, particularly in areas of early European colonisation. However, there are also positive factors, such as increasing involvement of Indigenous people in traditional sea and land management in coastal areas. Secondly, Indigenous sites are subject to an ongoing process of incremental destruction, usually associated with urban development, farming and mining. The obligation for identification and assessment of impact rests with the proponent of the development, and Indigenous heritage is often seen as being 'in the way' of progress. In many cases, consent for destruction of specific sites is issued in the absence of a comprehensive understanding of the nature and extent of the overall Indigenous resource.

Historical cultural heritage is also particularly threatened by pressures for redevelopment, on both a large and a small scale. The impacts range from complete destruction to inappropriate change, and may affect associated attributes, such as visual setting. Planning systems, land zonings and related regulations, although often well intentioned, do not necessarily assist in achieving conservation outcomes. Some building codes and standards (including, surprisingly, the green building agenda) also create pressure for demolition or inappropriate change. Inflexible paradigms may require building conservation, rather than allowing natural processes and evolution to ruins.

### 2.6.3 Risks and responses

In coastal and urban areas, population increase leads to more immediate and direct incidents that threaten heritage, such as demolition to make way for new development, damage from the introduction of new infrastructure, and adverse impacts on the setting of significant natural and cultural places. As noted above, climate change will bring about sea level rise, with the risk of inundation of coastal heritage areas.

Dealing with the pressures on natural and cultural heritage around Australia's coasts is hindered by inadequate survey, assessment and listing of Indigenous places; past ad hoc practices for listing of historic places on statutory registers (although this is now improving); and resource limitations that often restrict activities at the national level to reactive processes for dealing with threats to natural heritage, especially from invasive species.

■ Aerial view of Whitehaven Beach, Whitsunday Islands, Queensland  
Photo by Nick Rains





## 2.7 Population growth and urban development

For further information, see Chapter 10: Built environment.

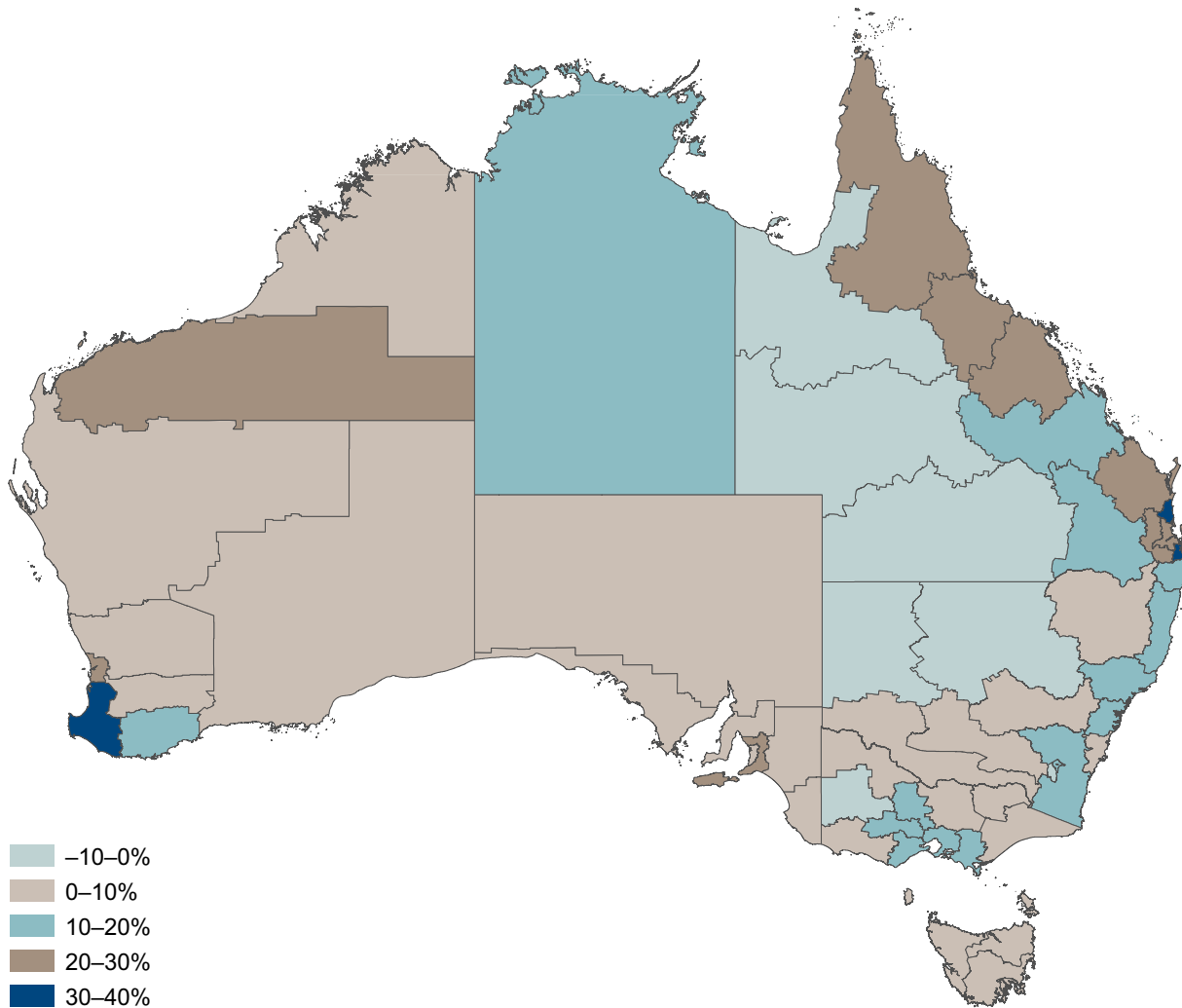
### 2.7.1 Population growth

Concern about changes in the size and composition of the population along Australia's coasts has been growing for several decades.<sup>15-16</sup> In 2004, coastal councils from around Australia established the National Sea Change Taskforce to document and promote their concerns. This led to two major pieces of research on demographic change and ways to address it.<sup>17-18</sup> Smith and Doherty<sup>15</sup> review a number of other contributions to this dialogue.

Australia's population has grown by about 18.1 million since federation and is currently around 22 million.<sup>19</sup> The most recent intergenerational report projected a population of around 36 million by 2050.<sup>20</sup> About 81% of the population lives within 50 kilometres of the coast.<sup>21</sup>

Population growth in Australia is expected to occur mainly around:

- the big cities (through natural increase, internal migration, international migration and tourism)
- high-amenity coastal regions (especially those located within, or close to, the metropolitan areas of the capital cities)
- the larger regional centres (both coastal and inland).<sup>22</sup>



Source: Australian Government Department of Sustainability, Environment, Water, Population and Communities<sup>24</sup>

