Australian Government

Great Barrier Reef Marine Park Authority

GREAT BARRIER REEF REGION STRATEGIC ASSESSMENT

Strategic Assessment Report

Draft for public comment

The Great Barrier Reef Marine Park Authority acknowledges the continuing sea country management and custodianship of the Great Barrier Reef by Aboriginal and Torres Strait Islander Traditional Owners whose rich cultures, heritage values, enduring connections and shared efforts protect the Reef for future generations.

None of the recommendations in the report, if implemented, are intended to have the effect of extinguishing native title.

Australian Government

Great Barrier Reef
Marine Park Authority

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GLOSSARY OF COMMONLY USED TERMS AND ACRONYMS

Action: Includes a project, a development, an undertaking, an activity or series of activities, and an alteration to any of these things. (Adapted from EPBC Act)

Adaptive management: A systematic process for continually improving management practices through learning from the outcomes of previous management. It includes a monitoring, evaluation, reporting and improvement cycle. (Adapted from *A guide to undertaking strategic assessments*)

Authority: Great Barrier Reef Marine Park Authority.

Avoiding impacts: Measures taken so that actions have minimal negative effect on the environment. (Adapted from *A guide to undertaking strategic assessments*)

Basin: An area of land where surface water channels to a hydrological network and discharges into the sea (for example a whole river system). Within the Great Barrier Reef catchment 35 basins have been defined, based on the major river systems. A basin can include small creeks and streams that discharge directly to the sea.

Benthic: The bottom of the seafloor which includes the collection of organisms living on or in the bottom.

Biodiversity: The variability among living organisms from all sources (including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part). It includes diversity within species and between species, and diversity of ecosystems. (EPBC Act and GBRMP Act)

Bycatch: Any animal, plant or marine product that was unintentionally caught (that is, not targeted) during commercial, recreational or traditional fishing activities including Queensland's Shark Control Program. Bycatch can either be retained (see by-product) or discarded.

By-product: Any animal, plant or marine product that was unintentionally caught but retained during a commercial, recreational or traditional fishing activity.

Capital dredging: Dredging for navigation, to create a new or enlarged channel, port, marina or boat harbour areas. Dredging for engineering purposes, to create trenches for pipes, cables, immersed tube tunnels, to remove material unsuitable for foundations and to remove overburden for aggregate.

Carrying capacity: The number of individuals an ecosystem can support without having any negative effects. It also includes a limit of resources and pollution levels that can be maintained without experiencing high levels of change.

Coastal ecosystem: Inshore, coastal and adjacent catchment ecosystems that connect the land and sea and have the potential to influence the health and resilience of the Great Barrier Reef.

Coastal reclamation: The process of creating new land where there was ocean, wetlands, or other waterbodies by filling the area with 'land fill' or infrastructure such as groynes and jetties.

Coastal zone: The area of land and sea in or adjacent to the Great Barrier Reef containing Queensland waters plus adjacent inland areas either within five kilometres of the coast or less than 10 metres above sea level (whichever is the further).

Cultural keystone species: The species that play special cultural roles for Indigenous and local peoples and are the ones they depend upon most extensively to meet their needs for food, clothing, shelter, fuel, medicine, and other necessities of life. These are the species that become embedded in a community's cultural traditions and narratives, their ceremonies, dances, songs, and discourse. Cultural keystone species can vary widely from one region to another and from one culture to another.

Cumulative impact: The impact on the environment resulting from the effects of one or more impacts, and the interactions between those impacts, added to other past, present, and reasonably foreseeable future pressures.

Cumulative risk: The combined risks to the environment by multiple impacts.

Discarded catch: See non-retained catch.

Driver: An overarching cause of change in the environment. (*Australia State of the Environment Report 2011*)

Ecologically sustainable use: Use of natural resources within their capacity to sustain natural processes while maintaining the life-support systems of nature and ensuring the benefit of their use to the present generation does not diminish the potential to meet the needs and aspirations of future generations. (EPBC Act)

Ecosystem: A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit. (EPBC Act)

Ecosystem-based management: An integrated approach to managing an ecosystem and matters affecting that ecosystem, with the main object being to maintain ecological processes, biodiversity and functioning biological communities. (GBRMP Act)

Ecosystem services: Actions or attributes of ecosystems of benefit to humans, including regulation of the atmosphere, maintenance of soil fertility, food production, regulation of water flows, water filtration, pest control and waste disposal. It also includes social and cultural services, such as the opportunity for people to experience nature. (*Australia State of the Environment Report 2011*)

Environment: Ecosystems and their constituent parts, including people and communities; natural and physical resources; the qualities and characteristics of locations, places and areas heritage values of places; and the social, economic and cultural aspects of the above. (EPBC Act and GBRMP Act)

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999.*

Extraction: The removal of any animal, plant or marine product through legal commercial, recreational or traditional fishing activities including Queensland's Shark Control Program.

Geomorphology: Scientific study of landforms and the processes that shape them. (*Australia State of the Environment Report 2011*)

GBRMP Act: *Great Barrier Reef Marine Park Act 1975.*

Great Barrier Reef catchment: The area adjacent to the Great Barrier Reef Region which drains into the Region.

Habitat**:** The environment occupied by an organism or groups of organisms. (Adapted from EPBC Act)

Halimeda*:* Green macroalgae which is responsible for distinctive circular deposits on parts of the Great Barrier Reef.

Heritage value: A place's natural and cultural environment having aesthetic, historic, scientific or social significance, or other significance, for current and future generations of Australians. (EPBC Act and GBRMP Act)

Impact: An event or circumstance which has an effect, either positive or negative, on a value.

Indigenous person: A person who is a member of the Aboriginal race of Australia; or a descendant of an Indigenous inhabitant of the Torres Strait Islands. (GBRMP Act)

Indigenous: For the purposes of the strategic assessment, the term 'Indigenous' should be read to apply specifically to Traditional Owners and Traditional Owner groups.

Indirect impact: An impact that is not the direct result of a particular action but has been made possible by that action. These include downstream or upstream impacts, as well as facilitated or consequential impacts resulting from further actions (including actions by third parties). (Adapted from *A guide to undertaking strategic assessments*)

Inshore: Enclosed coastal and open coastal water bodies which extend from the mean low water mark out to approximately 20 kilometres, but also includes areas further offshore that are habitats for recognised inshore specialist species.

Integrity: A measure of the wholeness and intactness of the natural and/or cultural heritage and its attributes. (*Operational guidelines for the implementation of the World Heritage Convention* paragraphs no. 88–95)

Listed migratory species**:** A migratory species that is native or included under a relevant international convention, which has been placed by the Environment Minister on the published list of migratory species. (Adapted from EPBC Act)

Listed threatened species: A native species which is extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent, as set out in the published list of threatened species established by the Environment Minister. (Adapted from EPBC Act)

Maintenance dredging: Dredging to ensure that previously dredged channels, berths or construction works are maintained at their designated dimensions.

Marine Park: Great Barrier Reef Marine Park.

Matters of national environmental significance: Those matters defined in the *Environment Protection and Biodiversity Conservation Act 1999.*

Mesphotic reefs: Corals found at water depths where light penetration is low.

Mitigating impacts: Measures put in place to reduce the level of impact arising from an action, including indirect and cumulative impacts. (Adapted from *A guide to undertaking strategic assessments*)

Morphology: The form and structure of animals and plants, without regard to their functions.

Non-retained (or discarded) catch: Marine life caught by commercial, recreational or traditional fishers which has been discarded. This includes targeted species discarded due to size or catch restrictions, low market value, 'catch and release' practices, or bycatch that has been unintentionally captured.

Outstanding universal value: Cultural and/or natural heritage which is so exceptional as to transcend national boundaries and to be of such significance to humanity as a whole to make it worthy of special protection. (Adapted from *Operational guidelines for the implementation of the World Heritage Convention*)

Offshore: Offshore water bodies extend from approximately 20 kilometres out to the edge of the Great Barrier Reef Marine Park boundary.

Offsetting impacts: Measures intended to compensate for the residual adverse impacts of an action on the environment. (Adapted from *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy,* 2012)

Palaeochannel: An ancient stream or riverbed, cut into the rock or soil and overlaid by sediment after the stream has changed its course or dried up.

Palaeoecology: The systematic study of the ecological relationships which prevailed among fossil plants and animals.

Pelagic: Relating to or living in or on oceanic waters. The pelagic zone of the ocean begins at the low tide mark and includes the entire oceanic water column and living organisms that inhabit this zone for all or part of their life (for example, plankton, pelagic fish).

Poaching: The illegal take of any animal, plant or marine product from land that is not one's own or is under official protection. It also includes the illegal take of a protected species.

Protected species**:** A species that is a cetacean; a listed marine species, a listed migratory species, a listed threatened ecological community, or a listed threatened species; a species of marine mammal, bird or reptile that is prescribed as endangered wildlife, vulnerable wildlife or rare wildlife under the *Nature Conservation Act 1992* (Qld); a species declared to be a protected species for the purposes of this definition; a species declared to be a strictly protected species for the purposes of this definition. (GBRMP Act)

Precautionary principle**:** The principle that lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage. (EPBC Act and GBRMP Act)

Pressure**:** An activity or group of activities that cause an impact on a value.

Program: The Authority's management arrangements, including future commitments, as described in the Program Report**.**

Recreation**:** An independent visit for enjoyment that is not part of a commercial operation. It is distinct from tourism where a visitor pays to use a commercial operation. (*Recreation Management Strategy for the Great Barrier Reef Marine Park)*

Refugia: An area where an organism can survive during a period of unfavourable conditions.

Resilience: The capacity of an ecosystem to recover from disturbance or withstand ongoing pressures.

Region: Great Barrier Reef Region as defined in the *Great Barrier Reef Marine Park Act 1975.*

Retained catch: Marine life caught and kept by commercial, recreational or traditional fishers including targeted and non-targeted species.

Risk: The possibility of something happening that impacts on objectives. It is the chance to either make a gain or a loss and is measured in terms of likelihood and consequence. *(Australian Standard for Risk Assessment (AS/NZS ISO 31000:2009))*

Ship: Vessels greater than 50 metres in overall length or carrying specialised product regardless of length (for example, oil tankers, chemical or liquefied gas carriers).

SEWPaC**:** The former Commonwealth Department of Sustainability, Environment, Water, Population and Communities, now the Department of the Environment.

State Development Area: Defined areas established to promote economic development for industry, infrastructure corridors and major public works.

Take: The act of or attempt to remove, gather, catch, kill, destroy, dredge for, raise, carry away, bring ashore, interfere with and obtain (by other means) an animal, plant or marine product.

Taxa: Groups of one or more populations of organisms.

Threshold: The breaking point above which an ecosystem or a component of an ecosystem can no longer sustain natural processes and remain in a healthy condition (for example, the point at which there is a phase shift from coral-dominated or algal-dominated reefs).

Throughput: The quantity of cargo that is passed through a port in a given period (exports and imports).

Tourism: Commercial activities that provide transport, accommodation or services to people who are visiting the Region principally for enjoyment. (Derived from GBRMP Act)

Trading port: A trading port refers to a port that has an associated pilotage area as defined in schedule 5 of the Transport Operations (Marine Safety) Regulation 2004. In these areas, the regional harbour master has the authority to direct the master of a ship to navigate or operate a ship in a prescribed way.

Traditional Owner: An Indigenous person recognised in the Indigenous community or by a relevant representative Aboriginal or Torres Strait Islander body as having spiritual or cultural affiliations with a site or area in the Marine Park or as holding native title in relation to that site or area; and who is entitled to undertake activities under Aboriginal or Torres Strait Islander custom or tradition in that site or area.

Traditional Owner group: The group of Traditional Owners who, in accordance with Aboriginal or Torres Strait Islander custom, speak for a site or area.

Trophic: Of or relating to nutrition.

Trigger value: A point which, if exceeded, would mean there was a significant risk of adverse effects on an ecosystem or a component of an ecosystem. Exceeding a trigger value would ‘trigger’ action to address contributing impacts and/or review the trigger value.

Turbidite: A type of sedimentary rock composed of layered particles that grade upward from coarser to finer sizes and are thought to have originated from ancient turbidity currents in the oceans.

Value: Those aspects or attributes of an environment that make it of significance.

Vulnerability: The degree to which a system, organism or community is susceptible to, and unable to cope with, an impact.

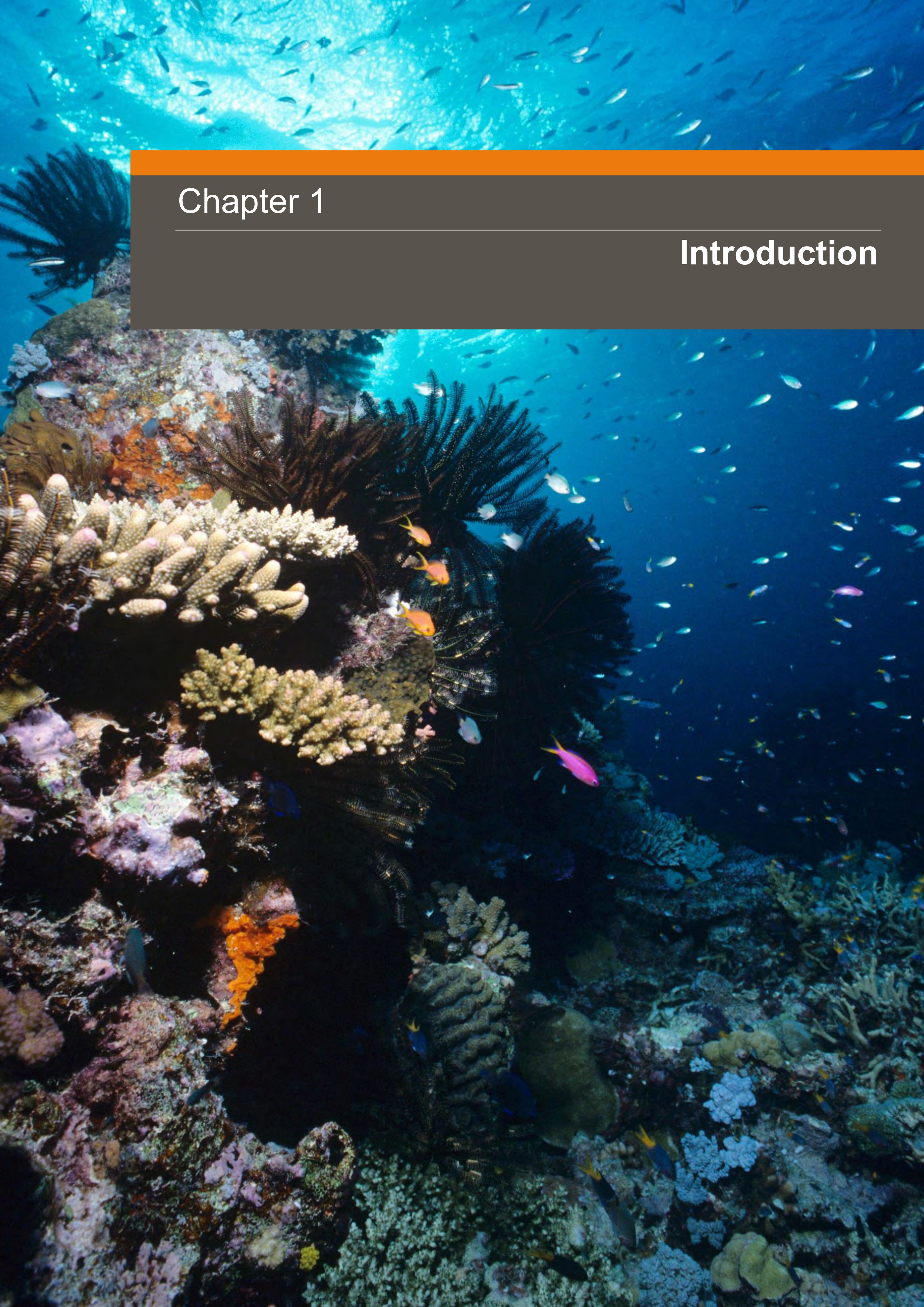
World Heritage Area**:** Great Barrier Reef World Heritage Area.

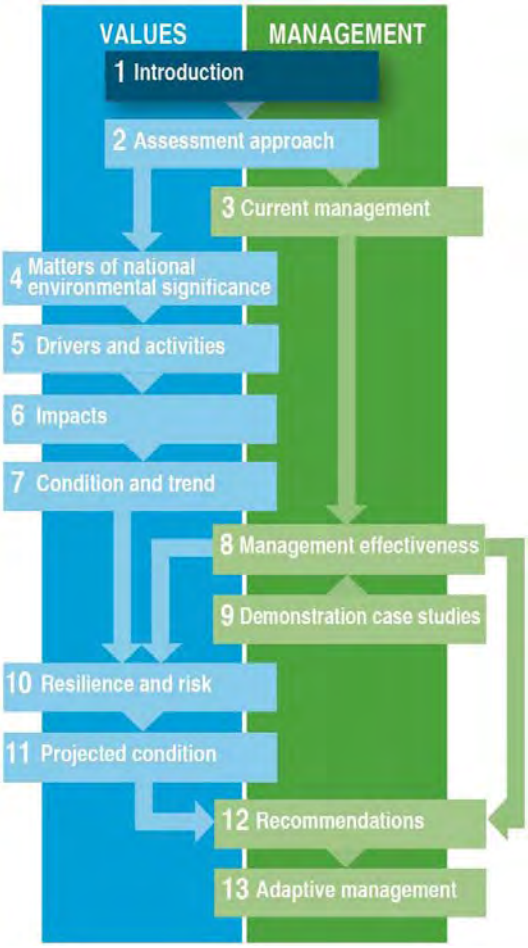
Wellbeing: The combination of economic prosperity, community liveability and environmental integrity, which is determined by the quality, quantity, distribution, use and preservation of economic, human, social and natural capital. (Commonwealth of Australia (2012) Sustainability Framework (Version 0– April 2012). Department of Sustainability, Environment, Water, Populations and Communities, Canberra, Australia)

Zones of influence: Areas where impacts have detectable effects on values.

Chapter 1

Introduction





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Cover page image: Underwater reefscape of hard and soft corals and reef fish.

1 Introduction

The Great Barrier Reef is an Australian icon and one of the most precious ecosystems on Earth. It is a world heritage property, recognised internationally for its outstanding universal value. Containing a maze of reefs and islands, it stretches more than 2300 kilometres along the Queensland coast (Figure 1.1). It is the world's largest coral reef ecosystem. It is rich in biodiversity, from mangroves and seagrasses to coral reefs and open waters.

Aboriginal and Torres Strait Islander people are the Traditional Owners of the Great Barrier Reef area and have a continuing connection to their land and sea country.

The Great Barrier Reef is critical to the cultural, economic and social wellbeing of the more than one million people who live in its catchment, and is valued by the national and international community. It is a marine protected area, conserving the Reef's environment and supporting a wide range of activities, including tourism, fishing, recreation, traditional use, research, defence, shipping and ports. The Reef's environment helps bring billions of dollars to Australia's economy each year and supports almost 70,000 jobs.[1]

1.1 The Great Barrier Reef

1.1.1 Traditional Owner connections

Traditional Owners have inherent rights and interests over their sea country. There are about 70 Aboriginal and Torres Strait Islander Traditional Owner clan groups whose customary estates include land and sea country within the Great Barrier Reef. The Great Barrier Reef Marine Park Authority (the Authority) acknowledges the Reef's Traditional Owners, past and present, and their unique and continuing association with the area.

For tens of thousands of years, much of what is now the Great Barrier Reef Region (the Region) was above sea level and occupied by past generations of Traditional Owners. Rising sea levels subsequently inundated the area, stabilising at current levels about 6500 years ago. As a result, many coastal, island and marine environments within and adjacent to the Region have only ever existed in the presence of Aboriginal and Torres Strait Islander peoples. At the same time, their continuous culture means Aboriginal and Torres Strait Islander connections to the marine environment retain the concept that the area was once a terrestrial landscape.

Indigenous heritage is dynamic and integrates nature, heritage and culture. Traditional Owners express their cultural heritage through their relationships with country, people, beliefs, knowledge, lore, language, symbols, ways of living, sea, land and objects — all of which arise from Indigenous spirituality. Many traditional cultural practices include plants, animals and the environment, making nature inseparable from cultural identity.

> *"The sea, its natural resources and our identity as Traditional Owners, are inseparable… Our ancestors have hunted and fished in this sea country since time immemorial…"* [2]

Through the Convention on Biological Diversity[3], the Australian Government has made a commitment to respect, preserve and maintain the knowledge, innovations and practices of Indigenous communities (Article 8(j)) and to protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements (Article 10(c)).

Figure 1.1 Great Barrier Reef Region, World Heritage Area and Marine Park

In all of its management arrangements, the Authority recognises the operation of section 211 of the *Native Title Act 1993* and the continued existence of native title rights and interests, and provides for management of traditional use of marine resources in accordance with Traditional Owner customs and traditions.

1.1.2 International importance

On 26 October 1981, the Great Barrier Reef was inscribed on the World Heritage List of the Convention Concerning the Protection of the World Cultural and Natural Heritage[4], on the basis of its natural outstanding universal value (Figure 1.2).

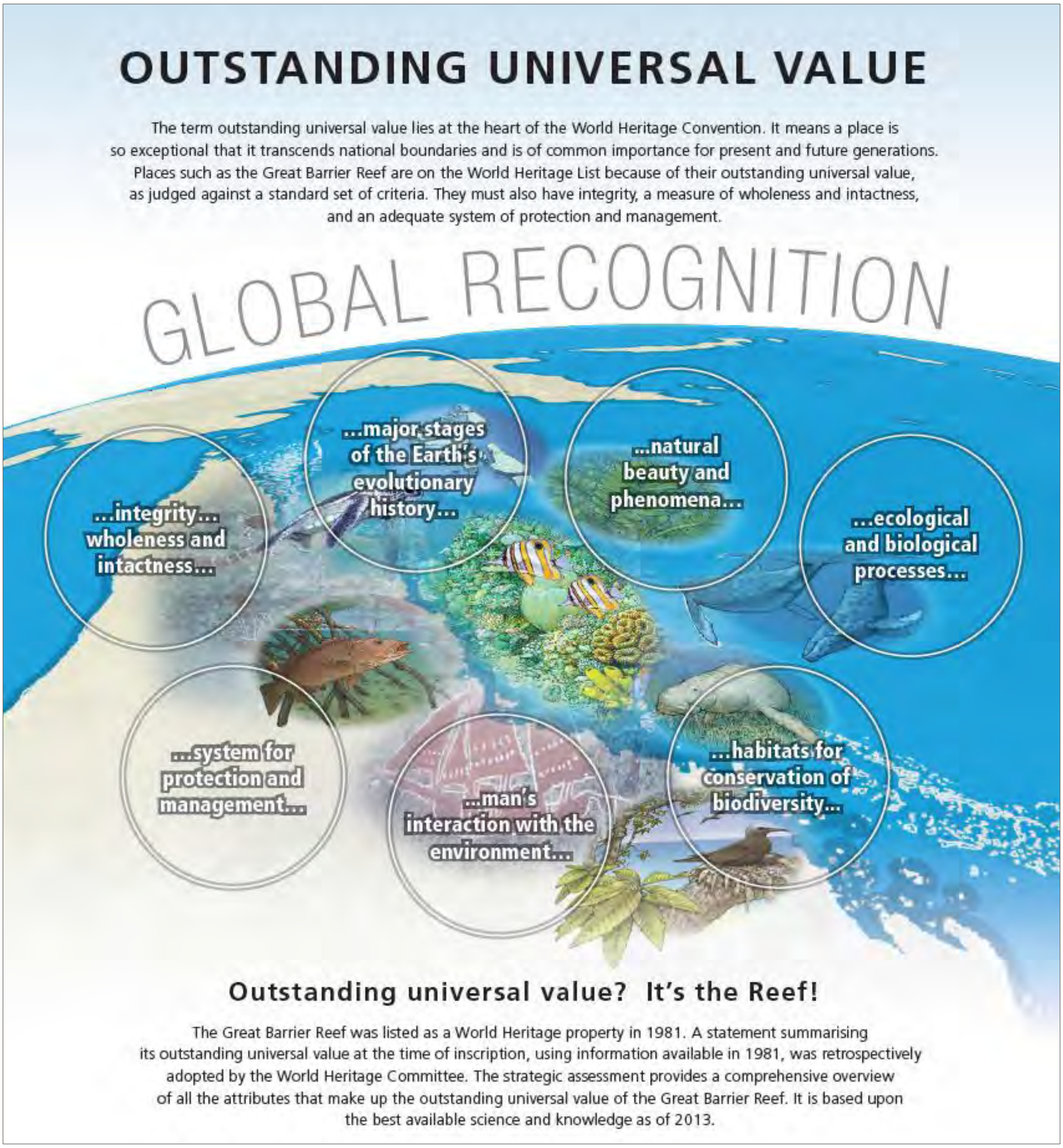

Figure 1.2 Outstanding universal value of the Great Barrier Reef

The Great Barrier Reef was the first coral reef ecosystem in the world to be made a World Heritage Area, recognised for its natural beauty and natural phenomena; its representation of major stages in the Earth's evolutionary history, including man's interaction with the environment; its ecological and biological processes; and its habitats for the conservation of biodiversity (see Figure 1.2). The Great Barrier Reef is one of only a small number of marine world heritage properties that have been inscribed by meeting all four 'natural' criteria.

World heritage recognition highlights the continuing international significance of the Great Barrier Reef. When considering the Reef's nomination for world heritage listing, the then International Union for the Conservation of Nature and Natural Resources (IUCN) stated:

> *… if only one coral reef site in the world were to be chosen for the World Heritage List, the Great Barrier Reef is the site to be chosen*.[5]

Articles 4 and 5 of the convention set out the obligation and responsibility to protect, conserve and rehabilitate the Reef's values for all future generations and to present those values to the world.[4]

Notably, a criterion at the time of listing referred to the "interaction between man and his natural environment". In the context of the Great Barrier Reef, this is recognition of the strong and continuing connections between Traditional Owners and their land and sea country — an aspect reflected in the consideration of values that underpin matters of national environmental significance in this assessment.

1.1.3 National importance

The Great Barrier Reef ecosystem has long been recognised for its remarkable biodiversity — from coastal estuarine systems, inshore fringing reefs and seagrass meadows to islands and spectacular outer barrier reefs. The Reef is an integral part of the Australian national identity. It is a subject of national pride, reflected in both the number of people who visit it and in the continuing public interest shown in its future health and management.

Early concerns for the Reef's future culminated in the Australian Government introducing the *Great Barrier Reef Marine Park Act 1975* (the Act). Today the main object of the Act is:

To provide for the long term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region.

The Act established the Authority and defined the Great Barrier Reef Region. It also enabled subsequent declaration of the Great Barrier Reef Marine Park (the Marine Park), introducing the concept of a multiple-use marine park where 'reasonable use' of natural resources could coexist with conservation.

Over subsequent years, sections of the Region were progressively declared as Marine Park. Today the Marine Park is one of the world's largest marine protected areas, covering approximately 344,000 square kilometres (see Figure 1.1). It is complemented by the Great Barrier Reef Coast Marine Park, established in adjacent state waters under Queensland Government legislation. Both marine parks form part of the Great Barrier Reef World Heritage Area.

The Great Barrier Reef is also formally listed as a national heritage place under Australia's national environment legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Its premier importance to the Australian tourism industry is recognised through its inclusion as one of the nation's 16 National Landscapes, along with places such as the Red Centre, Kakadu and Sydney Harbour.

1.1.4 Great Barrier Reef Marine Park Authority

The Great Barrier Reef Marine Park Authority is an Australian Government statutory agency, established under the Great Barrier Reef Marine Park Act. The Authority reports to the Australian Government Minister responsible for the environment and advises the Minister on the control, care and development of the Marine Park.

In managing the Marine Park, the Authority must have regard to, and seek to act in a way that is consistent with, the objects of the Act, the protection of the world heritage values of the Great Barrier Reef World Heritage Area, and the principles of ecologically sustainable use.

The Authority is made up of a five person board of management, supported by a staff of about 250 people. It is based in Townsville, North Queensland, and maintains offices in Cairns, Mackay and Rockhampton along the Great Barrier Reef coast, plus a small office in Canberra.

1.1.5 Management approach

The Great Barrier Reef Region is a multiple-use area, where biodiversity and heritage values are protected as well as the social and economic aspects of the environment.

Managing the Region is complex and involves a responsibility to maintain the area's natural and cultural integrity while allowing sustainable use. It is a challenging task because of the size and diversity of the Reef ecosystem; its economic importance; local, state, national and international interests; and jurisdictional, biophysical and social complexities.[6]

The Australian and Queensland governments work in a long-term partnership to protect and manage the Region. This cooperative approach was initially formalised by the Emerald Agreement in 1979 and reaffirmed in the Great Barrier Reef Intergovernmental Agreement signed in 2009. The Great Barrier Reef Ministerial Forum, consisting of two Commonwealth and two Queensland Government ministers, facilitates and oversees implementation and achievement of the objectives of the intergovernmental agreement.

The Field Management Program is a jointly-funded, cooperative partnership between the Australian Government and the Queensland Government. It undertakes operations and routine day-to-day management activities in the Marine Park, the adjacent Queensland Great Barrier Reef Coast Marine Park and on national park islands.

Many other Australian and Queensland government agencies have responsibilities within the Region, for example in relation to fisheries, tourism, science, natural resource management and shipping. The fundamental management partnership between the Australian and Queensland governments to protect the Great Barrier Reef is complemented by partnerships with these other agencies.

The Authority works in partnership with Traditional Owners on a range of sea country programs to conserve biodiversity and Indigenous heritage values, and promote sustainable use. Management is also enhanced through partnerships and stewardship arrangements with Great Barrier Reef stakeholders, such as industry associations, scientists, local government and community groups.

Through a network of Reef Advisory Committees and Local Marine Advisory Committees, the Authority receives technical and stakeholder advice on a range of issues associated with the health, use and management of the Great Barrier Reef.

Informed by the best available science, the Authority works to ensure long-term protection of the Reef environment, recognising the needs of communities and industries that rely on a healthy Marine Park for their economic, cultural and social wellbeing.

The Authority uses a number of tools to protect and manage the Marine Park, including zoning plans, plans of management, permits, policies and strategies, formal agreements and site management arrangements. Various management approaches are employed including education, planning, environmental impact assessment, monitoring, stewardship programs and enforcement.

Within the Marine Park, a number of activities are strictly prohibited by legislation (such as mining and oil drilling) and other activities are carefully managed according to the principles of ecologically sustainable use.

The Authority does not have direct management responsibilities for areas or activities outside the Marine Park, except in a few specific circumstances. However, it recognises the interconnectedness of the terrestrial and marine natural systems, and the significant effects that land-based activities can have on the Great Barrier Reef ecosystem. Consequently, the Authority actively works with those government departments, industries and communities whose actions have the potential to affect the marine ecosystem.

1.1.6 Evolving issues and management over time

The activities and impacts on the Reef that have required management over the past 50 years have changed substantially.

The prospect of drilling for oil and the mining of reef limestone stirred widespread public concern in the 1960s and were largely responsible for government initiatives to proactively manage the Great Barrier Reef in the 1970s. In the early 1980s, the agency's priorities were to address the risks arising from the absence of a planning regime, the exponential growth of tourism, the lack of basic scientific knowledge to underpin management decisions and the lack of a comprehensive management framework. Also in the 1980s crown-of-thorns starfish outbreaks were a focus for research and monitoring activities, and localised control at high value tourism sites was supported. By the late 1990s, management activities focused on the critical issues of biodiversity conservation, water quality, coastal development, fisheries, tourism and recreation. More recently, the impacts of climate change on the Reef, linkages between terrestrial and marine systems, improvements in catchment run-off and cumulative impacts of coastal development activities on ecosystem function have become key areas of additional management focus. Key management responses to these issues are listed in Table 1.1 and described in Chapter 3.

Table 1.1 Chronology of key management responses to emerging issues from the 1970s to the present

Since proclamation of the Great Barrier Reef Marine Park Act in 1975, the Authority has continually adapted its management arrangements to address the highest risks. *Adapted from the State Party Report on the state of conservation of the Great Barrier Reef World Heritage Area (Australia).*[7]

1970s	1980s	1990s	2000s	Present
• *Great Barrier Reef Marine Park Act 1975* • Great Barrier Reef Marine Park Authority established • Intergovernmental Agreement — Emerald Agreement	• Inscribed on World Heritage List • Marine Park sections proclaimed and zoning plans developed • Joint field management arrangements with Queensland established • Research and monitoring programs initiated	• *25 Year Strategic Plan* • Plans of management for Cairns Area and Whitsundays • Compulsory pilotage • Dugong Protection Areas • Environmental management charge • Cooperative Research Centre	• Consolidated Great Barrier Reef Marine Park Zoning Plan (representative areas program) • Plans of management for Hinchinbrook and Shoalwater Bay • *Reef Water Quality Protection Plan* • Aquaculture Regulations • Traditional Use of Marine Resources Agreements and sea country partnerships • Best practices and stewardship • Reef Guardian program • *Great Barrier Reef Climate Change Vulnerability Assessment and Action Plan* • *Outlook Report 2009* • Great Barrier Reef Inter-governmental Agreement • Research partnerships	• *Climate Change Adaptation Strategy* • *Informing the outlook for Great Barrier Reef coastal ecosystems* • *Biodiversity Conservation Strategy and vulnerability assessments* • *Great Barrier Reef Region Strategic Assessment*

1.2 Comprehensive strategic assessment

1.2.1 What is a strategic assessment?

Under the Australian Government's national environmental law — the EPBC Act — a strategic assessment may be conducted as part of the environmental impact assessment process.

Strategic assessments differ greatly from assessments of individual projects which only look at the specific effects of activities at a local level. Instead, strategic assessments are conducted over much larger scales and timeframes, enabling consideration at the overall landscape level.[8]

The benefit of this approach is that it allows a broader set of issues to be investigated like the environmental, social, cultural and economic impacts of development and other activities. It also allows assessment of the direct, indirect and cumulative impacts from activities on ecosystems.

Importantly, this process provides the community, governments, businesses and industry with an opportunity to achieve both conservation and planning outcomes at a much larger scale than can be reached through project-by-project assessments.

1.2.2 Two complementary strategic assessments

The comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone is being undertaken by the Australian and Queensland governments. There are two components to the comprehensive strategic assessment — a marine component and a coastal component (see Figure 1.3).

The comprehensive strategic assessment of the Great Barrier Reef analyses impacts affecting the Region, from activities on the land and on the water. The Authority is responsible for undertaking the marine component which is presented in this strategic assessment report. The Queensland Government is leading development of the strategic assessment of the Great Barrier Reef coastal zone.

1.2.3 Why undertake a strategic assessment?

The Authority is undertaking this strategic assessment to evaluate and improve its effectiveness in managing existing and emerging risks to the Great Barrier Reef, focusing on the relevant matters of national environmental significance.

> *The strategic assessment is part of the Australian Government's adaptive approach to managing the Great Barrier Reef.*

The findings of the strategic assessment have informed the recommendations of this report and a separate Program Report for the Great Barrier Reef Region. The Program Report is a detailed description of the Authority's management arrangements and future commitments to protect and manage matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area.

The comprehensive strategic assessment also forms part of the Australian Government's response to the World Heritage Committee's concerns regarding development impacts on the World Heritage Area, originally raised at its meeting in June 2011.

At that meeting the World Heritage Committee requested that Australia undertake a comprehensive strategic assessment of the Great Barrier Reef World Heritage Area, identifying planned and potential developments that could impact on the outstanding universal value of the World Heritage Area, and develop a long-term plan for sustainable development. A World Heritage Centre/International Union for Conservation of Nature monitoring mission subsequently visited the area in March 2012. It concluded that the Great Barrier Reef continues to demonstrate outstanding universal value and proposed 14 recommendations.[9]

At its meeting in June 2012, the World Heritage Committee noted the findings of the monitoring mission and, amongst other things, requested that the recommendations in the mission report be addressed. Recommendation R5 relates to the conduct of the strategic assessment and is set out on page 1-11.

At 348,000 square kilometres, the World Heritage Area is slightly larger than the Region because it includes all the islands and waters within its boundary, regardless of tenure.

Both the Region and the Marine Park include Commonwealth islands within their boundaries but do not include Queensland's islands and internal waters. In addition, there are 13 coastal areas excluded from the Marine Park. These areas were excluded to accommodate port interests and contain trading ports and non-trading ports or marinas (see Section 5.3.5). In total, the Marine Park covers 344,400 square kilometres.

All management arrangements under the jurisdiction of the Authority have been considered in this strategic assessment, together with partnerships and collaborative arrangements with other Australian and Queensland government agencies, and partnerships with stakeholders and members of the Great Barrier Reef coastal community.

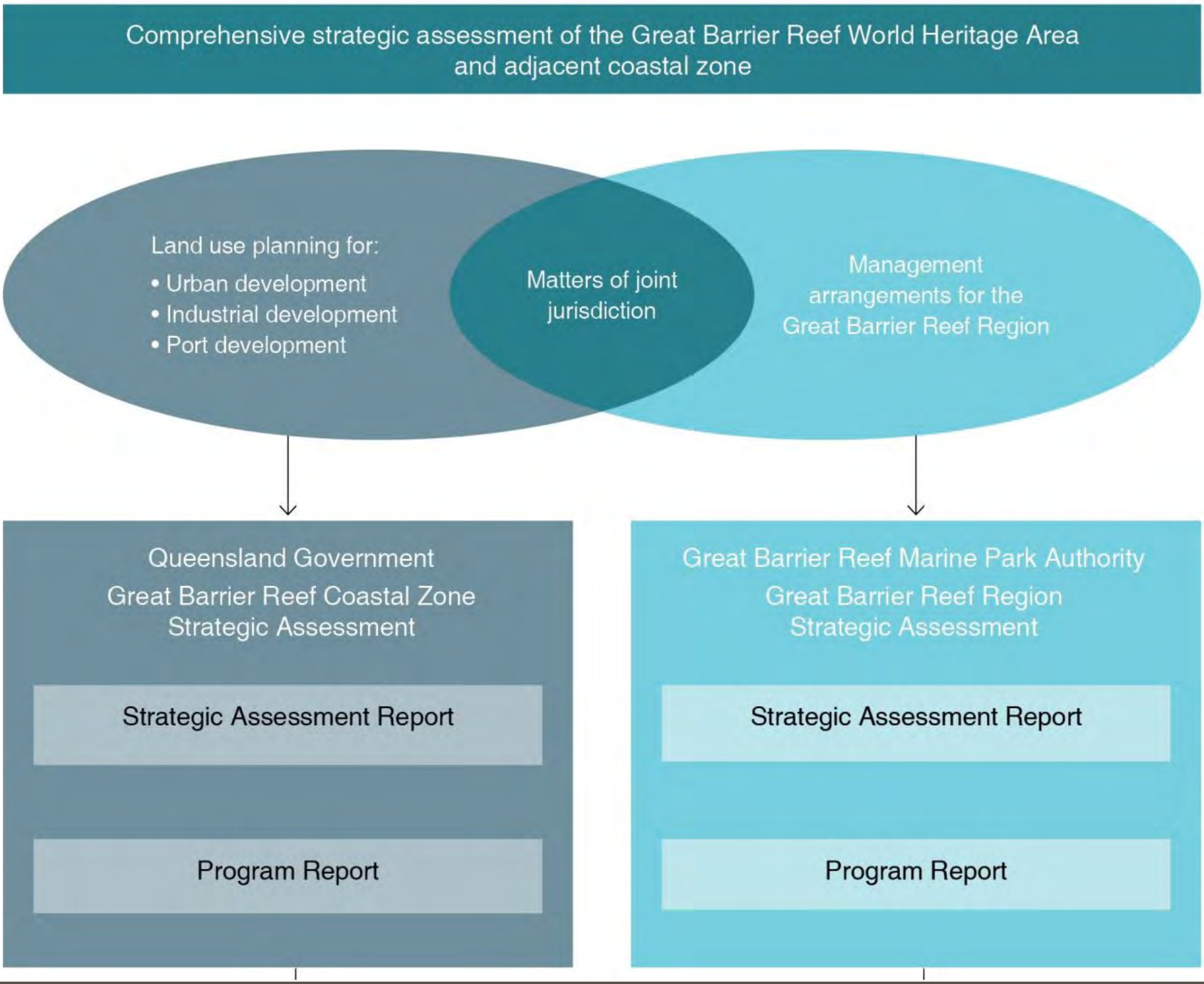

Figure 1.3 Components of the comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone

There are areas of overlap and joint management responsibility across the two strategic assessments. These aspects will be considered and addressed in both assessments.

World Heritage Centre/IUCN Monitoring Mission Report[9] — Recommendation R5

Complete the Strategic Assessment and resulting long-term plan for the sustainable development of the property for consideration by the World Heritage Committee at its 39th session in 2015. The assessment and long-term plan should be completed in a coordinated and fully consultative process, against a number of defined criteria for success, and considering the conclusions and recommendations of the mission as set out in this report. Expectations of the Strategic Assessment include that it will lead to:

- A long-term plan with agreed leadership at Federal and State levels, that addresses the entire property and the adjacent areas where activities can affect the outstanding universal value of the property, and ensures that any development that is approved results in an overall net benefit for the property;
- Explicit incorporation of all elements that make up the outstanding universal value of the property, and in particular the long-term conservation of the integrity of the property, into the decision-making process regarding all development and use that may negatively impact the property, both within the boundaries of the World Heritage Area and in areas adjacent to the property;
- Improved effectiveness of the overall protection, planning and management of the outstanding universal value of the property as a whole, and the catchments, and coastal and marine areas that are intimately linked to it, including if necessary legal/statutory reforms to strengthen protection and management;
- A clear and target-driven framework to support planning and assessment of development proposals to protect outstanding universal value, and restore it where necessary, and to ensure resilience of the site, including the consideration of cumulative impacts;
- A clear analysis and related policies and strategies that will sustain long-term sustainable development, compatible with the protection of outstanding universal value, including consideration of the all economic sectors, including sustainable tourism and recreation and commercial fishing, as well as coastal development;
- Spatial policies that will identify appropriate and limited locations and standards for coastal development, and also identify areas that should not be subject to development, and which will provide greater business certainty regarding development proposals and community confidence and understanding of future development scenarios;
- Increased public confidence in their ability to engage with and influence policy and development decisions, including independent mechanisms to scrutinize and advise on the assessment of impacts of development;
- Support for new and enhanced policies and measures to regulate and manage shipping, and provide appropriate emergency planning and response;
- Appropriate systems to secure that, where development and use is permitted it will lead to net benefits to the property as a whole, including from contributions from developers to mitigate impacts of development;
- Measures, such as legislative change to enhance compliance, that may increase the results achieved from the funding available for management, and to also increase overall levels of funding where required to provide for effective protection and management.

1.2.4 Scope of the Great Barrier Reef Region strategic assessment

The area considered in this strategic assessment is the Great Barrier Reef Region (see Figure 1.1), as defined in the Great Barrier Reef Marine Park Act, and places outside that Region to the extent that the Region may be affected by actions in those places.

The Region extends from the tip of Cape York in the north to just past Lady Elliot Island in the south. Its western boundary is mean low water and it extends eastwards between 80 and 250 kilometres. Established in 1975, it covers 346,000 square kilometres and includes Commonwealth islands. It does not include the islands or internal waters that fall under Queensland Government jurisdiction.

There are geographically small but important differences between the boundaries of the Region, the Great Barrier Reef World Heritage Area and the Great Barrier Reef Marine Park (Table 1.2). These are illustrated spatially in Figure 1.4, using the area around the city of Cairns as an example.

Table 1.2 Differences between the Great Barrier Reef World Heritage Area, Region and Marine Park
The Great Barrier Reef Region is the subject of this strategic assessment.