**Figure 11.5** Population change in Australia, 2001–10

## 2.7.2 Coastal population growth

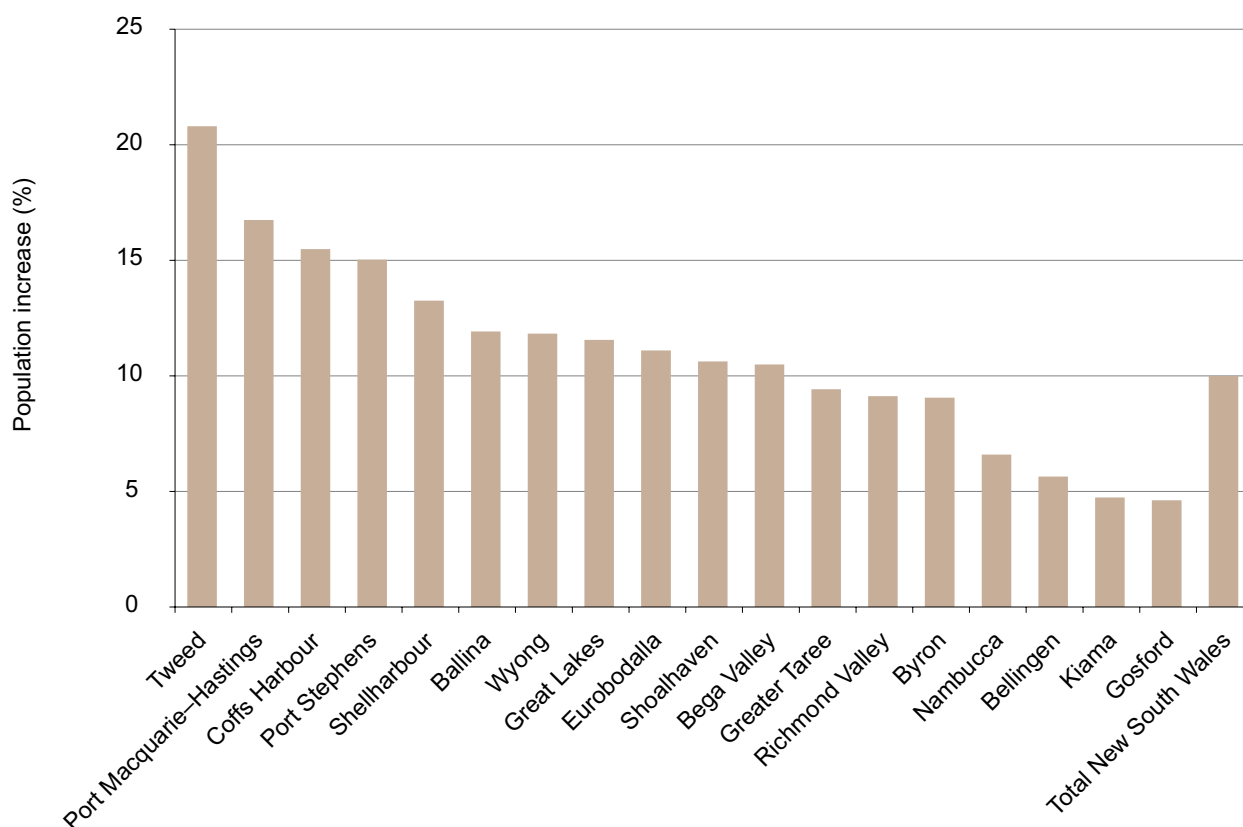
Australia's coastal population has been growing faster than the population of the rest of the country for some time (Figures 11.5 and 11.6) and is expected to increase by another one million people over the next 15 years.<sup>23</sup>

Increasingly, coastal councils around Australia are expressing concern about population growth in small settlements outside large centres. This growth is occurring faster than many local councils can manage and is associated with expectations for the provision of services that often cannot be supported by the rates base.<sup>23-24</sup>

Gurran et al.<sup>17</sup> made the following observations about the types of people who are moving to coastal

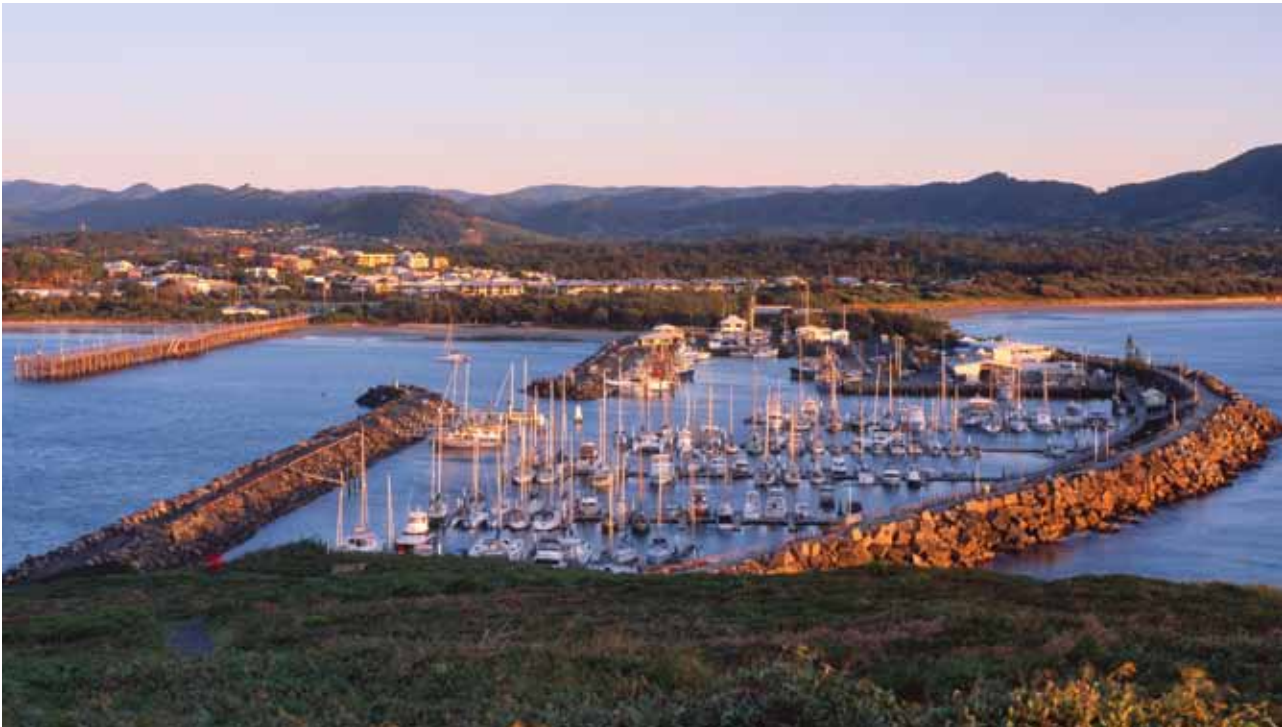
communities (although this report is six years old, the main points still apply):

- Although retirees contribute to the sea-change phenomenon, they are no longer the major drivers of coastal population growth.
- New residents of high-growth coastal regions are of a younger age profile than Australia as a whole and significantly younger than the existing profile of communities affected by sea change. However, this is not likely to affect the high median age of sea-change areas in the immediate future because the newcomers represent only a small proportion of the total population.
- As the 'baby-boomer' generation has started to retire, the number of retirees moving to the coast, including 'hill-change' areas immediately inland (such as the hinterland to the Gold Coast



Source: Australian Bureau of Statistics<sup>25</sup>

**Figure 11.6** Change in estimated resident population of New South Wales 'sea-change' local government areas, 2001–10



■ Coffs Harbour, New South Wales

Photo by Matt Lauder

and northern New South Wales coasts, which also offer high amenity and access to coastal population centres) is likely to rise again, contributing to an overall increase in the rate of population growth in these places.

slow migration to these places; changing lifestyle choices are also leading to demand for types of housing that are not available or affordable in metropolitan areas.

The challenges associated with the sea-change phenomenon are not the same everywhere, since different coastal communities are growing for different reasons and in different ways. The drivers for nonmetropolitan coastal development include:<sup>17</sup>

- the attractions of high environmental amenity and space associated with beach and bush—the attraction for some is being able to live near the coast as well as having access to cities for work and visiting relatives, while for others the attraction is getting away from population centres
- employment—many people move to the coast with the hope of finding employment (but unemployment rates in coastal areas are generally much higher than the national average)
- housing choices and affordability—housing affordability has been a major factor drawing people to nonmetropolitan coastal areas, although the difference is decreasing for the most desirable coastal destinations, which might

### 2.7.3 Environmental impacts

Urbanisation has been identified as a major pressure on biodiversity, water resources, cultural and natural heritage, marine environments and atmosphere in other chapters of this report. Growing coastal populations require houses, wastewater treatment, roads and other facilities. Environmental controls on urban development and the need for onsite containment of wastes are of vital concern in coastal areas, and adequate development and implementation of these can be a major challenge for resource-limited coastal councils.<sup>16</sup> As noted in Chapter 8: Biodiversity, the impacts of urbanisation are not just direct (e.g. removal or modification of ecosystems) but also indirect (e.g. the consumption of natural resources as an indirect result of consumption of goods by people living in urban areas).