Great Barrier Reef World Heritage Area	Great Barrier Reef Region	Great Barrier Reef Marine Park
348,000 km^2	346,000 km^2	344,400 km^2
Inscribed 1981	Established 1975	Declared in sections between 1979 and 2001; amalgamated into one section in 2003
Includes: • all islands within outer boundary (about 1050) • all waters seaward of low water mark (including internal waters of Queensland and port waters) • all 12 trading ports	Includes: • approximately 70 Commonwealth islands • all waters seaward of low water mark (excluding Queensland internal waters) Does NOT include: • internal waters of Queensland • Queensland islands (about 980)	Includes: • approximately 70 Commonwealth islands • all waters seaward of low water mark (excluding Queensland internal waters) Does NOT include: • internal waters of Queensland • Queensland islands (about 980) • 13 coastal exclusion areas

1.2.5 Matters of national environmental significance, including outstanding universal value

Matters of national environmental significance are Australia's national environmental assets as defined in the EPBC Act. The matters considered in this assessment are defined in the Authority's agreement with the then Minister for Sustainability, Environment, Water, Population and Communities in relation to this assessment (Appendix 1) and the terms of reference (Appendix 2).

These matters are:

- world heritage properties
- the Great Barrier Reef Marine Park
- national heritage places
- Commonwealth marine areas
- listed migratory species
- listed threatened species and ecological communities
- wetlands of international importance.

This report is focused on assessing, and recommending improvements to, management arrangements to protect matters of national environmental significance relevant to the Great Barrier Reef Region.

The report contains explicit consideration of matters relating to the outstanding universal value of the Great Barrier Reef World Heritage Area. Outstanding universal value is a concept central to world heritage properties (see Figure 1.2). It relates to the exceptional qualities of global significance that make an area worthy of special protection and includes the concept of 'integrity' which is a measure of the wholeness or intactness of the property's natural heritage and its attributes.[10]

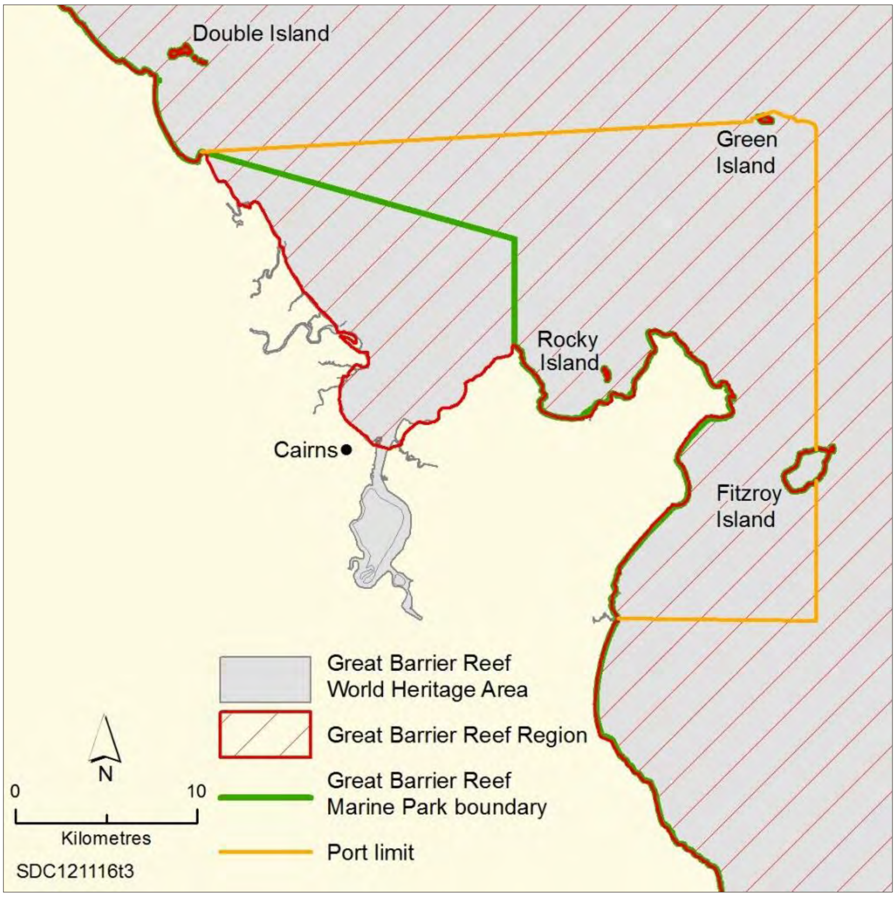

Figure 1.4 An example of the different coastal boundaries for the Great Barrier Reef World Heritage Area, Region and Marine Park

As illustrated in this map of the area around Cairns, the Great Barrier Reef World Heritage Area includes all internal waters and islands of Queensland, for example enclosed bays and estuaries, and Green and Fitzroy islands. The Great Barrier Reef Region includes all waters seaward of low water, but not the internal waters and islands of Queensland (such as Green and Fitzroy islands). The Region includes Commonwealth islands. The Great Barrier Reef Marine Park has the same boundary as the Region, except that defined areas around most trading ports are excluded. The Marine Park boundary around ports is different from the port limit which is defined in relation to operation of the port itself.

1.2.6 Strategic assessment process

In accordance with the EPBC Act, there is a set of legislative and non-legislative steps to be followed in undertaking a strategic assessment (Figure 1.5).

The Authority entered into an agreement with the then Minister for Sustainability, Environment, Water, Population and Communities in February 2012 (Appendix 1). It subsequently developed terms of reference for the assessment in consultation with the then Department of Sustainability, Environment, Water, Population and Communities (Appendix 2), and has now prepared drafts of the Strategic Assessment Report (this report) and the Program Report.

All responses received during the public comment period, along with advice from independent peer reviewers, will be taken into account in finalising the two reports. These documents and a supplementary report explaining how public responses have been taken into account, along with the responses themselves, will then be provided to the Minister for consideration.

The Minister may endorse the future management arrangements described in the Program Report if satisfied that the impacts relevant to the strategic assessment have been adequately addressed. The Minister may also recommend changes before endorsement. During these considerations, the Minister will have regard to the extent to which the endorsement criteria, as set out in the terms of reference (see below), have been met.

The Authority, the Department of Environment and the Queensland Government have worked together throughout the process of developing this Strategic Assessment Report and the Program Report.

Endorsement criteria for the strategic assessment

In determining whether or not to endorse the Program, the Minister will have regard to the extent to which the Program meets the objects of the *Environment Protection and Biodiversity Conservation Act 1999*. In particular, that it:

a) protects the environment, especially those aspects of the environment that are matters of national environmental significance

b) promotes ecologically sustainable development through the conservation and ecologically sustainable use of natural resources

c) promotes the conservation of biodiversity

d) provides for the protection and conservation of heritage

e) promotes a cooperative approach to the protection and management of the environment

f) assists in the cooperative implementation of Australia's international environmental responsibilities

g) recognises the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity

h) promotes the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in co-operation with, the owners of the knowledge.

Without limiting the matters the Minister may consider when making the decision to endorse the Program, the Minister will consider the manner in which the Program:

i) identifies direct, indirect and cumulative impacts on matters of national environmental significance

j) avoids impacts on matters of national environmental significance

k) mitigates the impacts on matters of national environmental significance

l) offsets the impacts on matters of national environmental significance

m) contributes to the enhancement of the existing environment and management of existing threats

n) demonstrates adaption to reasonable climate change scenarios.

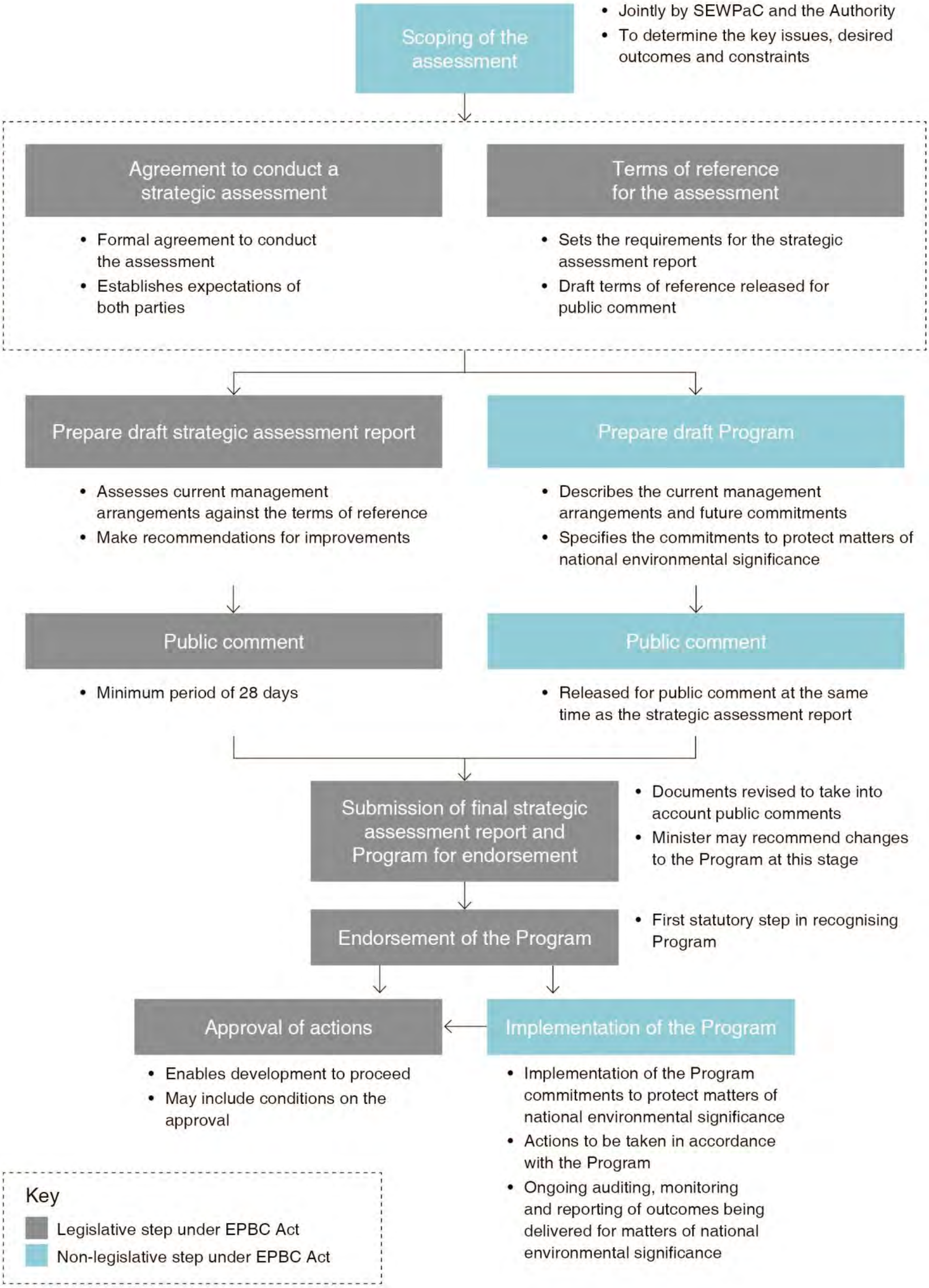

Figure 1.5 Strategic assessment process

The then Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) set out a standard process for developing a strategic assessment relating to matters of national environmental significance, in accordance with the EPBC Act. This diagram has been adapted from *A guide to undertaking strategic assessments*.[8]

1.2.7 Implications for the future

The strategic assessment process aims to strengthen protection of matters of national environmental significance in the Region. It is intended to guide future management activities by the Authority and its partners.

This report provides the rationale for recommended improvements to management arrangements for the Region.

With a 25-year horizon, the accompanying Program Report will provide the overarching strategic direction for the Authority's management of the Region. It will:

- define the environmental outcomes required to protect the Great Barrier Reef and the management measures to achieve them
- provide a comprehensive framework for the assessment of the cumulative impacts of development activities on the Great Barrier Reef
- provide proponents with greater certainty on where sustainable uses can occur, the type of activities that will be allowed and the conditions under which activities may proceed
- provide the Authority's management partners with a clear understanding of its management arrangements and the important contribution they make
- build upon current partnership and engagement programs delivering actions to achieve a healthier and more resilient Great Barrier Reef
- reduce administrative burden for the Authority, other government agencies and proponents
- be a foundation for management, building on three decades of management experience and incorporating adaptive management processes to respond to emerging issues.

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Chapter 2

Assessment approach

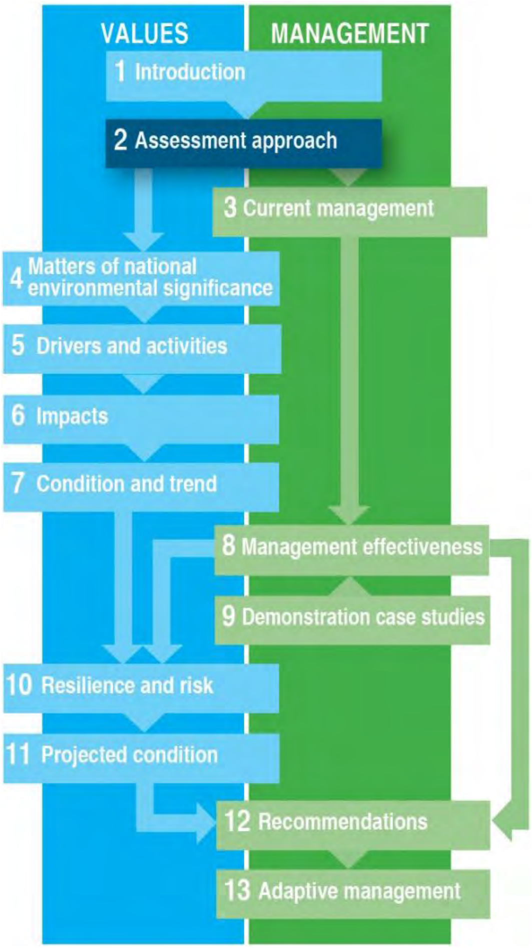


Table of contents

Cover page image: Diver undertaking a reef health impact survey.

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

7. Strategic assessment process

7.1 Collaboration with the Queensland Government and other Australian Government agencies

a) undertake the strategic assessment in consultation and collaboration with the Queensland Government, the Australian Government's Department of Sustainability, Environment, Water, Population and Communities and other relevant Australian Government agencies

7.2 Community engagement

a) document how the community and stakeholders were engaged in the strategic assessment process and how views and comments were taken into account in the preparation of the Strategic Assessment Report and the Program Report

………

7.4 Information and assessments

a) use the best available information to undertake the strategic assessment, including scientific data, expert opinion, and Traditional Owner and community knowledge

b) document the methods used to undertake the strategic assessment

c) for information used in the strategic assessment, indicate where possible:

i. the source of the information

ii. how recent the information is

iii. the reliability and limitations of the assessment.

2 Assessment approach

The strategic assessments for the Great Barrier Reef Region (the Region) and coastal zone have been closely coordinated and undertaken using similar methods, where appropriate. The approaches used were aligned through the development of a joint technical framework. The aspects of the framework relevant to the strategic assessment for the Region are summarised in this chapter.

2.1 Legislative basis

The Great Barrier Reef Region strategic assessment is being carried out under Part 10 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It must meet the objects of that Act, which are:

- to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance
- to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources
- to promote the conservation of biodiversity
- to provide for the protection and conservation of heritage
- to promote a cooperative approach to the protection and management of the environment involving governments, the community, landholders and Indigenous peoples
- to assist in the cooperative implementation of Australia's international environmental responsibilities
- to recognise the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity
- to promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

An agreement between the then Minister for Sustainability, Environment, Water, Population and Communities and the Great Barrier Reef Marine Park Authority (the Authority) signed on 16 February 2012 provides the basis for the assessment (Appendix 1).

Terms of reference set out the requirements for the strategic assessment, including its contents and the development process (Appendix 2). The Minister approved these on 30 August 2012.

2.2 Matters of national environmental significance

This report is focused on assessing and recommending improvements to management arrangements to protect the matters of national environmental significance, as set out in the EPBC Act, that are relevant to the Region.

Each of the matters of national environmental significance is described in detail in Chapter 4.

2.3 Definitions and terminology

A glossary of terms used is provided at the beginning of the report.

2.4 Principles

The following key principles underpin development of the strategic assessment:

- establish a system-wide understanding of values and attributes, including ecosystem processes, which underpin matters of national environmental significance
- establish a system-wide understanding of pressures and impacts on matters of national environmental significance, recognising these are likely to vary at different spatial and temporal scales
- include spatial representations of values and attributes, impacts and risks wherever relevant and possible
- use demonstration cases to examine in finer detail how management systems identify, protect and manage impacts on matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area
- use information that is publicly available and, where available, information which has undergone peer review
- promote rigour and transparency through expert advice where published information is not available or sufficient
- acknowledge and report confidence, uncertainties and gaps in information
- present information in a simple and clear fashion suitable for the public.

2.5 Complexity and scale

The biophysical, social and jurisdictional complexity of the Region and its adjacent coastal zone, as well as the factors influencing them, means this strategic assessment is conducted at a number of scales.

At each step, a Reef-wide overview is presented and supplemented by more information on specific values, issues or areas at a range of scales. Where appropriate, and where the level of detail is available, spatial variation is described and, where possible, mapped.

Demonstration case studies are used to investigate values and impacts, and to illustrate management effectiveness in greater detail and at a finer scale.

2.6 Steps in the assessment process

The steps taken in this strategic assessment reflect its terms of reference. The following individual steps are presented as separate chapters in the report, with the outcomes of each chapter informing subsequent chapters:

- describing the Authority's current management arrangements (Chapter 3)
- outlining the extent to which the matters of national environmental significance are relevant to the Region and establishing the values, or in the case of the property's outstanding universal value, the attributes, that are relevant to them (Chapter 4)
- describing the drivers and activities relevant to the Region (Chapter 5)

- describing and assessing the past and present impacts affecting the values and attributes, and summarising the implications for the matters of national environmental significance (Chapter 6)
- assessing the current condition and trend of the values and attributes, and summarising the implications for the matters of national environmental significance, including benchmarking the outstanding universal value of the World Heritage Area (Chapter 7)
- presenting an independent assessment of the effectiveness of the Authority's current management arrangements (Chapter 8)
- illustrating in finer detail current management effectiveness through selected demonstration case studies (Chapter 9)
- providing an understanding of ecosystem resilience, assessing the future risks to the values and summarising the implications for the matters of national environmental significance (Chapter 10)
- projecting the future condition for matters of national environmental significance (Chapter 11)
- recommending changes to improve the effectiveness of management arrangements (Chapter 12)
- describing how proposed future management arrangements will support adaptive management of matters of national environmental significance (Chapter 13).

This logic is illustrated in Figure 2.1.

The outcomes of the strategic assessment are reflected in Chapter 12 and in the accompanying Program Report which sets out the Authority's existing and proposed future management arrangements in relation to matters of national environmental significance.

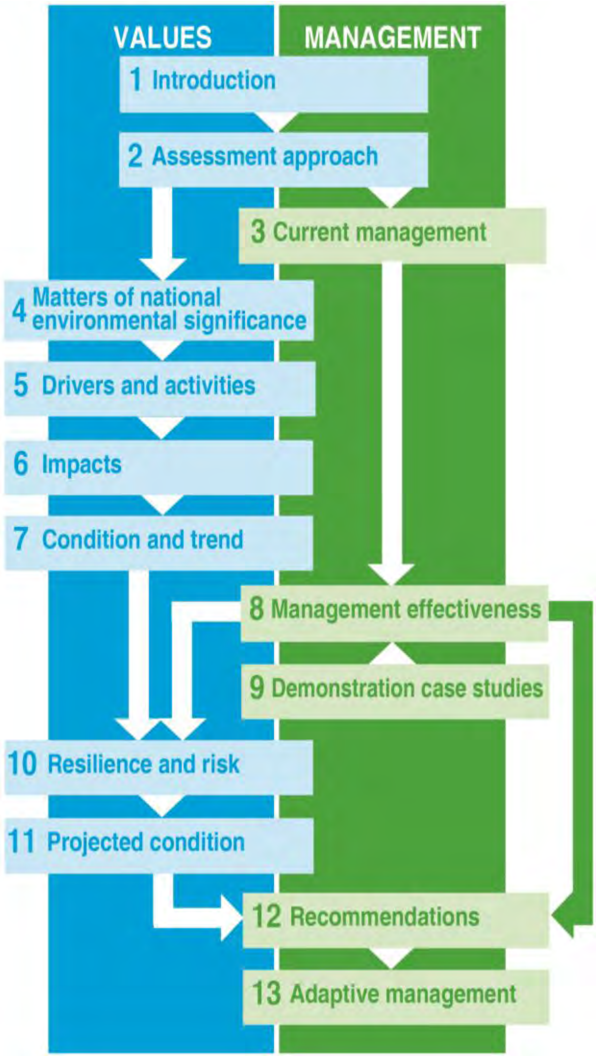


Figure 2.1 Steps in the assessment process

2.7 Assessment methods

2.7.1 Assessment logic

The strategic assessment is based on the assessment logic encompassed in the DPSIR framework (**D**rivers, **P**ressures, **S**tate, **I**mpact, **R**esponse). This type of logic is widely adapted and applied in managing and reporting on the state of the environment, for example the *Australia State of the Environment Report 2011*[1]. The typical terms used in the DPSIR framework are adapted in this assessment to remain consistent with those in the terms of reference.

A summary diagram of the logic adopted in the strategic assessment is provided in Figure 2.2.

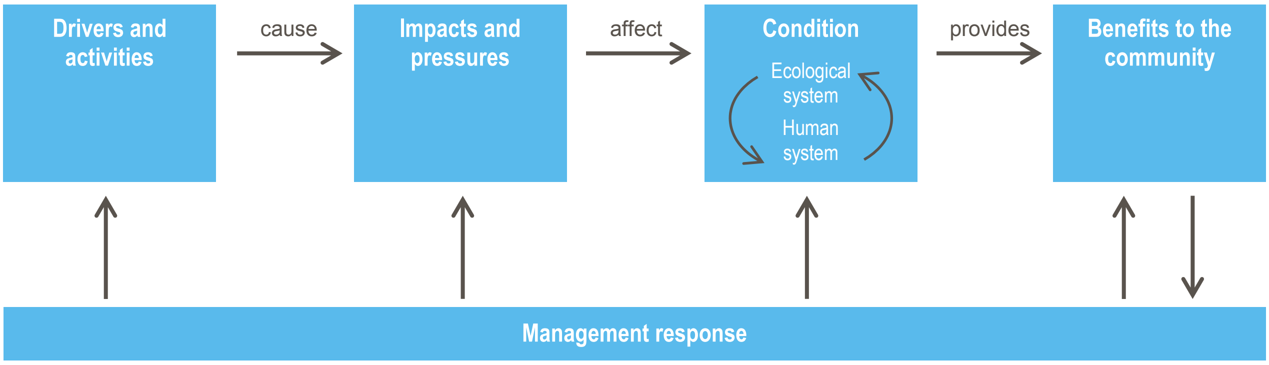


Figure 2.2 Assessment logic for the strategic assessment of the Great Barrier Reef Region
Based on the widely recognised Drivers, Pressures, State, Impact, Response (DPSIR) framework, the assessment examines the drivers and activities causing impacts or pressures that affect the state or condition of both the ecological and human systems of the Region. The benefits the community derives from the Region depends on the state of those systems. The management responses of the Authority and others can be directed at each component of the framework.

2.7.2 Structured assessments

Based on the terms of reference, this report provides a comprehensive assessment of drivers, activities and impacts that affect relevant matters of national environmental significance of the Region, and their current and future management.

The assessments are based on **key values and attributes** of the matters of national environmental significance, as established in Chapter 4. They have been grouped into four broad categories: biodiversity, geomorphological features, Indigenous and historic values, and community benefits derived from the environment. The **environmental processes** critical to the functioning of the matters of national environmental significance are also considered. The key values and attributes were determined using a number of sources, primarily:

- *Great Barrier Reef Outlook Report 2009*[2]
- *Informing the outlook for Great Barrier Reef coastal ecosystems*[3]
- *Great Barrier Reef Biodiversity Conservation Strategy 2013*[4]
- *Great Barrier Reef Heritage Strategy 2005*[5]
- *Geological and geomorphological features of outstanding universal value in the Great Barrier Reef World Heritage Area*[6]
- Traditional Owner and stakeholder input, including through the Authority's Reef Advisory Committees and Local Marine Advisory Committees, and targeted workshops and meetings (see Section 2.11).

An analysis of drivers and activities (Chapter 5) is used to establish a set of **past and present impacts** and **future risks**. They are based on those outlined in the Outlook Report 2009 with some additions and amendments to reflect advances in understanding and the different focus of the strategic assessment.

Structured assessments applying standard criteria are undertaken on the following topics:

- effects of past and present impacts on the key values and attributes of matters of national environmental significance (Chapter 6)
- current condition and trend of key values and attributes of the matters of national environmental significance (Chapter 7)
- benchmarking outstanding universal value compared to its condition at the time of world heritage listing (Chapter 7)
- effectiveness of current management (Chapter 8)
- likely future risks to the matters of national environmental significance (Chapter 10)
- projected condition of key values and attributes of the matters of national environmental significance (Chapter 11).

2.7.3 Assessing impacts

The DPSIR framework is based on the cause-and-effect chain that links drivers, activities and impacts to the state of the values relevant to the matters of national environmental significance, and the benefits derived from the environment (Figure 2.2 above). Assessing many impacts in large, interconnected systems such as the Great Barrier Reef is complex. Any given activity may lead to multiple impacts. Similarly, any given impact may be driven by multiple activities and affect many matters of national environmental significance.

A progression of best practice approaches is used to assess past and present impacts on matters of national environmental significance, from simple lists to process models. How well each of these tools is likely to account for the causal links implied in the DPSIR framework is summarised in Table 2.1.

Previously the Authority has undertaken assessments using some of the tools listed in Table 2.1, namely structured lists, value-impact matrices and influence diagrams (for example, in the Outlook Report 2009[2]), and conceptual diagrams (for example, in *Informing the outlook for Great Barrier Reef coastal ecosystems*[3]). In this assessment, most of the tools in the hierarchy are employed to progressively refine understanding of impacts and identify those of most concern.

Structured lists are used in Chapter 4 to identify key values and attributes of matters of national environmental significance (see Tables 4.8 and 4.9) and again in Chapter 6 to define the scope of the impacts to be considered and to connect the identified impacts to direct drivers and activities (see Table 6.2).

Based on a detailed analysis of each impact, **matrices** are used to assess the past and current effect of each impact on key values and attributes of biodiversity, geomorphological features, and Indigenous and historic heritage values (Tables 6.6 to 6.9). The resulting impacts on community benefits are also described (Section 6.7). While the matrices present a more complete understanding of the range of impacts and the effects of each impact acting on an individual value, they do not allow consideration of complex interactions and cumulative impacts.

Conceptual diagrams and influence diagrams are used to map relationships between different impacts, values and processes. Examples are presented throughout the report (see Figures 4.14 and 4.15). These types of diagrams are also employed during the process of building qualitative process models, the tenth tool in the hierarchy shown in Table 2.1.

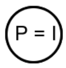
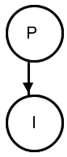
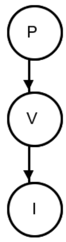
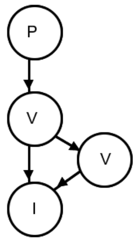
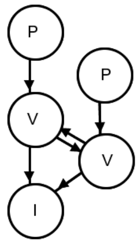
Qualitative models are used in Chapter 6 to document how key impacts affect matters of national environmental significance associated with coral reefs and seagrass meadows (including dugong). These models can be used to assess the multiple drivers and activities that act simultaneously on complex ecological systems.[7,8] The models were developed in workshops with experts in these fields. An advantage of qualitative models is that they provide a relatively rapid and flexible means to understand system dynamics, predict cumulative impacts and consider potential management interventions. Because they can be constructed and analysed relatively quickly, they can be used to compare alternative models about how a system works.

Bayesian networks, based on qualitative models, are employed in Chapter 11 (see Figures 11.1 and 11.2) to model possible future scenarios for the condition of coral reefs, seagrass meadows and dugongs, given the predicted trends in some impacts. Bayesian networks are **statistical models** that represent variables within a system and their dependencies.

Quantitative modelling has been applied to generate a series of exposure maps of coral reefs to key impacts and of key water quality variables (Section 6.8). These models are useful where management questions require definition of critical thresholds for limits to acceptable change to a matter of national environmental significance. Quantitative models can produce precise predictions for highly specified details of a system's biological and ecological components, processes and relationships; however, they typically require a large amount of data.

A more detailed explanation of the different types of modelling tools employed, together with a description of the modelling and spatial approaches adopted in the strategic assessment, is provided in Chapter 6 (see Section 6.8).

Table 2.1 Tools to improve understanding of cause-and-effect relationships
The table was adapted from Table 2 of Hayes et al. (2012)[9]. Reproduced by permission of CSIRO © 2012

	Complexity of cause-effect relationship				
	None[1]	**Simple[2]**	**Directed[3]**	**Diffuse[4]**	**Feedback[5]**
Tools					
1. Unstructured list	●	●			
2. Objective-indicator matrix	●	●			
3. Structured list		●	●		
4. Value-impact matrix		●	●		
5. Conceptual diagram or cartoon		●	●		
6. Influence diagram		●	●	●	
7. Fuzzy cognitive map		●	●	●	
8. Statistical model		●	●	●	●[6]
9. Bayesian network			●	●	●[7]
10. Qualitative process model				●	●
11. Quantitative process model				●	●

[1] No cause-effect relationship.
[2] Pressure directly affects indicator variable.
[3] Pressure directly affects a variable that has knock-on effects to indicator variable.
[4] Pressure indirectly affects an indicator variable via multiple interaction pathways.
[5] Multiple pressures simultaneously affect complex system with feedbacks between variables.
[6] Explicit analysis of feedback not possible with classic statistical techniques. Incorporation of process models within statistical analyses of time series (e.g., state space modelling) can account for system feedbacks; such techniques, however, require extensive data, especially for large systems.
[7] With difficulty; standard Bayesian networks limited to acyclic graph structures. Dynamic Bayesian networks can account for feedbacks, but are difficult to parameterize and analyse, typically making them impractical for complex systems.

P pressure or impact

V system variable — an element of the ecological or human system or benefit derived from that system that forms part of the cause-and-effect relationship but is not measured

I indicator variable — a measurable indicator (it could be a specific ecosystem element (e.g. seagrass abundance) or benefit derived from the ecosystem (e.g. income) or a surrogate measure for the health of matters of national environmental significance)

2.7.4 Assessing condition and trend

Detailed consideration of the available evidence informs the assessment of the current condition and trend of key values and attributes of the relevant matters of national environmental significance (Chapter 7). The assessment of condition is graded relative to the best available knowledge about likely original condition. The outcomes are presented separately for key values and attributes, including more detailed analysis of the condition and trend of values and attributes of particular concern. Each assessment is comprehensively referenced.

To reflect differences within the Region, the current condition and trend of the biodiversity values and attributes are reported separately for four broad areas: northern inshore (N.I.), northern offshore (N.O.), southern inshore (S.I.) and southern offshore (S.O.) (Figure 2.3). While the boundaries are not precisely defined, the north-south dividing line is in the vicinity of Port Douglas, which marks the broad division between the more developed and less developed catchments adjacent to the Region. The inshore-offshore dividing line is generally about 20 kilometres offshore. It corresponds to enclosed coastal and open coastal water bodies described in the *Water Quality Guidelines for the Great Barrier Reef Marine Park*[10] but also includes areas further offshore that are habitats for recognised inshore specialist species such as dugongs.

The assessment of terrestrial habitats that support the Great Barrier Reef is also presented for four areas: northern inland (N.In.), northern coastal (N.C.), southern inland (S.In) and southern coastal (S.C.) (Figure 2.3). Again, the north-south dividing line is around Port Douglas. The coastal areas are defined as being a minimum of five kilometres from the coastline or where land reaches the height of 10 metres Australian Height Datum, whichever is furthest from the coast. The inland area is the remainder of the Great Barrier Reef catchment.

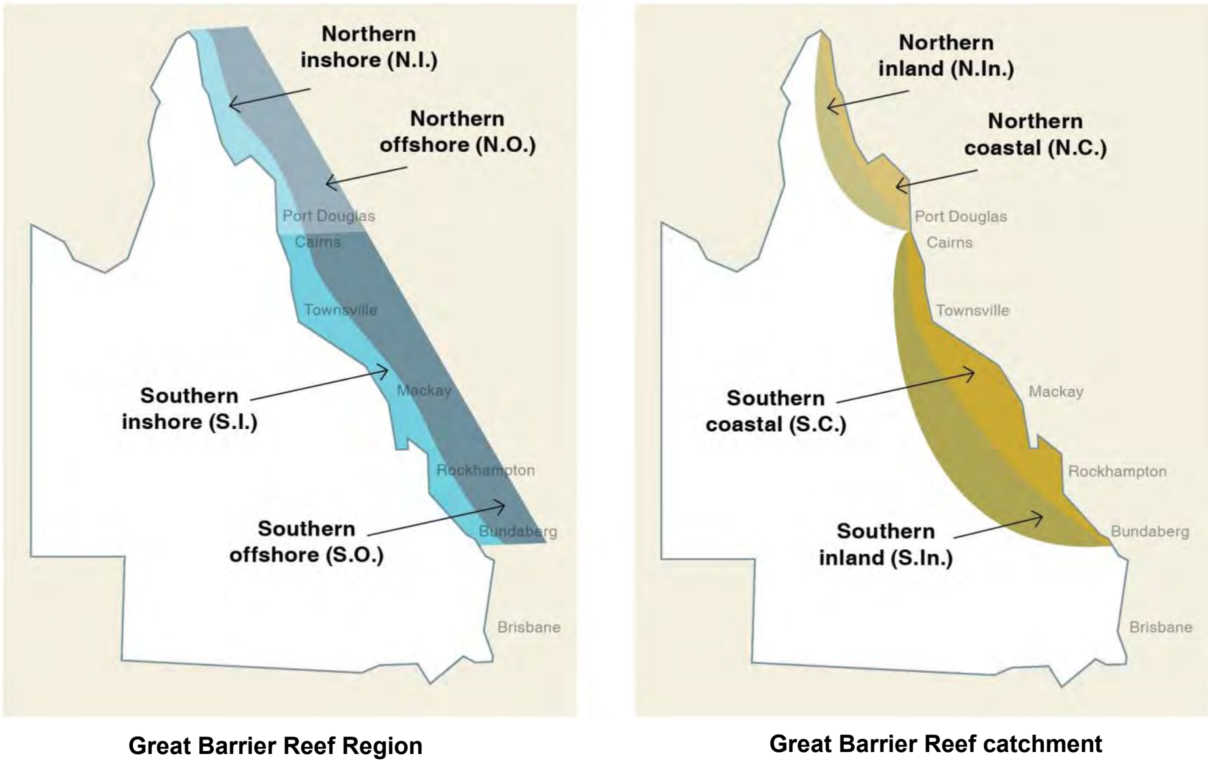


Figure 2.3 Indicative broad assessment areas for the Region and its catchment

2.7.5 Benchmarking outstanding universal value

For world heritage values, the terms of reference require that the current condition of key indicators of outstanding universal value be benchmarked against the retrospective Statement of Outstanding Universal Value.[11] This is the official statement adopted by the World Heritage Committee for the property and is the standard against which the property's state of conservation can be assessed. The statement is reproduced in full in Appendix 3.

The outstanding universal value is benchmarked by grading the current condition of the relevant attributes described in the statement, along with the trend of the value since 1981. The outcome is presented in Chapter 7.

2.7.6 Assessing management effectiveness

The Authority's current management arrangements for the Great Barrier Reef Region are summarised in Chapter 3.

A team of three independent assessors carried out an assessment of the effectiveness of these arrangements. The assessors have a comprehensive knowledge of protected area management, particularly in the Queensland marine environment. They reviewed documentation provided by the Authority and consulted stakeholders through formal meetings and an online survey (see Section 2.11).

The terms of reference for the assessment of management effectiveness are provided in Appendix 4 and the final report of the independent assessment is available on the Authority's website at www.gbrmpa.gov.au. The outcomes are summarised in Chapter 8.

The assessment approach is based on the management effectiveness framework used in the Outlook Report 2009.[2] This framework, developed by the International Union for Conservation of Nature/World Commission on Protected Areas, was specifically designed to evaluate management of protected areas. Some amendments were made to the framework to meet the requirements of the terms of reference for the strategic assessment (Appendix 2, Item 4.1.2) and to reflect advances in understanding and knowledge since 2009.

A similar assessment framework is used in each demonstration case study (see Section 2.8), including a review of the outcomes by the independent assessors.

The outcomes of the management effectiveness assessments inform subsequent assessments of future risk (Chapter 10) and projected condition (Chapter 11), and recommendations to improve management (Chapter 12 and the Program Report).

2.7.7 Understanding resilience

Assessment of the projected condition of matters of national environmental significance is informed, in part, by an understanding of ecosystem resilience — the capacity to recover from disturbance or withstand ongoing impacts. The description of ecosystem resilience considers factors such as: capacity to either resist (absorb) an impact, or to recover from that impact; capacity for recruitment; diversity; connectivity; scale and complexity (Chapter 10).

2.7.8 Assessing future risk

To assess future risks to the Great Barrier Reef ecosystem posed by identified impacts, the Australian Standard for Risk Assessment (AS/NZS 31000:2009) is adopted. The assessment is based on the assessments of current trends in drivers and activities, past and present impacts, current state of the values, effectiveness of management and current ecosystem resilience.

Both the likelihood and consequence of each predicted impact are ranked on a five-point scale and an overall risk level for each threat is determined, based on a combination of these two factors.

Where relevant, an impact is individually assessed for its likely future effect on biodiversity, geomorphological features, Indigenous heritage values and historic heritage values. The flow-on implications for community benefits are outlined. The outcomes are presented in Chapter 10.

2.7.9 Developing projected condition

The projected condition of matters of national environmental significance (Chapter 11) is based on:

- an understanding of drivers and activities and the past and present effects of impacts
- the evaluation of the current condition and trend of key values and attributes of the matters of national environmental significance, including consideration of integrity

- the effectiveness of current management arrangements to protect values and manage impacts, both on a broad scale and the demonstration case studies
- an understanding of ecosystem resilience
- the evaluation of overall risk, identifying the most serious future impacts
- a consideration of scenarios of the likely future projected condition of the Region, using the qualitative models outlined in Section 6.8.

The assessment of projected condition is presented for the key values and attributes and summarised for matters of national environmental significance.

2.7.10 Assessment structure

Grading statements
Grading statements are used to standardise the assessments. For example, the condition of each biodiversity value or the effectiveness of each aspect of the Authority's management arrangements is graded by rating it against a set of grading statements — four grades for each assessment.

The grading statements are based on those used in the Outlook Report 2009[2] and adapted, where necessary, to align with the strategic assessment's terms of reference. Additional statements are introduced for the assessment of heritage values, based on grading statements used in the *Australia State of the Environment Report 2011.*[1]

The assessment of outstanding universal value is adapted from a grading system developed by the International Union for Conservation of Nature to assess natural world heritage sites.[12]

Based on the relevant grading statements, a grade is assigned:

- for the effect of impacts on values and attributes: very low, low, high or very high
- for the current and projected condition of key values and attributes: very good, good, poor or very poor
- for management effectiveness: very effective, effective, partially effective and ineffective
- for future risks: low, medium, high and very high.

For each component, the grade is based on the best available information and is a 'grade of best fit'. It is a summary of all aspects and is not necessarily the appropriate grade for any individual area, species or impact. Where appropriate, specific information about individual elements of the component being assessed has been used to inform the assessment of the component as a whole (for example knowledge of the condition of individual species of sharks and rays has informed assessment of the value 'sharks and rays').

Trend
The approach to assessing values and impacts is further refined by including an indication of trend, similar to that used in the *Australia State of the Environment Report 2011.*[1]

In most cases the information about the condition of values reported in the Outlook Report 2009[2] is used as the baseline for determining trend. Therefore, the trend reported relates to the past five years, conforming with the Outlook Report cycle. An indication of trend over this time period helps inform consideration of changes in the effectiveness of management arrangements since 2009.

In assessing outstanding universal value, a longer timeframe is adopted to enable this to be benchmarked with the world heritage property's condition at the time of listing in 1981.

Where relevant and where the information is available, longer term trends are also described throughout the report.

There are four categories for trend: improving, stable, deteriorating or no clear trend. The category of 'no clear trend' is applied to a value when the available information is too variable to be able to establish a trend.

Confidence

In line with the *Australia State of the Environment Report,*[1] the level of confidence in each assessment is rated as either:

- adequate high quality evidence and high level of consensus
- limited evidence or limited consensus
- very limited evidence, assessment based on anecdotal information.

Where there is limited publicly available information, it is often possible to provide an assessment based on knowledge from within managing agencies, and that of Traditional Owners, topic experts and informed stakeholders. When using this type of information, a confidence grade is given of ‘very limited evidence, assessment based on anecdotal information’.

2.8 Demonstration case studies

Eight demonstration case studies are used to assess in finer detail the effectiveness of current management arrangements to protect and manage the Region’s values, and to guide improvements.

The case studies were chosen in consultation with the Queensland Government and the then Department of Sustainability, Environment, Water, Population and Communities, guided by criteria in the terms of reference (Appendix 2, Item 4.2.2). Given the joint management arrangements between the Authority and the Queensland Government, some of the case studies were prepared together for both strategic assessment reports.

The case studies are:

- dugongs
- corals
- islands
- Princess Charlotte Bay
- Cairns Planning Area
- Mackay Whitsunday — water quality improvement
- Keppel Bay
- East Coast Trawl Fishery.

The case studies and the rationale for their selection are provided in Chapter 9.

2.9 Recommended changes to management

In accordance with the terms of reference (Appendix 2, Item 6.1), this report includes recommended changes to the Authority’s current management arrangements to improve its effectiveness to deliver on its objectives. Improvements to related local, state and national government programs are also recommended where relevant (Chapter 12).

The outcomes of the assessment of current management effectiveness (Chapter 8), the demonstration case studies (Chapter 9) and the projections of future condition (Chapter 11) helped inform these recommendations.

2.10 Information used

The strategic assessment is based on the best available information as at June 2013, including scientific data, expert opinion, and Traditional Owner and stakeholder knowledge.

All references are cited in the text and listed at the end of each chapter. The web addresses provided were correct at the time of printing.

In addition to peer-reviewed literature, much of the information and synthesis is drawn from the Outlook Report 2009, as well as more detailed subsequent work. Examples include *Improving the outlook for Great Barrier Reef coastal ecosystems,*[3] the *Great Barrier Reef Biodiversity Conservation Strategy 2013*[4] and its supporting vulnerability assessments,[13] the *Recreation Management Strategy for the*

Great Barrier Reef Marine Park,[14] and the *2013 Scientific Consensus Statement Update* and supporting evidence*.*[15,16,17,18,19]

Information received from stakeholders through meetings, workshops and surveys in the latter half of 2012 contributed to the assessments of the Region's values, impacts occurring on those values, and management effectiveness, including potential areas for improvement.

Information relevant to Indigenous heritage values has been sourced from literature; meetings, workshops and surveys undertaken specifically for the strategic assessment in the latter half of 2012; and direct conversations with Traditional Owners. The Authority acknowledges and adopts the principle that Traditional Owners of the Region are the primary source of information on the value of their culture and heritage and how it is best managed and conserved. The Authority has developed long and lasting relationships with the Region's Traditional Owners and understands the importance of identifying Traditional Owners and other Indigenous people with rights and interests in the area, and of talking with the Traditional Owners who have the cultural authority to speak for their sea country. In addition, Authority staff have contributed their combined knowledge and experiences to the information provided. Some staff members are Traditional Owners of the Region or are Aboriginal or Torres Strait Islander people who have strong cultural connections with the Region. They have shared aspects of their cultural knowledge for the assessment.