Differences in motivation for moving to coastal areas affect the ways in which people interact with the environment. For example, recent studies of the

impacts of peri-urban development suggest that many people who move to coastal and hinterland areas for lifestyle reasons have little understanding of environmental management, especially how to control weeds and other pests.<sup>10</sup> Furthermore, when high-income, second-home owners become part-time residents in peri-urban areas, especially coastal ones, they tend to drive prices up and force those who provide labour locally to move further away, increasing their travel costs and impacts. Part-time residents also reduce per-household inputs to local economies and to the development of community ethics about environmental management.

#### 2.7.4 Tourism and recreation

Two other major impacts of population increase on coastal areas are tourism and recreation. Nature-based tourism is the reason for more than 3 million international tourist visits to Australia, nearly 13 million domestic overnight trips and more than 12 million domestic day trips annually (Table 11.1). Marine tourism and recreation, including recreational fishing, were estimated to contribute \$18.7 billion to the Australian economy in 2007–08, and recreational fishing is now considered to be

the nation's largest participatory recreational activity (see Chapter 6: Marine environment for further details). As well, many of the most attractive bushwalking opportunities and national parks occur in the coastal zone.

Interactions between coastal development and tourism can be complex. For example, tourism has the potential to support good management of coastal areas if incentives and regulations are adequate to encourage reinvestment of some revenue in the environment.<sup>26</sup> On the other hand, there can be conflict between tourism development and residential development in coastal areas—residential and retirement development sometimes undermine tourism appeal or values.<sup>27</sup>

Addressing population pressures on coasts requires cooperation and strategic decision-making across several levels of government—this has been slow to emerge in Australia. One major factor holding back progress is that managing population pressure is not only an environmental issue. It also requires coordinated management of a range of social issues including health, transport, energy and housing infrastructure (see Section 3).

**Table 11.1** Proportion of visitors by type of nature activity, 2008

Nature activity	Visitor (%)		
	International	Domestic overnight	Domestic day
Bushwalking or rainforest walks	37	51	39
Visiting national parks or state parks	66	47	42
Visiting botanical or other public gardens	56	19	25
Visiting wildlife parks, zoos or aquariums	58	16	13
Whale or dolphin watching	13	4	2
Snorkelling	18	4	1
Scuba diving	8	1	0
<b>Total nature visitors (million)</b>	<b>3.36</b>	<b>12.94</b>	<b>12.37</b>

Source: Tourism Research Australia<sup>28</sup>

## Governance of the coast

For two decades, government and governance have been a major focus of the debate about the management of Australia's coasts. More recently, this debate has focused on what government and governance mean for the resilience of coastal ecosystems and the communities whose futures are linked to the environment. These topics are the focus of this section—we suggest that they are the overarching factor that will determine how Australian coastal environments cope with the dual drivers of population growth and climate change.

### 3.1 Assessment by previous State of the Environment reports

In all previous State of the Environment reports, the overriding concern expressed about Australia's coasts has been that development has proceeded in a piecemeal, uncoordinated way. Along with cumulative impacts, this presents a risk that coastal assets may be degraded before they are fully assessed and before the objectives for their management and conservation have been set.

#### At a glance

All chapters of this report provide examples of promising responses to coastal challenges by governments, working individually and together. However, outcomes in relation to a number of major issues are still far from ideal.

There is significant uncertainty about how climate change will affect species and ecological systems. Local governments are expressing concern about the lack of guidelines, standards and national strategic approaches to addressing coastal development, growing populations and environmental impacts. A major debate about coastal governance has been running for nearly two decades in Australia. The concern among many stakeholders, including those charged with managing coastal settlements and environments, is that development of Australia's coasts has proceeded in a piecemeal, uncoordinated way. There is a risk that coastal assets could be degraded before they are fully assessed or objectives have been set for their management by Australia as a nation.

So concerned were coastal councils around Australia that, in 2004, they formed the National Sea Change Taskforce. The taskforce has been very active in developing and promoting solutions to state and Australian governments.

This debate took an important step forward in 2009, when the House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts handed down its report, *Managing our coastal zone in a changing climate: the time to act is now*. The report noted that there is limited national collaboration and cooperation to achieve consistencies, efficiencies and agreements on issues such as variation in planning laws, capacities of local councils, monitoring coastal habitat change and legal liabilities. The report made 47 recommendations to address these issues. Most of these recommendations have been noted or accepted in principle by the Australian Government. The quality and timeliness of actions will be critical if existing challenges to coastal sustainability are to be addressed and looming ones prepared for.

In addition, the recent Hawke report, which provided an independent review of the *Environment Protection and Biodiversity Conservation Act 1999*, recommended a range of changes to the Act that would allow it to be applied more strategically and at ecosystem and landscape scales. Many of these recommendations have been accepted by the Australian Government. It remains to be seen whether action is sufficient and soon enough to allow assessment and successful management of the cumulative effects of small developments along the coastal strip. How the three levels of government work together to address these cumulative impacts will be key in determining the future of Australia's coasts.

The 2001 national report made the following observations:<sup>29</sup>

There is clearly still a need for a nationally applicable Coastal Zone Policy to be developed to further assist in reducing the fragmentation of effort to manage the coastal zone and associated coastal waters. This issue was highlighted by a House of Representatives report in 1991, which said: 'The absence of a national perspective towards the entire Australian coastline could lead to national interests being undervalued or even lost for future generations, as the existing ad hoc, hodge-podge pattern of development slowly nibbles away at a precious and beautiful resource, the natural coastline.'

The 2006 report concluded:<sup>30</sup>

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.

In Chapter 6: Marine environment, we conclude:

'Creeping degradation' can be effectively prevented by the establishment of absolute standards for the environment. Important calls have been made for environmental benchmarks to be set for use in environmental accounts,<sup>31</sup> but a set of standards based on equivalent metrics is equally important. The lack of a set of standards for the Australian marine environment that are based on measurable and ecologically sound metrics means that acceptability on social and economic grounds can, and often does, result in greater pressures being applied to the Australian environment.

In marine systems, there are very few defensible metrics that can be used within management frameworks for this purpose.

a strategic approach could or should be developed, but there is little doubt that current approaches are too fragmented and at too limited a spatial scale.

Following the report of the coastal zone inquiry by the Resource Assessment Commission in 1993,<sup>32</sup> Australian, state, territory and local governments developed legislative, policy and program responses to meet the management challenges associated with increasing pressures in the coastal zone. Governments are continuing to improve these responses. At a national scale, the Australian Government released its report, *Climate change risks to Australia's coasts*, in 2009.<sup>1</sup>

Initiatives by state governments during the past decade include:

- the South East Queensland Healthy Waterways Strategy<sup>d</sup>
- the Victorian Coastal Spaces project<sup>e</sup> and the 2008 revision of the Victorian Coastal Strategy,<sup>f</sup> which has been developing as a partnership between the Victorian Government, the Victorian Coastal Council and Victoria's regional coastal boards since 1995
- several interlinked initiatives in New South Wales, including the development of an approach to comprehensive coastal assessment as a key component of the New South Wales Government's Coastal Protection Package (introduced in 2001); the New South Wales inquiry into infrastructure provision in coastal growth areas,<sup>g</sup> which recommended improvements to the New South Wales Government's regional strategies<sup>h</sup> to increase scrutiny, reporting and enforcement of compliance; and the 2009 NSW Sea Level Rise Policy Statement,<sup>i</sup> which specifies sea level planning benchmarks for the coastline

## 3.2 Emergence of the governance debate

Experts who have been involved with coastal issues for decades have emphasised the growing need for a more strategic approach to planning how coasts are managed. Such an approach should take account of the spatial and temporal scales at which pressures on coasts operate, and consider cumulative impacts of small pressures over time. Opinions differ about how

d [www.healthywaterways.org/Home.aspx](http://www.healthywaterways.org/Home.aspx)

e [www.dse.vic.gov.au/coasts-and-marine/coasts/publications/coastal-spaces-initiative-home-page](http://www.dse.vic.gov.au/coasts-and-marine/coasts/publications/coastal-spaces-initiative-home-page)

f [www.vcc.vic.gov.au/vcs.htm](http://www.vcc.vic.gov.au/vcs.htm)

g [www.parliament.nsw.gov.au/prod/parliament/committee.nsf/0/30DCE62D42BB14A4CA256FB600208C25](http://www.parliament.nsw.gov.au/prod/parliament/committee.nsf/0/30DCE62D42BB14A4CA256FB600208C25)

h [www.planning.nsw.gov.au/PlansforAction/Regionalplanning/tabid/161/Default.aspx](http://www.planning.nsw.gov.au/PlansforAction/Regionalplanning/tabid/161/Default.aspx)

i [www.planning.nsw.gov.au/PlansforAction/Coastalprotection/SeaLevelRisePolicy/tabid/177/Default.aspx](http://www.planning.nsw.gov.au/PlansforAction/Coastalprotection/SeaLevelRisePolicy/tabid/177/Default.aspx)

- the Tasmanian Climate Change and Coastal Risk Assessment Project,<sup>j</sup> including a report on indicative mapping of the Tasmanian coast's vulnerability to climate change and sea level rise
- the Adelaide Coastal Waters Study<sup>k</sup> and the Living Coast Strategy for South Australia<sup>l</sup>
- the Pilbara Coastal Water Quality Project.<sup>m</sup>

The Framework for a National Cooperative Approach to Integrated Coastal Zone Management was endorsed by the Australian, state and territory governments in October 2003. It encourages complementary arrangements that build on the successes and momentum established through ongoing state and territory coastal management initiatives. This was a formalisation of cooperative processes that had been evolving for some time. Other mechanisms included the Intergovernmental Coastal Advisory Group, which reported to the Marine and Coastal Committee.

Following from the framework, the *National cooperative approach to integrated coastal zone management: framework and implementation plan*<sup>33</sup> was released in 2006, with six priority areas:

- integration across the catchment–coast–ocean continuum
- management of land-based and marine-based sources of pollution
- planning for climate change and its impacts
- management of pest plants and animals
- planning for population change
- capacity building (the range of activities by which individuals, groups and organisations improve their capacity to achieve sustainability).

Coastal issues were also addressed under the Natural Heritage Trust I and II. Other Australian Government initiatives have included the Coastal Catchments Initiative<sup>n</sup> and the Sustainable Cities Initiative.<sup>34</sup>

j [www.dpiw.tas.gov.au/inter.nsf/WebPages/PMAS-6B56BV?open](http://www.dpiw.tas.gov.au/inter.nsf/WebPages/PMAS-6B56BV?open)

k [www.epa.sa.gov.au/environmental\\_info/water\\_quality/projects/adelaide\\_coastal\\_waters\\_study](http://www.epa.sa.gov.au/environmental_info/water_quality/projects/adelaide_coastal_waters_study)

l [www.environment.sa.gov.au/Conservation/Coastal\\_marine](http://www.environment.sa.gov.au/Conservation/Coastal_marine)

m [http://edit.epa.wa.gov.au/EPADocLib/pilbaracoastalwaterquality\\_Marine%20Report%201.pdf](http://edit.epa.wa.gov.au/EPADocLib/pilbaracoastalwaterquality_Marine%20Report%201.pdf)

n [www.environment.gov.au/water/publications/action/case-studies/nwqms-cci.html](http://www.environment.gov.au/water/publications/action/case-studies/nwqms-cci.html)

It appears that most of these initiatives have been absorbed into the Caring for our Country program,<sup>o</sup> which aims, by 2013, to:

- reduce the discharge of dissolved nutrients and chemicals from agricultural lands to the Great Barrier Reef lagoon by 25%
- reduce the discharge of sediment and nutrients from agricultural lands to the Great Barrier Reef lagoon by 10%
- deliver actions that sustain the environmental values of
  - priority sites in the Ramsar estate, particularly sites in northern and remote Australia
  - an additional 25% of (non-Ramsar) priority coastal and inland aquatic ecosystems of high conservation value, including, as a priority, sites in the Murray–Darling Basin
- improve water quality management in the Gippsland Lakes in Victoria, the Tuggerah Lakes Estuary in New South Wales and all priority coastal hot spots
- increase the community's participation in protecting and rehabilitating coastal environments and critical aquatic habitats.

In 2005–06, the then Minister for the Environment, the Hon. Ian Campbell MP, briefly explored the possibility of developing a 30-year strategic plan for Australia's coastal zone, but this initiative was abandoned. However, strategic application of the EPBC Act in coastal areas and elsewhere is being investigated; this has received impetus from the recent Hawke review, which examined the performance and future of the EPBC Act. That review recommended a range of changes to the Act that would allow it to be applied more strategically and at ecosystem and landscape scales. Many of these recommendations have been accepted by the Australian Government.<sup>35</sup>

Local government has responded to the challenges of coastal management in several ways across jurisdictional boundaries, including:

- formation of the National Sea Change Taskforce in 2004<sup>17,36</sup>—this initially comprised 70 coastal municipalities around Australia (the number varies) that have combined their efforts to examine strategies for a response to population pressures (see also Box 11.2)

o [www.nrm.gov.au](http://www.nrm.gov.au)

- coalitions between other coastal councils, including the Sydney Coastal Councils Group, the Geelong Regional Alliance, the Far North Queensland Regional Organisation of Councils, the Victorian Coastal Council and the South West Catchments Council (in Western Australia)
- increased attention to planning—for example, an Australian Local Government Association survey<sup>12</sup> found that two-thirds of municipalities had altered their town planning schemes and activities in the past three years in response to increased pressure of development, with a key focus on town boundaries and identification of green space between towns that requires protection; Gurran et al.<sup>18,37</sup> and the National Sea Change Taskforce<sup>16,23</sup> are among numerous expert groups that have proposed best-practice approaches to dealing with the challenges of coastal population growth and its environmental impacts.
- addressing the many uncertainties around insurance, planning and legal matters relating to the coastal zone—these are sources of much conflict between developers, local councils and advocates of better environmental management
- improving governance arrangements (including improving collection and use of information; encouraging research on alternative approaches to governance; raising community awareness of the issues facing the coastal zone; developing an intergovernmental agreement on the coastal zone, to be endorsed by the Council of Australian Governments; improving longer term strategic planning; and developing a national coastal zone policy and strategy, a national catchment-coast-marine management program and a national coastal council)
- improving mechanisms for achieving sustainable coastal communities and managing environmental impacts (including establishing a set of national coastal zone environment accounts; collecting better information on demographic trends and visitation rates; focusing on climate change impacts on biodiversity in Caring for our Country; focusing the National Reserve System on high-biodiversity coastal habitat, and expanding reserves to include better buffer zones and habitat connections; applying the EPBC Act to address cumulative effects of coastal development; using the management of the Great Barrier Reef and Victoria's coasts as case studies for integrated coastal zone management; ensuring that Ramsar wetlands—and Kakadu National Park, in particular—have effective plans to deal with climate change impacts; developing a national shorebird protection strategy; ensuring that natural resource management bodies include coastal and marine priorities in their planning; and ensuring that there are mechanisms to identify, register and manage Indigenous and non-Indigenous cultural heritage in vulnerable areas).