Eight Sustainable Regional Development Program projects, funded by the Australian Government, were undertaken during 2012–13 to address a number of important knowledge gaps for matters relevant to the strategic assessment. Where available, relevant outcomes of these projects are incorporated into the report and the reports cited. These projects are:

- *Improved dredge material management for the Great Barrier Reef Region*[20]: To provide improved information on which to base dredge spoil management decisions for the five major ports in the Great Barrier Reef World Heritage Area.
- *Ship anchorage management in the Great Barrier Reef World Heritage Area*[21]: To identify environmental impacts of existing offshore anchoring for the five major Great Barrier Reef ports and the likely future impacts of increased shipping.
- *Great Barrier Reef coastal ecosystems assessment framework*[22]: To examine development impacts in selected basins within the Great Barrier Reef coastal zone to assess present and future development pressures and potential offset opportunities.
- *Great Barrier Reef resilience decision framework*[23]: To develop a resilience framework to inform decision making in the Great Barrier Reef coastal zone.
- *Economic contribution of the Great Barrier Reef*[24]: To update understanding of the Great Barrier Reef's economic contribution, including analysis of commercial and non-commercial uses and detailed regional-scale analysis.
- *Geological and geomorphological features of outstanding universal value in the Great Barrier Reef World Heritage Area*[6]: To identify geological and geomorphological features of outstanding universal value that may not have been previously identified and provide an overview of the pressures affecting values.
- *Defining the aesthetic values of the Great Barrier Reef World Heritage Area*[25]: To identify and map aesthetic values and analyse the sensitivity of those values to impacts.
- *Integrated monitoring framework for the Great Barrier Reef World Heritage Area*[26]: To establish a framework for a standardised and integrated ecological, social and economic monitoring program to address critical information needs, align existing monitoring programs and provide a baseline for assessing the condition of values and effects of pressures, as well as the impact on those values. This project was also funded through the National Environmental Research Program — Marine Biodiversity Hub.

2.11 Consultation and engagement

An engagement plan provided a structured approach to consultation and engagement, based around four objectives:

- to improve decision-making by gathering a range of information, views and experiences from Traditional Owners and stakeholders as part of the strategic assessment process
- to provide a transparent framework for the development of a common understanding of the broad range of issues and to foster informed and engaged Traditional Owners and stakeholders as part of the process
- to seek feedback from Traditional Owners and stakeholders on the potential impact of different approaches, acknowledging that there may not be consensus
- to provide a mechanism to better understand implementation issues that may need to be considered.

2.11.1 Authority's advisory committees

Throughout the assessment process the Authority consulted with its established expert and community advisory groups:

- Four expertise-based Reef Advisory Committees provided advice on catchment and coastal, ecosystem, Indigenous, and tourism and recreation issues.
- Twelve community-based Local Marine Advisory Committees provided advice on management issues across the Region. There are committees for Cape York, Douglas, Cairns, Cassowary Coast, Hinchinbrook, Townsville, Bowen–Burdekin, the Whitsundays, Mackay, Capricorn Coast, Gladstone and Burnett.

The Reef Advisory Committees provided advice on elements of the strategic assessment as part of their normal meetings. Since June 2011, when development of a strategic assessment was first proposed, the matter has been an item for all of the 13 Reef Advisory Committee meetings held. Topics considered include the assessment's terms of reference, cumulative impact assessment approaches, the technical assessment framework, stakeholder engagement and the demonstration case studies. Out of session, members also participated in the online survey of management effectiveness (see Section 2.11.3 below).

In addition, 39 Reef Advisory Committee members provided further advice at the combined Reef Advisory Committee workshop on the strategic assessment in February 2013.

Similarly, members of the Local Marine Advisory Committees provided input at their regular meetings and at 'mini-workshops' (see Section 2.11.2 below). In addition, representatives of each committee contributed at the Local Marine Advisory Committee Chairs' meeting in October 2012 and the strategic assessment workshop in February 2013.

Participants at the Local Marine Advisory Committee Chairs' meeting in October 2012 also provided input on a number of the demonstration case studies, particularly on those that are regionally specific, as well as feedback on the proposed approach for benchmarking outstanding universal value.

2.11.2 Traditional Owner and stakeholder input

Opportunities for broader Traditional Owner and stakeholder input were provided through a series of purpose-designed workshops and follow-up surveys.

This targeted consultation achieved representation from a diverse range of interests including Traditional Owners; local government; ports, shipping and related development sectors; mining and resource sectors; research organisations; tourism operators; commercial fishers; recreational users including fishers; natural resource managers; farmers; conservation groups and the broader community.

There was a two-stage approach to seeking Traditional Owner and stakeholder input — an initial stage of understanding their values in relation to the Region, and the pressures and potential impacts on those values, followed by a second stage investigating their views of current management effectiveness and their aspirations for future management actions.

Stage one
An initial series of workshops explored Traditional Owner and stakeholder views about values and impacts. A total of 290 people attended the workshops between August and October 2012:

- Workshops were held in Cairns, Townsville and Rockhampton in August 2012.
- Twelve mini-workshops were held at the regular Local Marine Advisory Committee meetings in September 2012.
- Input from Traditional Owners was gathered at specific workshops in Cairns and Rockhampton in September 2012.

After the workshops, participants were invited to answer a short online survey to gain a deeper understanding of what is important to them and why. Of the 290 workshop participants, 135 people (47 per cent) responded to the survey. Results provided an indication of the relative importance that this group of people place on Great Barrier Reef values, its threats and their aspirations.

Stage two
Traditional Owners and stakeholders who participated in the stage one workshops were invited to reconvene to provide further advice on elements of the strategic assessment. Advice was sought on the key findings to date, including any discrepancies between expert opinion and on-ground community knowledge, and on future management actions which would help protect the Region's values. In addition, the independent assessors of management effectiveness provided participants with their preliminary assessment of the Authority's management effectiveness and received feedback.

The workshops were also an opportunity to update participants on the overall progress of the strategic assessment.

A total of 105 Traditional Owners and stakeholders attended workshops in Cairns, Townsville and Rockhampton in December 2012.

Outcomes
The outcomes of the Traditional Owner and stakeholder engagement were considered throughout the preparation of this report and are presented in relevant sections. The comments made during public consultation on the terms of reference were also taken into account in undertaking the strategic assessment.

The *Traditional Owner and Stakeholder Engagement – Report on Workshops and Surveys* (Appendix 5) provides a description of the process followed and the advice received.

2.11.3 Input into assessment of management effectiveness

Gathering the views of Traditional Owners and stakeholders (including members of the Authority's advisory committees) was an important part of the independent review of management effectiveness. This recognised their valuable knowledge and practical experience of management issues and the tools used by the Authority. The assessors received the views of Traditional Owners and stakeholders through:

- the Local Marine Advisory Committee Chairs meeting in October 2012, including testing an early version of the online survey for stakeholders
- the stage two Traditional Owner and stakeholder workshops (see above)
- an online survey specific to management effectiveness distributed to members of Local Marine Advisory Committees and Reef Advisory Committees, as well as participants of the regional workshops.

For the online survey, a total of 95 people made 172 assessments of 15 management topics. Participants without access to the internet were able to undertake the survey over the phone or in writing. Face-to-face interviews were undertaken with Traditional Owners to ensure their views were documented. The number of people responding to some management topics was quite low, making statistical analysis difficult. However, some general patterns of effectiveness were evident for most of the tools and were taken into account by the assessors.

2.11.4 Presentations and meetings

In addition to structured Traditional Owner and stakeholder engagement, Authority representatives met with a range of interested organisations, groups and individuals while developing the strategic assessment to inform them of the process and receive their input.

2.12 Independent review

A range of relevant experts, including members of the Reef Water Quality Protection Plan Independent Science Panel, reviewed the joint technical framework to ensure the methods used in the strategic assessments for the Great Barrier Reef Region and the adjacent coastal zone were coordinated, robust and effective.

Independent reviewers also assessed the effectiveness of the Authority's current management arrangements (see Section 2.7.6 above).

In addition, in accordance with the terms of reference, the draft Strategic Assessment Report will be peer reviewed by at least three appropriately qualified persons.

The outcomes of the independent assessment of management effectiveness and the peer review comments, together with the Authority's response, will be provided to the Minister for consideration.

2.13 Information gaps

The chapters considering drivers and activities, impacts and the current condition and trend of values conclude with an outline of key information gaps. They include the outcomes of a review of the Authority's scientific information needs, which involved consideration of existing information and policy documents that guide the Authority's priorities for research and monitoring.

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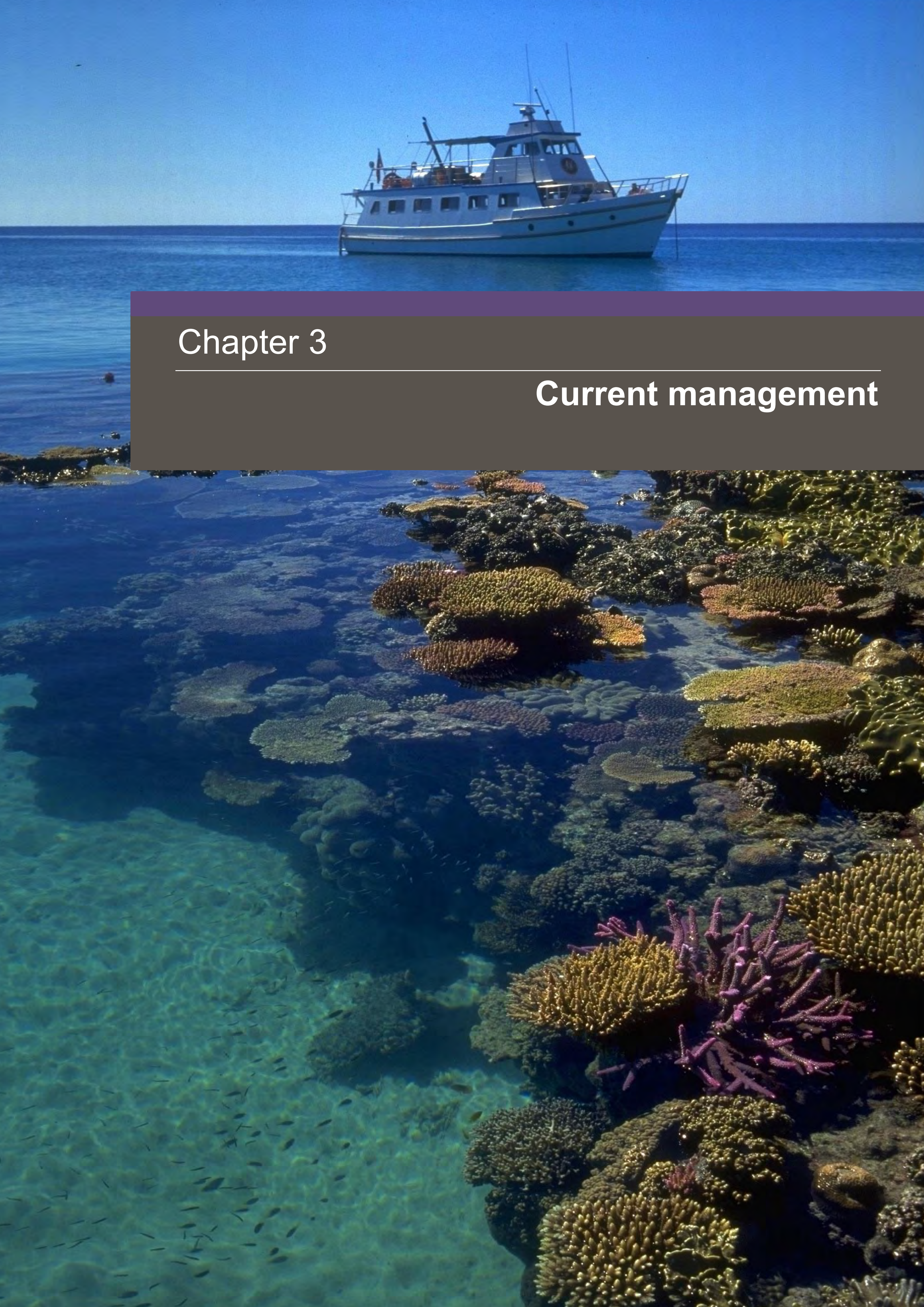

Chapter 3

Current management

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Cover page image: Vessel anchored offshore from Ellison Reef.

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

1.1 Provide an overview of the current Program*. For the purposes of the strategic assessment the life of the Program is 25 years. The overview is to include a description of:

a. the purpose of the Program, including Program objectives

b. the area to which the Program applies (the strategic assessment area)

c. legislation, plans, policies and other mechanisms that make up the Program, including Program commitments

d. relevant activities within the scope of the Program

e. international, national, state and regional context (environmental, social, cultural and economic) in which the Program operates, including activities outside the strategic assessment area that may influence the Program

f. relevant national, state, regional and local planning or management frameworks that affect the Program and contribute to protection and management the matters of national environmental significance

g. identification of how long the Program will be in effect and the process for review of the Program, including adaptive management

h. identification of the relevant authorities responsible for the implementation of the Program.

Note: In this report 'current Program' is also referred to as 'current management arrangements'.

3 Current management

This chapter provides an overview of the current management arrangements of the Great Barrier Reef Marine Park Authority (the Authority) in relation to the Great Barrier Reef Region (the Region).

The Queensland Government's contribution to the management of the Great Barrier Reef World Heritage Area and the protection of matters of national environmental significance in the Great Barrier Reef coastal zone is outlined in the complementary Great Barrier Reef Coastal Zone Strategic Assessment.

3.1 Context

Through an intergovernmental agreement, the Australian and Queensland governments have been working together for the long-term protection and conservation of the Great Barrier Reef Marine Park since its inception in 1975.

Management of the Region relies upon a number of Commonwealth and Queensland agencies to regulate access and to control or mitigate impacts associated with activities. These agencies use a combination of management tools, including zoning plans, plans of management, permits, policies and the *Reef Water Quality Protection Plan* (Reef Plan). They employ various management approaches including education, planning, environmental impact assessment, monitoring, stewardship and enforcement.

In this strategic assessment, the management arrangements under the jurisdiction of the Authority are considered. They include, but are not limited to:

- statutory instruments, including Regulations, zoning plans, plans of management and permits
- non-statutory mechanisms including policies, position statements and guidelines
- partnership and collaborative arrangements with other Commonwealth and Queensland government agencies
- partnerships with Traditional Owners in the management of marine resources
- partnership and stewardship programs, including education programs and engagement with local governments, communities, Indigenous persons and industry
- research and monitoring programs.

Based on the Authority's statutory functions as set out in the *Great Barrier Reef Marine Park Act 1975* (the Act), the Authority's management focus is the protection and conservation of the Great Barrier Reef Marine Park (the Marine Park). The Authority also assists in meeting Australia's international responsibilities in relation to the environment and protection of world heritage.

As the strategic assessment is being carried out under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), this chapter concludes with a description of how the Authority's current management arrangements, established to protect the Marine Park and assist in the protection of world heritage, also protect the other matters of national environmental significance relevant to the Region.

The description of the Authority's current management arrangements sets the basis for the assessments in later chapters including the examination of the effectiveness of the Authority's current management.

3.2 Purpose

The purpose of the Authority's current management arrangements is to achieve:

> *The long term protection, ecologically sustainable use, understanding and enjoyment of the Great Barrier Reef for all Australians and the international community through the care and development of the Marine Park.*

This is derived from the objects of the Great Barrier Reef Marine Park Act.

Objects of the *Great Barrier Reef Marine Park Act 1975* — Section 2A

(1) The main object of this Act is to provide for the long term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region.

(2) The other objects of this Act are to do the following, so far as is consistent with the main object:

- (a) allow ecologically sustainable use of the Great Barrier Reef Region for purposes including the following:
  - (i) public enjoyment and appreciation
  - (ii) public education about and understanding of the Region
  - (iii) recreational, economic and cultural activities
  - (iv) research in relation to the natural, social, economic and cultural systems and value of the Great Barrier Reef Region;
- (b) encourage engagement in the protection and management of the Great Barrier Reef Region by interested persons and groups, including Queensland and local governments, communities, Indigenous persons, business and industry;
- (c) assist in meeting Australia's international responsibilities in relation to the environment and protection of world heritage (especially Australia's responsibilities under the World Heritage Convention).

(3) In order to achieve its objects, this Act:

- (a) provides for the establishment, control, care and development of the Great Barrier Reef Marine Park; and
- (b) establishes the Great Barrier Reef Marine Park Authority; and
- (c) provides for zoning plans and plans of management; and
- (d) regulates, including by a system of permissions, use of the Great Barrier Reef Marine Park in ways consistent with ecosystem-based management and the principles of ecologically sustainable use; and
- (e) facilitates partnership with traditional owners in management of marine resources; and
- (f) facilitates a collaborative approach to management of the Great Barrier Reef World Heritage area with the Queensland government.

In managing the Marine Park, the Authority must have regard to, and seek to act in a way that is consistent with, the objects of the Act, the protection of the world heritage values of the Great Barrier Reef World Heritage Area, and the principles of ecologically sustainable use as set out in the Act, namely:

(a) decision-making processes should effectively integrate both long-term and short-term environmental, economic, social and equitable considerations
(b) the precautionary principle
(c) the principle of intergenerational equity — that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
(d) the conservation of biodiversity and ecological integrity should be a fundamental consideration in decision making
(e) improved valuation, pricing and incentive mechanisms should be promoted.

3.3 Strategic assessment area

In the Authority's agreement with the then Minister for Sustainability, Environment, Water, Population and Communities (Appendix 1), the strategic assessment area is defined as: *the Great Barrier Reef Region and areas outside the Great Barrier Reef Region, to the extent that actions in those areas may affect the Great Barrier Reef Region*.

Through its management arrangements, the Authority generally seeks to directly address activities that occur in the Marine Park and to influence activities outside this area that affect or may affect the Marine Park. Section 7(1A) of the Act states that a matter shall be taken to relate to the Marine Park if it relates to either the use or management of an area that would or might affect the Marine Park or the use of a place outside the Marine Park for a purpose relating to the Marine Park.

In regard to actions that may pollute water in a manner harmful to animals and plants in the Marine Park, Section 66(2)(e) of the Act provides the capacity to make a regulation to regulate or prohibit these actions, whether they are within the Marine Park or elsewhere.

3.4 Integrated management

3.4.1 Jurisdiction

Both the Australian and Queensland governments have direct legislative responsibilities within the World Heritage Area (Figure 3.1). Under Australia's constitution, regulation of natural resource management and environment protection on land are primarily the responsibility of state governments — in this case, Queensland. However, matters of national environmental significance, including world and national heritage properties and their values, are protected through national regulation.

The Australian and Queensland governments work in partnership to protect and manage the Region. The Queensland Government's role in the operation, management and regulation of the Region is based on:

- state title to Australia's territorial sea to a distance of three nautical miles from the territorial sea baseline (low water mark along the coast including the coast of islands). However, Queensland's rights over its coastal waters are subject to the operation of the Great Barrier Reef Marine Park Act, resulting in the Commonwealth having jurisdiction to regulate, through the Act, all waters within the Great Barrier Reef Marine Park in respect of matters relating to the Marine Park
- a role for the Queensland Government in management of the Marine Park, particularly permanent membership of the Marine Park Authority Board
- the ability for the Authority to delegate to Queensland Government officers or employees to act on the Authority's behalf where an arrangement is in force with the Queensland Government to enable this to occur
- the Queensland Government being responsible for the management of fisheries in the waters adjacent to the Queensland coast (including within the Marine Park). The Authority has a regulatory role in the management of fishing through its Zoning Plan and Regulations, as well

as permit requirements for a limited number of commercial and developmental fisheries. The Authority has an advisory role to other agencies in relation to the management of fisheries in the Region. The Commonwealth Department of Sustainability, Environment, Water, Population and Communities also has responsibilities relating to fisheries in the World Heritage Area through implementation of the EPBC Act. This requires the Australian Government to assess the environmental performance of those fisheries with an export component and promote ecologically sustainable management.

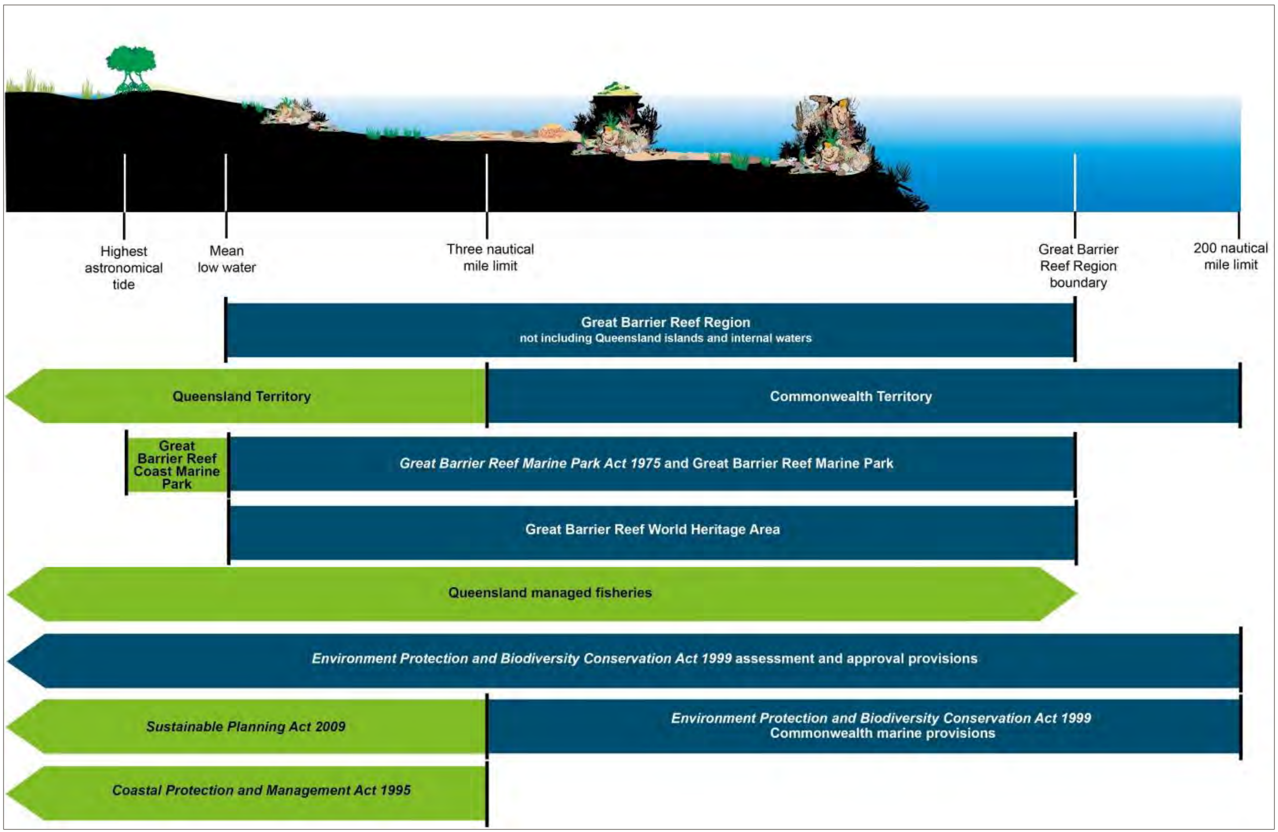

Figure 3.1 Jurisdictional boundaries for the Great Barrier Reef Region

The Great Barrier Reef encompasses both Commonwealth and Queensland jurisdictions. An agreement to jointly manage marine parks ensures integrated field management of both the Great Barrier Reef Marine Park and the adjacent Great Barrier Reef Coast Marine Park. Queensland territory extends from the land to the three nautical mile limit. Fisheries management, within the Region and beyond, is a Queensland Government responsibility. The assessment and approval provisions of the *Environment Protection and Biodiversity Conservation Act 1999* apply throughout the Region; however, its Commonwealth marine area provisions apply only in Commonwealth Territory. Adapted from the *Great Barrier Reef Outlook Report 2009*[1].

The Queensland Government manages the Great Barrier Reef Coast Marine Park, established under the *Marine Parks Act 2004* (Qld). This adjoins the Great Barrier Reef Marine Park and covers the area between low water mark and highest astronomical tide and Queensland's internal waters.

The State of Queensland has jurisdiction over approximately 980 islands. About 400 of these contain national parks under the *Nature Conservation Act 1992* (Qld) and are managed as part of the joint Field Management Program (see Section 3.8). The remaining Queensland islands have a variety of tenures (freehold, leasehold and unallocated state land) and are not part of the Field Management Program. They are managed by a range of other Queensland Government agencies and local governments.

Approximately 70 Commonwealth islands are part of the Great Barrier Reef Marine Park. Twenty-one of these include navigational lights or lightstations and in 1988 responsibility for management of those islands was transferred from the Australian Maritime Safety Authority to the Great Barrier Reef Marine Park Authority. The Australian Maritime Safety Authority remains responsible for the operation of the navigation lights and leases back this portion of land. The Authority manages Kent Island, Pipon Island, Unnamed Island (Pipon Island Group), Russell Island, North Reef Island, Low Isles, Pine Islet, Lady Elliot Island, Albany Rock, Coppersmith Island, Hannah Island, Bailey Islet, Clerke Island, Coquet Island, Eshelby Island, Hannibal Island, High Peak Islet, Rocky Island and South Brook Island, together with parts of Dent and Penrith Islands.

The Department of Defence is responsible for all the remaining Commonwealth islands in the Region, except for Little Fitzroy Island which is owned by the Department of Finance and Deregulation.

Development and land use activities in adjacent coastal and water catchment areas play a critical role in the health and resilience of the Great Barrier Reef. The Queensland Government is responsible for natural resource management and land use planning on Queensland islands, and the coast and hinterland adjacent to the Region, including through the *Sustainable Planning Act 2009* and the *Coastal Protection and Management Act 1995*.

Under the EPBC Act, the Australian Government is responsible for regulating activities having or likely to have a significant impact on matters of national environmental significance, whether they are undertaken in or outside of the Region.

3.4.2 Great Barrier Reef Intergovernmental Agreement

The Australian and Queensland governments' cooperative approach to management of the Great Barrier Reef was initially formalised by the Emerald Agreement in 1979 and was updated by the Great Barrier Reef Intergovernmental Agreement in 2009.

The objective of this latest agreement is to ensure an integrated and collaborative approach is taken by the Australian and Queensland governments to manage marine and land environments within and adjacent to the Great Barrier Reef World Heritage Area so as to:

- provide for the long-term protection and conservation of the environment and biodiversity of the Great Barrier Reef ecosystem, as encompassed by the World Heritage Area, and its transmission in good condition to future generations
- allow ecologically sustainable use of the Great Barrier Reef ecosystem subject to the overarching objective of long-term protection and conservation
- provide for meeting Australia's international responsibilities for the World Heritage Area under the World Heritage Convention.

To achieve these objectives, the agreement includes each government's ongoing commitment to:

- prohibit activities for the exploration and recovery of minerals or petroleum, and any drilling and mining within the World Heritage Area, including for the purposes of depositing materials
- maintain complementarity of relevant Commonwealth and Queensland management arrangements, in particular: marine park legislation and associated Regulations; zoning plans and plans of management; planning and development arrangements; environmental assessment and permit requirements; management of fishing activities
- continue a Commonwealth–Queensland Ministerial Council to facilitate implementation and achievement of the objectives of this agreement
- continue a joint program of field management, with shared funding on a 50:50 basis, for the Great Barrier Reef Marine Park and Queensland marine and national parks within the World Heritage Area
- continue joint action to halt and reverse the decline in quality of water entering the Reef
- continue joint action to maximise the resilience of the Reef to climate change
- address significant threats to the health and biodiversity of the Reef ecosystem, including pollution from the land and sea, the impacts of climate change, ecologically unsustainable fishing activities and other resource extraction activities
- periodically review the condition of the Reef ecosystem and any need for further action
- ensure that Indigenous traditional cultural practices continue to be recognised in the conservation and management of the Reef.

3.4.3 Great Barrier Reef Ministerial Forum

The Great Barrier Reef Ministerial Council was established under the 1979 Emerald Agreement and arrangements for the Council were updated through the Great Barrier Reef Intergovernmental Agreement in 2009. From 1 July 2011, the Council has been called the Great Barrier Reef Ministerial Forum.

The Ministerial Forum is comprised of two ministers each from the Australian and Queensland governments, with responsibility for matters relating to the environment and marine parks, science, tourism and/or natural resource management. Ministers responsible for mining may not be members.

The Ministerial Forum's role is strategic in that it facilitates and oversees implementation and achievement of the objectives of the intergovernmental agreement. The Ministerial Council met 32 times under the 1979 Emerald Agreement. Four meetings have been held under the 2009 intergovernmental agreement.

Key strategic initiatives of the Great Barrier Reef Ministerial Forum and Ministerial Council include establishment of the joint Field Management Program in 1979, implementation of zoning plans, the establishment of Dugong Protection Areas, endorsement of the Reef Water Quality Protection Plan, and agreement to conduct a comprehensive strategic assessment of planned and potential coastal development affecting the Great Barrier Reef.

Since the integrated governance and management model for the Great Barrier Reef has been in place it has facilitated development of complementary federal and state legislation, integrated management with relevant federal and state agencies, and guided the application of ecosystem-based management principles both inside and outside marine park boundaries. Indeed, it is considered by many to be the "gold standard" for large-scale marine protected area management.[2]

3.5 Legislation and conventions

The principal legislation relating to protection and management of the Region is the Commonwealth Great Barrier Reef Marine Park Act and its supporting Great Barrier Reef Marine Park Regulations 1983 (the Regulations).

In addition, there is a range of other Commonwealth and Queensland legislation relevant to management of the Region. Management is also guided by Australia's obligations under relevant international conventions.

The legislation and conventions relevant to the Region are listed below:

Great Barrier Reef Marine Park legislation

- *Great Barrier Reef Marine Park Act 1975* is the primary Act in respect to the Great Barrier Reef Marine Park.
- Great Barrier Reef Marine Park Regulations 1983 are the primary Regulations in force under the *Great Barrier Reef Marine Park Act 1975*.
- Great Barrier Reef Marine Park (Aquaculture) Regulations 2000 regulate the discharge of waste from aquaculture operations outside the Marine Park which may affect animals and plants within the Marine Park.
- *Great Barrier Reef Marine Park (Environmental Management Charge–Excise) Act 1993* and *Great Barrier Reef Marine Park (Environmental Management Charge–General) Act 1999* govern operation of the environmental management charge.
- Great Barrier Reef Marine Park Zoning Plan 2003 is the primary planning instrument for the conservation and management of the Marine Park.
- Cairns Area Plan of Management 1998, Whitsundays Plan of Management 1998, Hinchinbrook Plan of Management 2004 and Shoalwater Bay (Dugong) Plan of Management 1997 establish more detailed management arrangements for specific areas of the Marine Park.

Other Commonwealth legislation

- *Environment Protection and Biodiversity Conservation Act 1999* regulates actions that have, will have or are likely to have, a significant impact on matters of national environmental significance.
- *Environment Protection (Sea Dumping) Act 1981* prohibits dumping of waste or other matter from any vessel, aircraft or platform in Australian waters unless a permit has been issued.
- *Historic Shipwrecks Act 1976* prohibits certain activities in relation to historic shipwrecks and relics and requires discoveries to be notified.
- *Native Title Act 1993* recognises and protects native title and includes a mechanism for determining claims to native title.
- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* gives effect to Australia's commitments under the *International Convention for the Prevention of Pollution from Ships.*
- *Sea Installations Act 1987* regulates the installation of structures including tourism pontoons and power cables.

Queensland legislation

- *Coastal Protection and Management Act 1995*
- *Environmental Protection Act 1994*
- *Fisheries Act 1994*
- *Local Government Act 1993*
- *Marine Parks Act 2004*
- Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004
- *Native Title (Queensland) Act 1993*
- *Nature Conservation Act 1992*
- *State Development and Public Works Organisation Act 1971*
- *Sustainable Planning Act 2009*
- *Transport Operations (Marine Pollution) Act 1995*
- *Transport Operations (Marine Safety) Act 1994*
- *Transport Infrastructure Act 1994*
- *Vegetation Management Act 1999*
- *Water Act 2000*
- *Workplace Health and Safety Act 1995*

International agreements

- Convention concerning the Protection of the World Cultural and Natural Heritage, 1972
- Convention on Biological Diversity, 1992
- Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973
- Convention on the Conservation of Migratory Species of Wild Animals, 1979
- Convention on Wetlands of International Importance Especially as Waterfowl Habitats, 1971
- China–Australia Migratory Bird Agreement, 1986
- International Convention for the Prevention of Pollution from Ships, 1973
- Japan–Australia Migratory Bird Agreement, 1974
- Republic of Korea–Australia Migratory Bird Agreement, 2007
- United Nations Convention on the Law of the Sea, 1982
- United Nations Framework Convention on Climate Change, 1992

Supporting community-based management of sea country — Lama Lama people

Traditional Use of Marine Resources Agreements are a management tool available to Traditional Owners which recognise traditional lore, customary rights and traditional ecological knowledge in managing sea country through a formal partnership arrangement with the Authority and the Queensland Government. The agreements are developed by Traditional Owners to conserve biodiversity and protect their cultural and natural heritage values. The process of developing a marine resources agreement is managed by Traditional Owners, with support from the Authority, involving extensive consultation and negotiation within the Traditional Owner group. Through the structured planning process, the group documents its structure, governance, history, lore, custom and aspirations for managing sea country.

The Authority supports implementation of Traditional Use of Marine Resources Agreements by helping communities to develop implementation and compliance plans. In some areas, such as the Girringun region and Port Curtis Coral Coast, these plans have been incorporated into and implemented on country through federally-funded Indigenous ranger programs.

After a three year development phase, Lama Lama Traditional Owners have recently had accredited a Traditional Use of Marine Resources Agreement developed with the Authority and the Queensland Government. The group looks forward to putting many of its plans into action through the partnership arrangement with the Authority.

> *This is an exciting time as we work to implement our ideas and thoughts to manage our sea country resources in the best possible way, not only for current Lama Lama people but for our future generations as well.*

Lama Lama Traditional Owners, at Maarpa Island

During the development of their agreement, the Lama Lama people outlined how they plan to manage sea country resources such as turtle and dugong, and identified and documented culturally important areas of their sea country. Community meetings provided opportunities for Lama Lama Traditional Owners to come together, reach consensus and discuss aspirations for management of their sea country including hunting, conservation measures, science partnerships, future priorities and economic opportunities.

Meetings on sea country provided an important opportunity for the group, as elders and children have been able to visit various culturally significant sites within Princess Charlotte Bay. Children were shown the Marrpa (Cliff) Islands and rock art on Ronganhu. They also explored the islands and talked about custom and culture.

The Authority supported the Lama Lama Traditional Owners' recent successful application for a Fisheries Research and Development Corporation Indigenous Development Scholarship. The scholarship will sponsor a Lama Lama representative to visit a Pacific Island community to exchange information and learn about its ways of sea country management; traditional ecological knowledge; partnerships other communities have established with groups such as conservation volunteers; and how communities have established turtle and dugong ecotourism. Recognising the value of the knowledge exchange trip, the Authority is sponsoring an additional two Lama Lama Traditional Owners to join the trip. The information can then be shared with the broader Lama Lama community. The Authority will be the host organisation and will provide mentoring as well as technical and financial support. The scholarship will also sponsor five Lama Lama land and sea rangers to visit the Torres Strait Regional Authority's Land and Sea Management Unit to complete their coxswain training, with technical and mentoring support from the Authority.

Lama Lama children playing at Maarpa Island

Establishing relationships with James Cook University researchers has also been identified as a priority for the Lama Lama Traditional Owners. The possibility of researching inshore dolphins has already been investigated and resulted in the university providing dolphin identification training to the group. It has also led to a plan to bring a research vessel to Port Stewart to work with the rangers to undertake research on Lama Lama sea country.

3.6 Management tools

The Authority uses a wide range of tools to manage the Region:

- Acts and Regulations
- Zoning Plan
- plans of management
- permits (including environmental impact assessment)
- fees and charges
- Traditional Owner agreements
- compliance
- site infrastructure
- policy (including strategies, policies, position statements, site management arrangements and guidelines)
- partnerships
- stewardship and best practice
- education and community awareness
- research and monitoring
- reporting.

Each of these management tools is described in detail in Table 3.1.

An emerging management tool is offsets. These are measures that compensate for the residual impacts of an action on the environment, after avoidance and mitigation measures are taken. Where appropriate, offsets are considered during the assessment phase of an environmental impact assessment under the EPBC Act. The Great Barrier Reef Marine Park Regulations provide for permissions to be granted, subject to the provision of a security or financial guarantee for the recovery, restoration or removal of a structure and/or requiring the permission holder to make a financial contribution to undertake specified activities to protect the environment of the Marine Park.

Table 3.1 Management tools employed to protect and manage the Great Barrier Reef Region and relevant matters of national environmental significance

Management tool	Purpose	Current components and activities
Acts and Regulations	The *Great Barrier Reef Marine Park Act 1975* and Regulations govern the protection and management of the Great Barrier Reef Marine Park. They provide for the Zoning Plan and plans of management, and govern permitting decisions. The provisions are matched in areas of Queensland jurisdiction by the *Marine Parks Act 2004* and Regulations. Other Commonwealth and Queensland legislation also applies in the Region, for example the *Environment Protection and Biodiversity Conservation Act 1999.*	• *Great Barrier Reef Marine Park Act 1975* • Great Barrier Reef Marine Park Regulations 1993 • Providing advice, for example on projects assessed under the *Environment Protection and Biodiversity Conservation Act 1999* • Coordinating application of the Queensland *Marine Parks Act 2004* and Regulations, for example in relation to joint marine parks permits
Zoning Plan	Provides spatial control of use and, to a lesser extent, access within the Great Barrier Reef Marine Park. Establishes the framework for extractive use and the need for permits for some uses, such as tourism, infrastructure and research. Zoning plans are developed under Part 5 Division 2 of the *Great Barrier Reef Marine Park Act 1975.* Complementary arrangements are in place in adjacent areas under Queensland jurisdiction.	• Great Barrier Reef Marine Park Zoning Plan 2003
Plans of management	Set out specific arrangements for activities, areas, species or ecological communities. They complement zoning and permitting arrangements. Some components are legally binding. Plans of management are developed under Part VB of the *Great Barrier Reef Marine Park Act 1975.* There is the capacity for the Authority to enter into agreements or arrangements for management of an area, species or ecological community with a community group having a special interest in an area, including some form of native title.	• Cairns Area Plan of Management 1998 • Hinchinbrook Area Plan of Management 2004 • Whitsundays Plan of Management 1998 • Shoalwater Bay (Dugong) Plan of Management 1997
Permits (including environmental impact assessment)	Facilitate opportunities for sustainable use of the Marine Park. Permits are issued mainly for tourism, research, harvest fisheries, dredging and infrastructure (e.g. jetties and marinas) and include detailed risk-based environmental impact assessment. Matched in adjacent areas of Queensland jurisdiction, generally providing a joint permit. Fisheries licences are issued and managed by the Queensland Government.	• Permits granted under Part 2A of the Great Barrier Reef Marine Park Regulations 1983 and under Queensland Marine Parks Regulations 2006
Traditional Owner agreements	Traditional Use of Marine Resources Agreements are formal agreements describing how Traditional Owner groups work with Australian and Queensland governments to manage traditional activities in sea country. They are made in accordance with Part 2B of the Regulations. They do not affect the operation of section 211 of the *Native Title Act 1993* and are not intended to extinguish native title	• Kuuku Ya'u People's Indigenous Land Use Agreement • Traditional Use of Marine Resources Agreements for Girringun region; Dharumbal–Woppaburra section; Wuthathi region; Port Curtis Coral Coast; Lama Lama region; Yuku-Baja-Muliku region

Management tool	Purpose	Current components and activities
	rights and interests. Indigenous Land Use Agreements are between one or more native title groups and other people or parties about the use and management of land and waters.	
Compliance	Activities that encourage adherence with legal requirements, both through education and enforcement.	• Eyes and Ears Incident Reporting program • Field Management Program jointly undertaken with the Queensland Government
Site infrastructure	On-ground infrastructure is installed to manage use and protect the values of individual sites. Implemented and maintained by the Authority and the Queensland Government through the Field Management Program.	• No-anchoring areas • Public moorings • Reef protection markers • Signs • Transit lanes
Fees and charges	Three main fees and charges apply in the Marine Park: • The cost of assessing an application for a permit for commercial activities is partly recovered through payment of a permit application assessment fee. • The environmental management charge applies to some commercial activities operating under a permit issued by the Authority. The revenue is applied to Marine Park management. • Bonds (usually as a bank guarantee) may be held by the Authority to cover the risks associated with a proposed activity.	• Permit application assessment fees are currently charged for activities of a commercial nature including tourist programs; vessel chartering; construction or maintenance of a facility; operation of a land-based sewage outfall; and the construction and operation of a mooring. • Most tourism visitors to the Marine Park pay the environmental management charge. For operations involving the hire of equipment, installation and operation of tourist facilities, and sewage outfalls, quarterly charges are paid by the operator. • Bonds are generally secured as part of a deed of agreement between the permittee and the Authority.
Policy	Developed by the Authority, under section 7(4) of the *Great Barrier Reef Marine Park Act 1975,* detailing the way in which the Authority intends to manage the Marine Park or perform its other functions. Policy documents are not legislative instruments. They are specific arrangements that guide decision makers and the public. Types of policy documents include: strategies, policies, site management arrangements, position statements and guidelines.	**Strategies** • *Great Barrier Reef Biodiversity Conservation Strategy 2013* • *Great Barrier Reef Climate Change Adaptation Strategy and Action Plan 2012–17* • *Great Barrier Reef Heritage Strategy 2005* • *Recreation Management Strategy for the Great Barrier Reef Marine Park* **Policies** • Cruise shipping policy for the Great Barrier Reef Marine Park • Dredging and spoil disposal • Environmental impact management • Managing activities that include the direct take of a protected species from the Great Barrier Reef Marine Park • Managing bareboat operations in the Great Barrier Reef Marine Park • Managing scientific research in the Great Barrier Reef Marine Park • Managing tourism permissions to operate in the Great Barrier Reef Marine Park (including allocation, latency and tenure) • Marine tourism contingency plan for the Great Barrier Reef Marine Park

Management tool	Purpose	Current components and activities
		• Moorings in the Great Barrier Reef Marine Park • Operational policy on whale and dolphin conservation in the Great Barrier Reef Marine Park • Sewage discharges from marine outfalls to the Great Barrier Reef Marine Park • Structures **Site management arrangements** • Site plans for Raine Island, Moulter Cay and Maclennan Cay; Clump Point, Mission Beach; Low Isles, offshore from Port Douglas; Michaelmas Cay locality; Upolu Cay Reef; Bauer Bay; South Molle Island; Blue Pearl Bay, Hayman Island; Whitsundays Plan of Management setting 5 site plans; Tongue Bay; Hill Inlet and Whitehaven Beach; Fitzroy Reef; Keppel Bay and islands; Lady Elliot Island Reef; Lady Musgrave Island Reef **Position statements** • Aquaculture within the Great Barrier Reef Marine Park • Conservation of dugongs in the Great Barrier Reef Marine Park • Indigenous participation in tourism and its management • Management of commercial jet ski operations around Magnetic Island • Management of tourist flights in the vicinity of Magnetic Island • Management of memorials within the Great Barrier Reef Marine Park • Managing access to the Restricted Access Special Management Areas surrounding Raine Island, Moulter Cay and Maclennan Cay • Marine tourism contingency plan for the Great Barrier Reef Marine Park • No structures sub-zones • Translocation of species in the Great Barrier Reef Marine Park **Guidelines** • Coral transplantation • Emergency disposal of foreign fishing vessels • Management of artificial reefs in the Great Barrier Reef Marine Park • Managing visitation to seabird breeding islands • Permits Information Bulletin — no structure sub-zones • Use of hydrodynamic numerical modelling for dredging projects in the Great Barrier Reef Marine Park
Partnerships	Formal arrangements, often executed through a memorandum of understanding or an agreement, to enable a partnership approach to management of the Marine Park.	• Great Barrier Reef Intergovernmental Agreement 2009 between the Australian and Queensland governments • High Standard Tourism program with Ecotourism Australia • Management agreement with the Department of Defence on the implementation of the strategic environmental assessment of defence activities in the Marine Park. • Marine Strandings Hotline

Management tool	Purpose	Current components and activities
		• Memorandum of understanding with the Department of the Environment, Water, Heritage and the Arts relating to the integration and application of the *Environment Protection and Biodiversity Conservation Act 1999* and the *Great Barrier Reef Marine Park Act 1975* • Memorandum of understanding with Queensland ports on port activities in or adjacent to the Great Barrier Reef Marine Park (2009) • Local Marine Advisory Committees • Reef Advisory Committees
Stewardship and best practice	Voluntary arrangements with stakeholders that provide the opportunity for contributions to protection and management. Provision of expertise and advice to stakeholders and natural resource management bodies.	• Eyes and Ears Incident Reporting program • Eye on the Reef monitoring program • Low Isles Preservation Society • Marine Contingency Coordination Framework for Environmental Incidents • Marine monitoring program water quality monitoring volunteers • Pro-vision Reef Stewardship Action Plan • Reef Guardian program, including schools, councils, fishers, farmers and graziers, and tourism (in development) • Responsible Reef Practices (for tourism and recreational users)
Education and community awareness	Programs to inform and motivate members of the community about the Great Barrier Reef and its protection and management, including ways they can contribute.	• Community Access Points which distribute zoning maps and educational material • Onboard website for tourism operators • Reef Guardian Schools • Reef HQ Aquarium • The Authority's publications including Reef in Brief and fact sheets • The Authority's websites and social media channels
Research and monitoring	Undertaken, commissioned or partnered by the Authority to better inform decisions on protection and management of the Great Barrier Reef, guided by the Authority's S*cientific information needs for the management of the Great Barrier Reef Marine Park 2009–2014*.	• Commissioned research projects to address specific management issues • Eye on the Reef monitoring program • Independent and partnered research by research institutions and the Great Barrier Reef Foundation • Marine monitoring program • National Environmental Research Program, Tropical Ecosystems Hub, 2011–2015
Reporting	Undertaken by the Authority to meet statutory, national and international obligations, and to provide direction for strategic planning within the agency.	• Field Management business strategy (annual) • Great Barrier Reef Marine Park Authority annual report • Great Barrier Reef Outlook Report (five-yearly) • World Heritage periodic reporting (six-yearly)

3.7 Management activities

The Authority's management tools are designed to protect values and allow ecological sustainable use. The current management activities of the Authority are grouped into 15 topics covering the major uses and the most serious areas of risk to the Region. The groupings are based on the management topics considered in the *Great Barrier Reef Outlook Report 2009*[1], with amendments to reflect emerging issues.

The management topics addressed by the Authority are:

Values

- biodiversity protection
- heritage (Indigenous and historic)
- community benefits

External impacts on values

- climate change and extreme weather
- water quality protection (catchment run-off)
- coastal development (protection of coastal ecosystems)

Direct use

- tourism (marine-based)
- fishing – commercial
- fishing – recreational
- recreation
- port activities
- shipping
- defence activities
- research activities.

Management tools are applied as appropriate to each management topic. The tools applied to each topic are summarised in Table 3.2.

Table 3.2 Management tools used to address management topics in the Great Barrier Reef Region

		Management topic														
	Management tool	Biodiversity protection	Indigenous heritage	Historic heritage	Community benefits	Climate change and extreme weather	Water quality protection	Coastal development	Tourism	Fishing — commercial	Fishing — recreational	Recreation	Port activities	Shipping	Defence activities	Research activities
Regulatory	Acts and Regulations	●	●	●	●		●	●	●	●	●	●	●	●	●	●
	Zoning plans	●	●	●	●		●	●	●	●	●	●	●	●	●	●
	Plans of management	●	●	●	●				●	●	●	●			●	●
	Permits	●	●	●	●		●		●	●*		●	●	●		●
	Traditional Owner agreements	●	●		●											
	Compliance	●	●	●	●		●		●	●	●	●	●	●	●	●
	Site infrastructure	●	●	●	●				●		●	●				
	Fees and charges						●		●	●*			●			
Non-regulatory	Policy	●	●	●		●	●	●	●			●	●			●
	Partnerships	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Stewardship and best practice	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Education and community awareness	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Research and monitoring	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Reporting	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

*commercial harvest fisheries only

3.8 Partners in management

In addition to the Australian and Queensland governments' partnership established through the intergovernmental agreement, the Authority has partnership arrangements or stewardship programs with Traditional Owners, industry sectors, community groups and individuals who directly participate in protection and management of the Great Barrier Reef. The main contributors to protection and management are listed below:

Australian Government

- **Great Barrier Reef Marine Park Authority**
  Protects and manages the Great Barrier Reef Marine Park.
- **Department of Sustainability, Environment, Water, Population and Communities**
  Develops and implements national policies, programs and legislation to protect and conserve Australia's natural environment and heritage. Responsible for implementing the Environment Protection and Biodiversity Conservation Act.
- **Department of Climate Change and Energy Efficiency**
  Leads the development and coordination of Australia's climate change policies and programs.
- **Australian Customs Service**
  Enforces a range of Commonwealth laws at sea and at various international entry points, including ports. Coastwatch provides aerial surveillance of Australian coastal waters.
- **Australian Maritime Safety Authority**
  Manages shipping activities throughout the Great Barrier Reef Region. Coordinates emergency responses to marine emergencies and marine pollution, for example oil spills.
- **Australian Quarantine Inspection Service**
  Responsible for quarantine inspection services for all vessels entering Australian waters.
- **Department of Agriculture, Fisheries and Forestry**
  Develops and implements policies and programs to ensure Australia's agricultural, fisheries, food and forestry industries remain competitive, profitable and sustainable.
- **Department of Defence**
  Responsible for all defence activities within the Great Barrier Reef Region, including the management of defence activities in designated defence training areas.
- **Department of Resources, Energy and Tourism**
  Develops and delivers policies to increase Australia's international competitiveness in relation to resources, energy and tourism, consistent with the principles of environmental responsibility and sustainable development.
- **Australian Institute of Marine Science**
  Undertakes research that supports management of tropical marine environments — the Great Barrier Reef World Heritage Area is a primary focus.
- **CSIRO**
  Australia's national science agency.

Queensland Government

- **Department of National Parks, Recreation, Sport and Racing**
  The **Queensland Parks and Wildlife Service** is responsible for day-to-day field management in the Great Barrier Reef Marine Park and the adjacent Great Barrier Reef Coast Marine Park, as well as island and mainland national parks.
- **Department of Environment and Heritage Protection**
  Responsible for management of Queensland's environment, including water, salinity, native title and threatened species. It is the Queensland Government's lead agency on environmental management matters including the assessment and approval of works in intertidal areas, internal waters and the Great Barrier Reef catchment.
- **Department of Agriculture, Fisheries and Forestry**
  Responsible for management and research on fisheries and fisheries habitat in the Great Barrier Reef Region. The Queensland Boating and Fisheries Patrol enforces fisheries regulations, and marine parks and transport legislation.

- **Department of Premier and Cabinet**
  Provides overall coordination and direction for Queensland Government involvement in Great Barrier Reef matters. Within the department, the Reef Secretariat provides leadership for the *Reef Water Quality Protection Plan*.
- **Department of State Development, Infrastructure and Planning**
  Delivers major infrastructure, economic development and planning services, this includes developing regional plans along the Great Barrier Reef coast.
- **Department of Transport and Main Roads**
  Provides policy and strategic advice relating to Queensland's ports system. Within the department, **Maritime Safety Queensland** is responsible for licencing, registration and the safe navigation of vessels. It is the lead response agency for oil and chemical spills.
- **Queensland Water Police**
  Enforces marine parks legislation and investigates crimes on the water.

Other partners

- **Traditional Owners**
  Traditional Owners have inherent rights and interests over their sea country in the Region. They work with the Authority to protect cultural and heritage values, conserve biodiversity and enhance the resilience of the Great Barrier Reef.
- **Native title bodies**
  Assist in the permit referral process for applications for activities in the Marine Parks.
- **Local government**
  Responsible for local planning and development decisions and providing public services such as local roads, waste removal and water treatment within the Great Barrier Reef catchment.
- **Natural resource management bodies**
  Support natural resource management activities in the Great Barrier Reef catchment.
- **Research institutions**
  Provide improved knowledge about the Great Barrier Reef and advice on its implications for management.
- **Industry groups and individual operators**
  Organise and participate in programs that contribute to protection and management (for example, tourism operators, commercial fishers, farmers, graziers, Association of Marine Park Tourism Operators and other tourism associations, Queensland Seafood Industry Association, Growcom, Queensland Cane Growers Association and ports corporations).
- **Community groups**
  Organise and participate in community activities that help people to understand and protect the Great Barrier Reef.
- **Environmental non-government organisations**
  Raise public awareness about the state of the Great Barrier Reef and advocate for its increased conservation and protection.
- **Schools**
  Educate and engage students in marine activities and conservation.

Fishers work with government to protect dugongs in Bowling Green Bay

Between July 2010 and September 2011, there were seven dugong deaths reported in Bowling Green Bay. This was of particular concern as it is considered that recovery of the severely depleted dugong population south of Cooktown requires mortality from human causes to be as close to zero as possible. The deaths were understood to be associated with incidental capture in fishing nets. Fishing representatives from the Burdekin Sustainable Fisheries Alliance — a local stewardship initiative — worked to address this issue in partnership with the Authority, Queensland Government agencies and the Queensland Seafood Industry Association as part of the Burdekin Regional Management Project.

Alliance members developed substantial modifications to the type of large mesh net used in the high-risk areas, making the nets shorter with a shallower drop and lead core rope weighting to further reduce the risk of catching dugongs. The group also suggested that an adjacent high-risk area where dugongs were known to inhabit should be closed to mesh netting.

In 2011, following public consultation, the Authority introduced amendments to the Great Barrier Reef Marine Park Regulations 1983 in relation to commercial netting rules, designating:

- the No Netting Area where no netting activities (other than small mesh bait netting) are allowed
- the Restricted Netting Area where limited lower-risk netting activities are allowed.

The large mesh nets now allowed are restricted to the type developed by the Burdekin Sustainable Fisheries Alliance. The areas within Bowling Green Bay where the rule changes apply are shown in Figure 3.2.

Since the changes were introduced, no dugong mortalities have been reported from the area.

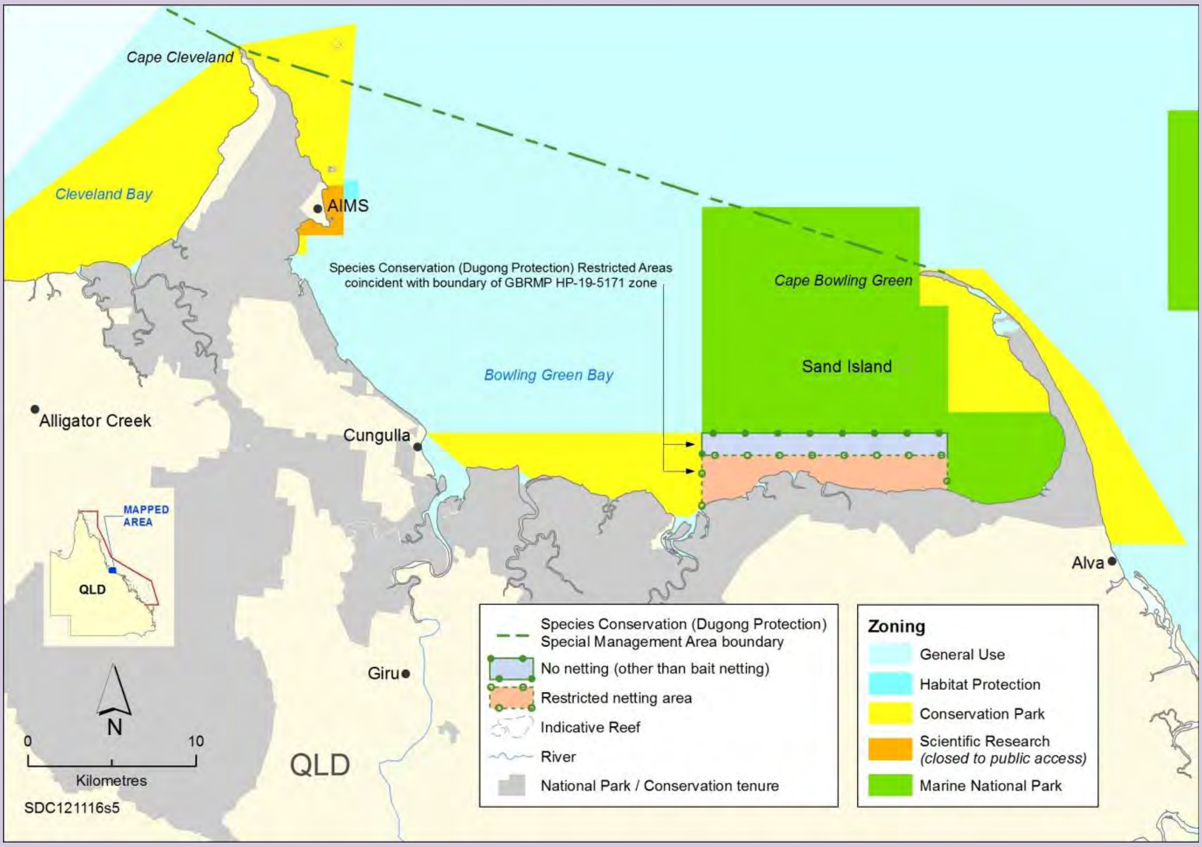

Figure 3.2 Bowling Green Bay Special Management Area

A group of net fishers is now working with researchers to trial a new net design that may further reduce the likelihood of fatal interactions with species of conservation concern, while improving safety and maintaining fishing efficiency for target species such as barramundi. The modified net has a collapsible panel that allows large animals to push through the net rather than becoming entangled. The panels are readily refitted therefore minimising any impact on fishing efficiency. A preliminary study, conducted by the Moreton Bay Seafood Industry Association, provided 'proof of concept'. The net is now being tested through a research project funded by the Fisheries Research and Development Corporation.

3.9 Field Management Program

The Field Management Program is established under the Great Barrier Reef Intergovernmental Agreement. It is at the frontline of efforts to manage the Great Barrier Reef World Heritage Area. While various initiatives deal with external threats to the Reef at their source, the Field Management Program — jointly funded by the Australian and Queensland governments — is about protecting and strengthening the resilience of the ecosystem on a day-to-day basis.

The program aims to achieve effective compliance with relevant Commonwealth and Queensland laws among Marine Park users. It also seeks to attain public use that is ecologically sustainable, with a focus on fishing, shipping, tourism, and traditional use of marine resources. In addition, the program works to protect and, where feasible, recover species of conservation concern and vulnerable habitats.

On a practical level, this work entails daily activities such as monitoring compliance of zoning rules through patrols, maintaining marine and island facilities such as camping grounds and moorings, fire and weed control on islands, engaging Traditional Owners on their sea country, and responding to boating or shipping incidents such as fuel spills. It also involves protecting key, and often remote, seabird and turtle rookeries in the 348,000 square kilometre World Heritage Area.

A joint Field Management Strategy Group, comprising representatives of the Australian and Queensland governments, oversees the Field Management Program. This group is responsible for preparing a five-year business strategy which identifies priority areas, high-level strategies, budgets and outcomes.

3.10 Management priorities

3.10.1 Current priorities

To address the challenges the Reef is facing while achieving the greatest value for the available resources, the Authority's management must be well-targeted, knowledge-based, scientifically robust and measurable.

The Authority regularly reviews its management priorities and arrangements to ensure its resources are applied most effectively to achieve the long-term protection, ecologically sustainable use, understanding and enjoyment of the Great Barrier Reef. The four current priorities and their intended effect are listed in the *Great Barrier Reef Marine Park Authority Strategic Plan 2012–2016* (Table 3.3).

Table 3.3 Current strategic priorities for the Authority
The current priorities for the Authority are set out in its *Strategic Plan 2012–2016*

Strategic priorities	Intended effect
Address the key risks affecting the outlook for the Great Barrier Reef	• The declines in coastal ecosystem health, particularly in water quality and biodiversity, are halted and reversed; and where time scales for this change are long, then plans are in place to achieve it as soon as possible. • Coastal communities and Reef users understand and have capacity to adapt to pressures of climate change and prevent damaging practices threatening Reef health.
Ensure management of the Marine Park supports ecologically sustainable use	• The natural functions and resilience of the Reef's ecosystems are maintained, or if necessary restored, through effective decisions governing natural resource management and environmental protection and working in partnership with Traditional Owners, coastal communities, Reef users and local government. • The protective legal measures built into the *Great Barrier Reef Marine Park Act 1975* and related laws are effective and supported by a comprehensive field management program delivered jointly with the Queensland Government.
Encourage stewardship of the Great Barrier Reef by educating others, drawing on the best available scientific information	• Management and all activities contributing to the health and resilience of the Reef are underpinned by the best available science. • Communities and Reef users demonstrate a high level of participation in activities that contribute to the health and resilience of the Marine Park.
Maintain a high performing, effective and efficient organisation	• The Authority's workplaces are safe, positive and supportive of its staff. • The Authority is an accountable, responsive and adaptive organisation that complies with all obligations to the government and the Australian public.

3.11 Applying the tools to achieve the priorities

The following is a summary of how the Authority applies its management tools to achieve its four current management priorities.

3.11.1 Addressing the key risks

The Outlook Report 2009 identified climate change, continued declining water quality from catchment run-off, loss of coastal habitats from coastal development and remaining impacts from fishing and illegal fishing and poaching as the priority issues reducing the resilience of the Great Barrier Reef. The Authority is working in partnership with other agencies and stakeholders to reduce the magnitude of these risks and build the resilience of the Reef ecosystem to withstand and recover from their effects.

The identified key risks principally arise beyond the boundaries of the Region and their management is jurisdictionally complex. As a result, **partnership** arrangements (such as through the *Reef Water Quality Protection Plan)*, **stewardship programs** (such as Reef Guardian programs for councils, farmers and fishers, and tourism and fishing industry actions on climate change), and **education** (such as through the Reef Guardian Schools program, Reef HQ Aquarium and the Authority's communications program) are key management tools.

The Authority also works in collaboration and plays a key advisory role in **environmental impact assessment** processes — both Commonwealth and state — for proposed developments that have the potential to affect the Great Barrier Reef environment, for example major port expansions. This work includes processes under the EPBC Act and the *State Development and Public Works Organisation Act 1971 (Qld)*. The Authority also provides comment and advice on catchment planning and management relevant to protecting the health of the Reef environment.

The Authority works in close collaboration with the Queensland Government on fisheries management. Of particular importance are strategies to address the remaining impacts from fishing, with an emphasis on illegal fishing and poaching, reducing incidental catch of species of conservation concern, reducing death of discarded species, addressing issues associated with any unsustainable extraction of top predators, and fishing of fish spawning aggregations.

The **Zoning Plan** plays a key role in managing the location of fishing activities in the Region and building the resilience of the Reef ecosystem. In addition, fishing activities must comply with Marine Park Regulations and Queensland fisheries legislation. Harvest (dive-based) fishery operations within the Marine Park require a Marine Park **permit**, as do netting activities (other than bait netting) in the Special Management Area within Princess Charlotte Bay. Any developmental fishery program will also require a permit from the Authority. The joint Field Management Program plays a key role in **compliance** activities in the Region, including in relation to fishing.

Partnerships with Traditional Owners — formalised in **Traditional Use of Marine Resources Agreements** — address issues such as the sustainable take of culturally significant species and supporting Traditional Owner cultural practice in the conservation and management of the Great Barrier Reef. The agreements incorporate traditional and contemporary scientific knowledge and environmental management for the ongoing protection of the Great Barrier Reef and are used by Traditional Owners as a formal tool to conserve and protect species and ecosystems critical to the health of people, culture and country. They can incorporate specific management strategies for the conservation and sustainable use of key species, as well as habitats. Other management activities that Traditional Owners may identify in their agreement implementation plan include restoring and maintaining waterways and coastal ecosystems; maintaining and protecting significant heritage values including sites; sharing and documenting traditional ecological knowledge, culture and language; and research and monitoring of sea country including through partnerships with managing agencies and leading scientific institutions.

Research to improve understanding of the risks facing the Reef and their likely effects is supported in a range of research programs, including in the National Environmental Research Program Tropical Ecosystems Hub, the Australian Research Council Centre of Excellence for Coral Reef Studies, the Australian Institute of Marine Science (AIMS), CSIRO, the Fisheries Research Development Corporation, the Australian Marine Mammal Centre, James Cook University, University of Queensland and the Great Barrier Reef Foundation. **Monitoring** of impacts (such as the marine monitoring program which samples water quality) and the state of the Reef ecosystem itself (such as field management monitoring surveys, the Eye on the Reef program and the AIMS long-term monitoring program) provide scientific evidence to support assessments of management effectiveness. Monitoring of social and economic drivers and activities is being developed.

Policy arrangements such as the *Great Barrier Reef Climate Change Adaptation Strategy and Action Plan 2012–2017* and the *Great Barrier Reef Biodiversity Conservation Strategy 2013* explain the way in which the Authority intends to manage the Marine Park or perform its other functions, and the way in which the Authority considers the Act or other legislative instruments apply. Policies are not legislative instruments.

Regular **reporting** on the condition of the Great Barrier Reef and on the factors affecting it helps track the progress being made towards reducing risks. This reporting includes five-yearly Outlook Reports, annual Paddock to Reef reporting by Reef Plan partners and the one-off report *Informing the outlook for Great Barrier Reef coastal ecosystems*.

Benefits of zoning

The Authority's Great Barrier Reef Zoning Plan 2003 substantially increased protection for biodiversity in the Marine Park, in particular the increase in no-take zones from less than five per cent to 33 per cent of the Marine Park. The Zoning Plan set a global benchmark for marine conservation, providing protection from extractive uses for at least 20 per cent of every bioregion, while allowing for a range of ecologically sustainable uses and the continuation of traditional activities.[1,3,4,5,6,7,8,9,10,11,12,13]

The benefits of the Great Barrier Reef zoning were synthesised by a group of 21 leading scientists in 2010 in the international journal *Proceedings of the National Academy of Sciences.*[14] Their conclusions are summarised below.

> *Overall, the available evidence suggests that the large-scale network of marine reserves on the Great Barrier Reef is proving to be an excellent investment in social, economic, and environmental terms.*[14]

More, bigger fish: The network of no-take marine reserves is providing significant, long-term benefits for the species of coral reef fish that are targeted by fishers (especially coral trout), with not only more fish, but bigger fish in reserves — some reserves having around twice as much fish biomass.[14,15]

Improved fish recruitment: Larger fish contribute disproportionately more larvae than smaller fish. Recent research in the Keppel Islands suggests increased reproduction by the more abundant, bigger fish in reserves is not just benefiting populations within those reserves, but the benefits are 'spilling over' to other reefs, including reserve and fished reefs.[16] Therefore, the reserve areas are having flow-on benefits to the entire ecosystem, not just the reefs within the reserve network.[16]

Improved resilience: The spillover effects also mean the connectivity between reserve reefs is intact.[16] Spatial analysis shows most reserve reefs are within the dispersal range of other reserve reefs, so they are able to function as a network.[14] Networks are more resilient than isolated components, meaning the Zoning Plan is contributing to the resilience of the overall system.

Sharks, dugongs and turtles: These species are harder to protect because they are slow growing and slow breeding. They are also highly mobile, moving in and out of protected zones. Despite this, available evidence shows zoning is benefiting these species.[14,17,18] For effective management of mobile species, zoning needs to be complemented by measures to protect populations outside the reserve zones.[14,19,20,21]

Reduced crown-of-thorns starfish outbreaks: Outbreaks of crown-of-thorns starfish appear to be less frequent on reserve reefs than fished reefs.[14,22] This is particularly important as crown-of-thorns starfish have been the greatest cause of coral mortality in the Region in recent decades.[23]

Zoning benefits for seabed habitats: Zoning has improved protection of seabed habitats, with at least 20 per cent of most habitat types protected from trawling.[14,24]

The benefits of zoning depend on compliance: A relatively small amount of illegal fishing can rapidly reduce the benefits of marine reserves.[14] It is therefore important to have good enforcement and compliance to ensure the ecosystem benefits of zoning are maintained.

3.11.2 Ensuring use is ecologically sustainable

The Authority has a direct management responsibility to ensure use of the Marine Park is ecologically sustainable.

The **Zoning Plan** defines the activities that can occur in various locations and provides the framework for extractive use within the Marine Park. Generally, applications are assessed and permits issued jointly with the Queensland Government. A range of uses of the Marine Park, such as tourism, infrastructure, some fisheries and some research activities, require a **permit** from the Authority. Permits enable the Australian and Queensland governments to reduce impacts on high use and sensitive areas, separate potentially conflicting activities, collect data for planning of Marine Parks and monitor potentially damaging activities. During 2011–12, 625 permissions were granted, 36 permissions were varied and 70 were transferred to another permit holder. A permit application assessment **fee** generally applies for all commercial activities.

There is a formal **environmental impact assessment** process under the Act for evaluating the likely possible risks or impacts to the environment from a proposed activity or development. Common activities where a detailed assessment process is undertaken include, but are not limited to, the construction and operation of pontoons, jetties, moorings, pipelines and marinas as well as dredging. The assessment criteria include ecological, social and economic considerations, Traditional Owner interests, as well as current and future use of the proposed location.

As most ports in the Region are located outside the Marine Park, their activities are mostly managed by the Queensland Government, unless those activities are deemed to affect matters of national environmental significance under the EPBC Act, for which the Department of Sustainability, Environment, Water, Population and Communities has responsibility. As part of environmental assessments under the EPBC Act, the Authority provides **specialist advice** on the impacts of development in, and adjacent to, the Marine Park to ensure consistency of decision making and environmentally sustainable outcomes. It also provides advice on assessments of fisheries under the EPBC Act.

The Zoning Plan establishes a **designated shipping area** for the Marine Park so coastal and international shipping traffic follow lower risk routes through the Reef. The Authority is a member of the North-East Shipping Management Group, which addresses the risks shipping poses to the Great Barrier Reef, Torres Strait and the Coral Sea region.

Plans of management for the Cairns Area, the Whitsundays and Hinchinbrook set out detailed management arrangements applying to all users of these areas. The plans focus on protecting key natural values and allowing a range of uses. **Site infrastructure** such as moorings, no-anchoring areas and transit lanes support sustainable use of popular sites within planning areas and elsewhere.

The Authority's activities are guided by a series of **policy documents** supporting sustainable use. Examples include a recreation management strategy, and policies on the management of tourism permits and on moorings.

Tourism visitors and some other users pay the **environmental management charge**. All funds received are applied directly to management including education, research, ranger patrols and policy development.

All these formal management arrangements are supported by a **compliance program** conducted under the joint Field Management Program. The Field Management Compliance Coordination Unit coordinates vessel and aerial surveillance activities across the Marine Park. A cooperative multi-agency approach allows a broad range of legislation and compliance tools to be used.

3.11.3 Fostering stewardship

The Authority recognises the Marine Park plays an important role in the lifestyles and livelihoods of Queenslanders. Engaging Traditional Owners, stakeholders and local communities through positive and constructive relationships is essential in successfully managing activities within the Region.

With its main office in Townsville and other offices in Cairns, Mackay and Rockhampton, the Authority is able to closely connect with the Region's coastal communities.

The Authority places a strong emphasis on fostering **stewardship** with Marine Park users by encouraging and supporting them to play a role in protecting the area, and to achieve best practices in all their activities. Examples include the High Standard Tourism program which is a formal **partnership** with Ecotourism Australia and the tourism industry; the Eye on the Reef monitoring program predominantly with tourism operators; crown-of-thorns starfish control undertaken by the Association of Marine Park Tourism Operators; climate-related initiatives with the tourism and fishing industries; the Pro-vision Reef Stewardship Action Plan for coral and aquarium fishers and the Reef Guardian program.

The Authority's Reef Guardian program recognises the good environmental work undertaken by communities and industries to protect the Reef. It involves a hands-on, community-based approach to make the Reef healthier and more resilient by working closely with those who rely on the Reef or live in its catchment.

A number of projects are underway to trial regional stewardship approaches, for example a National Environmental Research Program funded project focused on the Mackay and Bowen–Burdekin Local Marine Advisory Committees.

Traditional Use of Marine Resources Agreements provide a mechanism for close collaboration with Traditional Owners.

A series of voluntary Responsible Reef Practices provide a **best practice** guide to recreational and tourism users on sustainable practices that can be voluntarily adopted when visiting the Marine Park, in the office and at home.

The Authority has four **Reef Advisory Committees**: Catchment and Coastal; Ecosystem; Indigenous; and Tourism and Recreation. One of their key roles is to advise the Authority on actions that can be taken to address the risks to the Marine Park identified in the Outlook Report 2009. They are competency-based committees comprising a cross-section of stakeholder interests.

The Authority is advised at a local level by voluntary community-based **Local Marine Advisory Committees**. Established in 1999, there are now 12 committees from Cooktown to Bundaberg. Members are appointed by the Authority and offer a wide range of perspectives. The committees enable local communities to have effective input into managing the Marine Park, while providing a forum for interest groups, government and the community to discuss issues around marine resources. They also help in communications between the public and the Authority.

Education and communication are recognised as essential to managing the Reef and preserving it for future generations. The Authority communicates through its website, traditional media outlets, social media, its regional offices, awareness campaigns, community events and a range of other avenues. Through Reef HQ Aquarium — the Australian Government's national education centre for the Great Barrier Reef — thousands of people each month receive messages about the Reef, risks to its resilience and what can be done to protect it. The aquarium is located in Townsville and managed by the Authority.

3.11.4 Effective and efficient organisation

The Authority recognises that being a high performing, effective and efficient organisation is central to achieving its goals and objectives. The Authority places strong emphasis on maintaining and developing effective knowledge management systems, services and processes.

The Authority's governance framework is based on the legislative requirements of the Great Barrier Reef Marine Park Act, as well as the *Financial Management and Accountability Act 1997*, the *Public Service Act 1999* and a focus on engaging the community in management of the Marine Park.

An audit committee has been established in compliance with section 46 of the Financial Management and Accountability Act and Regulation 22C of the Financial Management and Accountability Regulations 1997. This committee provides independent assurance and assistance to the Chief Executive Officer and the Marine Park Authority Board on the Authority's risk, control and compliance framework, and its financial statement responsibilities.

3.11.5 Current resources for management

The Authority's budget for 2012–13 was $53.96 million. This included a direct appropriation from the Australian Government; the Australian and Queensland governments' contribution to field management; revenue from the environmental management charge; and targeted funding from the Caring for our Country program for the Reef Rescue initiative and the Ensuring the Resilience of our

Reef initiative. In the past, a significant part of the Authority's budget (about 20 per cent) has come from the environmental management charge, principally from visitors participating in a tourist activity. A downward trend in visitation to the Marine Park has resulted in a decline in revenue from the charge in recent years.

In addition to the Authority's resources, a range of Australian and Queensland government investments contribute substantially in monitoring and protecting the Great Barrier Reef, and increasing its long-term resilience.

Protecting the Great Barrier Reef — a priority for the nation

A number of Australian and Queensland government investments contribute substantially to protection and management of the Region. For example, in addition to the Authority's resources, the Australian Government has provided the following resources over recent years:

- more than $7.53 million for a new initiative to control crown-of-thorns starfish in the Great Barrier Marine Park
- more than $200 million through the Reef Rescue initiative over the five years to June 2013 to reduce the discharge of sediments, nutrients and pesticides from agricultural lands to the Great Barrier Reef lagoon. There is a government commitment to invest a further $200 million in the Reef Rescue program to 2018
- $52.7 million in regional base funding to the six reef catchment natural resource management regional bodies (2008–09 to 2012–13)
- $12.5 million over four years from 2013 to the Great Barrier Reef Foundation to coordinate research in areas such as reef resilience and climate change
- $2.8 million for projects to inform the comprehensive strategic assessment and long-term sustainable development planning for the Great Barrier Reef World Heritage Area and adjacent coastal zone
- $12.4 million over four years for reef ecosystem research through the National Environmental Research Program, including $3.68 million over four years for water quality research aimed at better understanding the drivers and impacts of water quality on the biodiversity of the Great Barrier Reef
- more than $11.25 million for 14 projects in catchments that flow into the Great Barrier Reef lagoon for activities which restore, manage and better protect biodiversity
- $61.9 million for the four years to December 2014 for research relevant to the Great Barrier Reef through the National Environmental Research Program Tropical Ecosystems Hub. This aims to address issues of concern for the management, conservation and sustainable use of the Great Barrier Reef, tropical rainforests including the Wet Tropics World Heritage Area, and the terrestrial and marine assets underpinning resilient communities in the Torres Strait
- science and monitoring associated with the Australian Institute of Marine Science and the CSIRO

The Queensland Government invests in a range of activities designed to protect the Reef. This includes:

- $35 million a year spent on Reef water quality initiatives
- more than $8 million a year for joint field management for the Marine Park which includes compliance, management of visitor facilities and education
- more than $21 million a year for fisheries management, as well as an additional $9 million for a buy out of the net fishery on the east coast of Queensland which is expected to have profitability benefits for the fishery, as well as conservation benefits
- $12 million (statewide) over three years for Everyone's Environment Grants which will provide funding to community-based groups to tackle environmental degradation. A number of the successful grants will directly contribute to improvements in Reef health, for example through community Coastcare and waterway clean ups
- $500,000 a year to the Queensland Wetlands Program which provides a number of tools to help restore the function of important wetlands adjacent to the Reef
- about $3 million a year to support on-ground activities through its natural resource management program in Reef catchments
- an investment of $1 million to control crown-of-thorns starfish through the Skilling Queensland program. This program provides a range of activities including job preparation, work placement and accredited training to assist local long-term unemployed jobseekers. Work placement participants assist in small scale control of the crown-of-thorns starfish infestation on selected and popular coral reefs.

3.12 Involvement in other planning and management frameworks

3.12.1 National

A further layer to the Authority's operating environment is the broad range of national policies and programs that intersect with regulation and management of the Marine Park. The key policy areas relevant to the Marine Park relate to its major uses and pressures. These include environment protection, biodiversity conservation, fisheries management, natural resource management, coastal development, tourism and climate change. Other policy areas of relevance include customs, maritime safety, Indigenous affairs, resources and energy. Table 3.4 provides examples of how the Authority is involved in implementing or contributing to a range of national planning and management frameworks.

Table 3.4 Great Barrier Reef Marine Park Authority involvement in national planning and management frameworks

Portfolio area	Activities
Environment	• *Environment Protection and Biodiversity Conservation Act 1999* — as set out in a memorandum of understanding with the Department of Sustainability, Environment, Water, Population and Communities • *Reef Water Quality Protection Plan* — a collaborative program to ensure that run-off from broadscale land use has no detrimental impact on the health and resilience of the Great Barrier Reef by 2020 • Caring for our Country: crown-of-thorns starfish control; Ensuring the Resilience of our Reef • Caring for our Country — Reef Rescue: Land and Sea Country Indigenous Partnerships program; marine monitoring program • National Environmental Research Program • National Representative System for Marine Protected Areas • National working groups: marine biodiversity decline; national partnerships approach to the sustainable harvest of marine turtles and dugongs; national plan of action for the conservation and management of sharks; Oceans Policy Science Advisory Group
Tourism	• National Landscapes • National Long-term Tourism Strategy
Science	• Australian Research Council — Linkage programs • Australian Research Council — Centre of Excellence for Coral Reef Studies • Integrated Marine Observing System • Fisheries Research and Development Corporation
Indigenous - Closing the Gap	• Caring for our Country — Reef Rescue Land and Sea Country Indigenous Partnerships Program
Education	• Development of teaching units that cover key issues for the Reef and which meet the Australian Curriculum national requirements
Foreign Affairs	• AusAID funding — managing Caribbean coral reefs in a changing climate; co-hosting the International Coral Reef Initiative with Belize
Climate Change	• National Climate Change Adaptation Framework — a Council of Australian Governments initiative • Participation in the National Climate Change Adaptation Research Facility's Marine Biodiversity and Resources Adaptation Research Network
Transport	• Chairman of the Authority is on the board of the Australian Maritime Safety Authority • North–East Shipping Management Group

3.12.2 State

The Authority is involved in a range of Queensland Government initiatives relevant to the Great Barrier Reef and its catchment. Table 3.5 provides examples of how the Authority is involved in implementing or contributing to a range of Queensland Government initiatives.

Table 3.5 Examples of Great Barrier Reef Marine Park Authority involvement in Queensland Government initiatives

Portfolio	Activities
Environment	• Gladstone Healthy Harbour Partnership for the ongoing monitoring and improvement of Gladstone Harbour and surrounding catchments • Queensland Wetlands Program governance group • Reef Protection Package research and development program
Fisheries	• Review of trawl management arrangements (Trawl Plan Review)
Planning	• Development and implementation of state management plans — for example Green Island, Michaelmas Cay
Tourism	• Draft Queensland Ecotourism Plan • Relevant national park and coastal marine park management plans • Great Barrier Reef experience audits and product development • Superyacht itineraries and information about marine park management

3.12.3 Regional

The Authority partners with natural resource management bodies to achieve planning and management outcomes within the Great Barrier Reef catchment. Examples include the Reef Catchments' Urban Think Tank and Healthy Waterways Alliance.

3.12.4 Local

The Authority works collaboratively at a local level with councils, schools, researchers, Traditional Owners, stakeholders and other government agencies to achieve a wide range of management outcomes. It is represented on a wide range of formal committees such as local government groups and informal, issues-based working groups. The Authority's Local Marine Advisory Committees also play a role in information exchange between the community and the Authority.

3.13 Protecting matters of national environmental significance

The current management program contributes to the protection of each matter of national environmental significance. By virtue of protecting the values of the Marine Park, the associated matters of national environmental significance are also afforded protection.

A number of management tools, including the Great Barrier Reef Marine Park Act and Regulations, the Zoning Plan, plans of management and the *Reef Water Quality Protection Plan 2009* afford protection to all matters of national environmental significance. Other tools, such as Dugong Protection Areas, are designed to protect specific matters of national environmental significance.

The Great Barrier Reef Intergovernmental Agreement underpins collaborative joint management arrangements between the Authority and the Queensland Government, relating to the protection and management of the Great Barrier Reef. This includes joint arrangements for field management, climate change adaptation and management of fisheries resources.

The values of the **Great Barrier Reef World Heritage Area** are protected and conserved by the Authority under the Act and the EPBC Act. In addition to its obligations to protect and conserve the environment, biodiversity and heritage values of the Region, the Authority has an obligation under section 2A(2)(c) of the Act to ‘assist in meeting Australia’s international responsibilities in relation to the environment and protection of world heritage (especially Australia’s responsibilities under the World Heritage Convention)’. It fulfils this obligation by providing advice to the Department of Sustainability, Environment, Water, Population and Communities on activities (within or outside the property) likely to have a significant impact on the world heritage values of the property. The Authority’s advisory role is critical as many of the threats to the Great Barrier Reef ecosystem (such as coastal development and catchment land use practices) are the result of activities occurring outside the Region and for which the Authority has no jurisdictional control.

Additionally, more than 99 per cent of the Great Barrier Reef World Heritage Area is located within the Great Barrier Reef Marine Park for which the Authority has direct management responsibility in collaboration with the Queensland Government and its partner agencies. Impacts to the property’s outstanding universal value arising from activities within the Great Barrier Reef Region are managed through the Authority’s suite of regulatory and non-regulatory management tools. The Authority seeks to reduce impacts on the property’s outstanding universal value from activities occurring outside the Region through its partnership, stewardship and education programs and in its advisory capacity as described above.

Obligations under the Convention Concerning the Protection of the World Cultural and Natural Heritage also include a duty of presentation and giving the heritage values of the property ‘a function in the life of the community’ (Articles 4 and 5). The Authority assists in meeting these obligations by working closely with the tourism industry to promote the presentation of the property’s outstanding universal value. This includes the development of interpretive material and the High Standard Tourism program associated with marine parks permits. The Authority’s Reef Guardian program and its multiple-use management approach are central to ensuing the property’s values are given a function in the life of the community.

The Authority also contributes to periodic reporting to the World Heritage Committee on Australia’s international responsibilities for the environment and protection of the Great Barrier Reef World Heritage Area.

The **Great Barrier Reef Marine Park** is a matter of national environmental significance and the Authority is responsible for its protection and management under the Act. Legislative management tools, such as the Regulations, the Zoning Plan, plans of management and permits, set out requirements for the protection of biodiversity and management of ecological sustainable use. The objects of the Act encourage community engagement in the protection and management of the Region and there is strong focus on engagement with Traditional Owners, primarily through the Authority’s Traditional Use of Marine Resources Agreement program, and stakeholders more broadly through the Authority’s partnerships, education and stewardship activities, including its Reef Guardian program. These tools are important as they have the capacity to influence actions outside the Marine Park but which affect the Marine Park (such as catchment management).

The Great Barrier Reef was listed as a **national heritage place** in 2007. The place has the same boundary as the World Heritage Area, and its listing is based on the world heritage values identified by the World Heritage Committee. The Authority contributes to the protection and management of the national heritage place using the same tools and approaches as described above for the World Heritage Area.

The **Commonwealth marine area** includes all parts of the Great Barrier Reef Region beyond Queensland state waters (that is, greater than three nautical miles from high water) extending beyond the Region into the Torres Strait, Coral Sea and to the south of the Region. Within the Region, the Commonwealth marine area is a subset of the Marine Park. Management tools that relate to the Marine Park deliver protection to the Commonwealth marine area. Other initiatives, to which the Authority is a party, such as the North-East Shipping Management Plan and Reef Plan, will provide benefits to species and habitats within the Commonwealth marine area.

All **listed migratory species** are protected under Regulations, which means they cannot be taken or interfered with, unless a permit has been obtained. The policy *Managing activities that include the direct take of a protected species from the Great Barrier Reef Marine Park* informs the permitting process. In addition, the following management measures are in place to protect and manage listed migratory species:

Sharks and rays

- shark and rays spatial protection via inshore habitat conservation areas such as dugong protection areas
- vulnerability assessment for sharks and rays under the *Biodiversity Conservation Strategy 2013.*[25,26]

Marine turtles

- position statement on managing access to the Restricted Access Special Management Areas surrounding Raine Island, Moulter Cay and Maclennan Cay[27]
- *Raine Island Climate Change Adaptation Plan 2010–2070*[28]
- Indigenous Land and Sea Country Partnerships Program, including Traditional Use of Marine Resources Agreements and Indigenous Land Use Agreements, that can include provisions for the traditional use of marine resources
- code of practice for the sustainable management of dugong and marine turtle tourism in Australia[29]
- population model for the southern Great Barrier Reef green turtle stock[30]
- monitoring of foraging green turtles in Shoalwater Bay
- spatial and temporal closures of some islands and/or surrounding waters to protect nesting activities
- rehabilitation facilities for sick and injured marine turtles (Reef HQ Aquarium)
- vulnerability assessment for marine turtles under the *Biodiversity Conservation Strategy.*[26]

Estuarine crocodiles

- signage warning the public of estuarine crocodile sightings, for example Low Isles.

Seabirds and shorebirds

- position statement on managing access to the Restricted Access Special Management Areas surrounding Raine Island, Moulter Cay and Maclennan Cay[27]
- guidelines for visitation to seabird breeding islands[27]
- coastal bird monitoring and information strategy
- prohibition on fishing with more than six hooks in the Great Barrier Reef Marine Park
- seasonal closures of islands and intertidal areas to protect important breeding and feeding areas.
- vulnerability assessment for seabirds and shorebirds under the *Biodiversity Conservation Strategy*.[26]

Whales

- operational policy on whale and dolphin conservation in the Great Barrier Reef Marine Park[27]
- Regulations for managing vessel and aircraft interactions with whales and dolphins (Part 4A of the Regulations).
- Whale Protection Area in the Whitsundays to protect calving grounds.
- vulnerability assessment for dwarf minke whales under the *Biodiversity Conservation Strategy.*

Australian snubfin dolphin and the Indo-Pacific humpback dolphin

- operational policy on whale and dolphin conservation in the Great Barrier Reef Marine Park
- Regulations for managing vessel and aircraft interactions with whales and dolphins (Part 4A of the Regulations)
- Dugong Protection Areas provide some protection to inshore dolphin habitats
- vulnerability assessment for inshore dolphins under the *Biodiversity Conservation Strategy.*

Dugongs

- position statement on the conservation of dugongs in the Great Barrier Reef Marine Park[27]
- Great Barrier Reef Marine Park Zoning Plan 2003 (dugongs were explicitly considered in its development)[31]
- Indigenous Land and Sea Country Partnerships Program — Traditional Use of Marine Resources Agreements

- Indigenous Land Use Agreements (these can include provisions for the traditional use of marine resources)
- code of practice for the sustainable management of dugong and marine turtle tourism in Australia[27]
- vulnerability assessment for dugongs under the *Biodiversity Conservation Strategy*.[26]

All **listed threatened species** are protected under Great Barrier Reef Marine Park Regulations, which means they cannot be taken or interfered with, unless a permit has been obtained. Permits are not required for traditional use. The policy *Managing activities that include the direct take of a protected species from the Great Barrier Reef Marine Park* informs the permitting process. Specific management tools for listed threatened species are the same as those specified above for relevant listed migratory species.