### 3.3 Recent developments

In 2009, the House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts handed down its report to the Australian Government: *Managing our coastal zone in a changing climate: the time to act is now*.<sup>38</sup> This report was based on an 18-month inquiry, which received 100 written submissions and 180 exhibits, and held 28 public hearings around Australia. The report noted that there is limited national collaboration and cooperation to achieve consistencies, efficiencies and agreements on issues such as variation in planning laws, capacities of local councils, monitoring coastal habitat change and legal liabilities. It made 47 recommendations, including:

- improving research, and the use of research, on climate change and its impacts in the coastal zone (including sea level rise, extreme sea level events and ocean acidification)
- improving mechanisms for considering adaptation strategies and practices to promote resilience to climate change (including better risk and vulnerability assessment, building adaptation skills for professionals and communities, improving information accessibility and sharing, building professional and community networks, meeting human resource needs, and improving disease mitigation)

The Australian Government has noted, accepted or accepted in principle most of these recommendations.<sup>39</sup> The quality and timeliness of actions will be critical if existing challenges to coastal sustainability are to be addressed and looming ones prepared for.





■ Coastline, Tasmania

Photo by Andrew C Webb

Following this inquiry, a Coasts and Climate Change Council<sup>p</sup> was established in late 2009 to engage with communities and stakeholders and to advise the Australian Government on key issues. The council provided a report to the Minister for Sustainability, Environment, Water, Population and Communities in December 2010, with the recommendations that the Australian Government:

As a matter of urgency define and progress a 10-year national agenda to ensure that Australia is positioned to address the significant near, medium and long term risks facing the well being of our coastal regions from the impacts of climate change.

Take a leadership role in driving the science and information base for decision-support tools; developing national standards for risk assessment; tackling legal reform to enhance

national consistency and to reduce liability risks; and in the provision of technical support for local governments who are at the cutting edge of impacts on communities, property owners and businesses.

Recognise the need to improve collaboration and delivery of outcomes across a range of federal, state and local government agencies and in doing so, align adaptation to climate change in coastal regions with national micro-economic reform, social equity, regional development and population sustainability agendas.

Continue the appointment of the Coasts and Climate Change Council for at least 12 months to assist in communicating the issues facing Australia from the impacts of climate change on the coast, engaging with a wide range of stakeholders and community groups on their issues and needs, and providing advice to the Minister for Climate Change and Energy Efficiency on ways to improve coastal adaptation to climate change.

<sup>p</sup> [www.climatechange.gov.au/climate-change/australias-coasts-and-climate-change/adapting/coasts-and-climate-change-council.aspx](http://www.climatechange.gov.au/climate-change/australias-coasts-and-climate-change/adapting/coasts-and-climate-change-council.aspx)

### Box 11.2 Abbreviated version of the National Sea Change Taskforce's 10-point plan for coastal Australia<sup>23</sup>

1. Adopt and implement the recommendations of the coastal inquiry conducted by the bipartisan House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts.
2. Introduce a new funding formula to enable coastal councils to respond effectively to the social and economic needs of coastal communities and to provide regional facilities and services.
3. Provide funding for coastal councils to undertake natural resource management activities in coastal areas.
4. Develop a national growth management policy to better coordinate the planning and provision of infrastructure in regional and rural areas, including rapidly expanding coastal communities.
5. Ensure that the Australian Bureau of Statistics collects accurate and consistent data on nonresident populations in coastal areas, to enable more effective allocation of resources to meet demand associated with tourists, nonresident workers and part-time residents.
6. Assist coastal councils to address the social and economic needs of ageing populations and to meet the shortfall in aged-care accommodation and services in these areas.
7. Introduce a consistent national response to the legal and insurance risks associated with coastal planning and the impact of climate change, to assist coastal councils to implement plans for adaptation and coastal infrastructure protection in response to rising sea levels.
8. Declare 2012 as the Year of the Coast.
9. Initiate a collaborative national approach to address the shortage of affordable housing in coastal communities.
10. Review current governance and institutional arrangements for the coastal zone.

As a result of this report, the term of the council has been extended to December 2011. Its focus will be on advising the government on how to prepare coastal communities for the impacts of climate change.

Building on the reports by the House of Representatives Standing Committee, and the Coasts and Climate Change Council, the National Sea Change Taskforce published a 10-point plan for coastal Australia in 2010 (Box 11.2). Although this plan focuses on governance issues and management of infrastructure, the same principles are relevant to environmental governance and management of environmental assets. Furthermore, social and economic problems are likely to reduce the ability of local governments to manage the natural environment strategically. This illustrates a key observation about coastal governance: that environmental, social and economic management cannot be considered independently of one another (see also Section 4 on resilience).

We are not in a position to provide detailed comments on the effectiveness of these approaches. The recommendations of the various inquiries discussed above are based on a much more rigorous and detailed process than we could carry out. We note, however, that the overpowering weight of opinion and evidence is that major steps need to be taken very soon to address governance arrangements for Australia's coasts. Without these reforms, there are high risks that uncoordinated and nonstrategic development will lead to continued degradation of environmental, social, economic and cultural assets of the coasts. This is likely to make coastal communities and ecosystems vulnerable to shocks and surprises that may be both highly undesirable and irreversible.



# Risks to and resilience of coastal communities and environments

In the context of this chapter, resilience is the ability of coupled coastal communities and ecosystems to recover from shocks without moving to a new way of functioning that delivers different, and probably lower, values and benefits to humans and other species.<sup>40</sup> The resilience of coastal environments is coupled with the social, economic and cultural systems that support Australian people living or depending on the coasts. Conversely, factors that affect the resilience of human communities are likely to affect their relationships with ecological communities. This is a broader approach to assessing the state of the environment than has been used previously, but we argue that a strong body of evidence indicates that it is now important to take this broader system view.

## 4.1 General risks to our coasts

Many of the pressures that affect our coasts are detailed in Section 2. Climate change is already having impacts on many aspects of the coastal environment, and these impacts will increase.

The future risks to coasts are the combination of risks to marine environments, and risks to estuaries and the terrestrial environments that stretch to the sea. Along the coasts, these risks are likely to be additive and sometimes interactive (e.g. pollution coming to the coast via rivers can interact with oceanic weather events). These risks are dealt with in detail in other chapters and are not repeated here. In summary, they include:

- risks associated with atmospheric processes, especially climate change
- risks associated with the expansion and future management of the built environment and related infrastructure

■ Coogee Beach, Sydney, New South Wales  
Photo by Matt Lauder

### At a glance

The resilience of, and future prospects for, coastal natural environments are inextricably coupled with the social, economic and cultural systems that lead to Australian people living on, depending on or influencing the coasts.

Globally, the threat of rising sea levels as a result of climate change is one of the most concerning pressures on coastal communities. It brings into focus all other aspects of the resilience of coasts, because it potentially affects their economic, social, cultural and environmental assets and processes. In Australia, a sea level rise of a metre or more during this century is plausible, and several hundred thousand homes are potentially at risk of inundation. Rising sea levels will also result in greater wave action on the shore, leading to increased rates of coastal erosion, particularly during extreme weather events, which are increasing in frequency. The capacity for coastal habitats and species to migrate inland to higher ground is limited in many parts of Australia by both the natural limits to the coastal plains and human-built structures such as seawalls, beach groynes and offshore reefs. Direct impacts on certain types of cultural sites, including many of significance to Indigenous people, are also possible. One of the major determinants of the future of Australia's coasts is how extreme and rapid the effects of climate change will be on coastal Australia.

The emerging risks from climate change remain incompletely addressed for Australia's coasts. Recent research comparing Australian coastal governance with examples elsewhere in the world has concluded that the ability to adapt to emerging pressures, especially climate change, is low and declining in many parts of Australia. Recommended remedies include allocating authority and resources between levels of governance according to their effectiveness at each level (rather than trying to manage everything centrally); strengthening development rules and incentives to encourage relocation before irreversible problems arise; allowing for uncertainties by building flexibility into rules and incentives so that they can be adjusted when knowledge and circumstances change; transferring public and private benefits, costs, risks, uncertainties and responsibilities from governments to beneficiaries of development; and viewing catastrophes as opportunities for learning and change, not signals to automatically rebuild.