The Shoalwater and Corio Bays Area is a **listed wetland of international importance** and is partly within the Region. The Authority, through its Field Management Program, undertakes dedicated management activities including patrols, engagement activities with Traditional Owners, supporting marine turtle and dugong monitoring, and monitoring shorebird populations. The Shoalwater Bay (Dugong) Plan of Management and Dugong Protection Area were designated to support the most important dugong seagrass habitat in the southern region of the Marine Park. Other management initiatives, such as Reef Plan, also indirectly address broader impacts that may affect the area.

3.14 Timeframe and review

The Authority has been responsible for the protection and management of the Great Barrier Reef since the introduction of the Great Barrier Reef Marine Park Act in 1975.

In recognition of the need to continually adapt its work to emerging issues, the Authority regularly reviews it management programs and priorities. An important part of the Authority's management approach is ensuring that work programs reflect current priorities and that decision making is transparent and accountable. A number of reviews of various aspects of the Authority's business have been conducted over the past 20 years [32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50] resulting in changes to organisational structure, legislative arrangements and work programs.

The five-yearly production of an Outlook Report, including an assessment of management effectiveness, provides the foundation for cyclical business planning and decision making by the Authority.[51] The Outlook Report 2014 will use the best available science and build upon the information presented in the Outlook Report 2009 and the strategic assessment to assess the current state of the Reef, commercial and non-commercial use, factors influencing its condition, management measures, risk, current resilience and the long-term outlook. It will form an important part of the ongoing adaptive management cycle by reviewing and evaluating the information and outcomes of both reports and resultant management changes.

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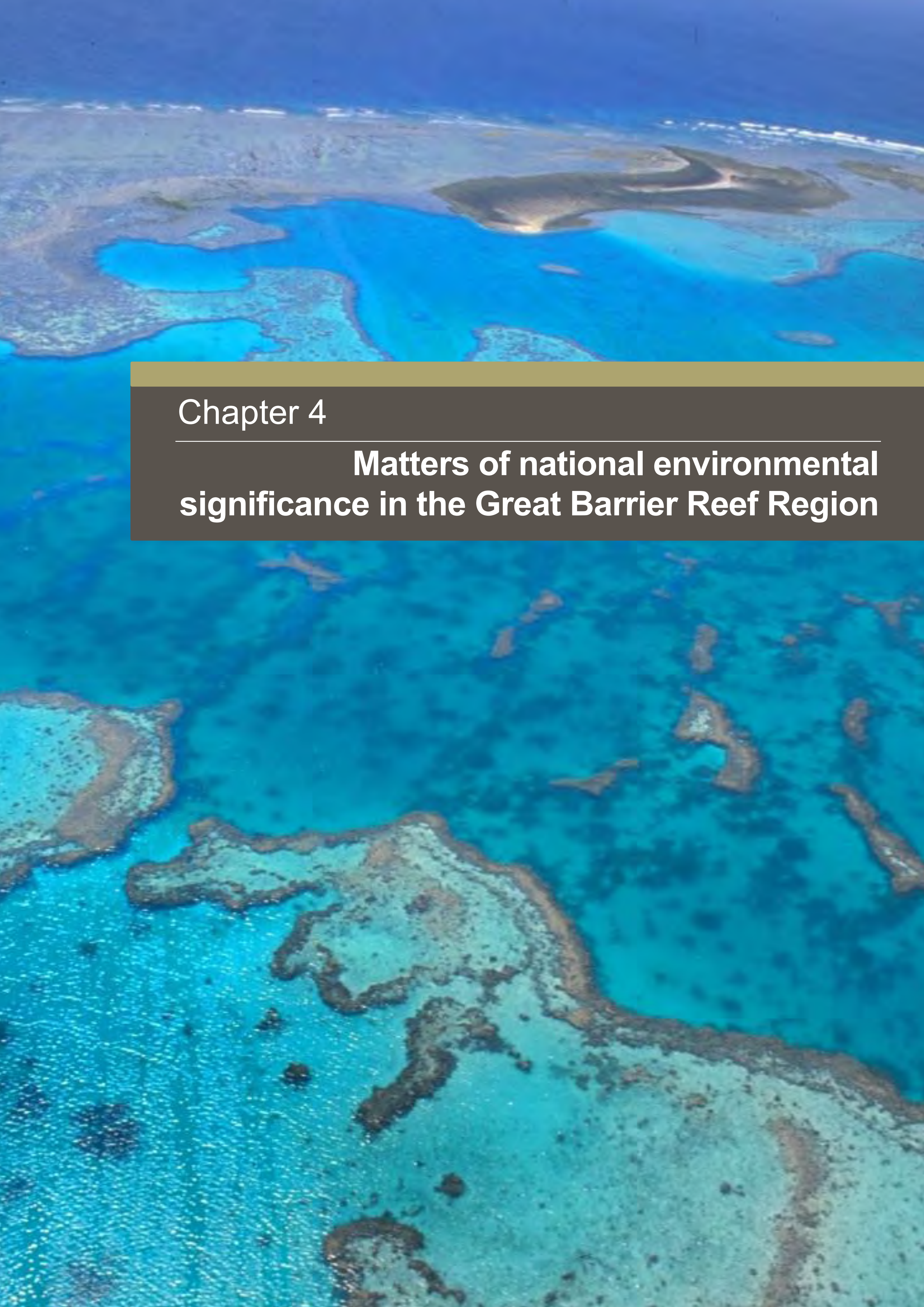

Chapter 4

Matters of national environmental significance in the Great Barrier Reef Region

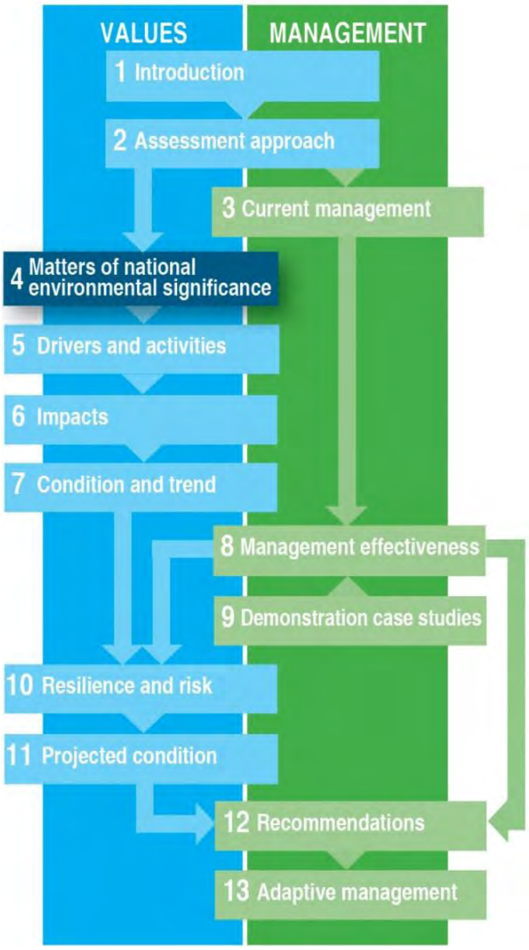

Table of contents

Cover page image: Aerial view of Stanley Reef

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

2.1 Description of matters of national environmental significance

2.1.1 Describe the extent to which the following relevant matters of national environmental significance, as defined in the Environment Protection and Biodiversity Conservation Act 1999 apply to the strategic assessment area:

a) world heritage properties, including consideration of the outstanding universal value of the Great Barrier Reef World Heritage Area

b) national heritage places

c) wetlands of international importance

d) listed threatened species and ecological communities

e) listed migratory species

f) Commonwealth marine areas

g) the Great Barrier Reef Marine Park.

The description must:

h) identify key terrestrial, coastal and marine environmental, biodiversity and heritage values and/or attributes which underpin the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area

i) describe ecosystem processes considered critical to the functioning of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area

j) provide sufficient information to allow an understanding of the connectivity between the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area.

4 Matters of national environmental significance in the Great Barrier Reef Region

4.1 What are matters of national environmental significance?

The Great Barrier Reef is recognised both nationally and internationally as an important natural area, worthy of protection. Since the 1970s, the Australian Government has progressively recognised and protected the Great Barrier Reef as one of Australia's most precious ecosystems (Figure 4.1). This commenced with the introduction of specific legislation in 1975 and its nomination as a World Heritage Area in 1981. Throughout the 1980s, 1990s and early 2000s, progressive declaration of sections of the Great Barrier Reef Marine Park (the Marine Park) put in place arrangements for the long-term protection of the ecosystem.

Introduction of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) brought a new national focus to protecting and managing Australia's most prized environmental assets. These are referred to as matters of national environmental significance. In 2009, the Marine Park was included as a matter of national environmental significance.

Seven matters of national environmental significance are relevant to the Great Barrier Reef Region (the Region) and therefore considered in this assessment:

- world heritage properties
- the Great Barrier Reef Marine Park
- national heritage places
- Commonwealth marine areas
- listed migratory species
- listed threatened species and ecological communities
- wetlands of international importance.

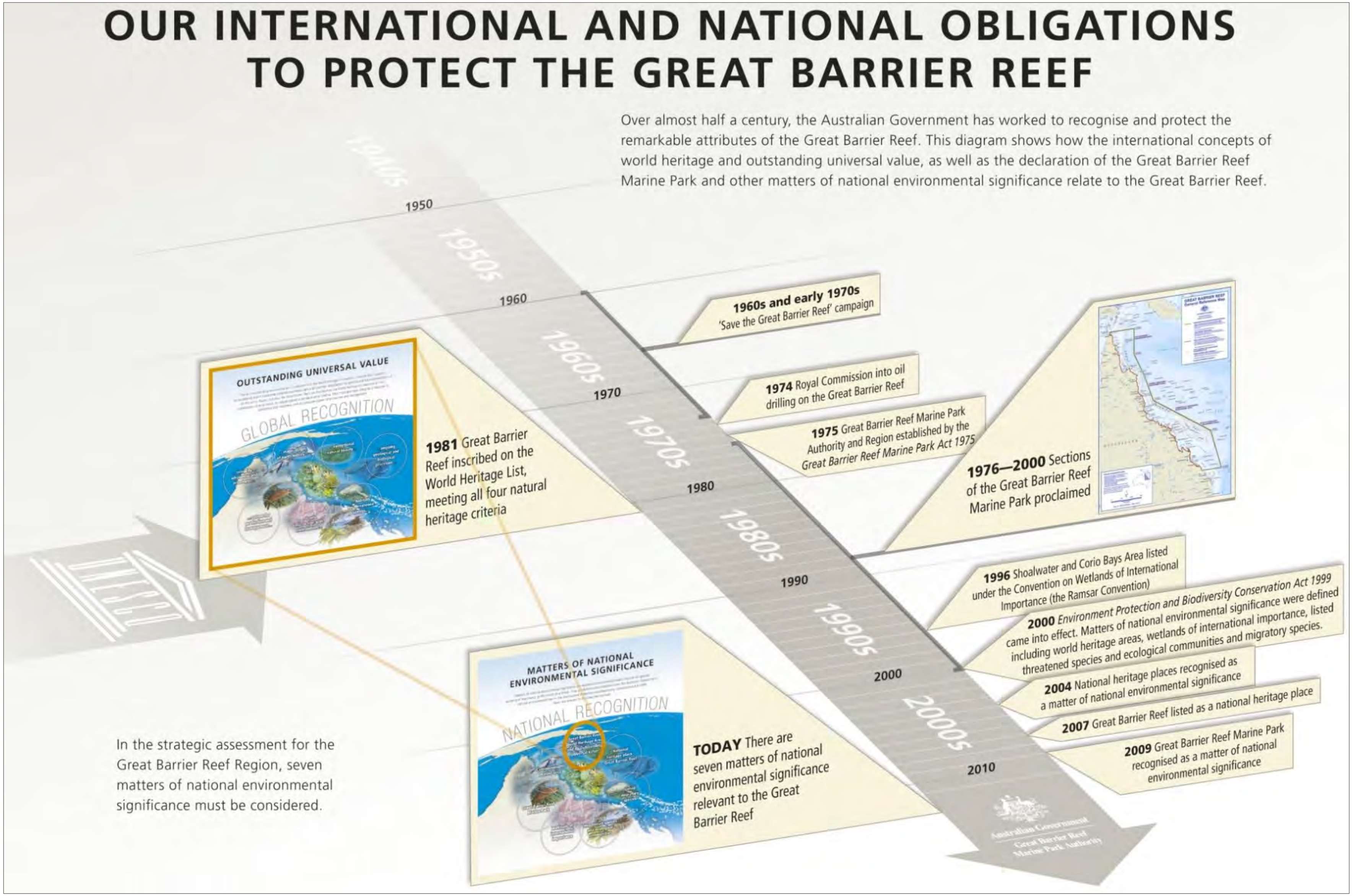

Figure 4.1 Timeline for the matters of national environmental significance relevant to the Great Barrier Reef Region

All of the matters of national environmental significance are interconnected; each a part of the rich and complex Great Barrier Reef environment (Figure 4.2).

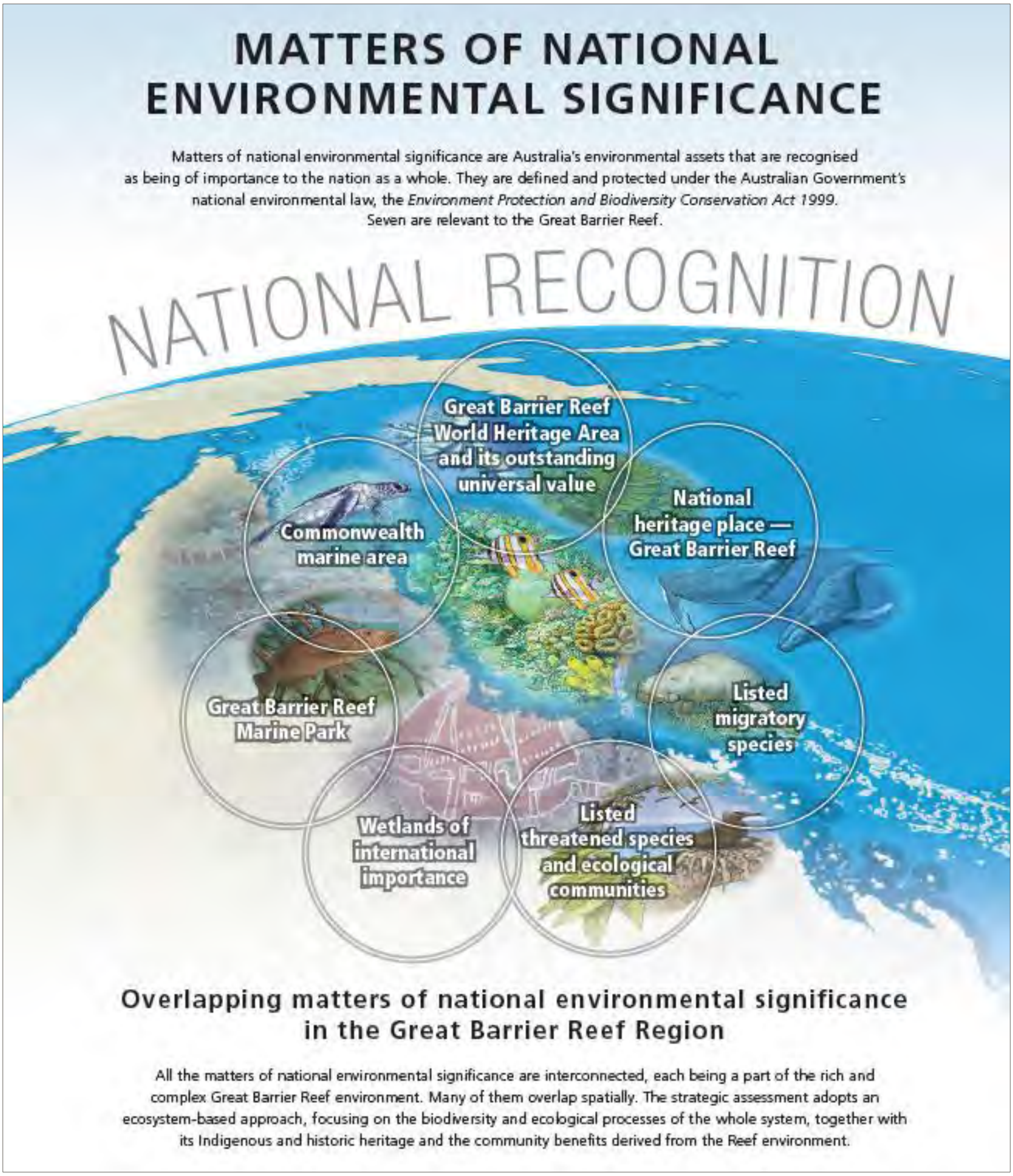

Figure 4.2 Matters of national environmental significance in the Great Barrier Reef Region

In addition, many of these matters overlap spatially (Figure 4.3). For example, the Great Barrier Reef Marine Park makes up almost all (about 99 per cent) of the Great Barrier Reef World Heritage Area. Listed threatened and listed migratory species range throughout the Region, with some also present in the adjacent coastal zone or Commonwealth marine areas beyond the Region.

In this chapter, the extent to which each matter of national environmental significance applies to the Region is described in detail. A common set of key values and attributes relevant to the matters is presented. In addition, the environmental processes relevant to the matters are outlined.

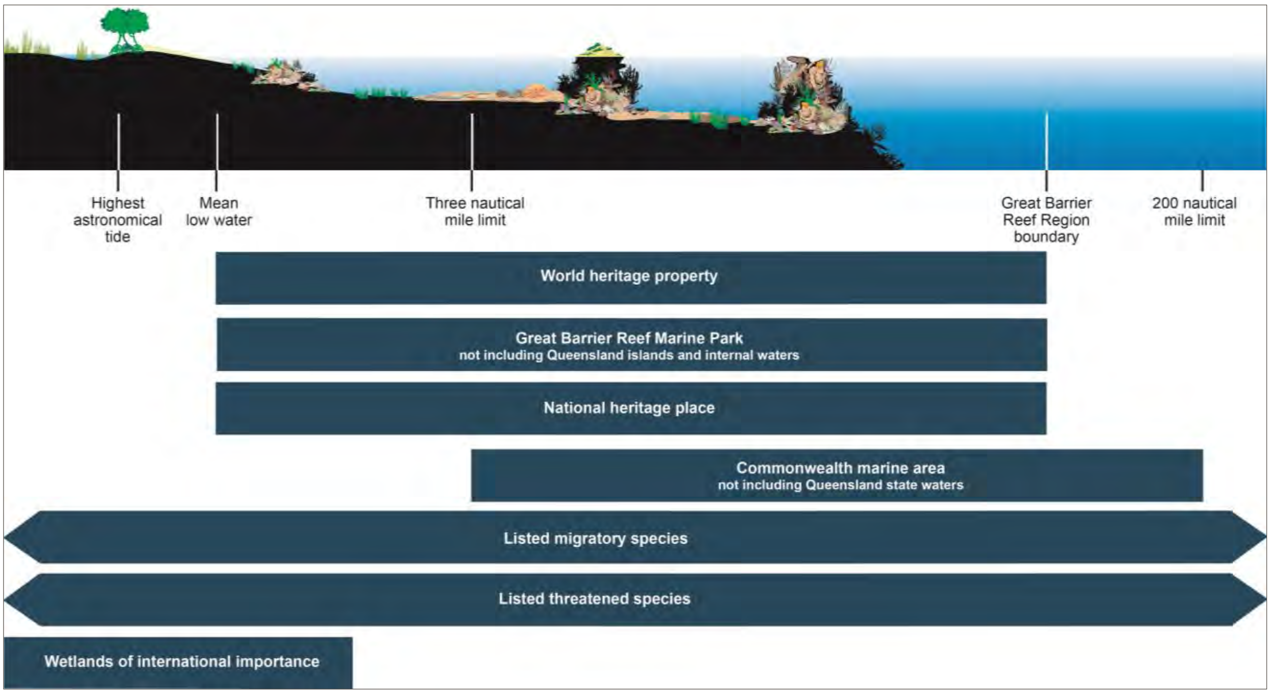

Figure 4.3 Spatial extent of the matters of national environmental significance for the Great Barrier Reef Region

The matters of national environmental significance overlap across the Region and some extend well beyond its boundary.

4.2 World heritage properties

The Great Barrier Reef is a world heritage property encompassing both Commonwealth and Queensland areas seaward of low water mark (see Figure 1.1, Chapter 1). Another world heritage property, the Wet Tropics of Queensland, is adjacent to the Great Barrier Reef World Heritage Area. There are close natural and cultural connections between the two properties.

4.2.1 Outstanding universal value

The Great Barrier Reef World Heritage Area covers 348,000 square kilometres and includes both marine areas and islands. There are 1050 islands including some 600 continental islands, 300 coral cays and 150 mangrove islands. It is inscribed on the World Heritage List because of its natural outstanding universal value.

> *Outstanding universal value is defined as cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity.* [1]

Outstanding universal value is central to the way the World Heritage Convention is implemented. A property is considered '*to be of outstanding universal value*' if it meets one or more of ten world heritage criteria and is inscribed on the World Heritage List. In addition, to be deemed to be of outstanding universal value *'a property must also meet the conditions of integrity and/or authenticity and must have an adequate protection and management system to ensure its safeguarding'.*[1]

UNESCO's Operational Guidelines[1] recognise that '*no area is totally pristine and that all natural areas are in a dynamic state and to some extent involve contact with people'* and that human activities *'may be consistent with the outstanding universal value of the area where they are ecologically sustainable'*.

Recognition of the Great Barrier Reef's outstanding universal value was based on the natural world heritage criteria in place at the time — acknowledging the Reef's natural values, together with the strong ongoing links between Aboriginal and Torres Strait Islanders and their sea country. The criteria have been amended and renumbered since the Reef was inscribed. The criteria at the time of listing and the equivalent current criteria are presented in Table 4.1.

Table 4.1 World heritage criteria relevant to the Great Barrier Reef

Short title	Criteria at time of listing	Current criteria
Major stages of the Earth's evolutionary history	(i) outstanding examples representing the major stages of the Earth's evolutionary history	(viii) be outstanding examples representing major stages of Earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features
Ecological and biological processes	(ii) outstanding examples representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment	(ix) be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals
Natural beauty and phenomena	(iii) unique, rare or superlative natural phenomena, formations or features or areas of exceptional natural beauty, such as superlative examples of the most important ecosystems to man	(vii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance
Habitats for conservation of biodiversity	(iv) habitats where populations of rare or endangered species of plants and animals still survive	(x) contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation

Only those values, or attributes, that are consistent with the four criteria for which the Great Barrier Reef was inscribed can be considered to be its world heritage values. However, given the broad scope of the criteria under which it was listed, almost all aspects of the Reef's environment contribute to its outstanding universal value. This includes the Region's biodiversity, geomorphological features, aspects of Traditional Owner connections to the area, its environmental processes and its aesthetic value. The notable exception is historic heritage values (for example, shipwrecks and lightstations) which are not encompassed by the natural criteria.

The attributes that contribute to the property's outstanding universal value are interconnected and are distributed across the entire extent of the property.

A Statement of the Outstanding Universal Value of the Great Barrier Reef World Heritage Area[2] is the official statement adopted by the World Heritage Committee outlining how the property met the criteria for outstanding universal value, integrity and protection and management at the time of listing. The statement was prepared retrospectively. In line with International Union for Conservation of Nature (IUCN) guidelines,[3] the statement is based on information that was available in 1981 and addresses the criteria in place at the time of inscription. It does, however, adopt the contemporary numbering for the relevant criteria.

The statement provides guidance on the world heritage attributes of the property. It is reproduced in full at Appendix 3 and is summarised below.

Criteria (i) now (viii) — major stages of the Earth's evolutionary history

The Great Barrier Reef, extending 2300 kilometres along Queensland's coast, is a globally outstanding representation of the major stages of the Earth's evolutionary history. The area has been exposed and flooded by at least four glacial and interglacial cycles, and over the past 18,000 years reefs have grown on the continental shelf. During glacial periods, sea levels dropped, extending the coastline further east and exposing the reefs as flat-topped hills of eroded limestone with large rivers meandering between them. During interglacial periods, rising sea levels caused the formation of continental islands and coral cays, and new phases of coral growth. Today's varied seascapes and landscapes have been moulded by changing climates and sea levels, and the erosive power of wind and water, over long time periods. A recent report *Geological and geomorphological features of outstanding universal value in the Great Barrier Reef World Heritage Area*[4] identifies the geological and geomorphological features of outstanding universal value and provides an overview of the pressures affecting values. The outcomes are summarised in Section 4.3.2.

Criteria (ii) now (ix) — ecological and biological processes

The ecological and biological processes of the Region reflect the maturity of an ecosystem that has evolved over millennia. Globally significant marine fauna groups include more than 4000 species of molluscs, more than 1625 species of fish, as well as a great diversity of sponges, anemones, marine worms, crustaceans, and many other taxonomic groups. The establishment of vegetation on the cays and continental islands exemplifies the important role of birds in processes such as seed dispersal and plant colonisation. Biodiversity attributes and environmental processes which support the Great Barrier Reef are described in more detail in Section 4.3.1 and Section 4.10. Human interaction with the natural environment is illustrated by strong ongoing links between Aboriginal and Torres Strait Islanders and their land and sea country, and includes numerous shell deposits (middens), fish traps, story places and marine totems. A description of Indigenous heritage values is provided in Section 4.3.3.

Criteria (iii) now (vii) — natural beauty and natural phenomena

The Great Barrier Reef demonstrates superlative natural beauty above and below the water, providing spectacular scenery. It is one of a few living structures visible from space, appearing as a complex string of reefs along Australia's north-east coast. From the air, the vast mosaic patterns of reefs, islands and coral cays produce an unparalleled aerial panorama. The Whitsunday Islands provide a magnificent vista of green vegetated islands and spectacular sandy beaches. Hinchinbrook Island supports vast mangrove forests, rugged vegetated mountains and lush rainforest gullies. The Reef's natural phenomena include annual coral spawning, migrating whales, nesting turtles, and significant spawning aggregations of many fish species.

Criteria (iv) now (x) — habitats for conservation of biodiversity

The enormous size and diversity of the Region means it is one of the richest and most complex natural ecosystems on Earth, and one of the most significant for biodiversity conservation**.** The diversity of habitats supports tens of thousands of marine and terrestrial species, many of which are of global conservation significance. For example, the waters of the Region provide major feeding grounds for one of the world's largest populations of the threatened dugong and it is an important area for humpback whale calving. Furthermore, six of the world's seven species of marine turtle occur in the Region, with internationally important breeding grounds for green, loggerhead and hawksbill turtles. A more detailed description of Great Barrier Reef species and habitats is provided in Sections 4.3.1, 4.6, 4.7 and 4.8.

Integrity

At the time of inscription it was considered that to include virtually the entire Great Barrier Reef within the property was the only way to ensure the integrity of the coral reefs in all their diversity. The Statement of Outstanding Universal Value[2] also notes that some of the key ecological, physical and chemical processes that are essential for the long-term conservation of the marine and island ecosystems and their associated biodiversity occur outside the boundaries of the property. A description of environmental processes which support and connect the Great Barrier Reef environment is provided in Section 4.9.

A better understanding of aesthetics

In 2012, a World Heritage Centre/IUCN monitoring mission visited the Great Barrier Reef to assess the state of conservation of the World Heritage Area and to contribute to the strategic assessment process. The mission report noted the property's aesthetic values are less well understood than other aspects and recommended that "further work is needed in relation to identifying and documenting the attributes related to the aesthetic values of the property".[5] The committee's finding is consistent with the 1997 review of the outstanding universal value of the Great Barrier Reef.[6]

In response to the recommendations of the monitoring mission and the World Heritage Committee, the Australian Government commissioned a report to consider the aesthetic values of the World Heritage Area.

The report[7] broadly defines aesthetic values to include not only visual elements, but also experiential elements, such as responses of the community to place. It is also important to note that the relevant world heritage criterion includes two different concepts: aesthetic beauty and superlative natural phenomena. The latter describes large and spectacular natural events such as large aggregations of single species. In the report, both concepts are analysed with respect to the attributes that define them, as well as their levels of sensitivity. The attributes are mapped conceptually, rather than geographically, conveying the interconnections between all elements within and adjacent to the property.

The report lists the environmental and experiential attributes against each of the elements in the Statement of Outstanding Universal Value for the property. The environmental attributes identified are: the Reef as entity; coral reefs; continental islands; beaches; coral cays; water clarity (calmness, intensity of colour); marine animals (abundance, diversity, colour, size); blue holes; lagoon floors; mangroves; seagrass meadows; shoals; cliffs and rocky shores; bays; estuaries; rainforest; birds; and butterflies. The experiential attributes identified are: beauty; naturalness; tranquillity; solitude; remoteness; discovery; and inspiration.

This approach provides a different lens for considering impacts on aesthetic attributes, and thus provides the potential for recommended changes or additions to current management practices in order to ensure the elements that make up the relevant world heritage criterion are adequately protected.

A recent IUCN report[8] highlights the approach set out in the report as providing useful input into international discussions on the breadth of aesthetic values and their attributes, as well as offering ideas for development of new integrated methods.

4.3 The Great Barrier Reef Marine Park

The Region includes the Great Barrier Reef Marine Park (the Marine Park) — one of the seven relevant matters of national environmental significance. The Region and the Marine Park cover the same area, with the exception of 13 coastal exclusion areas that are not within the Marine Park (see Figure 1.1). The Marine Park covers 344,400 square kilometres and includes the subsoil beneath the seabed extending to a depth of 1000 metres and the airspace above extending to a height of 915 metres. It does not include Queensland islands and internal waters.

In accordance with the *Great Barrier Reef Marine Park Act 1975*, the Marine Park is managed to protect and conserve the biodiversity, heritage values and environment of the Region. The term 'environment' is defined broadly and, as well as ecosystems, natural resources and heritage values, it encompasses physical resources — the area's geomorphological and geological aspects; and people and communities — social, economic and cultural aspects.

The Marine Park is a multiple-use area allowing ecologically sustainable use.

As a result, there is a very wide range of values relevant to this matter of national environmental significance. The values of the Marine Park are grouped into four categories:

- biodiversity, including habitats and species
- geomorphological features
- Indigenous and historic heritage
- community benefits of the environment, comprising the cultural, social and economic benefits derived from the Region's environment.

The following is a description of the values relevant to this matter of national environmental significance.

4.3.1 Biodiversity

Biodiversity is the variety of life on Earth. It includes all living things and the way they interact with each other and their environment.

The Great Barrier Reef is one of the world's most diverse and remarkable ecosystems, with a wide range of habitats and many thousands of different species recorded.

Habitats

The range of habitats in the Marine Park can be grouped into eleven broad types, based on those defined in *Great Barrier Reef Outlook Report 2009*[9]*:*

- islands
- beaches and coastlines
- mangrove forests
- seagrass meadows
- coral reefs (less than 30 metres deep)
- deeper reefs (greater than 30 metres deep)
- lagoon floor
- shoals
- *Halimeda* banks
- continental slope
- open waters.

Within each of these there is great variation with 70 different biological regions recognised — 30 within the coral reefs and 40 in surrounding areas (Figure 4.4 and Figure 4.5).

Each habitat is briefly described below.

Islands are an important component of the Great Barrier Reef ecosystem. Continental islands and mangrove islands are located relatively close to the coast, whereas cays are mostly further offshore and are associated with reefs. Several species of terrestrial plants and animals are endemic to Great Barrier Reef islands (such as *Pisonia* forests).[10] While there are more than 1050 islands within the outer boundary of the Marine Park, only 70 (those declared as Commonwealth islands) are part of the Marine Park. The remainder are under Queensland Government jurisdiction.

Russell Island, a continental island in the Marine Park between Cairns and Innisfail

The **beaches and coastlines** within the Marine Park stretch approximately 2300 kilometres along the mainland coast of Queensland and on the islands. Sandy shores typically occur on the exposed coastline, on islands and on reefs (as coral cays). They are the habitats that support a wide range of species including as nesting grounds for shorebirds, seabirds and marine turtles. Muddy shores are generally adjacent to river mouths and estuaries in areas sheltered from prevailing winds. They act as depositional areas for sediments and nutrients discharged from the catchment or transported along the coast. Rocky coasts are intermittently distributed, providing hard structure which resists the erosive forces of wind and waves and provides habitat for many sessile species such as oysters.

Mangrove forests are an intertidal habitat of trees and shrubs covering an estimated 2070 square kilometres along the coast of the Marine Park. They grow in sheltered areas where fine sediments accumulate and where there is inundation by seawater during the tidal cycle. The mangrove forests along the Great Barrier Reef coast are very diverse, with at least 39 mangrove species and hybrids recorded.[11,12,13] The highest diversity is in the far north of the Marine Park.[13] Mangroves provide essential structure and habitat for a range of terrestrial, marine and intertidal species and play a critical ecosystem role as sources of primary production; carbon sequestration; nursery and breeding sites for many species; filtering of suspended sediments from the water; and as physical barriers from storms and extreme weather events.[14] The mangrove forests along the Great Barrier Reef coast are an integral part of the Great Barrier Reef ecosystem.

Mangrove forests along the Great Barrier Reef Marine Park coast

Seagrass meadows are distributed widely throughout the Marine Park, especially in the protected sediment-covered areas.[14,15] They colonise a broad range of areas — rivers, inlets, reefs and intertidal, subtidal and deepwater areas.[15,16] Based on the limited surveys undertaken, shallow water seagrasses (less than 15 metres deep) are estimated to cover approximately 5700 square kilometres and deepwater seagrasses (deeper than 15 metres) are estimated to be present over up to 40,000 square kilometres, although at depths below 15 metres they generally become very sparse (less than five per cent cover).[15,17,18,19,20,21] Fifteen species of seagrass occur within the seagrass meadows of the Great Barrier Reef.[20,22,23] The meadows are habitat for a diverse range of species. They are primary producers, stabilise bottom sediments and are a store for carbon.[24]

Coral reefs are one of the most biologically diverse ecosystems on the planet. The Great Barrier Reef is the world's largest coral reef ecosystem, ranging over 14 degrees in latitude, comprising more than 2900 separate coral reefs and containing more than 400 species of hard coral. Coral reef habitats cover an area of 26,000 square kilometres — about seven per cent of the Marine Park. They can be broadly classified into inner, mid and outer shelf platform reefs and can be made up of different types of reef. Reef types, including fringing, inshore turbid, shelf, ribbon, deltaic, northern detached and submerged coral reefs, represent major stages in Earth's evolutionary history and are examples of the Region's outstanding universal value.[4] They also provide vitally important habitat for a wide diversity of plants and animals. In addition to their biological value, coral reefs deliver a range of ecosystem services including shoreline protection, and provide community benefits including from fisheries and tourism.

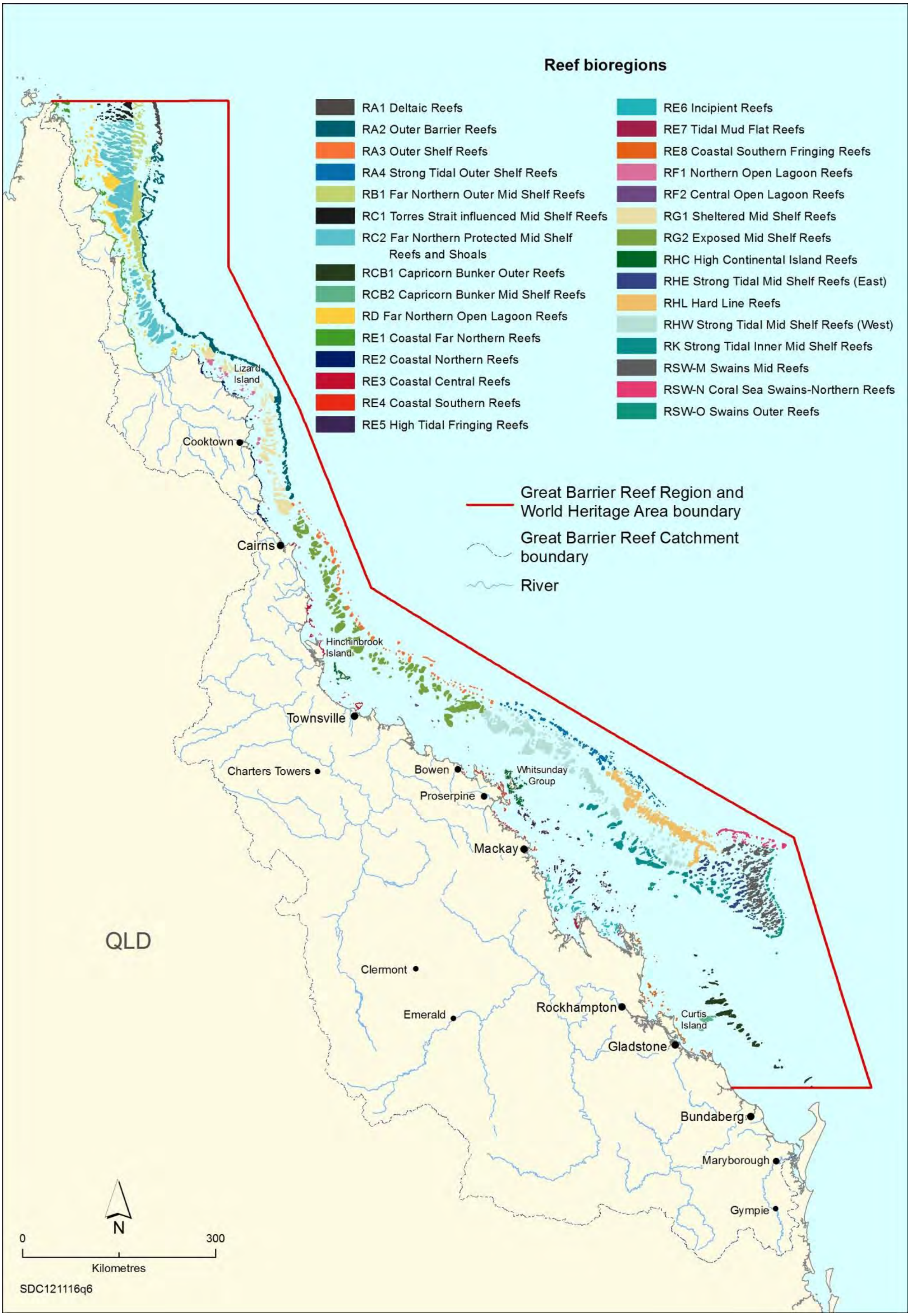

Figure 4.4 Reef bioregions of the Great Barrier Reef

Thirty reef bioregions have been identified in the Great Barrier Reef Marine Park. Each represents an area with distinct groups of plants and animals and physical features.

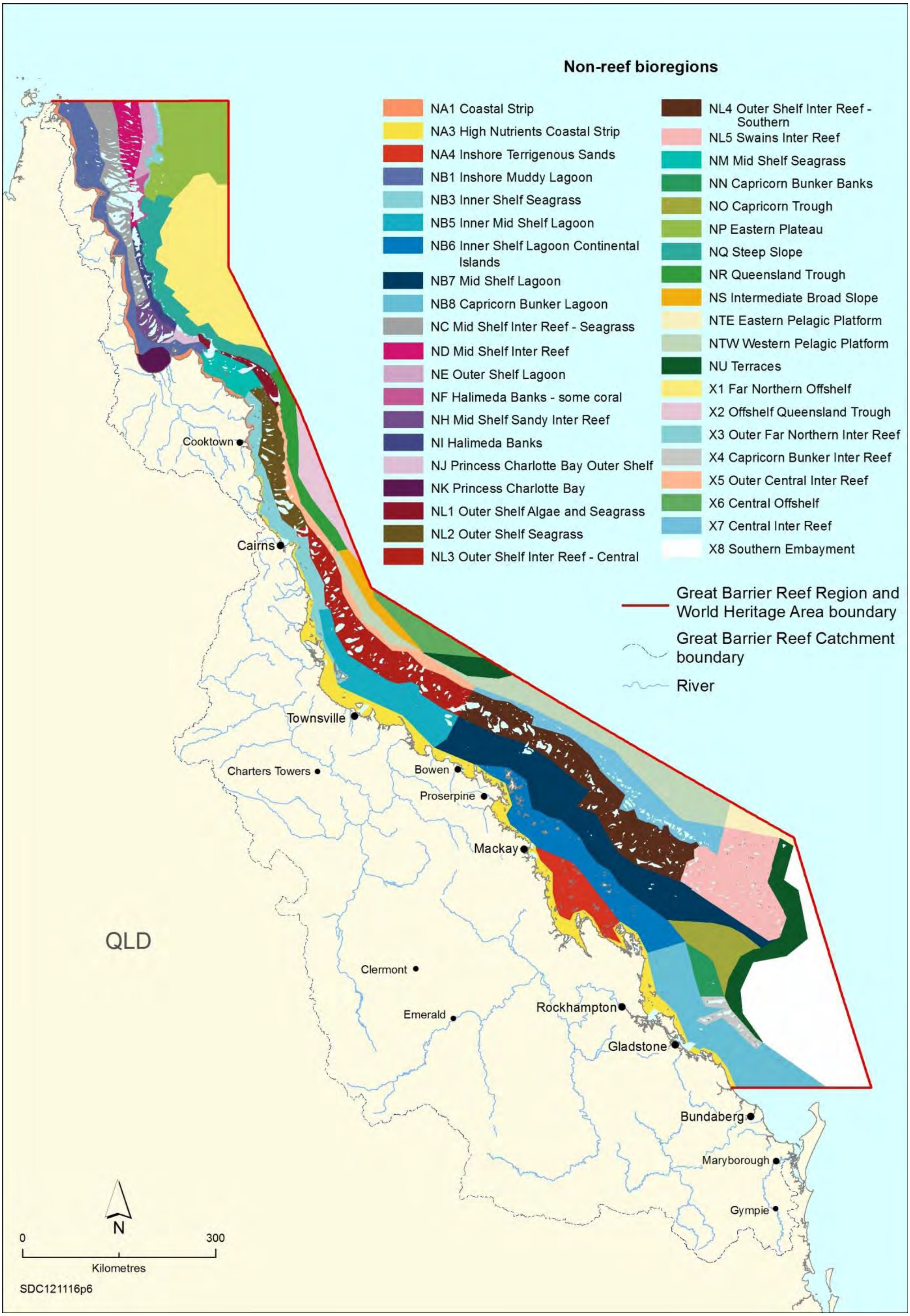

Figure 4.5 Non-reef bioregions of the Great Barrier Reef

Forty non-reef bioregions have been identified in the Great Barrier Reef Marine Park. These cover all the areas between and beyond reef areas. Each represents an area with distinct groups of plants and animals and physical features.

The **deeper reefs** that occur in the Region are poorly understood compared to their shallow water counterparts. Mesophotic coral reefs are characterised by the presence of light-dependent corals occurring in areas where there is limited light for photosynthesis (between 30 and 150 metres).[25,26] Modelling indicates mesophotic reefs are likely to be widespread along the Great Barrier Reef shelf edge and may constitute a high proportion of the total coral reef area in the Marine Park.[27] In fact, about 60 per cent (25,600 square kilometres) of the seabed where coral reefs are likely to grow is potential deep reef habitat compared to about 40 per cent (16,110 square kilometres) which is suitable for shallower corals.[28] In the northern part of the Marine Park, the steeply sloping drop-off at the edge of the continental shelf means there is limited area for mesophotic reefs, and they are generally shallower than 70 metres. Further south, where reefs are set back from the shelf-edge, submerged reefs have developed on the shoulder of the continental shelf to depths of about 150 metres. Deeper, cold water coral reefs typically occur in depths where light does not penetrate and temperature is fairly constant at four degrees Celsius.[29] They can be hotspots of biodiversity on the deep seabed.[30]

The **lagoon floor** habitat makes up approximately 210,000 square kilometres of the Marine Park. It covers the area between reefs and the coast and has an average depth of between 20 and 40 metres. Scientists have catalogued 5300 species of marine organisms from non-reef habitats in the Region.[31] The lagoon habitat is variable and includes some outcrops of marine life forming clumps that rise above the seafloor with sponges, sea-whips, gorgonians (sea fans) and interreef gardens.[32] Crinoids (feather stars) are sometimes extremely abundant in offshore areas. The lagoon floor supports many species, such as nematodes and microbial communities, which are the basis of many food chains and are important elements of a healthy functioning ecosystem. Larger organisms use the lagoon floor for food and shelter and as a nursery habitat. These include shellfish, crabs, prawns, sea urchins, sea stars and sea cucumbers, sponges, worms and fish (including sharks and rays). The lagoon floor is an important habitat for commercial, traditional and recreational fishers.

Shoals cover approximately 278 square kilometres of the Marine Park. They are submerged features on the seafloor that attract and support many fish and other species in areas away from obvious emergent coral reefs.[33,34,35] They may be unconsolidated sediments of sand, rubble, rock or reef substrate, or structurally more complex and diverse communities of filter feeders and corals. Plants and animals that use the habitat include gorgonians, sponges, algae, macroalgae and seagrasses.

Halimeda **banks** comprise large areas of the far northern Great Barrier Reef, inshore of the Ribbon Reefs, and also in the central northern Great Barrier Reef.[31] They are dominated by a live veneer of the calcareous green algae *Halimeda* which when it dies forms banks, typically up to 20 metres thick, on the seafloor usually in waters 40 metres or more deep. This habitat is poorly studied.[9]

The **continental slope** is a complex area composed of relic reefs, landslides, canyons and plateaux that extends down to more than 2000 metres.[36,37] It comprises approximately 15 per cent of the Marine Park. There has been little investigation of this remote habitat or the deepwater seabed habitats beyond.[9]

Open water habitat is critical to the healthy functioning of the whole Great Barrier Reef ecosystem. In particular, it provides connectivity between other habitats, from the coast to beyond the continental slope. Open water is dominated by microorganisms (plankton) and supports a range of other plants and animals such as invertebrates, fish, reptiles and marine mammals.

In addition to these habitats within the Marine Park, some **terrestrial habitats** in the coastal zone adjacent to the Region directly support the biodiversity of the Marine Park, for example the trapping of nutrients and sediments in wetlands. These habitats are described below.[38]

- **Saltmarshes** are an important, highly productive, interface between the marine and terrestrial environments, providing feeding and breeding areas for many marine species.
- **Freshwater wetlands** slow the overland flow of water; cycle nutrients and sediments; are important dry season refugia for many species; and are used by some marine species for parts of their life cycle.
- **Forested floodplains** help slow, capture and recycle nutrients and sediments; protect the soil surface from the erosive forces of rain; and are important nursery areas for many species with connections to the Great Barrier Reef.
- **Heath and shrublands** help slow the overland flow of water; prevent erosion; recycle nutrients and sediments; and are important as buffers on steep coastal hill slopes.
- **Grass and sedgelands** are used for feeding and roosting by migratory birds; help slow the overland flow of water; and capture nutrients and sediments.

- **Woodlands** reduce flooding by slowing the overland flow of water, and regulate sediments and nutrient supply to the Great Barrier Reef.
- **Forests** contribute to the hydrological cycle through evapotranspiration, cloud formation and rainfall generation.
- **Rainforests** minimise soil loss from erosion, including binding and stabilising soils, and provide habitat for species that also use Great Barrier Reef islands.
- **Connecting waterbodies,** such as rivers, creeks, estuaries and floodplains, are the aquatic link between the marine and terrestrial environment, transporting water, nutrients and sediments, and providing a movement corridor, as well as feeding and breeding areas for some marine and coastal species. Aquatic connectivity is provided through surface waterbodies and groundwater.

Species

Nearly all groups of marine plants and animals are abundantly represented in the Great Barrier Reef, with thousands of different species recorded. They range from microscopic plankton to massive whales and include benthic organisms (those that live on the seafloor) such as corals and seagrasses and pelagic organisms (those that live in the water column) such as larvae and some fishes. Some of the species in the Marine Park are listed nationally as migratory or threatened (Sections 4.6 and 4.7).

Table 4.2 is a summary of the key groups of Great Barrier Reef species. It is recognised that there are many new species yet to be discovered and named.

Table 4.2 Plants and animals of the Great Barrier Reef

Thousands of species make up the Great Barrier Reef ecosystem. Nowhere near all of them have been identified and described. For some, the number of species recorded is provided; for others the most up-to-date estimate is given.[39,40]

Plants and animals of the Great Barrier Reef	Number of species recorded
Whales and dolphins	more than 30
Dugongs	1
Sharks and rays	134
Bony fish	1625
Crocodiles	1
Marine turtles	6
Sea snakes	14 breeding species
Seabirds	22 nesting species
Echinoderms	630
Crustaceans	about 1300
Molluscs	as many as 3000
Worms	at least 500
Hard corals	411
Soft corals and sea pens	at least 150
Sponges	at least 2500
Mangroves	39
Seagrass	15
Marine macroalgae	630

4.3.2 Geomorphological features

The geomorphological features within the Region are closely linked to its biodiversity. Their diversity provides structure for the diversity of habitats and species, and some features, such as coral reefs and *Halimeda* banks, are biologically constructed. Geomorphological features can be broadly grouped into coral reefs, islands and shorelines, channels and canyons, river deltas, *Halimeda* banks and seagrass meadows. The following descriptions are summarised from Whiteway *et al.* 2013[4].

Coral reefs are an important geomorphological feature of the Marine Park as well as foundational for its biodiversity values. They take on many forms (Figure 4.6) depending on past environmental conditions and stages of development. Their diversity of shape and size can be a function of substrate size, depth and, to a lesser extent, relative sea level history and carbonate productivity.[41,42]

Fringing reefs grow along the coasts of the mainland or continental high islands.[43] The Great Barrier Reef includes many fringing reefs (758 of the 2904 named reefs), but they are generally small with an average area of less than one square kilometre. Together they comprise just 350 square kilometres or 1.8 per cent of the total reef area.[44] Fringing reefs are more common around continental high islands than along the mainland coast, with 352 fringing reefs concentrated in the Whitsunday, Cumberland and Northumberland island groups.[44]

Inshore turbid zone reefs are typically located in shallow water (less than 10 metres) and usually within 10 kilometres of the coast. They occur in locations where reef development is affected by continual or repeated land-based sediment inputs, elevated turbidity and fluctuating salinities.

Shelf reefs include a range of reef types in the mid-shelf area, including irregular reef patches, crescentic reefs, lagoonal reefs and planar reefs.

Ribbon reefs are barrier reefs on the steepest northern edge of the continental shelf. They are distributed over approximately 700 kilometres of the shelf edge between Cooktown and the Torres Strait, with individual ribbon reefs up to 28 kilometres long. Seaward of the ribbon reefs, the shelf quickly drops to considerable depth, reaching 1000 metres within a kilometre. Narrow passages, typically less than 800 metres wide, separate the reefs and allow water exchange between the Great Barrier Reef lagoon and the open ocean, including nutrient-rich waters upwelled from deeper waters off the shelf edge. The flows through these narrow channels are relatively strong. These geomorphological features, coupled with currents, provide conditions conducive to the formation of *Halimeda* banks.

Deltaic reefs are shelf-edge reefs with a triangular shape. Examples of deltaic reefs can be found in the northernmost 100 kilometres of the Great Barrier Reef shelf edge, where short deltaic reefs (less than four kilometres long) occur parallel to the shelf edge, separated by passages up to 200 metres wide and 35 metres deep. Strong currents are funnelled through the narrow passages between these reefs, transporting sediments into quieter back reef areas.[45] These deposits can then be colonised by reef communities.

The northern detached reefs are shelf-edge reefs that are separated from the main shelf edge by deep channels that may exceed 300 metres deep and be as much as six to seven kilometres wide.[44,46] They form on isolated pinnacles of continental crust, with different reef sizes and shapes depending on the substrate depth and geometry.[44]

Submerged reefs are ‘drowned’ reefs that formed during periods of lower sea level (in glacial periods), which currently have little or no upward coral growth.[47,48] They are most often found in waters from 20 to 120 metres deep (but can be deeper), with examples occurring both on the shelf and along the shelf edge. Submerged reefs include mesophotic and deeper water reefs and can take a variety of forms such as submerged barrier reefs, reef terraces, and isolated coral reef pinnacles and knolls.[47] Of the 2904 named reefs, almost one fifth (566 reefs) are classified as submerged.[49]

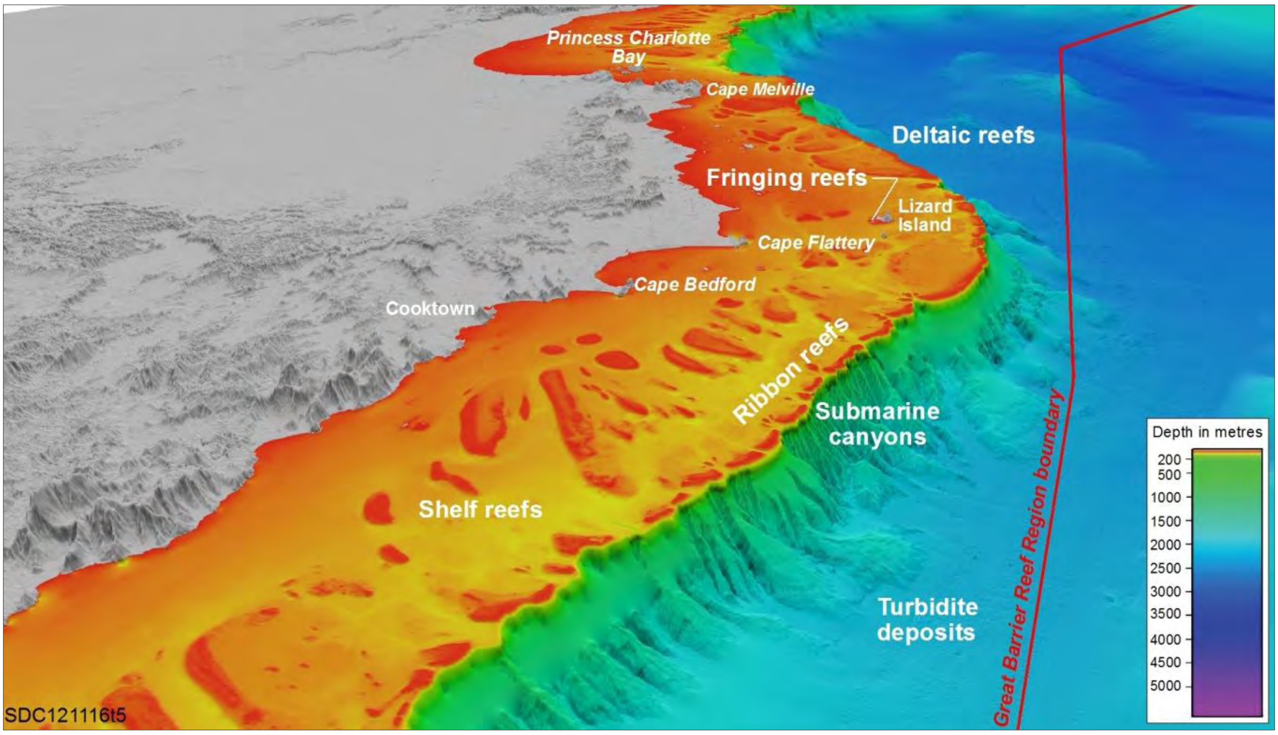

Figure 4.6 Three-dimensional bathymetry of the Great Barrier Reef shelf
Image courtesy of Dr Robin Beaman (www.deepreef.org)

Islands and shorelines are distributed throughout the Great Barrier Reef. Carbonate reef islands (coral cays) are deposits of carbonate sediments mostly made up of the skeletal remains of reef organisms that have been deposited by waves and currents. There are about 300 coral cays throughout the Reef. They have formed on reef platforms after the mid-Holocene and are thus relatively young geomorphological features. They are geomorphologically diverse, varying in size, shape, sediment composition, location on the reef platform, elevation, age structure, the extent of consolidation or cementation, and the extent to which they have been colonised by vegetation. Vegetated coral cays tend to be more stable than those with no vegetation. Unvegetated cays are very dynamic and, in some cases, can be short-lived. Therefore, the number of reef islands can vary over time. It has been estimated that there are about 213 unvegetated coral cays and only 43 vegetated cays, with an additional 44 islands classified as low wooded islands.[4]

Heron Island, a vegetated coral cay

Mangroves occur in the intertidal environments predominantly along the continental coastline and have also colonised shorelines of many islands and reef platforms, including along the shorelines of high islands such as Hinchinbrook Island and Orpheus Island. As well as a feature of biodiversity, they play a role in the geomorphology of the Reef. The depositional environments associated with mangroves usually result in organic muds, often including the shells of various molluscs. Mangrove dominated shorelines on high islands occur throughout the Great Barrier Reef. They are best developed in sheltered locations such as embayments or island coasts away from the prevailing wind,[50] and behind emergent reef flats. Mangrove islands (fully covered by mangroves), in contrast, are rare in the Region, with Murdoch Island being the only example.

The area contains more than 600 continental high islands — outcrops isolated from the mainland coast during the last major sea level rise.[44] Some are within the Marine Park, most are Queensland islands. The continental high islands exhibit a range of shapes, sizes and rock types similar to that observed along the mainland coast. Examples of islands dominated by granite include Lizard Island, Hinchinbrook Island, Magnetic Island and the Palm Island and Whitsunday groups. Dunk Island comprises granite intrusions in basement metamorphic rocks. Islands underlain by sandstone are less common, the Flinders Island Group being an example.

Some islands, such as Lady Elliot Island, preserve sequences of gravel and shingle ridges that run parallel to the shore and grow seaward. These ridges are formed as coral fragments are transported onshore by waves and overwash during storm activity, with individual ridges formed during multiple events.[51,52,53,54,55] They can provide information about the frequency and severity of past storm events.

Channels and canyons are some of the lesser known geomorphological features of the Great Barrier Reef.

Palaeochannels are past river channels that have been inundated by sea level rise. They include the channel depression and the associated fluvial sedimentary features deposited by the former river, such as deposits and in-filled channels.

Karstic channels are shaped by the dissolution of layers of soluble bedrock, usually carbonate rock such as limestone composed of reef carbonates. In the Region, they are developed on reefs exposed during periods of low sea level (glacial periods). Landforms include steep slopes and gorges, for example the deep steep-sided passages between Hook and Hardy Reefs.[41,56] 'Blue holes' — deep circular depressions with steep sides that are thought to be submerged sinkholes — are also a karstic landform[57] and are rare both in the Region and globally. There are just three identified examples of blue holes within the Region, at Molar Reef, Cockatoo Reef and an unnamed reef, all located in the Pompey Complex east of Mackay. The blue hole at the unnamed reef is the deepest of the three, with an explored depth of 90 metres. It is one of the best examples in the world.[56]

The Blue Hole at Cockatoo Reef in the Pompey Complex, east of Mackay

Recent improvements in bathymetric mapping have revealed extensive and large submarine canyons, associated landslides and turbidite deposits within the Region (see Figure 4.6). Submarine canyons are important for sediment transport and hosting deepwater ecosystems. They can modify shelf-edge oceanography to produce upwellings.[58] They also preserve information about sea level change, as well as sediment and tectonic movements.[59,60,61] For example, recent research has identified areas of the northern shelf edge prone to collapse and possibly capable of generating a large tsunami.[62] Around the Ribbon Reefs, most submarine canyons are between five and 20 kilometres long, have average widths ranging between 900 and 8000 metres, and maximum incision depths of between 144 and 815 metres.[58,63] The largest submarine canyon is Bligh Canyon, extending beyond the continental shelf and into the Coral Sea Basin (Figure 4.7). It is more than 200 kilometres long, almost 10 kilometres wide, and has incised as much as 300 metres into the seabed.[64] It begins approximately 200 kilometres east of the Lockhart River mouth and extends out across the Region and into the Coral Sea Marine Reserve. Turbidite deposits form at the base of the continental shelf and are the result of sediment transport from the shelf, including underwater landslides, and are responsible for distributing vast amounts of sediment into the deep ocean. They also provide historical records about sedimentation in the adjacent shelf area, tectonic movements and responses to sea level.[65]

Approximately 30 major rivers and several hundred smaller, often short-lived, streams drain into the Great Barrier Reef lagoon.[66] Many of these rivers and streams transport significant loads of terrestrial sediment, including bedload sediments (medium sands and coarser) that can accumulate to form **river deltas.** The combination of relatively high sediment yields and relatively low wave energy (except during cyclones), due to the protection of the outer barrier reefs, means sizeable deltas have formed at the mouths of many rivers, especially the Barron, Herbert, Burdekin and Fitzroy rivers.

***Halimeda* banks** are formed by *Halimeda,* a genus of benthic green algae which produces calcified green deposits in a plant-like form.[67] It is believed *Halimeda* began growing on the Great Barrier Reef earlier than corals, and in some locations, Holocene *Halimeda* banks overlie older Pleistocene *Halimeda* deposits.[68]

Seagrass meadows are classed as a geomorphic feature because they stabilise the seabed by decreasing current velocity, thus allowing suspended sediment to settle to the seafloor.[69] Seagrass roots then stabilise the sediment. Seagrass meadows are also important as they support a range of carbonate secreting organisms that grow on their surface which contribute to the carbonate sediments within the Region. Seagrass meadows are present in water depths up to 60 metres, but particularly occur in areas with high sediment and nutrient availability, such as close to the mainland.[69,70]

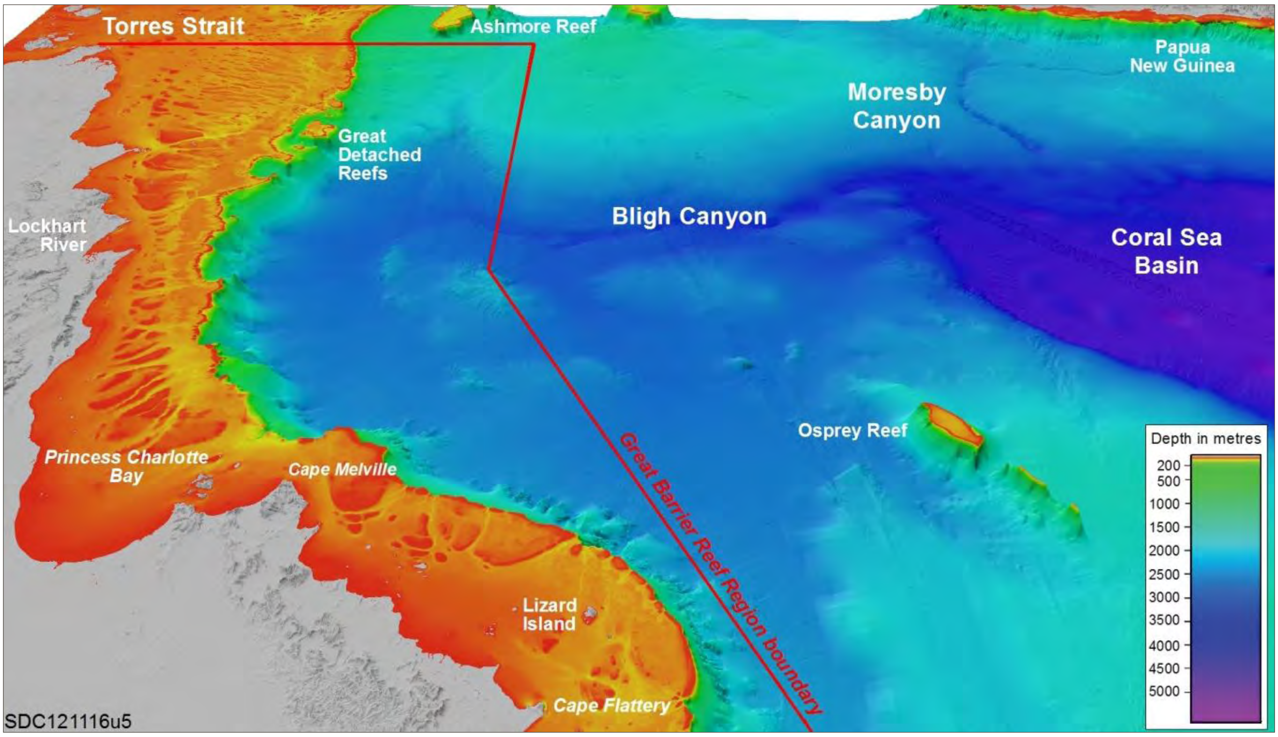

Figure 4.7 Three-dimensional bathymetry of submarine canyons along the Great Barrier Reef shelf edge
Image courtesy of Dr Robin Beaman (www.deepreef.org)

4.3.3 Indigenous and historic heritage values

In 2008, the importance of the Great Barrier Reef's heritage values was formally recognised by an addition to the main object of the Great Barrier Reef Marine Park Act that required their long-term protection and conservation.

In line with the definition in the Great Barrier Reef Marine Park Act and the EPBC Act, the heritage values of the Marine Park include:

> '*its natural and cultural environment having aesthetic, historic, scientific or social significance, or other significance, for current and future generations of Australians*'.

For the Great Barrier Reef Marine Park, the natural heritage referred to in the definition is encompassed by the biodiversity and geomorphological values discussed above.

The Indigenous and historic components include both tangible heritage (such as places) and intangible heritage (such as experiences, traditions, historic events and stories). The values relevant to these two categories are discussed below.

Indigenous heritage

Indigenous heritage recognises the heritage of Aboriginal and Torres Strait Islander peoples who are the First Australians and Traditional Owners of the Great Barrier Reef. While Aboriginal and Torres Strait Islander peoples have some common heritage values, there are also many unique expressions of heritage between Aboriginal and Torres Strait Islander peoples. In addition, differences are also found between families, clans, groups and communities.

Indigenous heritage is a unique, dynamic and diverse living heritage. It continuously links generations of Aboriginal and Torres Strait Islander peoples through time and is an important part of their cultures.[71]

For Indigenous peoples, relationships with country, people, beliefs, knowledge, lore, language, totems, symbols, ways of living, sea, land, sky and objects all arise from a spiritual belief, and cultural practice and association.[71]

Heritage is a central element in Indigenous custom and its conservation ensures continued respect for Indigenous ancestors and the ancestral beings who shaped the land and waterways.[72]

There are more than 70 Aboriginal and Torres Strait Islander Traditional Owner clan groups who hold heritage values for their land and sea country in and adjacent to the Region. These include cultural, spiritual, economic, social or physical values (or a mixture of these) and demonstrate continuing connections with the Great Barrier Reef and its natural resources. An example of the types of values Traditional Owners report is provided in Figure 4.8.

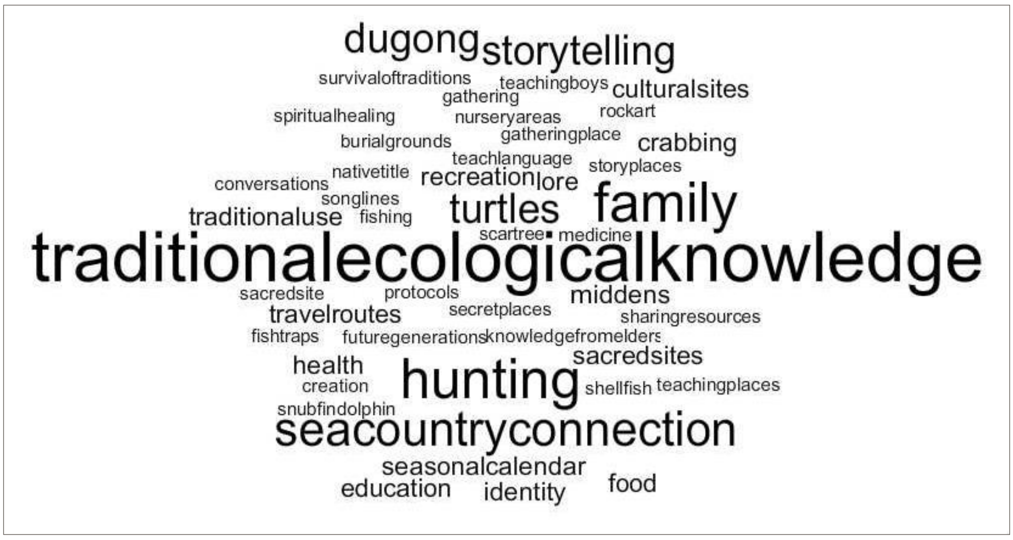

Figure 4.8 Dominant values identified by Rockhampton Traditional Owner participants at a strategic assessment workshop

Values raised most often are represented in larger text.

For Aboriginal and Torres Strait Islander peoples, the significance of individual features is derived from their interrelatedness within the cultural landscape.

> *Cultural landscapes represent the combined works of nature and humankind, they express a long, intimate and diverse relationship between people and their natural environment.*[73]

Throughout this report Indigenous heritage values are combined into four broad categories:

- cultural practices, observances, customs and lore
- sacred sites, sites of particular significance, places important for cultural tradition
- stories, songlines, totems and languages
- Indigenous structures, technology, tools and archaeology.

While this report presents information on heritage values under discrete headings, in reality Indigenous values cannot be separated. In addition, the natural environment described above is fundamental to Traditional Owners and their connection to land and sea country. All aspects are connected and interrelated and information described for any one particular aspect should be viewed in this context.

Cultural practices, observances, customs and lore are comprised of intangible features such as skills, folklore, rituals, religious beliefs and intellectual traditions — passed down from generation to generation. Indigenous heritage is an intrinsic part of custom and continues to be observed by Indigenous people in sea country management. For example, controlling use of and access to sea country estates by Traditional Owners and non-Traditional Owners regulates resource use based on cultural practices and belief systems. It is consistent with the recognition of traditional customs, practices and lore. Seasonal and cultural use of marine resources and the opening or closing of harvesting seasons according to ecological events (for example, flowering of particular plants or the arrival of migratory bird species) continue to be practiced by Great Barrier Reef Traditional Owners.[74]

Important skills and Traditional ecological knowledge are passed down from one generation to the next, enabling Aboriginal and Torres Strait Islander peoples to follow the same seasonal patterns as their ancestors. The passing of these skills and knowledge means different resources are exploited at different times of the year. For hunting and fishing, this depends on which species are ‘fat’ at a given time.[75] Hunters and fishermen also use their skills and experience to determine if individuals have suitable body condition for use.

Traditional ecological knowledge is more than understanding availability of seasonal resources; the knowledge involved can fulfil multiple purposes. The Yuibera Traditional Owners, near Mackay, use the head of the cycad plant as a vegetable when ripe, however the plant itself also signifies the presence of water which has implications for fire regimes.[76]

Sacred sites, sites of particular significance and places important for cultural tradition are tangible aspects of the Region’s Indigenous heritage. Sacred sites are significant heritage places for Indigenous people and their enduring traditions. As an example, they may be creation or resting places for ancestral spirits, places that contain healing water and medicinal plants, burial grounds, traditional tracks of Aboriginal peoples’ movements or sites associated with special events.[77]

Many are areas of great importance for the conservation of biodiversity across land and sea country, and many communities are unable to separate the reasons for protecting the spiritual connections between people and the earth from the reasons for conserving this biodiversity. In most cases, natural and cultural heritage values of sites are inextricably entwined. They form a continuum rather than being separate entities.[78]

‘Sea country’ is not additional to clan estate on land — it is inseparable from it. As on land, sea country contains evidence of events that occurred during the Dreaming by which all geographic features, animals, plants and people were created. Sacred sites often relate to creation events, Dreaming tracks or songlines along which spiritual beings travelled during the creation period. A defining feature of sacred natural sites is that Aboriginal people have known about and cared for them since time immemorial. Aboriginal and Torres Strait Islanders peoples have custodial responsibilities as part of their lore which tie them to country, thereby ensuring the maintenance of spiritual, cultural, biological and other values of such sites.[78]

Many groups have unique maritime and coastal cultures that have evolved over thousands of years. Worrungu Bay (near Cape Upstart) is a significant area for the Juru people. The bay is a women’s meeting area. Juru women would collect shellfish from the swamp and walk to the sand dunes area and cook them on the fire.[79]

Cape Hillsborough National Park is known for containing burial grounds of the Yuibera clan and is a sacred place for Indigenous spirits. Mangrove areas along the coast are still used for men's ceremonies in the early wet season and the eastern area of the beach contains fish traps that can only be seen during a very low tide.[76] There are also fish traps on Hinchinbrook Island, where they operate as a system of stone-walled pools that flood at high tide, trapping fish as the tide goes out.

Expressive social activities such as **stories, songlines, totems and languages,** as well as music and dance, are part of Indigenous heritage and everyday life and are an integral aspect of ceremonies.[74] For Aboriginal and Torres Strait Islander peoples all that is sacred is in the land, water, air and sea. Knowledge of the environment, places or objects may be passed down the generations through these mediums. Stories and songs, dance, dress, art and language connect people to a place or time. They provide history, learning and perspective.

Lizard Island is a sacred place, known as Jiigurru (or Dyiigurra), to the Dingaal (or Dingiil) Aboriginal people of North Queensland. During the Dingaal Dreamtime, the Lizard group of islands was formed. The island group is thought to be a stingray, with Jiigurru being the body and the other islands forming the tail.[80]

Some Aboriginal and Torres Strait Islander peoples can be identified by their totems, which can be any animal, plant, tree or object such as birds, marine turtles, sharks, crocodiles, fish, cordyline plant, pandanus tree, sand dunes and wind. The diamond stingray (Yama) is the totem of the Wuthathi tribe (Shelbourne Bay, North Queensland) and many other sea creatures are totem emblems for Aboriginal and Torres Strait Islanders.[80] Totems are an important part of cultural identity and they can be used in song, dance and music and on cultural implements. Some Aboriginal and Torres Strait Islander people's customs forbid eating the animal that is their totem, while others make exceptions for special occasions such as ceremonies. For some, their totems are their favoured form of sustenance.

Indigenous structures, technology, tools and archaeology are perhaps the more well-known and documented features in Indigenous heritage literature.

Archaeological sites can include:

- occupation (residential) sites — areas containing stone tools, food remains, ochre, charcoal, cooking stones and shells
- middens — deposits of food refuse, usually shellfish
- grinding grooves — evidence of tool making or food processing found on flat sections of rock
- rock art (which often tells Dreaming stories and sometimes provides pictorial evidence of past rituals central to the lives of Traditional Owners)
- scarred trees as a result of bark being removed for food or to make canoes, water containers, shields or huts.

Tools and implements reflect the geographic location of each group and their trading interactions with other groups. There are distinct differences in the materials used in implements for daily activities (such as hunting, cooking and collecting) as people used resources that were available to them.

Archeological evidence documents the trade links between coastal and hinterland Aboriginal people. Nywaigi people have found many stone axes and grinding stones that people have been using for thousands of years. The stones were traded with neighbouring tribes from the mountains where the stones originated.[79] Nomadic Aboriginal people of the Whitsunday Islands, the Ngaro, built sturdy three-piece bark canoes that were capable of open sea journeys.[81]

Ancient rock art sites provide an insight into the chronicle heritage of Indigenous people, while oral histories transferred through time deliver traditional knowledge and understanding about tools or technology. Bindal Traditional Owners from the Townsville area have documented the presence of important rock art at Cape Ferguson. There are drawings of circles believed to represent shields and also bora rings and initiation.[79]

Mandingablbay Yidinji Traditional Owners, like other coastal Aboriginal groups in the Cairns area, developed a wide range of technologies from local material used for hunting, fighting, making substantial shelters, baskets, fish traps and tools. Single outrigger canoes were used extensively for fishing, hunting and travelling well into the twentieth century.[81]

Historic heritage
For the purpose of this assessment historic heritage relates to the occupation and use of an area since the arrival of European and other migrants. It illustrates the way in which the many cultures of Australian people have modified, shaped and created the cultural environment. By its very nature, it will continue to evolve to represent the flow of history and changing community perceptions.[82]

While some specific aspects of the Reef's historic heritage have been well documented, knowledge of many historic places or events is limited. The following is a summary of the broad range of the Marine Park's historic heritage.

There are more than 470 **historic shipwrecks** (that is, shipwrecks greater than 75 years old) in the Marine Park.

The **World War II features and sites** of the Great Barrier Reef include shipwrecks, more than 200 aircraft wrecks, unexploded ordnances and structures on islands.

The **lightstations**, comprising the lighthouse, accommodation and other infrastructure, servicing the Marine Park are associated with the rich shipping and navigational history of the Great Barrier Reef. There is a range of lightstations along the Reef on Commonwealth and Queensland islands, including Commonwealth and state heritage-listed lightstations built in the 1800s, 'concrete tower' aids to navigation dating from between the 1920s and the 1960s, and 'steel frame' aids to navigation.

The continuing scientific importance of the Great Barrier Reef means **places of scientific significance** are of particular heritage value. They include research stations and expedition sites such as those of the 1928 Yonge expedition to Low Isles — the first detailed scientific study of a coral reef in the world.

Places of historic significance include Endeavour Reef where Captain Cook ran aground, and routes taken by Cook, Flinders and Bligh on their voyages through the Great Barrier Reef. Islands within the Region have also played a major role in the heritage of the Reef. Places of historic significance include those connected with Edmund Banfield on Dunk Island and Mrs Watson's cottage on Lizard Island. Places that illustrate changes in use of the Great Barrier Reef are also significant — from early guano mining on islands, through dugong and turtle factories, to limestone and granite mining, and oil exploratory leases.

Places of social significance are also part of the Marine Park's historic heritage, including iconic sites such as the Green Island underwater observatory — reputed to be one of the first underwater observatories in the world; the Cod Hole — an iconic dive site; John Brewer Reef — the site of the first floating hotel; and Whitehaven Beach — a spectacular and highly visited white sand beach in the Whitsundays.

4.3.4 Community benefits of the environment

The strategic assessment explicitly considers the community benefits derived from the environment. This recognises that the Marine Park is a multiple-use marine protected area as well as the interconnectedness of people and their environment, as reflected in the definition of the environment in both the Great Barrier Reef Marine Park Act and the EPBC Act:

> *'Environment includes ecosystems and their constituent parts, including people and communities; natural and physical resources; the qualities and characteristics of locations, places and areas; heritage values of places; and the social, economic and cultural aspects of the above'.*

In 2005, the Millennium Ecosystem Assessment provided clear evidence of the links between healthy ecosystems and human wellbeing. It showed that at the most fundamental level, humans need functioning ecosystems for clean water, fresh air, food, shelter and climate regulation.[83] People also derive less tangible benefits from healthy ecosystems such as nature appreciation, opportunities for relaxation and enjoyment, and a better understanding of the complex world in which we live. Four types of ecosystem services were described by the Millennium Ecosystem Assessment: *supporting* (for example, food webs and habitats); *regulating* (for example, shoreline protection and climate regulation); *provisioning* (for example, seafood and pharmaceuticals) and *cultural* (for example, aesthetics and recreation).[83]

The Reef environment contributes much to the community's wellbeing, both locally and more indirectly throughout Australia and the world. The Reef's biodiversity, geomorphological features, heritage values and natural beauty supports people economically, provides them with food and enriches their lives.

Benefits vary according to people's cultural connections, experiences, personal perspectives, and dependence upon and familiarity with the Region. Traditional Owners have long highlighted the benefits that their communities derive from the Region's environment, including access to the Reef's resources, employment and improved health outcomes.

> *"Our concerns about the health of our people are directly connected to the ability of our people to access our traditional country. Being healthy means looking after our spiritual health and our physical health*." Girringun Aboriginal Corporation[84]

The Region's values considered important by the community were explored in a series of workshops and surveys with stakeholders and Traditional Owners in the latter half of 2012 (see Section 2.11), as well as through discussions with the Authority's advisory committees and through one-on-one talks. The range of information, views and experiences greatly assisted in determining the full set of values for the Region. In addition, the process strengthened a common understanding of the broad range of values that the Region supports and their current condition and trend. The values that consistently emerged from the Traditional Owner and stakeholder workshops (see Appendix 5) are presented in Table 4.3.

For the strategic assessment, concepts involved in human wellbeing have been adapted to group the cultural, social and economic benefits derived from the environment into the following broad elements: income and employment; access to Reef resources; understanding, appreciation and enjoyment; personal connection; health benefits; and aesthetics.

Reef-dependent activities such as commercial fishing, marine tourism and the Reef-based recreation industry generate **income and employment** for thousands of people both within and outside the Reef catchment, as the flow-on benefits reach far beyond the boundaries of the World Heritage Area. These industries play an important role in regional Queensland and rely on a healthy Reef ecosystem for long-term economic stability.[85] Tangible benefits are measured in terms of the financial contribution that they make to the Queensland and Australian economies.

Access to Great Barrier Reef resources by Reef-dependent industries, Traditional Owners, recreational users and others enables users to visit the Reef and to derive benefit from it. An important consideration in accessing the Reef is the need to balance the requirements of the variety of uses.

Understanding, appreciation and enjoyment help people use the Reef's resources wisely. Understanding comes from learning — from reading, listening, sharing knowledge, observing or from direct experience. It may also develop through employment; place of residence; recreational experiences; family, personal or spiritual connections; or remotely through social media. Stewardship activities together with scientific knowledge and cultural knowledge gained from stories passed from one generation to the next provide a context for understanding the Reef and its values. It also allows reflection on what the Reef may have been like in the past; how it contributed to human wellbeing, and how it has responded to human activities. This understanding can provide direction for future management and use. Knowledge held by Traditional Owners, tourism operators, farmers, fishers, scientists, managers and catchment residents can promote widespread understanding of the Great Barrier Reef at local, national and international levels.

Aesthetics are also closely related to the way in which people value and enjoy the Reef. Attributes of aesthetic qualities emphasise psychological, social or cultural dimensions and may be determined by how people travel to a place, what they do when they get there, and what experiences they have. Places that are easy to access are less likely to provide opportunities for enjoying nature, solitude or tranquillity, but may enhance opportunities for socialising and personal comfort. Psychological, social or cultural dimensions of aesthetics also include a sense of history, a sense of place, inspiration, spiritual connections, opportunities for learning, relaxation, recreation and escapism.[7]

Health benefits of natural ecosystems are now well recognised in the literature and through initiatives like *Healthy Parks, Healthy People* which explore the many ways in which nature significantly contributes to human health and wellbeing.[86] Reef visitors and coastal residents benefit from relaxation and stress reduction through Reef-based recreational activities; healthy inputs to diets from freshly caught local seafood; and exercise from snorkelling, boating and island and beach walks.

Personal connection is derived from peoples' spiritual connections, cultural ties, employment, stewardship activities, places of residence and recreational activities. It links each individual stakeholder, visitor, local resident and Traditional Owner to the Great Barrier Reef environment.

Table 4.3 Values consistently identified in Traditional Owner and stakeholder workshops, 2012

Values	Aspects consistently identified
Specific sites and habitats	
Islands, beaches and coastlines; estuaries, deep water, bays, inlets and coral reefs	**Natural heritage:** obligation to have it there for our children **Cultural:** significance for Traditional Owners (e.g. locations of fish traps, sites for traditional use of marine resources and ceremonies); other cultural heritage values (e.g. locations of shipwrecks, lighthouses, sites of Captain Cook's landings) **Economic:** support commercial fishing; shipping (deep water); tourism and recreation **Social:** support recreation (e.g. walking, camping, snorkelling, diving, fishing, reef-walking, wildlife watching, relaxation, spending time with family and friends); education; health; lifestyle; stewardship; traditional use **Aesthetic:** reefs and islands can be seen from space; place of natural wonder; spectacular pristine beauty; awesome; spiritual; majestic and calming; looked upon with pride; unique habitats
Wetlands	**Natural heritage:** important breeding and feeding grounds for a variety of fish species, migratory birds and other animals **Cultural**: as part of Traditional Owner belief systems, wetlands contain physical materials such as medicines and food sources **Economic:** support commercial fishing and tourism **Social:** support recreation (e.g. fishing, wildlife watching, education)
Seagrass meadows	**Natural heritage:** important breeding and feeding grounds for a variety of fish species, turtles, dugong and other animals **Cultural:** supports dugong and turtle populations and continued cultural expression for Traditional Owners **Economic:** support commercial fishing and tourism **Social:** support recreation (e.g. snorkelling, stewardship, education)
Species	
Fishes, estuarine crocodiles, birds, whales, dolphins, dugongs, sharks, rays, sea snakes, marine turtles, corals	**Natural heritage:** having such a large protected area for species to move through without risk **Cultural:** traditional hunting of some species and totemic and spiritual significance for Traditional Owners **Economic:** support commercial fishing and tourism **Social:** support recreation (e.g. snorkelling, diving, wildlife watching, education) **Aesthetic:** 'wow' factor
Ecosystem processes	
Connectivity	**Natural heritage**: linking biophysical processes, supporting biodiversity **Cultural:** connection of people to land and sea through stories; also in terms of the way Indigenous people moved seasonally from inland areas to the sea in search of food. Connectivity occurs from west to east (i.e. catchment to sea) and from north to south (through travel and trade routes).
Integrity	**Natural heritage:** linking biophysical processes; supporting biodiversity **Cultural:** accessing and maintaining sites for traditional use of marine resources, ceremonies and stories
Spawning (coral, fish)	**Natural heritage:** contributes to biodiversity **Economic:** support commercial fishing and tourism
Water quality	**Economic:** supports commercial fishing and tourism **Social:** supports human health; recreation (e.g. swimming, snorkelling, diving) **Aesthetic:** water colour and clarity

4.4 National heritage places

The Great Barrier Reef World Heritage Area was one of 15 world heritage properties included as a national heritage place on the National Heritage List in 2007. The place has the same boundary as the World Heritage Area (see Figure 1.1, Chapter 1). While there are specific criteria that apply to the listing of national heritage places, the national heritage listing of the world heritage properties was done on the basis of those values identified by the World Heritage Committee. Therefore, for the purposes of this assessment, the values of the Great Barrier Reef national heritage place are taken to correspond to the world heritage criteria. As a result, the two matters of national environmental significance are addressed in a similar way in the report with the same set of values, or attributes, underpinning them.

The national heritage criteria identified as corresponding to those for which the property was world heritage listed are:

- the place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history
- the place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history
- the place has outstanding heritage value to the nation because of the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history
- the place has outstanding heritage value to the nation because of the place's importance in demonstrating the principal characteristics of:
    - a class of Australia's natural or cultural places; or
    - a class of Australia's natural or cultural environments
- the place has outstanding heritage value to the nation because of the place's importance in exhibiting particular aesthetic characteristics valued by a community or cultural group.

4.5 Commonwealth marine areas

All parts of the Great Barrier Reef Region beyond state waters (that is, greater than three nautical miles from the territorial sea baseline) are a matter of national environmental significance as a Commonwealth marine area (Figure 4.9).

The Commonwealth marine area also extends beyond the Region into the Torres Strait, Coral Sea and to the south of the Region. The environmental processes within the Region are connected with these areas, as are some of the Region's species. In addition, some users of the Region (for example, tourism operators and commercial, charter and recreational fishers) also use Commonwealth marine areas adjacent to the Region.

Within the Region, the Commonwealth marine area is a subset of the Marine Park. Protection of the environment is a common aspect shared by the Marine Park and the Commonwealth marine area. Management arrangements for the Commonwealth marine area within the Region are effectively the same as those for the Marine Park. Management of Commonwealth marine areas outside the Region is the responsibility of the Director of National Parks as part of the Commonwealth marine reserves network.

Because of these commonalities, the Great Barrier Reef Marine Park (Section 4.3) is generally used in this report as a surrogate for the Commonwealth marine area. Similar values are relevant to both areas.