- risks associated with inland waters as they flow to the coast, which themselves are affected by changes in land use and management
- risks to terrestrial and marine biodiversity
- risks to coastal cultural heritage.

## 4.2 Future risks associated with climate change

Climate change is a major driver of change for Australia. Commenting on Australia's vulnerability, the Intergovernmental Panel on Climate Change (IPCC) noted in 2007:<sup>41</sup>

Even if adaptive capacity is realized, vulnerability becomes significant for 1–2 °C of global warming. Energy security, health (heat-related deaths), agriculture and tourism have larger coping ranges and adaptive capacity, but they may become vulnerable if global warming exceeded 3 °C.

Since then, further studies suggest that the risks may be more immediate than indicated by the IPCC.<sup>41-42</sup>

The indirect effects of climate change are likely to be particularly important for coastal environments and settlements. They include:

- decreased water availability and water security due to reduced rainfall and increased evaporation, reducing run-off to streams and recharge of groundwater systems
- impacts on the coastal zone, such as inundation from sea level rise (see Section 4.3) and changes in the frequency and severity of tidal and storm surges
- damage to energy, water, communications and built infrastructure
- a decline in agricultural and aquacultural productivity due to increased drought, fire and water temperatures
- damage to iconic natural ecosystems, such as the Great Barrier Reef and Kakadu National Park
- a decline in biodiversity.

Climate change could also act in combination with other pressures to challenge the resilience of coastal communities and environments. For example, if commercial fishing, recreational fishing (tourism) or aquaculture were negatively impacted by climate

change, a town may be less resilient to other pressures (e.g. a decline in forestry or agricultural activity). The decline in the Western Australian rock lobster fishery, for example, is affecting small coastal communities, and the decrease in economic activity in these communities is being felt in many sectors.

Drawing on information from the IPCC, the CSIRO concluded that the three sectors in the Australian and New Zealand region that are most vulnerable to climate change are coastal communities, water security and natural ecosystems.<sup>43</sup>

More subtle effects on cultural heritage places may result from changes in atmospheric moisture, wind effects, and climate and pollution acting together.<sup>44</sup> Increases in the frequency of heatwaves could see people moving temporarily to coastal areas to take advantage of sea breezes, which would exacerbate the existing population pressures. Extension in the range of various disease vectors (notably mosquitoes) is a direct threat to coastal settlements and could lead to major habitat modification and/or use of chemicals for vector control. In some areas, climate change is expected to have the positive effect of reducing cold weather, which could also add to coastal population pressures.

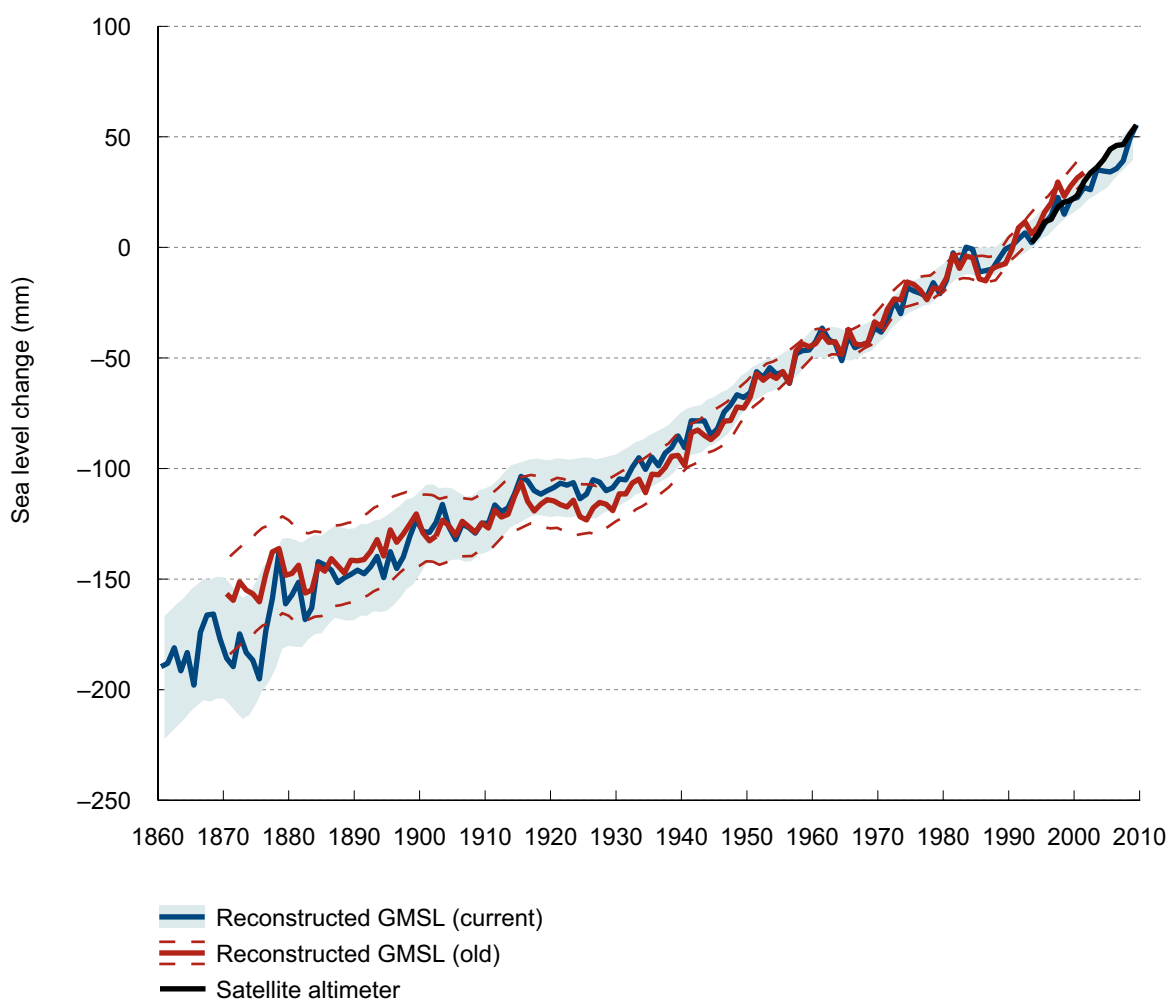
Chapter 3: Atmosphere discusses the potentially adverse effects of climate change, via extreme events such as bushfires and dust storms, on respiratory and cardiovascular health, both acute and chronic. Coastal areas already struggle to maintain adequate health facilities for their growing populations.

## 4.3 Sea level rise

The impact of sea level rise will be felt most strongly in our coastal regions. Sea level rise is a result of expansion of the oceans as they warm; addition of water to the ocean from melting glaciers, ice caps, and the ice sheets of Greenland and Antarctica; and changes in the relative level of seabeds and the land (see Chapter 6: Marine environment and Chapter 7: Antarctic environment for further discussion). Sea level is now rising globally, and the rate of rise increased from the 19th to the 20th century and during the 20th century (Figure 11.7). Since the early 1990s, the rate of rise has been almost double the average for the 20th century.

Sea level is forecast to continue to rise during the 21st century and beyond, in response to increasing concentrations of greenhouse gases in the atmosphere. Including an allowance for the melting of ice sheets, IPCC projections are for a rise of 18–79 centimetres by 2095 compared with 1990.