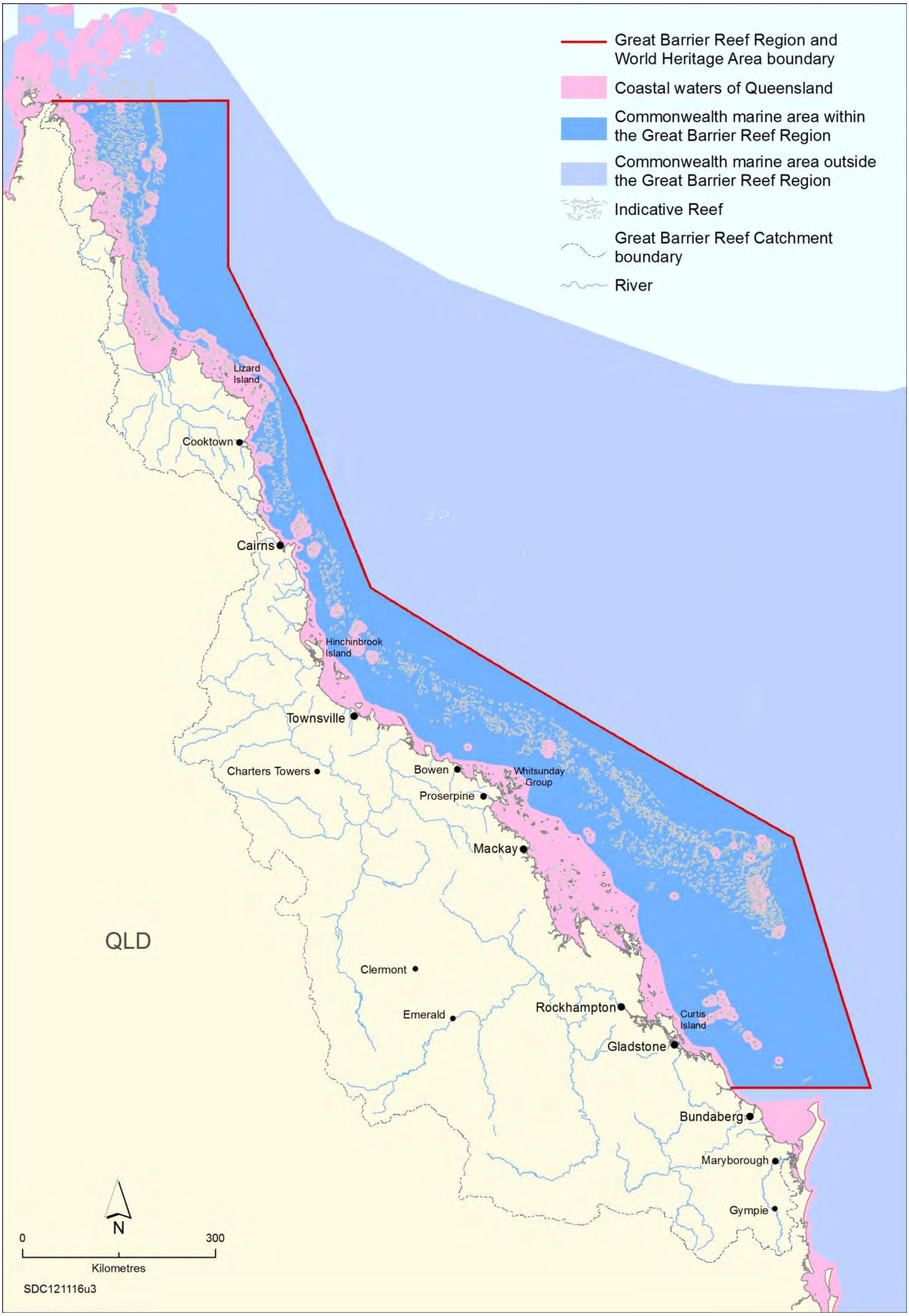

Figure 4.9 Boundaries of the Commonwealth marine area within and outside the Region

4.6 Listed migratory species

The Great Barrier Reef Region supports 77 of the currently listed migratory species comprising six marine turtle species; 11 mammal species including the dugong and two inshore dolphins; five species of shark; 54 species of shorebirds and seabirds; and the estuarine crocodile (Table 4.4).

The fact that these species move during their life histories — sometimes very large distances — means they spend much of their time outside the Region and hence may be exposed to impacts well beyond the boundaries of the Region or even the nation.

Table 4.4 Listed migratory species in the Great Barrier Reef Region

The species marked with the symbol - [T] - are also listed threatened species (see Table 4.7). The scientific name is presented in *italics.*

Species group	Migratory species	
Marine turtles	Flatback turtle[T] (*Natator depressus)*	Green turtle[T] (*Chelonia mydas)*
	Hawksbill turtle[T] (*Eretmochelys imbricata)*	Loggerhead turtle[T] (*Caretta caretta)*
	Leatherback turtle[T] (*Dermochelys coriacea)*	Olive ridley turtle[T] (*Lepidochelys olivacea)*
Crocodiles	Estuarine crocodile (*Crocodylus porosus)*	
Whales	Antarctic minke whale (*Balaenoptera bonaerensis)*	Blue whale[T] (*Balaenoptera musculus)*
	Bryde's whale (*Balaenoptera edeni)*	Fin whale[T] (*Balaenoptera physalus)*
	Humpback whale[T] (*Megaptera novaeangliae)*	Killer whale (*Orcinus orca)*
	Sei whale[T] (*Balaenoptera borealis)*	Sperm whale (*Physeter macrocephalus)*
Dugong	Dugong (*Dugong dugon)*	
Dolphins	Australian snubfin dolphin (*Orcaella heinsohni)*	Indo-Pacific humpback dolphin (*Sousa chinensis)*
Sharks	Longfin mako (*Isurus paucus)*	Porbeagle (*Lamna nasus)*
	Shortfin mako (*Isurus oxyrinchus)*	Whale shark[T] (*Rhincodon typus)*
	White shark[T] (*Carcharodon carcharias)*	
Seabirds	Black-naped tern (*Sterna sumatrana)*	Bridled tern (*Onychoprion anaethetus)*
	Brown booby (*Sula leucogaster)*	Caspian tern (*Sterna caspia)*
	Common noddy (*Anous stolidus)*	Common tern (*Sterna hirund)*
	Greater frigatebird (*Fregata minor)*	Grey-headed albatross[T] (*Thalassarche chrysostoma)*
	Lesser crested tern (*Sterna bengalensis)*	Lesser frigatebird (*Fregata ariel)*
	Little tern (*Sterna albifrons)*	Masked booby (*Sula dactylatra)*
	Northern giant petrel[T] (*Macronectes halli)*	Osprey (*Pandion haliaetus)*
	Red-footed booby (*Sula sula)*	Roseate tern (*Sterna dougalii)*
	Sooty albatross[T] (*Phoebetria fusca)*	Southern giant petrel[T] (*Macronectes giganteus)*
	Wandering albatross[T] (*Diomedea exulans*)	Wedge-tailed shearwater (*Puffinus pacificus)*
	White-bellied sea eagle (*Haliaeetus leucogaster)*	White-winged black tern (*Chlidonias leucopterus)*
	Wilson's storm petrel (*Oceanites oceanicus)*	
Shorebirds	Bar-tailed godwit (*Limosa lapponica)*	Black-tailed godwit (*Limosa limosa)*
	Caspian plover (*Charadrius asiaticus)*	Cattle egret (*Ardea ibis)*
	Common sandpiper (*Actitus hypoleucos)*	Curlew sandpiper (*Calidris ferruginea)*
	Eastern curlew (*Numenius madagascariensis)*	Eastern great egret (*Ardea modesta)*
	Eastern reef egret (*Egretta sacra)*	Glossy ibis (*Plegadis falcinellus)*
	Great knot (*Calidris tenuirostris)*	Greater sand plover (*Charadrius leschenaultii)*
	Greenshank (*Tringa nebularia)*	Grey plover (*Pluvialis squatarola)*
	Grey-tailed tattler (*Tringa brevipes)*	Latham's snipe (*Gallinago hardwickii)*
	Lesser golden plover (*Pluvialis dominica)*	Lesser sand plover (*Charadrius mongolus)*
	Little curlew (*Numenius minutus)*	Marsh sandpiper (*Tringa stagnatillis)*
	Red knot (*Calidris canutus)*	Red-necked stint (*Calidris ruficollis)*
	Ruddy turnstone (*Arenaria interpres)*	Sanderling (*Calidris alba)*
	Sharp-tailed sandpiper (*Calidris acuminata)*	Swinhoe's snipe (*Gallinago megala)*
	Terek sandpiper (*Xenus cinereus)*	Wandering tattler (*Tringa incana)*
	Whimbrel (*Numenius phaeopus)*	Wood sandpiper (*Tringa glareola)*

4.6.1 Marine turtles

All six species of marine turtle that occur in the Region and adjacent areas (green turtle, hawksbill turtle, flatback turtle, leatherback turtle, loggerhead turtle and olive ridley turtle) are listed as both migratory and threatened species. Many migrate to nesting or foraging areas outside the Region. Important nesting, inter-nesting and foraging areas for four of the species have been identified in the Region.[87] Leatherback and olive ridley turtles are rarely sighted within the Region — there are no known nesting sites and very little is known about how they use the Great Barrier Reef. There is also very limited knowledge about foraging flatback turtles.

A brief description of each species is provided below.

The **green turtle** is found in tropical, subtropical and temperate waters around the world and is the most abundant of the six species of marine turtle found in the Region. Green turtles are slow growing, taking decades to mature to breeding adults. Age at maturity is estimated to be about 30 to 40 years. Two genetic stocks of green turtles breed within the Great Barrier Reef Marine Park — southern and northern stocks.[88,89] Within a feeding area, the proportion of adult females that prepare to breed in a year is variable and is a function of the Southern Oscillation Index two years before the breeding season.[90,91] Nesting for the southern stock is concentrated in the Capricorn Bunker group of islands; the total nesting population is expected to be approximately 8000 females in an average breeding season.[92] Nesting for the northern stock is concentrated on Raine Island and Moulter Cay, and there is significant fluctuations in the size of the annual nesting population. Size estimates of the nesting population in the waters around Raine Island have varied between 788 and 135,300 females.[88] These cays support one of the few remaining large breeding aggregations of green turtles in the world.[89,92] The southern stock is recovering at almost four per cent per annum. The northern stock is stable but showing signs of decline.[92] Green turtles are generalist feeders, eating predominantly seagrass but also algae, mangrove fruit and jellyfish. Southern stock turtles forage in waters mainly south of Cape Melville and eastwards to New Caledonia and sometimes Fiji.[92] Northern stock turtles forage in waters mainly north of Cape Melville, throughout Torres Strait and waters of eastern Indonesia and Papua New Guinea. Green turtles that nest in the Coral Sea have also been found foraging in the Region.

Green turtle hatchling on Raine Island

Hawksbill turtles that nest in the Region are part of the Torres Strait–northern Great Barrier Reef breeding stock. The number of females nesting annually at Milman Island, an important nesting site, has previously been estimated at between 100 and 500.[93] However, there is no published monitoring data since 2000. Hawksbill turtles eat primarily algae, but also feed on sponges, soft corals, seagrass and shellfish.[94] They grow very slowly and do not reach sexual maturity until after 31 years of age.[95] It is estimated that the breeding stock is declining by around three per cent per year.[96] Hawksbill turtles nesting in the Region have been found in Papua New Guinea and elsewhere in the Region.[93]

Flatback turtles are the only marine turtle that nests solely in Australia. The stock which nests in the Great Barrier Reef is known as the eastern Australian stock. There is little data on age at maturity for the species, but it is likely to be 20 or more years.[97,98] Three decades of research and monitoring of the eastern Australian stock at rookeries in the central Great Barrier Reef indicate that the population is stable.[99] All class sizes of flatback turtles are carnivorous, with post-hatchlings feeding on zooplankton and adults feeding principally on soft-bodied invertebrates including soft corals, sea pens, holothurians and jellyfish.[97] The foraging distribution for the eastern Australian stock extends from Hervey Bay to Torres Strait and possibly into the Gulf of Papua.[100]

Flatback turtle nesting

Loggerhead turtles that inhabit the Great Barrier Reef are part of the eastern Australian stock which breeds in southern Queensland. Loggerhead turtles in the south-western Pacific Ocean are slow growing, taking about three decades to mature to breeding adults. In 1976–77, the estimated population of nesting loggerhead turtles in the Great Barrier Reef was 3500; the population subsequently declined to fewer than 500 females in the 1999–2000 breeding season.[101] Annual monitoring shows the long-term decline has reversed at all monitored nesting beaches since 2001 when turtle excluder devices on otter trawlers became mandatory.[102] In eastern Australian coastal waters, loggerhead turtles feed principally on molluscs and crabs.[103] The foraging distribution for the eastern Australian stock extends from northern New South Wales to the Northern Territory, Papua New Guinea, south-west Pacific and Coral Sea.

There are no major rookeries for the **leatherback turtle** in Australia.[104] The progressive decline in breeding frequency recorded in eastern Australia — from low density, annual nesting recorded in the 1970s and 1980s to now, when no nesting is observed[104] — indicates the population that visits Australian waters is likely to be in decline. This correlates with reports of a significant decline in Pacific Ocean leatherback turtle populations[105] and recorded declines in the numbers of animals interacting with shark control equipment set along the Queensland coast.[106] Leatherback turtles are one of the fastest growing marine turtles. Individuals from the eastern Pacific population are estimated to reach maturity in 13 years.[107] Leatherback turtles are carnivorous and, in Australian waters, they feed extensively on colonial tunicates,[108] jellyfish and other soft-bodied invertebrates.[109,110]

There are two main breeding areas for **olive ridley turtles** in Australia, one in the Northern Territory with an estimated annual nesting density of a few thousand, and the other along the north-western coast of Cape York Peninsula between Weipa and Bamaga.[111] There are no records of olive ridley turtles nesting along the east coast of Australia, even though sexually mature females have been recorded in foraging areas off Townsville.[111] No Queensland rookeries are within national parks or similar protected habitat.[111] However, a substantial part of their east coast foraging range is contained within the Region, although there is no information upon which to conclude the population status of the species in the Region. Adult and large immature olive ridley turtles are carnivorous, feeding principally on molluscs and small crabs.[111]

The important feeding and breeding areas of marine turtles within the Region are presented in Figure 4.10.

The six marine turtle species are considered collectively in the report under the grouping of ‘marine turtles’.

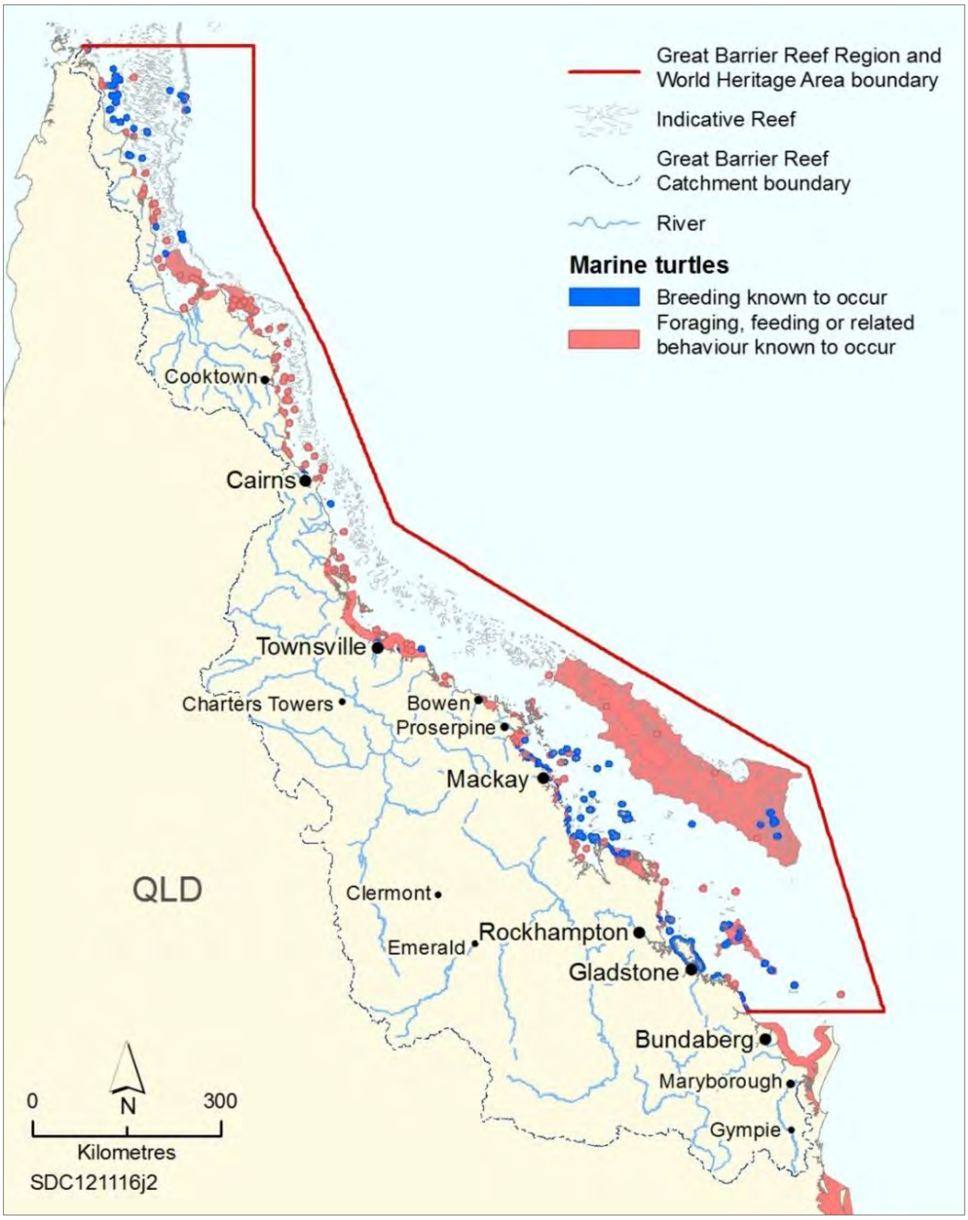

Figure 4.10 Identified important feeding and breeding areas for four species of marine turtles within the Region
The species mapped are the green, hawksbill, flatback, and loggerhead turtles.[87]

4.6.2 Estuarine crocodiles

On the east coast of Queensland, estuarine crocodiles inhabit reef, coastal and inland waterways from north of Gladstone. Following extensive harvesting of wild populations in northern Australia between the 1940s and 1960s, management measures to protect the species were adopted by all states and the Australian Government. In Queensland, the species was fully protected in 1974.[112]

Estuarine crocodiles are considered temporary migrants in the Region. They occur widely but at low densities, principally along the mainland coast and on and around islands. Coastal river systems and their associated wetlands are their primary habitat and also where they nest. Crocodiles on islands are not likely to be a major component of the species population.[113]

4.6.3 Whales

Eight listed migratory whale species are relevant to the Region, with each spending only part of their life history within its boundaries. Four of the species are also listed threatened species, namely blue whales, fin whales, humpback whales and sei whales. Australian populations of these species have previously declined, primarily as a legacy of past commercial exploitation.

Blue, fin and sei whales are baleen whales. All are wide-ranging oceanic species and, in general, spend summers in higher latitudes and winters in warmer tropical waters.[114] They are rarely sighted within the Region and very little is known about their movements or use patterns there.

In contrast, **humpback whales** are the most commonly sighted listed marine mammal species in the Region. The east Australian population is recovering from severe depletion by commercial whaling in the 20th century.[115] Humpback whales migrate to the Region during the winter months to calve and mate.[116] Modelling of environmental suitability for humpback whales identified two core areas where there is a higher probability of humpback whales: offshore Proserpine extending south to Mackay within the inner reef lagoon (including the Whitsundays), and the Capricorn and Bunker groups of islands and reefs approximately 100 kilometres east of Gladstone.[117] Continued recovery of the population means humpback whales are being sighted more frequently in the Region, including in areas where they have not occurred for decades.

Humpback whales are both a listed migratory and a listed threatened species

The **Antarctic minke whale, Bryde's whale, killer whale** and **sperm whales** are believed to be seasonal migrants to the Region, occurring mostly during the winter months. However, there is very little information about these species. Killer whales are rarely sighted within the Region, although there have been anecdotal reports of the species near Moreton Bay, south of the Region, during humpback whale calving season. Sperm and Bryde's whales are known from records obtained through the joint Field Management Program's Marine Wildlife Stranding program and reports from the Authority's Sightings Network.[118]

Until recently, there was thought to be only one species of minke whale, referred to as *Balaenoptera acutorostrata*. There are now two generally accepted species, the common minke whale (*B. acutorostrata*) and the Antarctic minke whale (*B. bonaerensis*) — a listed migratory species. The dwarf minke whale, which is regularly sighted in the Region, is currently regarded as an undescribed subspecies of *B. acutorostrata* and is therefore not a listed migratory species.

In this report, all listed migratory and threatened whale species are generally considered as a group along with other whale species in the Region. The detailed understanding of the humpback whale relative to other whale species means it is used as an example in some assessments in this report.

4.6.4 Dolphins

The **Australian snubfin dolphin** and **Indo-Pacific humpback dolphin** are listed migratory species that occur in the Region. They share similar life history traits and habitat preferences. They are long-lived, slow-growing and late-maturing; have low reproductive rates, low relative abundances, and high habitat and diet specificity; maintain small group sizes; and occupy small home ranges, with little overlap. Each localised population is estimated to have fewer than 100 individuals.[119,120] These traits make them susceptible to a number of pressures in and adjacent to the Region. Along the east coast of Queensland these dolphins are primarily found in shallow waters less than 20 metres deep, close to the coast, close to river and creek mouths and in the proximity of seagrass meadows.[121] The aggregation of snubfin dolphins around the mouth of the Fitzroy River is the southernmost identified resident population in Australian waters.[120]

There are currently no overall population estimates for the Australian snubfin or Indo-Pacific humpback dolphins in the Region,[122] however there are local population estimates for Australian snubfin dolphin aggregations in Cleveland-Halifax Bays[119] and in Keppel Bay-Fitzroy River[120] of about 70 dolphins each. An aggregation has also been recorded at Princess Charlotte Bay-Bathurst Bay on Cape York Peninsula.[123] There have been population estimates for Indo-Pacific humpback dolphins in Cleveland Bay (50 or less)[119]; the Capricorn coast (about 64); Keppel Bay (about 107); and Port Curtis (about 85)[124]. Modelling suggests that current mortality in the populations of these species is greater than what they can sustain.[119,120]

All dolphin species are considered as a group in the report and, where relevant, the two listed species are discussed separately.

4.6.5 Dugongs

The Great Barrier Reef Region supports globally significant populations of dugongs. They occur along the length of the Region, feeding mainly on seagrasses. Dugongs play an important ecological role in coastal marine ecosystems.

North of Cooktown, there is a healthy population and the population trend over the last several decades of monitoring has been stable.[125] However, dugong populations south of Cooktown have been mostly declining for decades with an estimated population of only 600 animals between the Daintree River and the southern limit of the Region in 2011[126,127] compared with an estimate of 2059 when the previous survey was conducted in 2005. This is the lowest number recorded in this area since surveys began in 1986.

Dugongs are considered separately as a discrete key value throughout the report and are the subject of a demonstration case study (Chapter 9).

4.6.6 Sharks

The **whale shark** is both a listed migratory and listed threatened species. It is the world's largest fish, with the largest recorded being 12 metres long.[128] Despite its size, it feeds primarily on plankton. The whale shark has a broad global distribution in tropical to warm-temperate waters. It is often seen far offshore, but also comes close to shore and sometimes enters lagoons of coral reefs. The species is widely distributed in Australian waters and is regularly sighted throughout the Region.

Whale sharks are regularly sighted in the Region

White sharks are also a listed migratory and listed threatened species. They are a large apex predator that grow to at least six metres and can weigh up to 2000 kilograms.[129] They are most frequently observed in coastal temperate and subtropical regions but have been observed in tropical areas such as the Coral Sea, Papua New Guinea, the central Pacific, northern Brazil and the tropical south-west Indian Ocean.[130] They occur mainly in coastal waters but also spend significant time in the open ocean.[130] White sharks are rarely sighted in the Region, although there are a few reports in waters off central Queensland. Some animals tagged in New South Wales waters have been tracked swimming north into the Great Barrier Reef, indicating connectivity over long distances.[131] The ranges of the **longfin mako, porbeagle** and **shortfin mako** extend well beyond the Region. The **porbeagle** is a wide-ranging, coastal and oceanic shark that is found from the surface down to 370 metres.[129] The **shortfin mako** is a wide-ranging oceanic and pelagic shark found in waters down to 650 metres.[129] The **longfin mako** is a widely-distributed, but rarely encountered, oceanic tropical shark.

The listed shark species are considered in the report as part of the larger group of sharks and rays.

4.6.7 Seabirds

Within the Region, 23 seabird species are listed as migratory under the EPBC Act. In the description below, the species are divided into *inshore and coastal*, and *offshore and pelagic* foragers due to differences in feeding behaviour and associated implications for their ecology.[132,133] Seabirds and their habitat are also protected under three bilateral migratory bird agreements between Australia and Japan, China and the Republic of Korea.[134]

Seabirds are generally long-lived, characterised by late sexual maturity, small clutch sizes, slow chick growth rates and extended fledgling periods. They require habitats with suitable areas for both breeding and foraging. Specific requirements for breeding vary between species, but commonly include an area free from disturbance by terrestrial predators and storms and tide; the presence of others of their species, including potential mates; and suitable access to foraging grounds.[135]

The timing of seabird breeding activity in the Region is complex and poorly understood.[132] Most seabirds breed on relatively remote islands, with each species tending to nest in a specific habitat type. Coral cays are the preferred habitats of most seabirds, providing 73 per cent of the major nesting sites.[135] More than 75 cays have been identified as seabird breeding colonies, with 56 considered to be key sites and 20 minor sites (Figure 4.11).[134,135] The most significant nesting sites are Raine Island, Michaelmas Cay, the cays of the Swain Reefs and the islands of the Capricorn and Bunker Groups.[134] For the majority of species, peaks in breeding occur between October and April, though for some species, nesting can occur year round.[132] However, for some seabird species on the Great Barrier Reef, such as masked boobies in the Swain Reefs, nesting peaks during the winter months.[136]

Inshore and coastal foraging seabirds

There are eight species of inshore and coastal foraging seabirds that nest within the Region, five of which are listed migratory species (Table 4.4). The Region supports more than 50 per cent of Australia's inshore foraging roseate terns, lesser crested terns and black-naped terns (Table 4.5).[134,135]

Generally, inshore and coastal foraging seabird species source food closer to their breeding colony compared with offshore and pelagic foragers. For example, in the Great Barrier Reef, crested terns mostly forage singularly or in pairs over shallow reef flats and coastal waters[137] within two to three kilometres of their colony[138] (though some venture up to 12 kilometres away[133,138]). Roseate terns and black-naped terns forage within three kilometres of the colony and the lesser crested tern forages even closer.[139] Colonies of inshore and coastal foraging seabirds are also smaller, more numerous and more widely distributed.[140]

Table 4.5 Estimated population of listed migratory inshore and coastal foraging seabirds known to breed in the Great Barrier Reef Region
Source: Adapted from Congdon, 2008[132]

Species	Estimated population in the Region
Caspian tern *(Hydroprogne caspia)*	70
Roseate tern *(Sterna dougallii)*	6000
Black-naped tern *(Sterna sumatrana)*	3900
Little tern *(Sternula albifrons)*	1000
Lesser crested tern *(Thalaseus bengalensis)*	6300

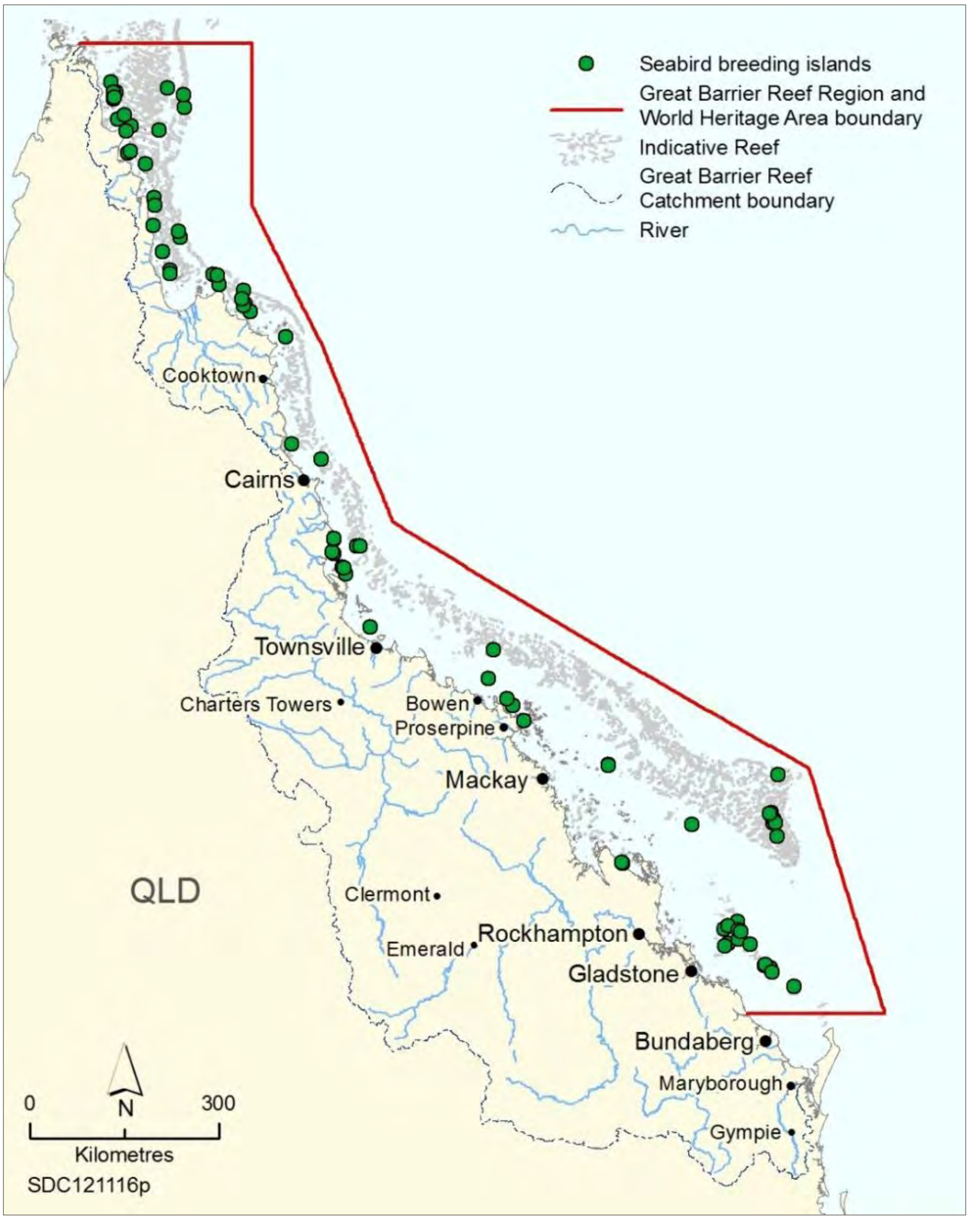

Figure 4.11 Principal seabird breeding islands in the Region

Offshore and pelagic-foraging seabirds

There are 12 species of offshore and pelagic-foraging seabirds that nest within the Region, 10 of which are listed migratory species (Table 4.6).[10] The Region supports more than 50 per cent of offshore foraging black noddies and approximately 25 per cent of wedge-tailed shearwaters, and brown and masked boobies.[134,135]

Offshore and pelagic-foraging seabirds usually have single clutches and much slower growing chicks with longer fledging periods than seabirds with other methods of foraging.[132] Pelagic-foraging species such as sooty terns may live up to 32 years and larger species such as boobies and frigatebirds even longer.[132] Most offshore and pelagic-foraging seabird species do not become sexually mature or return to breed for between five to 12 years after fledging. The nestling period for some species, such as frigatebirds, can be up to six months.[132]

Red-footed boobies on Raine Island. From top of branch, two brown juveniles, a white adult and a light brown bird in an intermediate phase.

Characteristically, these species nest in large colonies, often spread over multiple, closely spaced islands that are close to abundant food and provide suitable nesting habitat. The most important example is the wedge-tailed shearwater where approximately 500,000 individuals breed on the 13 islands of the Capricorn and Bunker Groups which comprise a staggering 66 per cent of the biomass of breeding seabirds in the Region.[135,141] They feed on pelagic fish whose abundance and distribution are determined by oceanographic upwellings.[135]

The listed migratory seabird species are considered in this report as part of the larger group of seabirds.

Table 4.6 Estimated population of listed migratory offshore and pelagic-foraging seabirds known to breed in the Region

Source: Adapted from Congdon, 2008[132] and King, 1993[142]

Species	Estimated population in the Region
Wedge-tailed shearwater *(Ardenna pacifica)*	560,000
Red-footed booby *(Sula sula)*	172
Brown booby *(Sula leucogaster)*	18,500
Masked booby *(Sula dactylatra)*	1100
Greater frigatebird *(Fregata minor)*	20
Lesser frigatebird *(Fregata ariel)*	2500
Sooty tern *(Onychoprion fuscata)*	48,000
Bridled tern *(Onychoprion anaethetus)*	13,900
Common noddy *(Anous stolidus)*	46,000
Black noddy *(Anous minutus)*	300,000

4.6.8 Shorebirds

There are 41 species of shorebirds known to inhabit the Region, 30 of which are listed migratory species (see Table 4.4). These species use a wide range of habitats within and adjacent to the Region, including beaches, rocky shores, estuaries, intertidal flats, coral cays and reefs, freshwater wetlands, grasslands, pasture land and sewage treatment plants.

Most are generalists, with several exceptions including the sooty oystercatcher, which are generally only found on rocky ocean shores.[143] The most crucial habitats for shorebirds are tidal flats. Loss or degradation of habitat in any of their feeding, breeding or staging areas can result in failure to breed or death from starvation or predation. Maintenance of these habitats in an undisturbed condition is particularly important for migratory shorebirds to enable them to build adequate body condition prior to their annual northward migration.

The majority of migratory shorebirds spend part of the year in Australia, departing for their breeding grounds in northern China, Mongolia, Siberia and Alaska between March and May. They arrive back in Australia between August and November after their return migration. Birds migrate along the East Asian-Australian Flyway, which includes numerous stopover sites for resting and feeding.[144]

There are no population estimates for the Region's shorebirds. Significant declines in some shorebird populations have been reported in Australia.[145]

Internationally significant numbers of shorebirds occur at a number of sites with the Region, particularly the islands off False Orford Ness in Cape York, Pelican Island and nearby islands, the Cairns foreshore, Cape Bowling Green, Burdekin River delta, Pioneer River to McEwan's Beach and Notch Point near Mackay, Shoalwater Bay and Broad Sound.[143]

The listed migratory shorebird species are considered in the report as part of the larger group of shorebirds.

4.7 Listed threatened species and ecological communities

Twenty six species that are currently listed as threatened under the EPBC Act occur in the Great Barrier Reef Region. There are six marine turtle species, five marine mammal species, seven shark and ray species, and six seabird and shorebird species (Table 4.7).

Table 4.7 Listed threatened species in the Great Barrier Reef Region

The species marked with the symbol - M - are also listed migratory species (see Table 4.4). The scientific name is presented in *italics.*

Status	Marine turtles	Marine mammals	Sharks and rays	Seabirds
Vulnerable	Flatback turtle M *Natator depressus* Green turtle M *Chelonia mydas* Hawksbill turtle M *Eretmochelys imbricata*	Fin whale M *Balaenoptera physalus* Humpback whale M *Megaptera novaeangliae* Sei whale M *Balaenoptera borealis* Subantarctic fur seal *Arctocephalus tropicalis*	Dwarf sawfish *Pristis clavata* Freshwater sawfish *Pristis pristis* Green sawfish *Pristis zijsron* Whale shark M *Rhincodon typus* White shark M *Carcharodon carcharias*	Northern giant petrel M *Macronectes halli* Sooty albatross M *Phoebetria fusca* Wandering albatross M *Diomedea exulans*
Endangered	Loggerhead turtle M *Caretta caretta* Leatherback turtle M *Dermochelys coriacea* Olive ridley turtle M *Lepidochelys olivacea*	Blue whale M *Balaenoptera musculus*	N/A	Grey-headed albatross M *Thalassarche chrysostoma* Southern giant petrel M *Macronectes giganteus*
Critically endangered	N/A	N/A	Grey nurse shark — east coast population *Carcharias taurus* Speartooth shark *Glyphis glyphis*	Herald petrel *Pterodroma heraldica*

The water mouse, *Xeromys myoides,* may occur in coastal saltmarsh, mangroves and adjacent freshwater wetland habitats adjacent to the southern half of the Region. It is not considered in this assessment. None of the listed ecological communities are known from the Region.

4.7.1 Marine turtles

The six listed threatened marine turtle species which occur in the Region are also listed migratory species and are discussed in Section 4.6.1.

4.7.2 Marine mammals

The four listed threatened whale species which occur in the Region are also listed migratory species and are discussed in Section 4.6.3.

The **subantarctic fur seal** is rarely seen within the Region and those recorded are believed to have been transients. Dispersing juvenile and adult male sub-Antarctic fur seals are known to make long journeys of up to 3000 kilometres. Given its very rare occurrence in the Region, this species is not considered further in this report.

4.7.3 Sharks and rays

The Region is within the range of the critically endangered east coast population of **grey nurse sharks**. The species is rarely sighted within the Region, with only some records in the central and southern parts.

The grey nurse shark, a critically endangered species, is rarely sighted in the Region

The **dwarf sawfish**, **freshwater sawfish** and **green sawfish** all occur in similar habitats within and adjacent to the Region.[129] Sawfish are commonly found in estuaries and freshwater rivers and are known to move easily between fresh and saltwater.[129] They are long-lived and mature late; have slow growth rates, low reproduction rates and low abundance; and can exhibit habitat and prey specificity. These life history traits make them susceptible to a number of impacts occurring in and adjacent to the Region.[146]

The **speartooth shark** belongs to the genus *Glyphis,* a small group of poorly known sharks. It is thought to have a fragmented distribution, confined to a few highly turbid, tidal rivers and estuaries in northern Australia.[147] The species has not been recorded in or near the Region since 1982 when it was recorded in the Bizant River flowing into Princess Charlotte Bay.[147] The speartooth shark is listed as critically endangered under the EPBC Act.

The **whale shark** and the **white shark** are listed as both threatened and migratory species and are discussed in Section 4.6.6 above.

As with the listed migratory sharks (Section 4.6.6), all these threatened shark and ray species are considered in this report within the group 'sharks and rays'. Particular issues in relation to these threatened species are highlighted where relevant.

4.7.4 Seabirds

Five of the six listed threatened seabird species which occur in the Region are also listed migratory species and are discussed in Section 4.6.7. There are very few sightings in the Region of the listed threatened seabirds. The **grey-headed albatross**, **northern giant petrel, sooty albatross**, **southern giant petrel** and **wandering albatross** are all primarily associated with offshore areas of the Region, near and beyond the continental shelf. Their most critical foraging habitat is considered to be waters south of 25 degrees latitude[148] (and hence outside the Region). There is no breeding habitat within the Region.[148]

There are few records of the **herald petrel** for the Great Barrier Reef. All have been at Raine Island where, from 1979 to 1987, 13 birds were banded. Of these, only three individuals have been recaptured at Raine Island (the last in 1985) and one has been recovered breeding on Round Island in the Indian Ocean in 2010.[149] Since 1987, there has been only one observed incidence of breeding by herald petrels on the island.[150]

As with the listed migratory seabirds, all these threatened seabird species are combined in this report in the grouping 'seabirds'.

4.8 Wetlands of international importance

4.8.1 Shoalwater and Corio Bays Area

The Shoalwater and Corio Bays Area was listed under the Convention on Wetlands of International Importance (the Ramsar Convention) in 1996. The area extends over terrestrial and marine areas and part is within the Region (Figure 4.12).

It is the largest wilderness area within the Central Mackay Coast biogeographic area and is representative of coastal, sub-coastal, aquatic landscapes and ecosystems which are relatively undisturbed habitat for significant plants and animals, including rare and threatened species.[151]

The Shoalwater and Corio Bays Area supports about 791 plant species and sub-species, 445 fish species, 22 frog species, 66 reptiles species, 226 birds species, 24 mammal species and 23 bat species. Listed threatened marine species that occur at the site include the green turtle, hawksbill turtle, flatback turtle and loggerhead turtle. Dugongs, a listed migratory species, also occur in the area. Dozens of listed migratory bird species have been recorded at the site, and it is of international importance to the migratory eastern curlew, whimbrel and great knot. The area supports more than 20,000 shorebirds, most of them migratory. Six shorebird species occur in numbers greater than one per cent of their estimated flyway population size — grey-tailed tattler, bar-tailed godwit, eastern curlew, whimbrel, terek sandpiper, and Australian pied oystercatcher.[152]

The area is part of the traditional lands of the Darumbal people. The dune fields contain archaeological sites including shell middens, scatters of stone tools and dinner camp sites. The area is connected with the broader Great Barrier Reef ecosystem and beyond. For example, 69 adult green turtles previously recorded at distant breeding areas throughout the Coral Sea were recaptured between 2000 and 2004 while foraging in western Shoalwater Bay.[153]

Freshwater Beach, Shoalwater Bay

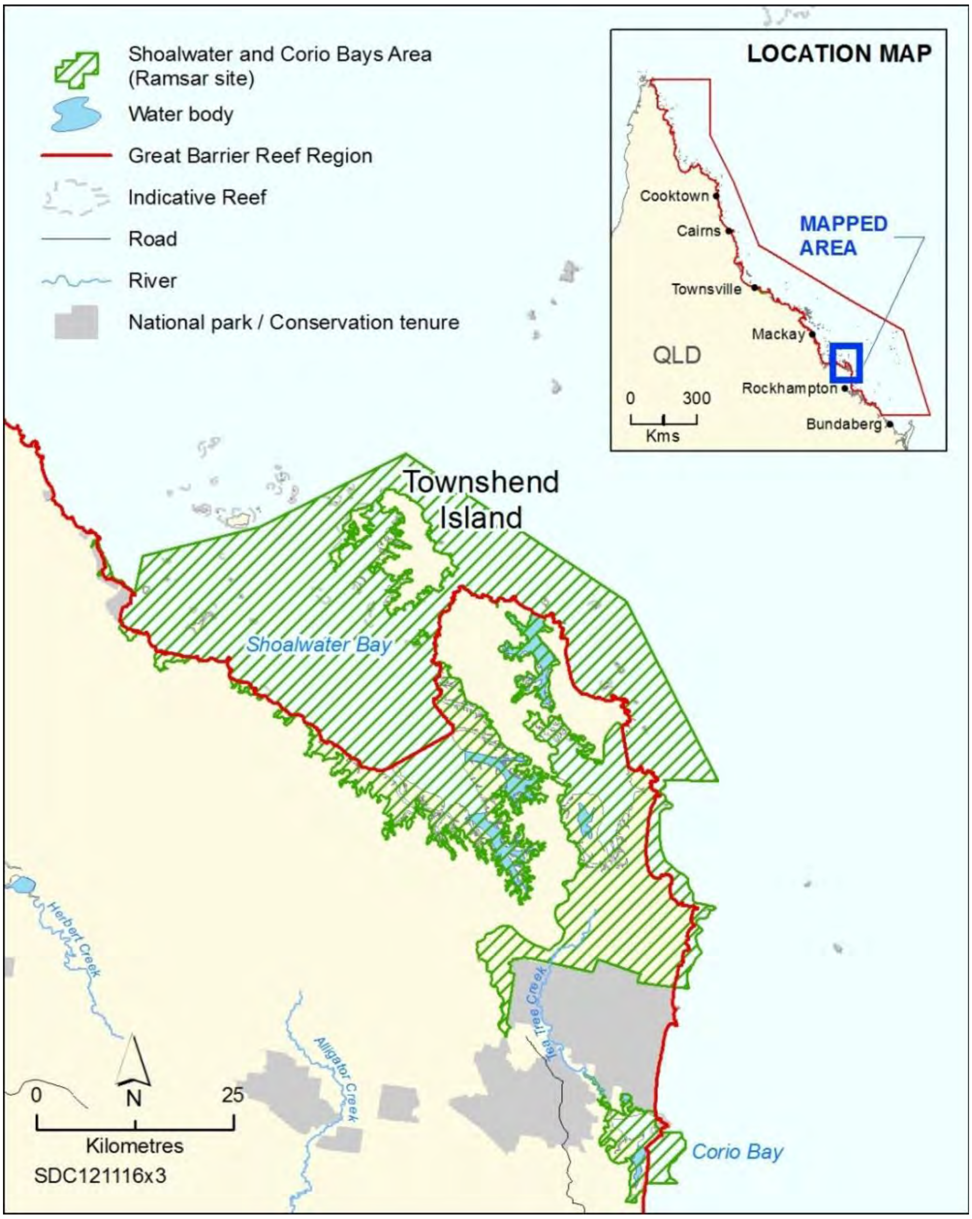

Figure 4.12 Shoalwater and Corio Bays Area
The Shoalwater and Corio Bays Area is a wetland of international importance, part of which is within the Region.