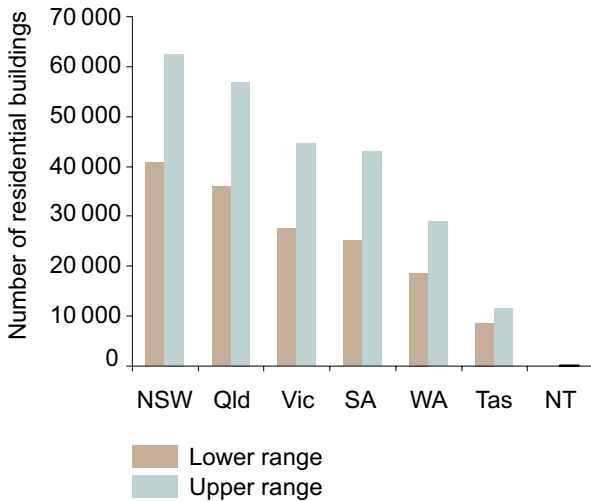
However, our current understanding of the response of ice sheets to global warming is inadequate, and a larger rise is possible. The rate of sea level rise is currently near the upper end of current projections—observations indicate that global sea level is currently rising (since 1993) at around 3 millimetres per year.<sup>45</sup>



**Figure 11.7** Global mean sea level (GMSL) changes between 1860 and 2009, compared with the 1990 average sea level

The blue solid line is sea level estimated from coastal and island sea level data. The one standard deviation uncertainty estimates are indicated by the shading. The Church and White<sup>47</sup> estimates for 1870–2001 are shown by the red solid line and dashed red lines indicate the one standard deviation errors. The series are set to have the same average value over 1960–90 and the new reconstruction is set to zero in 1990. The average rate of rise from 1900 to 2000 was around 1.7 millimetres per year. The rate of rise measured by satellite altimeters since 1993 has been around 3.2 millimetres per year, and from tide gauges around 3.0 millimetres per year.

Sea levels are rising around Australia. A sea level rise of a metre or more during this century is plausible.<sup>48</sup> It could be less<sup>49</sup> or much more.<sup>50</sup> Between 160 000 and 250 000 individual homes are potentially at



NSW = New South Wales; NT = Northern Territory; Qld = Queensland; SA = South Australia; Tas = Tasmania; Vic = Victoria; WA = Western Australia

Source: Australian Government Department of Climate Change and Energy Efficiency<sup>1</sup>

**Figure 11.8** Estimated number of existing residential buildings at risk of inundation from a 1.1-metre sea level rise (including 1-in-100 storm tide for New South Wales, Victoria and Tasmania, and high tide events for other states and territories)

risk of inundation from a 1.1-metre rise in sea level (Figure 11.8).<sup>48</sup>

Rising sea levels will result in inundation of low-lying coastal regions, and increased access of higher water levels and greater wave action to the shore. This will increase the rate of coastal erosion, particularly during extreme weather events, which are increasing in frequency.<sup>45</sup> Expansion of mangroves into newly flooded coastal lands is also likely, where the topography is suitable. The capacity for coastal habitats (such as beaches, dunes and wetlands) to migrate inland to higher ground is limited in many parts of Australia by both the natural limits to the coastal plains (where steep hills approach the coast) and the human structures (such as seawalls, beach groynes and offshore reefs) built to defend against extreme weather events. The progressive effect is a reduction in natural habitats at the shoreline (particularly low-slope, soft-sediment habitats) and an increase in human structures that provide habitat of a different type (mainly hard structures, such as rock walls). The ecological impacts of these changes are currently gradual, but could become sudden and unexpected. They are likely to be profound.<sup>51</sup>

Direct impacts on certain types of cultural sites are possible. Aboriginal middens, for example, are invariably located close to foreshores and are particularly prone to erosion. Historical sites associated with defence, coastal trade or transport—such as gun emplacements, docks, wharves, shipyards, fishing ports and whaling stations—are also at direct risk from rising sea levels.

Potential impacts of sea level rise around Australia are summarised in Box 11.3.

### Box 11.3 Potential impacts of sea level rise around Australia

Global sea levels increased by 1.7 millimetres per year during the 20th century. Over the past 15 years, this trend has increased to approximately 3.2 millimetres per year. The rate varies significantly around Australia.

#### New South Wales

A sea level rise of 1.1 metres will put at risk between 43 900 and 65 300 residential buildings, with a current value of between \$14 billion and \$20 billion, and up to 4800 kilometres of roads, 320 kilometres of railways and 1200 commercial buildings, with an estimated value of up to \$10.4 billion, \$1.3 billion and \$9 billion, respectively.

Local government areas of Lake Macquarie, Wyong, Gosford, Wollongong, Shoalhaven and Rockdale contain more than 50% of the residential buildings at risk in New South Wales.

Since the early 1990s, New South Wales has experienced a sea level rise of approximately 2.1 millimetres per year.

**Box 11.3 continued****Northern Territory**

A sea level rise of 1.1 metres will put at risk between 260 and 370 residential buildings, with a current value of between \$100 million and \$134 million, and up to 2045 kilometres of roads, 32 kilometres of railways and 24 commercial buildings, with an estimated value of up to \$1.8 billion, \$100 million and \$500 million, respectively.

Darwin is particularly vulnerable to riverine flooding and more intense cyclonic activity. Impacts on infrastructure are expected to be extreme under a 'business as usual' climate scenario, including major threats to vital port infrastructure on the Northern Territory coast.

Since the early 1990s, northern Australia has experienced sea level rises of up to 7.1 millimetres per year.

**Queensland**

Queensland's highly developed and populated coastal communities are likely to be significantly affected by the impacts of climate change. A sea level rise of 1.1 metres will put at risk between 48 300 and 67 700 residential buildings, with a current value of between \$15.4 billion and \$20 billion, and up to 4700 kilometres of roads, 570 kilometres of railways and 1440 commercial buildings, with an estimated value of up to \$12.9 billion, \$2.3 billion and \$15 billion, respectively.

Since the early 1990s, northern Australia has experienced sea level rises of around 7.1 millimetres per year, while eastern Australia has experienced increases of around 2.0–3.3 millimetres per year.

**South Australia**

A sea level rise of 1.1 metres will put at risk between 25 200 and 43 000 residential buildings, with a current value of between \$4.4 billion and \$7.4 billion.

Nearly half (47%) of the South Australian coastline is sandy beaches, and more than half of these sandy beaches are backed by soft-sediment plains. Rising sea levels will make these coastlines significantly more vulnerable to shoreline recession and foredune destabilisation.

Since the early 1990s, southern Australia has experienced sea level rises of 2–7 millimetres per year.

**Tasmania**

A sea level rise of 1.1 metres will put at risk between 12 000 and 15 000 residential buildings, with a current value of \$4 billion, and up to 2000 kilometres of roads, 160 kilometres of railways and 300 commercial buildings, with an estimated value of up to \$4.5 billion, \$700 million and \$1 billion, respectively.

Since the early 1990s, Tasmania has experienced sea level rises of 2.6–3.4 millimetres per year.

**Victoria**

A sea level rise of 1.1 metres will put at risk between 31 000 and 48 000 residential buildings, with a current value of between \$8 billion and \$11 billion, and up to 3500 kilometres of roads, 125 kilometres of railways and 2000 commercial buildings, with an estimated value of up to \$9.8 billion, \$500 million and \$12 billion, respectively.

Since the early 1990s, south-eastern Australia has experienced sea level rises of 1.3–2.8 millimetres per year.

**Western Australia**

Western Australia has the longest coastline of any Australian state or territory. A sea level rise of 1.1 metres will put at risk between 20 000 and 30 000 residential buildings, with a current value of between \$5 billion and \$8 billion, and up to 9000 kilometres of roads, 114 kilometres of railways and 2100 commercial buildings, with an estimated value of up to \$11.3 billion, \$500 million and \$17 billion, respectively.

Since the early 1990s, the southern coast of Western Australia has experienced sea level rises of up to 4.6 millimetres per year, while the western coast has experienced increases of up to 7.4 millimetres per year.

Source: Australian Government Department of Climate Change and Energy Efficiency<sup>52</sup>





## 4.4 Resilience and adaptive capacity

Many small island states, including Australia's external territories and nations with which Australia interacts in relation to environmental issues in the region, are highly sensitive to sea level rise resulting from climate change and have limited scope for adaptation (i.e. the ability to change to remain resilient). Australian mainland coastal communities have considerably more scope and resources to plan for, and adapt to, climatic and other change. That capacity to adapt will only be realised, however, if planning and action are effectively coordinated at the national, state and local levels.

Abel et al.<sup>40</sup> reviewed the literature on how high-income countries are approaching the challenges of climate change around their coasts. They found common themes:

- The origins of, and potential solutions to, problems of development and sea level rise are at different scales of space and time. Issues include lack of feedback from local to higher levels of governance, lack of capacity to initiate and implement local change, and defensive structures at one location causing erosion at others.
- Stakeholders are in conflict about the distribution of public and private benefits and costs in relation to climate change responses. Criteria for evaluating policy outcomes are unclear, and the rights of future generations are largely neglected (i.e. conserving assets and resources for the future is given little weight compared with values for current generations).
- Stakeholders' decisions are influenced strongly by rules, norms and incentives, particularly property rights, compensation, liabilities and development controls.
- Where development is already intense, property rights, costs sunk in structures and lobbying by those affected work against policies for moving coastal settlements away from advancing water levels. (This situation is being experienced by many coastal councils in Australia. An example is the opposition to a planned retreat strategy proposed by Byron Shire Council, which is still in dispute.<sup>53</sup>)
- Arguments for action are weakened by large uncertainties about rates and magnitudes of sea level rise and future actions of governments.

- In the literature dealing with the United States, New Zealand and Australia, the role of Indigenous people in adaptation to sea level rise was discussed frequently.

Abel et al.<sup>40</sup> noted that:

Coastal development is spreading along the World's coasts. Sea levels are rising, so major future asset losses are expected. Planned retreat from the sea behind natural ecological defences is one adaptation option. To maintain it, land could be set aside for colonisation by coastal ecosystems, or buildings constructed on condition they are removed when sea level reaches a specified distance from the building.

A study of south-east Queensland concluded that the option of 'planned retreat', and hence a major opportunity to maintain the resilience of this area, is disappearing (Box 11.4).

The issues identified for south-east Queensland are very similar to those identified consistently over the past two decades by a range of experts in coastal management and governance and, more recently, by the coalition of coastal councils that forms the National Sea Change Taskforce (see Section 3.2).

If the limits of the resilience of coastal settlements and ecosystems are exceeded, adaptive strategies framed around incremental change are unlikely to be adequate to prevent major harmful impacts on key sectors. Instead, the functioning and management of coastal communities and ecosystems might have to change fundamentally to cope with changing circumstances.

## 4.5 Hopeful signs

Although the above assessments are somewhat critical of current arrangements with regard to resilience, some very hopeful trends are emerging that will potentially build greater resilience of coastal social-ecological systems. In Section 3.2, we reported on a range of cooperative initiatives being taken by coastal councils to address many of the deficiencies discussed above. One of these, the South East Queensland Healthy Waterways Partnership, is cooperating with the CSIRO to use management strategy evaluation to address some of the environmental, economic and social impacts of coastal urban areas.<sup>54</sup>

■ Cape Keraudren Coastal Reserve, Western Australia  
Photo by Nick Rains

### Box 11.4 A study of the coastal resilience of south-east Queensland

Based on an examination of plans, records, policies and development approvals, combined with interviews and workshops with a range of stakeholders, Abel et al.<sup>40</sup> concluded that the option of planned retreat (movement of buildings and other infrastructure away from areas likely to be inundated as sea level rises in the future) is disappearing because:

- the state government promotes population increase
- the need to protect coastal ecosystems does not seem urgent, so houses are built on the coast
- liability laws favour development
- planning ignores cumulative impacts and the chance that these impacts could eventually cause major irreversible changes in coastal communities and ecosystems
- political pressure to build defences (e.g. seawalls) grows as the value of built assets increases.

To implement planned retreat, changes to coastal governance would be needed, for which the authors proposed five guiding principles:

- Allocate authority and resources between levels of governance according to their effectiveness at each level (rather than trying to manage everything centrally).
- Strengthen development rules and incentives to encourage relocation before irreversible problems arise.
- Allow for uncertainties by building flexibility into rules and incentives so that they can be adjusted when knowledge and circumstances change.
- Transfer public and private benefits, costs, risks, uncertainties and responsibilities from governments to beneficiaries of development.
- View catastrophes as opportunities for learning and change, not signals to automatically rebuild.

In Section 3.3, we reported on the 2009 report to the Australian Government by the House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts, and the subsequent establishment of the Coasts and Climate Change Council and its recommendations to government. Both sets of recommendations go to the heart of the issues about resilience and adaptive governance raised in this section. Coastal management might move in these directions in the coming decade, resulting in improvements in coastal resilience and the state of coastal environments.

## Outlook for coasts

Although coastal environments are facing major pressures, including the direct impacts of expanded human settlements and a range of indirect impacts of human activities (such as impacts from tourism, recreation, invasive species and acid sulfate soils), awareness is growing of the interlinking of ecological, social, economic and cultural issues. Few people with a stake in Australia's coasts want to see environmental and other assets decline. Based on the issues raised in Sections 3, 4.1 and 4.2 of this chapter, two major uncertainties that are likely to determine the future of Australia's coasts are:

- how government and governance arrangements develop (especially whether cooperative and strategic approaches to managing coastal resources can be developed that are effective over the same spatial scales as the challenges)
- how extreme and rapid the effects of climate change are on coastal Australia.

### 5.1 Undesirable futures

'Business as usual' is likely to lead to undesirable outcomes for coastal Australia. There are already signs that it is becoming difficult to manage the combined pressure of permanent and temporary populations. Coastal communities that face social and economic problems are unlikely to be conducive to good environmental management, regardless of the levels and types of regulations and sanctions imposed. Local councils in many areas already struggle to maintain infrastructure; if current pressures are not addressed, pollution events and other forms of environmental destruction are likely to become more frequent.

Although there is a relatively high level of protection of major vegetation groups along most of Australia's coasts, data on how well ecosystems are protected appears to be inadequate (partly because there is no nationally agreed classification of ecosystems—see Chapter 8: Biodiversity). Increasing population pressure is highly likely to have deleterious impacts on coastal ecosystems, which will be hard to manage if good information on what is there, both inside and outside reserves, is not available.

### 5.2 Desirable futures

Desirable futures—that is, futures in which harmony exists between the demands that humans place on coastal environments and the sustainability of coastal ecosystems—are most likely if major reform of coastal governance is achieved in the next decade or sooner, so that strategic action can be taken to identify and prepare for risks from sea level rise. Whether through incentives, regulation or both, coastal communities will need to balance infrastructure and services against population size and make-up. This will require dialogue about such issues as where and how people live, and how the facilities and services offered by coastal centres compare with those offered in larger centres.

Coastal communities might improve their financial base by playing a role in emerging carbon economies. The concept of 'blue carbon'—carbon sequestration by healthy coasts and oceans—is gaining considerable currency in international discussions.<sup>55</sup>

These changes will be important first steps in addressing pollution, waste management, recreation, tourism, invasive species and other pressures on coastal environments. Another requirement will be improved information on which species and ecosystems are being affected, and are likely to be affected, by human activities on coasts. The advanced level of dialogue and tangible plans for action that have been put forward by a range of stakeholders—culminating in the recommendations of the 2009 report by the House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts, *Managing our coastal zone in a changing climate: the time to act is now*<sup>38</sup>—are a good start towards desirable coastal futures. However, whether action is taken quickly enough will depend partly on political will and partly on the magnitude and speed of climate change in coming decades.



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■ Red or spider mangrove (*Rhizophora stylosa*)  
 Low Isles, Great Barrier Reef Marine Park, Queensland  
 Photo by Reg Morrison

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