4.8.2 Bowling Green Bay Area

The Bowling Green Bay Area is a wetland of international importance adjacent to the Region, listed under the Ramsar Convention in 1993. The site is located about 50 kilometres south-east of Townsville and covers more than 47,000 hectares, including Cape Bowling Green and parts of Cape Cleveland (Figure 4.13). The area is part of the traditional lands of the Juru and Bindal people.

Ninety-nine per cent of the Ramsar site is within a Queensland national park. At the northern extremities of Cape Bowling Green and Cape Cleveland, there are small lighthouse areas (approximately 80 hectares and three hectares respectively). A further 208 hectares have been excised at the western end of Bowling Green Bay for the Australian Institute of Marine Science. Several small townships are encompassed by the area but do not form part of it.

The area is identified as being regionally unique and internationally important for the diversity and extent of marine, estuarine and freshwater wetland types it supports. As one of the remaining, relatively intact wetlands adjacent to the Region, it supports the Great Barrier Reef ecosystem, including through nutrient assimilation and sediment stabilisation.

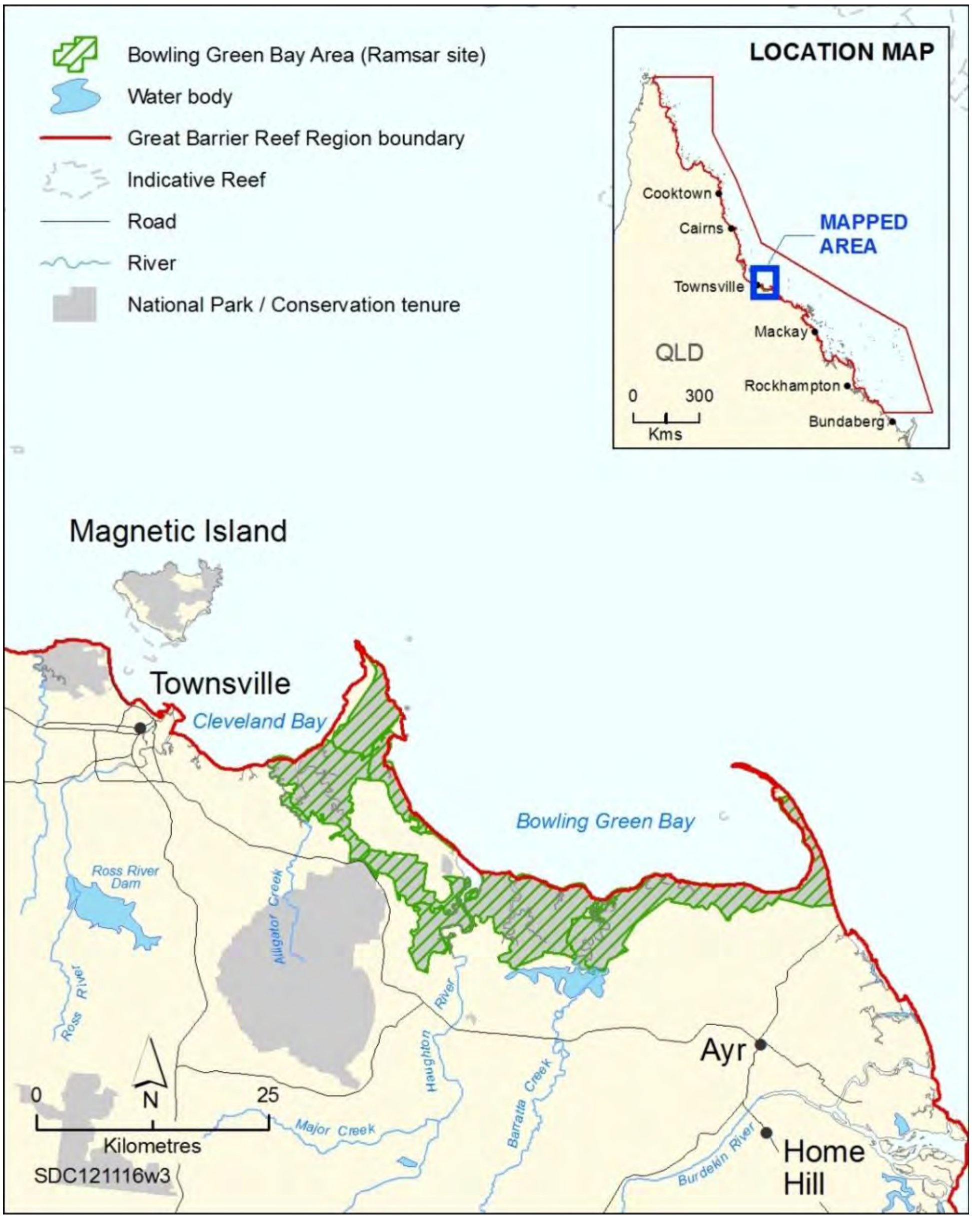

Figure 4.13 Bowling Green Bay Area

The Bowling Green Bay Area is a wetland of international importance directly adjacent to the Region.

4.9 Environmental processes

Environmental processes are the forces, cycles, reactions and interactions that alter and shape a natural area, keeping it healthy and functioning. They support and connect the Great Barrier Reef environment, and interact with and influence each other. They can also be affected by activities within and adjacent to the Region — transferring effects onto the Region's values.

The following is a description of the principal environmental processes in the Region. It includes the ecosystem health processes identified in the Outlook Report 2009[9], with minor updates and amendments, and the major geomorphological processes that are altering and shaping the Reef environment. In many cases, the ecological and geomorphological processes are one and the same, for example reef building and erosion have both ecological and a geomorphological aspects.

The major processes are illustrated in Figure 4.14. All these processes are critical to the Region and are comprehensively considered throughout the report. They are individually assessed in Chapter 7.

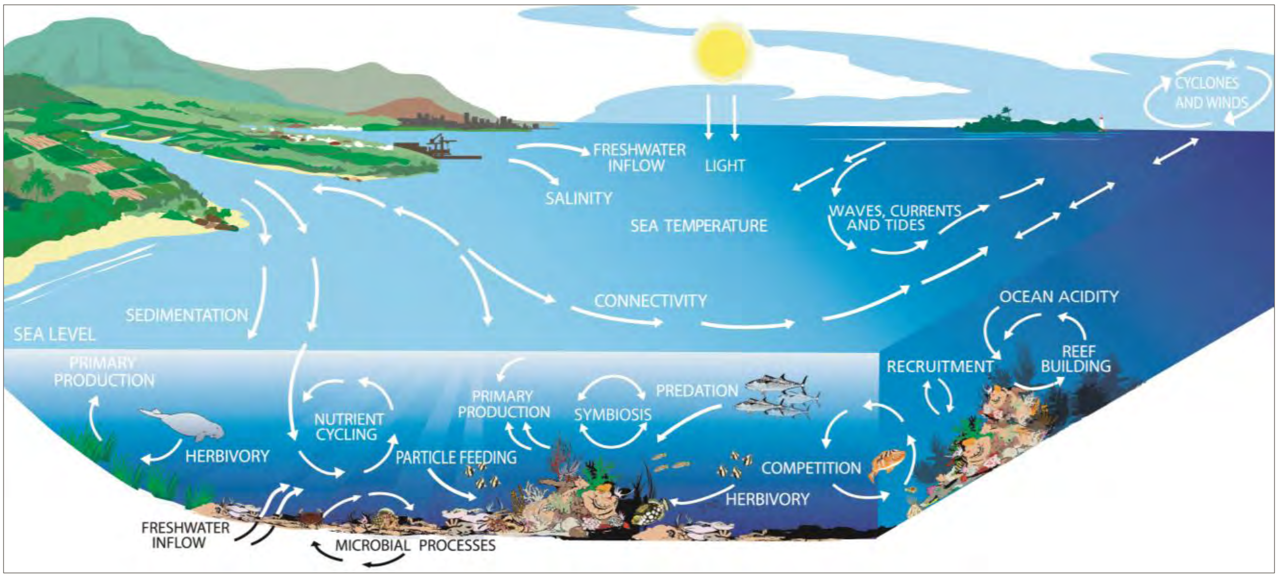

Figure 4.14 Key environmental processes of the Great Barrier Reef Region

Waves, **currents** and **tides** all mix oceanic water and have an important effect on marine life. The Great Barrier Reef is part of a larger system of ocean circulation throughout the Pacific Ocean, which delivers nutrients and larvae from other regions as well as deep water into the Region. At the largest spatial scale (thousands of kilometres), major oceanic currents of the Coral Sea affect patterns of connectivity between reefs and the temperature of the Region's waters.[154] At small scales (centimetres to metres) turbulence can affect the settlement patterns of organisms such as corals. While surface currents are primarily driven by wind, deeper ocean currents are mainly driven by relative densities of seawater, affected by salinity and temperature.[154]

Upwelling of cold, nutrient-rich, sub-thermocline waters to the sea surface create 'hotspots' of marine primary production. In the Great Barrier Reef, upwelling intrusions include those on the central Great Barrier Reef which are enhanced during conditions of consistently low winds. During these conditions, the southward-flowing East Australian Current flows faster, lifting the thermocline closer to the surface, spilling cooler waters onto the shelf.[154,155]

Cyclones regularly affect coral reefs and other habitats at regional and local levels. In the past five years there have been several cyclones of category three and above affecting the Great Barrier Reef. In addition to strong winds and rain, the powerful waves generated during cyclones can seriously damage habitats and geomorphological features, particularly coral reefs and shorelines.[154] **Wind** also plays a role; in particular, it can cause dramatic changes in the shape of islands and the coast and affect ocean currents.[154]

Damage to corals on Rib Reef by Cyclone Larry

Sea level is an important determinant of species and habitat distribution as well as affecting individual foraging and reproduction activities. It varies naturally day-to-day with the tides and over longer time scales from the El Nino Southern Oscillation and the Pacific Decadal Oscillation. In addition, cyclonic winds can also cause storm surges, an onshore rise of water above the predicted astronomical tide. Taking a longer time period, over the past 100,000 years sea levels have risen and fallen many times, shifting the position of reef growth on the continental shelf.[47] However, it is believed that sea level has been fairly constant for the past 6500 years, resulting in today's well-defined depth profile across virtually all the Marine Park's reefs.[44] Sea level is now rising in Australian waters especially in northern areas.[156,157]

Sea temperature is a key environmental factor controlling the distribution and diversity of marine life. It is critical to reef building and is one of the key variables that determine the north-south limits of coral reefs and coral reef diversity.[158] When temperature limits are exceeded, physiological processes may break down. For reef habitats, the most critical mechanism affected is the symbiotic association between animals (such as corals and clams) and the algae which live within their tissues and provide much of their nutrition. If sea temperatures exceed a certain threshold these algae are expelled – an effect known as 'bleaching'.[159] Sea temperature also plays a role in ocean circulation through deep ocean currents as cooler, denser water sinks to the bottom and warmer, less dense water rises.

Freshwater inflow from the creeks and rivers in the Great Barrier Reef catchment naturally form a thin layer of freshwater on the surface of the heavier seawater and, during flood events, may extend to mid-shelf and outer reefs. This can result in extensive fluctuations in ocean **salinity**, especially in intertidal and shallow habitats. Heavy rainfall directly on the ocean can also reduce surface salinity. At natural volumes and frequencies, freshwater inflow from catchments triggers essential migration, reproduction and recruitment of various fish and crustaceans.[160] Depending on geology and soil permeability, freshwater also moves as groundwater to estuaries or the sea. Some mangroves, saltmarsh plants and seagrasses depend on freshwater seepage. Some marine animals (for example sea snakes) consume freshwater from submarine groundwater seepages.[161] Freshwater may also seep through the ocean floor from drowned river channels through 'wonky holes'.[162] Salinity is also a key driver of ocean circulation.[154]

Sedimentation — the inflow, dispersion and resuspension of sediments — has been a natural phenomenon in the Region since the current sea level was reached about 6500 years ago.[44,163,164] Inshore areas are most exposed to sedimentation, especially areas close to river mouths. Longshore drift, tides and currents redistribute sediment across the continental shelf and along the coast. The deposited sediments can be colonised by mangroves and seagrass meadows.

Levels of **light** control the depth range of marine plants (for example, seagrasses and algae) as well as all animals which have a symbiotic dependence on photosynthesis (for example corals). Light attenuation in the water column is determined by depth and the amount of sediment in the water.[165] Thus, it is a more limiting factor in inshore areas compared to offshore habitats less affected by catchment run-off. The availability of light is central to the productivity of seagrass meadows as well as the symbiotic relationship between corals and algae and the reef building activities of corals, and calcareous and coralline algae.

Nutrient cycling plays a critical role in maintaining biodiversity. Most nutrient concentrations (for example nitrogen and phosphorus) in the open ocean are very low — they are effectively nutrient deserts.[166] Low concentrations of nitrates, in particular, severely limit productivity. Open ocean coral reefs accommodate nutrient deficiency by having a high level of nutrient cycling.[166] For reefs nearer land, additional nutrients are derived from terrestrial sources. Nitrates also boost algal production and can result in planktonic algal blooms that in turn trigger secondary blooms of planktonic consumers. Algal blooms can affect ecosystems when there is an overabundance of nutrients, causing deleterious effects known as eutrophication.[167]

The ocean plays an important role in global **carbon cycling**.[168] Carbon is exchanged in and out of the ocean daily, but it can also be stored there for millions of years. Overall, the ocean is a carbon 'sink' as it takes more carbon from the atmosphere than it gives out. Carbon dioxide from the atmosphere dissolves in the surface waters of the ocean where it stays as dissolved gas, or gets taken up by organisms. Photosynthesis by phytoplankton (free-floating microscopic algae) in surface waters turns the carbon into organic matter. Other organisms use carbon to make calcium carbonate for their shells and skeletons. The use of carbon by biological and chemical processes allows more carbon dioxide to enter the water from the atmosphere. The living organic matter in the ocean eventually decomposes and is broken down into simpler forms of matter (detritus). Some sinks to the ocean floor, where it forms layers of carbon-rich sediments. This part of the carbon cycle can lock up carbon for millions of years.[168]

The total amount of carbon in the ocean is about 50 times greater than the amount in the atmosphere and least half of the atmospheric oxygen comes from photosynthesis by marine plants. Currently, almost half the carbon emitted to the atmosphere by fossil fuel burning is absorbed and sequestered into the ocean.[168,169]

It is estimated that an increase in the amount of carbon dioxide absorbed by the ocean has already changed global **ocean acidity**, reducing the ocean's pH by 0.1 units compared to the long-term average. The acidity of the ocean is of vital importance to those marine animals that grow shells or skeletons — more acidic water reduces their ability to grow strong skeletons.[170,171]

Redox (reduction-oxidation) processes are chemical reactions where the oxidation state of atoms and elements are changed through the transfer of electrons.[172] They are vital chemical reactions fundamental to ecosystems. Processes such as photosynthesis, denitrification and respiration are all important marine redox reactions.

As part of the carbon cycle, most food webs are originally based on **primary production**: the production of food by photosynthesis using energy from the sun. In tropical marine ecosystems, contributions to primary production come not only from plants such as macroalgae, turf algae, seagrasses and mangroves, but also, in large part, from phytoplankton and corals which have microscopic algae within their tissues. Primary production is closely linked to concentrations of available inorganic nutrients.[173]

The role of **microbial processes** in trophic interactions is not well known, having received only very limited scientific study.[174] Marine snow, a continuous shower of mostly organic detritus falling from the upper layers of the water column, and the increasing frequency of diseases are visible outcomes of changes in bacterial levels in the water column and in benthic organisms.[175] However, most microbial processes remain invisible. Some microbial processes cause sub-surface water to become completely depleted of oxygen. Others, including the processing of detritus and the maintenance of biologically active substrates, are fundamental to the functioning of benthic ecosystems. Microbial processes are very responsive to organic and inorganic nutrient concentrations and environmental conditions.[174]

Herbivory is a key process for the health and resilience of coral reefs. [176,177,178] By feeding on the algae of a reef, herbivores (such as some fish and green turtles) reduce the amount that competes with corals for space to establish and grow. Herbivores have a particularly important role in maintaining reef ecosystems because, without their constant presence, many reefs would be rapidly overtaken by algae.[176,177] Fish are important herbivores on the coral reefs of the Great Barrier Reef.[178] Dugongs are an important herbivore in seagrass meadow habitats.

Particle feeding is undertaken by a wide range of animals from the very large (whale sharks) to the microscopic (copepods). Most marine invertebrates, such as sea cucumbers, scallops, sponges, corals and many crustaceans (such as prawns, crabs and lobsters) are particle feeders.[166] They are an important part of the energy and nutrient cycle, feeding on detritus, bacteria, plankton and particulate nutrients.[166]

Predation — animals consuming other animals — has a fundamental influence on marine ecosystems by controlling the abundance of many prey animals and causing a range of cascading effects through the food web.[166] Predators and top predators in coral reef ecosystems include most big bony fish and sharks, as well as a wide array of smaller finfish and invertebrates, seabirds, some marine turtles and marine mammals.

Symbiosis, the interdependence of different organisms for the benefit of one or both participants, is much more prevalent in the oceans than on land. Examples include the association between giant anemones and anemone fish and the *Chelonibia* barnacle found on marine turtles.[179] One of the most important symbioses is between hard corals and microscopic algae.[180] The algae photosynthesise like other green plants, however up to 95 per cent of the nutrients produced are used by the coral host organism.[180,181] In coral reefs, reef building is literally powered by the sun via algal photosynthesis. Symbiosis with algae also occurs in soft corals and anemones, as well as in an assortment of other animals like sponges, flatworms and molluscs.[182] This symbiosis is an example of **mutualism**, where both organisms benefit from the relationship.

In **parasitism**, another type of symbiosis, one organism (the parasite) benefits at the expense of another (the host). For example, parasitic isopod crustaceans live on the gills of many reef fish, gaining shelter and food. High numbers of parasites can be an indicator of poor environmental conditions.[183]

Recruitment occurs when juvenile organisms survive to be added to a population. It plays an important role in the replenishment of populations, reef building and connectivity.[184] For coral reefs, it is especially important after disturbances such as mass coral bleaching or cyclones. The intensity and timing of fish spawning events plays an important role in the large scale patterns of recruitment.[185]

Competition for all resources, including space, nutrients and food is always intense in tropical marine ecosystems. This is partly because they are diverse, so that individual species have many others to compete with, and also because the habitats are three-dimensional. Water, far more than air, is a medium that allows for high levels of biological interaction and nutrient transfer, and therefore competition. Competition between corals and algae for space is a fundamental process on coral reefs.[186] For coral reefs to be maintained in the ecosystem there must be continual settlement and growth of juvenile corals. This recruitment may be hampered if a reef becomes overgrown by algae.[187]

Ecological **connectivity** is the movement of biota and materials across and through landscapes and seascapes. It may be related to **migration** between breeding and foraging areas (for example, humpback whales and marine turtles), movement by ocean currents (for example, coral spawn, fish spawn) or dispersal movements by species (for example dugongs). The diagram of the life cycle of the red emperor fish (Figure 4.15) illustrates the importance of a variety of coastal and marine ecosystems and their relationship to this commercially and recreationally important fish. Connectivity through migration forms an important part of the life cycle of a number of species that travel through and within the Region, including a number of species that are matters of national environmental significance (for example, marine turtles and whales). **Genetic connectivity**, the opportunity for a plant or animal to find and potentially produce viable offspring with other individuals of the same species, is a crucial process in the ecosystem. Currents can play a major role in the genetic connectivity of some plants and animals, for example transporting some larvae for thousands of kilometres. At the other extreme, animals that bear live young are much more restricted in their genetic connectivity.[188]

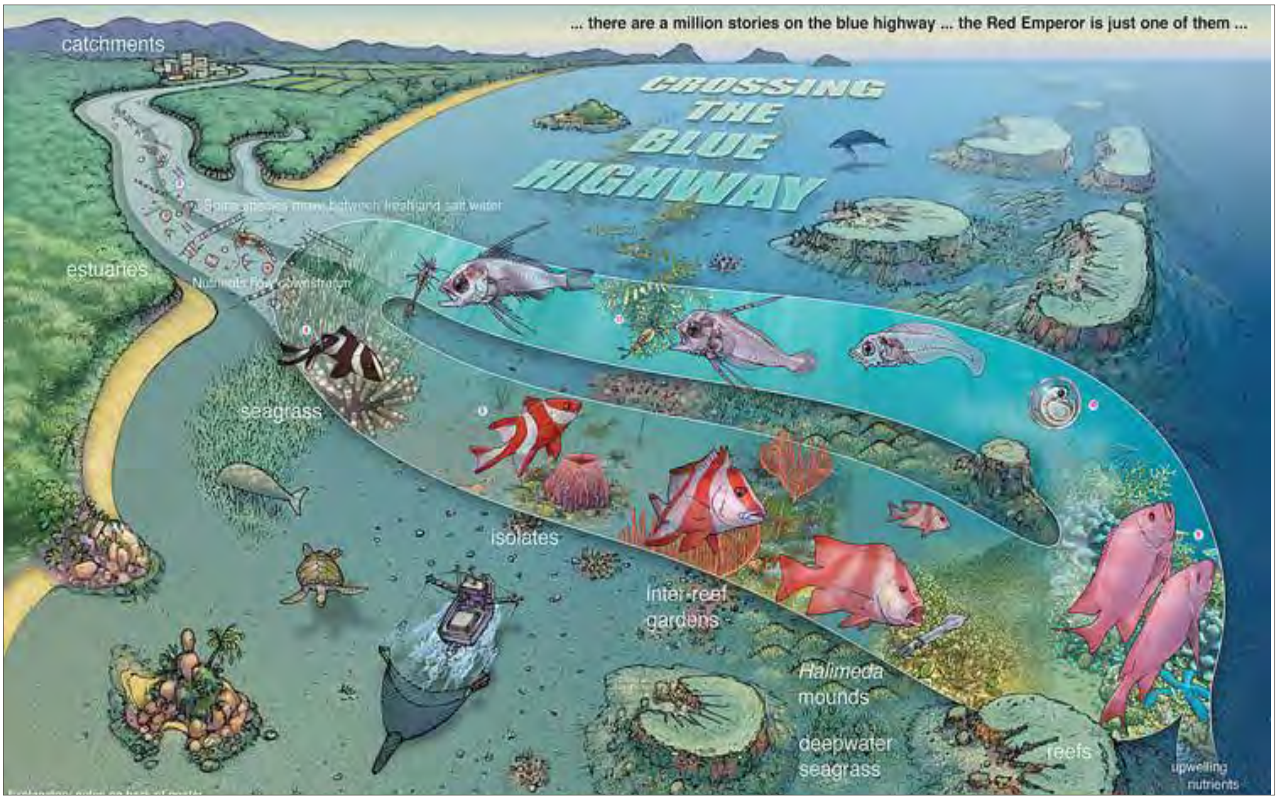

Figure 4.15 Crossing the blue highway

The journey of the red emperor — a fish popular with commercial and recreational fishers — is an example of the importance of connectivity to matters of national environmental significance. At different stages of its growth and development the species uses different habitats across the breadth of the Reef (© Russell Kelley www.russellkelley.info and the Australian Coral Reef Society www.australiancoralreefsociety.org).

The importance of connectivity

Connectivity between and within species and habitats is a key process in the Great Barrier Reef ecosystem. Connections may occur over short periods, from generation to generation, over seasons or in cycles. There are connections between estuarine and inshore habitats and those further offshore; north-south connections between habitats; connections between open water and seabed habitats; and larger scale connections to environments outside the Region such as the Hervey Bay area and further south, Torres Strait and the Coral Sea. Connectivity is important to every aspect of the Reef, including processes as different as nutrient flows, migration, larval dispersal and gene flow.

Migration is a key component of connectivity on a broad scale. A number of listed species live in the Reef for only part of the year or for part of their life — this includes the humpback whale, green, loggerhead and hawksbill turtles, and some seabirds. Some fish species, like marlin, are also highly mobile and travel well beyond the Region for parts of their life cycle.[189] Conservation threats to these migratory species often occur well beyond the Region. For example, some marine turtles that nest or forage in the Region may be injured or killed in areas hundreds, and even thousands, of kilometres away.[92,102] Other species, such as dugongs, can move along the coast, especially if they are in search of food after impacts in their regular feeding areas.[190,191,192]

Larval corals and fishes disperse widely between reefs, usually carried by water movement, and often strongly influenced by larval behaviour.[193] There is now definitive evidence of the larvae of two coral reef fish species transferring from areas that have been closed to fishing to adjacent fished areas. This illustrates the benefits of no-take (green) zones for reef fish conservation and sustainable harvesting.[194]

The life cycles of many fish include movement between marine habitats and adjacent estuaries, pools and floodplain habitats. These species depend on these habitats remaining healthy, connected and accessible. Within the marine environment there are ecological connections between mangroves and seagrass meadows adjacent to coral reefs, including for some reef fish populations.[195]

Connectivity between habitats can also increase the resilience of the Reef ecosystem. For example, connectivity between mangroves and coral reefs provide benefits for herbivorous fish populations which contribute to coral reef resilience by grazing on algae.[196]

The loss and modification of coastal wetlands and the deterioration of connecting water bodies has reduced or severed the connectivity between marine and adjacent freshwater habitats. This makes the role of the protected wetland systems such as the Shoalwater and Corio Bays Area and the Cape Bowling Green Bay Area wetlands of international importance even more important.

Birds play a key role in connecting different ecosystems, both locally and across the oceans. On a local scale, birds distribute plant species. For example, about 63 per cent of the plant species on Milman Island in the northern Great Barrier Reef are believed to have been introduced by birds.[197] One key species is the pied imperial pigeon which roost on islands within the Reef at night and feed in mainland forests during the day. Migratory waders, some of which travel from as far afield as Siberia, provide connectivity to ecosystems across the globe. As with migratory marine species, populations of waders overwintering in Australia are affected by factors in other parts of their migratory journey.

Traditional Owners describe the importance of connectivity as part of their association with their land and sea country. It encompasses the biological connectivity vital to a healthy marine environment and the cultural connectivity that links them to the natural environment.

> *"Cultural value is how it is all connected and makes us connected to country"*[198]

Hydrological connectivity between the Great Barrier Reef and adjacent land areas varies greatly between catchments.[199] Figure 4.16 illustrates the relative importance of areas within four basins of the Great Barrier Reef catchment — the Mulgrave-Russell, Haughton, Fitzroy, and Baffle — in terms of their hydrological and ecological connectivity to the adjacent marine areas.

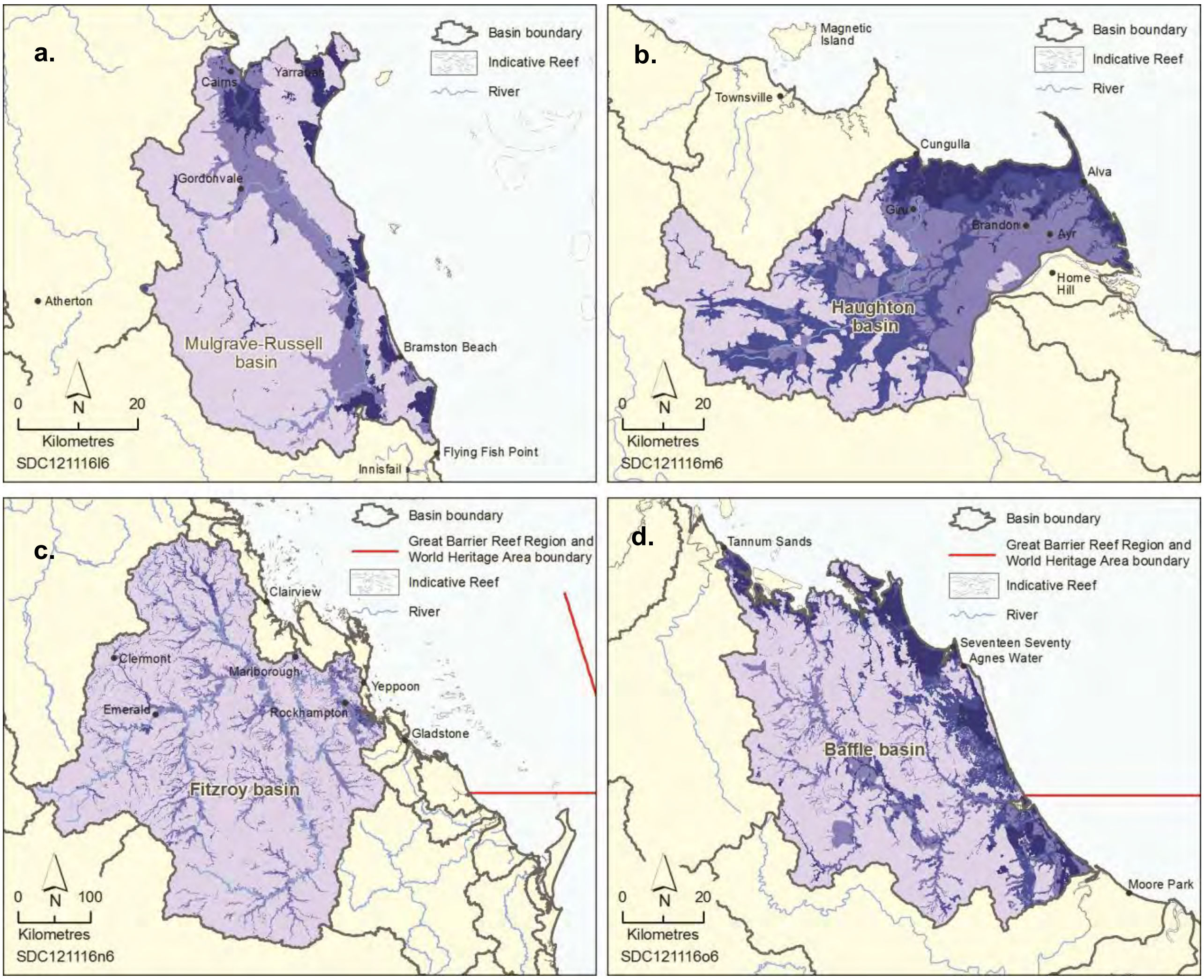

Figure 4.16 Connections between catchment basins and the Great Barrier Reef Region

The maps show (a) Mulgrave–Russell, (b) Haughton, (c) Fitzroy and (d) Baffle basins within the Great Barrier Reef catchment.
The darker blue areas are of higher importance to the healthy functioning of the Great Barrier Reef ecosystem, supporting its biodiversity and ecological processes, and providing connectivity. The analysis[200] takes into account values such as habitats, likelihood of erosion, highest astronomical tide, and land use for the Mulgrave-Russell[201,202], Haughton[203,204], Fitzroy[205,206], and Baffle[207,208] basins. It represents the surface level only and does not include groundwater.

On long time scales, **evolution** is an important part of natural systems such as the Great Barrier Reef, operating in both time and space.[209] Speciation, mutation and adaptation are all important components of evolution. **Extinction** of populations and species is another ecosystem process, caused by reductions in population size or genetic variation, and often associated with the removal or modification of habitats.[210]

Reef building is both a geomorphological and an ecological process including **calcification** by living coral, **erosion**, **deposition** and **accretion**.[211] Only a small proportion of a coral reef is living coral — the remainder is coral-based pavement, boulders, fragments, beach-rock accretions and sediment. Cyclone wave action can break coral and mobilise vast amounts of sediment so that reef shapes change and cays appear and disappear.[44] Coral-based sediment fills in depressions and can consolidate and accrete to form soft rock.[44]

Erosion can occur through physical processes such as waves, wind and currents; chemical processes such as increased ocean acidification; or biological processes such as bioerosion. Erosion during previous periods of lower sea levels has influenced the shape of the continental shelf and slope, which in turn modifies behaviour of currents and upwellings.[212] Today, as coral reefs are growing they are also being eroded, usually through physical abrasion (such as by waves) and bioerosion (by molluscs, marine worms, sponges, crustaceans, echinoderms and fish). Fish are the most effective bioeroders, with one adult humphead parrotfish consuming more than five tonnes of structural reef carbonate per year.[213] This biological activity results in the breakdown of the reef substratum and nutrient cycling.[214] Erosion is also a major process in shaping the Marine Park's coastline.

On a geological timescale, **tectonic forces** such as continental drift, friction, subsidence and the vertical movement of the seafloor, have played a role in shaping the Australian continent, its mountain ranges and its continental shelf.

4.10 Connections between matters of national environmental significance

As outlined above, the matters of national environmental significance, defined and protected under the EPBC Act, range from individual listed threatened and migratory species to the entire Great Barrier Reef Marine Park and World Heritage Area. The Marine Park and World Heritage Area provide critical habitat and ecosystem processes that support the life cycles of listed species. Conversely, listed species are important natural attributes of the Marine Park's environment and the outstanding universal value of the world heritage property. Accordingly, there is substantial overlap and connections between the matters of national environmental significance relevant to the Region. In addition, the matters of national environmental significance and the values that relate to them do not occur in isolation but are embedded within complex and dynamic systems. They are distributed throughout the Region; there is no part that does not contain values of national significance.

Effective future protection of these matters relies on the integration of management measures and a focus on protection of the Great Barrier Reef environment as a whole.

Given the scale and complexity of the Region and the diversity of values that relate to the matters of national environmental significance, the report focuses on a suite of key values and attributes relevant to the Region's matters of national environmental significance.

For the strategic assessment, the key values and attributes of the seven matters of national environmental significance in the Region are grouped into four broad categories:

- biodiversity, including the Region's habitats and species — some of which are listed migratory or threatened species or are part of a wetland of international importance
- geomorphological features
- Indigenous and historic heritage
- community benefits of the environment, comprising the cultural, social and economic benefits derived from the Region's environment.

The key values and attributes presented in Table 4.8 are based on those identified in the description of each matter in Sections 4.2 to 4.8 above. The key environmental processes relevant to each matter are based on the description in Section 4.9 and are presented in Table 4.9.

For some of the matters of national environmental significance, for example the listed threatened and listed migratory species, only a subset of the values and attributes are identified as relevant. For the Great Barrier Reef Marine Park and Commonwealth marine areas, all those listed are considered relevant. This is because of the broad definition of the 'environment' within the governing legislation of these two matters, including heritage, social and cultural aspects.

It is important to note that not all attributes of the outstanding universal value of the Great Barrier Reef world heritage property are identified individually in Table 4.8. Where relevant, certain attributes mentioned in the Statement of Outstanding Universal Value[2] have been grouped into an overarching value for the property. For example, the statement identifies attributes such as 'migrating whales' and 'humpback whale calving'. These and other relevant attributes have been grouped under the value 'whales'. In addition, although not specifically identified in Table 4.8, attributes such as those relating to the life cycle of particular species are considered throughout the assessment. Integrity, as a fundamental concept of outstanding universal value, is considered in Table 4.8 and, where relevant, throughout the report.

Inclusion of the terrestrial habitats that support the Great Barrier Reef as values reflects the important role these habitats have in maintaining ecosystem processes and supporting biodiversity within the Region.

Table 4.8 Key values and attributes of matters of national environmental significance

For the World Heritage Area, connections are based on the Statement of Outstanding Universal Value[2]. For the listed species, the key linkages (such as important habitats and components of their diets) are shown for each group of species. For wetlands of international importance, the connections are those discussed in the Ramsar Convention information sheet.[151]

	World heritage properties								Listed migratory and threatened species								
Key values and attributes	**Criterion i (now viii)**	**Criterion ii (now ix)**	**Criterion iii (now vii)**	**Criterion iv (now x)**	**Integrity**	**Great Barrier Reef Marine Park**	**National heritage places**	**Commonwealth marine areas**	**Marine turtles**	**Estuarine crocodiles**	**Whales**	**Dolphins**	**Dugongs**	**Sharks and rays**	**Seabirds**	**Shorebirds**	**Wetlands of international importance**
Biodiversity — Great Barrier Reef habitats																	
Islands		●	●	●	●	●	●	●	●	●					●	●	●
Beaches and coastlines			●		●	●	●	●	●	●					●	●	●
Mangrove forests			●	●	●	●	●	●	●	●				●	●	●	●
Seagrass meadows				●	●	●	●	●	●			●	●	●			●
Coral reefs (<30 m)		●	●	●	●	●	●	●	●					●			●
Deeper reefs (>30 m)		●	●	●	●	●	●	●	●					●			
Lagoon floor				●	●	●	●	●				●	●	●			
Shoals				●	●	●	●	●				●		●	●		
Halimeda banks		●			●	●	●	●	●								
Continental slope					●	●	●	●									
Open waters			●	●	●	●	●	●	●	●	●	●	●	●	●		●
Biodiversity — terrestrial habitats that support the Great Barrier Reef																	
Saltmarshes						●		●		●					●	●	●
Freshwater wetlands						●		●		●					●	●	●
Forested floodplain						●		●									●
Heath and shrublands						●		●									
Grass and sedgelands						●		●								●	●
Woodlands						●		●									●
Forests						●		●									●
Rainforests			●			●		●									
Connecting water bodies				●	●	●	●	●	●	●		●	●	●	●	●	●
Biodiversity — species																	
Mangroves			●	●	●	●	●	●									●
Seagrasses				●	●	●	●	●	●				●				●
Macroalgae				●	●	●	●	●	●								
Benthic microalgae				●	●	●	●	●									

	World heritage properties								Listed migratory and threatened species								
Key values and attributes	**Criterion i (now viii)**	**Criterion ii (now ix)**	**Criterion iii (now vii)**	**Criterion iv (now x)**	**Integrity**	**Great Barrier Reef Marine Park**	**National heritage places**	**Commonwealth marine areas**	**Marine turtles**	**Estuarine crocodiles**	**Whales**	**Dolphins**	**Dugongs**	**Sharks and rays**	**Seabirds**	**Shorebirds**	**Wetlands of international importance**
Corals			●	●	●	●	●	●									
Other invertebrates		●		●	●	●	●	●	●		●	●		●	●	●	●
Plankton and microbes				●	●	●	●	●			●						
Bony fish		●	●	●	●	●	●	●			●	●		●	●	●	●
Sharks and rays				●	●	●	●	●			●			●			
Sea snakes				●	●	●	●	●									
Marine turtles			●	●	●	●	●	●	●								●
Estuarine crocodiles				●	●	●	●	●		●							
Seabirds			●	●	●	●	●	●							●		
Shorebirds				●	●	●	●									●	●
Whales			●	●	●	●	●	●			●						
Dolphins				●	●	●	●	●				●					
Dugongs				●	●	●	●	●					●				●
Geomorphological features																	
Coral reefs	●		●		●	●	●	●									
Islands and shorelines	●		●		●	●	●	●	●						●	●	●
Channels and canyons	●				●	●	●	●									
River deltas	●				●	●	●	●									
Halimeda banks	●				●	●	●	●									
Seagrass meadows	●				●	●	●	●	●								●
Indigenous heritage																	
Cultural practices, observances, customs and lore		●			●	●	●	●	●	●	●	●	●	●	●	●	●
Sacred sites, sites of particular significance, places important for cultural tradition		●			●	●	●	●									●
Stories, songlines, totems and languages		●			●	●	●	●	●	●	●	●	●	●	●	●	●
Indigenous structures, technology, tools and archaeology		●			●	●	●	●									●
Historic heritage																	
Places of historic significance — historic shipwrecks						●		●									
Places of historic significance — World War II features and sites						●		●									
Places of historic significance — lightstations						●		●									

	World heritage properties								Listed migratory and threatened species								
Key values and attributes	**Criterion i (now viii)**	**Criterion ii (now ix)**	**Criterion iii (now vii)**	**Criterion iv (now x)**	**Integrity**	**Great Barrier Reef Marine Park**	**National heritage places**	**Commonwealth marine areas**	**Marine turtles**	**Estuarine crocodiles**	**Whales**	**Dolphins**	**Dugongs**	**Sharks and rays**	**Seabirds**	**Shorebirds**	**Wetlands of international importance**
Places of historic significance — other						●		●									●
Places of scientific significance (research stations, expedition sites)						●		●									
Places of social significance — iconic sites						●		●									
Community benefits of the environment																	
Income						●		●									●
Employment						●		●									●
Understanding						●		●									
Appreciation			●			●	●	●									●
Enjoyment			●			●	●	●									
Access to Reef resources						●		●									
Personal connection						●		●									
Health benefits						●		●									
Aesthetics			●		●	●	●	●	●	●	●	●	●	●	●	●	●

Table 4.9 Key environmental processes relevant to matters of national environmental significance

For the World Heritage Area, connections are based on the Statement of Outstanding Universal Value[2]. For listed species, processes that have a major supporting role in maintaining the species are shown (for example, the role that beaches play in the nesting of listed marine turtles). For wetlands of international importance, the connections shown are those discussed in the Ramsar Convention information sheet.[151]

	World heritage properties								Listed migratory and threatened species								
Key environmental processes	**Criterion i (now viii)**	**Criterion ii (now ix)**	**Criterion iii (now vii)**	**Criterion iv (now x)**	**Integrity**	**Great Barrier Reef Marine Park**	**National heritage places**	**Commonwealth marine areas**	**Marine turtles**	**Estuarine crocodiles**	**Whales**	**Dolphins**	**Dugongs**	**Sharks and rays**	**Seabirds**	**Shorebirds**	**Wetlands of international importance**
Waves, currents and tides	●	●			●	●	●	●	●						●	●	
Cyclones	●	●			●	●	●	●	●	●		●	●	●	●	●	
Wind	●	●			●	●	●	●							●		
Sedimentation	●	●			●	●	●	●	●				●			●	●
Sea level	●	●			●	●	●	●	●	●						●	●
Sea temperature		●			●	●	●	●	●	●							
Light		●			●	●	●	●	●				●				
Nutrient cycling		●			●	●	●	●									●
Ocean acidity		●			●	●	●	●									
Freshwater inflow and salinity		●			●	●	●	●									●
Microbial processes		●			●	●	●	●									
Particle feeding		●			●	●	●	●									
Primary production		●			●	●	●	●	●				●				
Herbivory		●			●	●	●	●	●				●				
Predation		●			●	●	●	●	●	●	●	●		●	●	●	
Symbiosis		●			●	●	●	●									
Competition		●			●	●	●	●	●	●	●	●	●	●	●	●	
Connectivity	●	●			●	●	●	●	●	●	●	●	●	●	●	●	●
Recruitment		●			●	●	●	●	●	●	●	●	●	●	●	●	●
Reef building	●	●	●		●	●	●	●									

4.11 Summary of outcomes

- The seven matters of national environmental significance relevant to the Great Barrier Reef Region are interconnected and overlapping. They range from individual listed threatened and migratory species to the entire Great Barrier Reef Marine Park and world heritage property.
- The matters of national environmental significance are distributed throughout the Region and there is no part that does not contain values relevant to them.
- A total of 62 key values relevant to the matters of national environmental significance in the Region are identified. Twenty key environmental processes are also identified.
- The key values and attributes are combined into one comprehensive set which forms the basis of the assessments throughout the report. They are grouped into four broad categories: biodiversity, including the Region's habitats and species, geomorphological features, Indigenous and historic heritage values, and community benefits derived from the environment.

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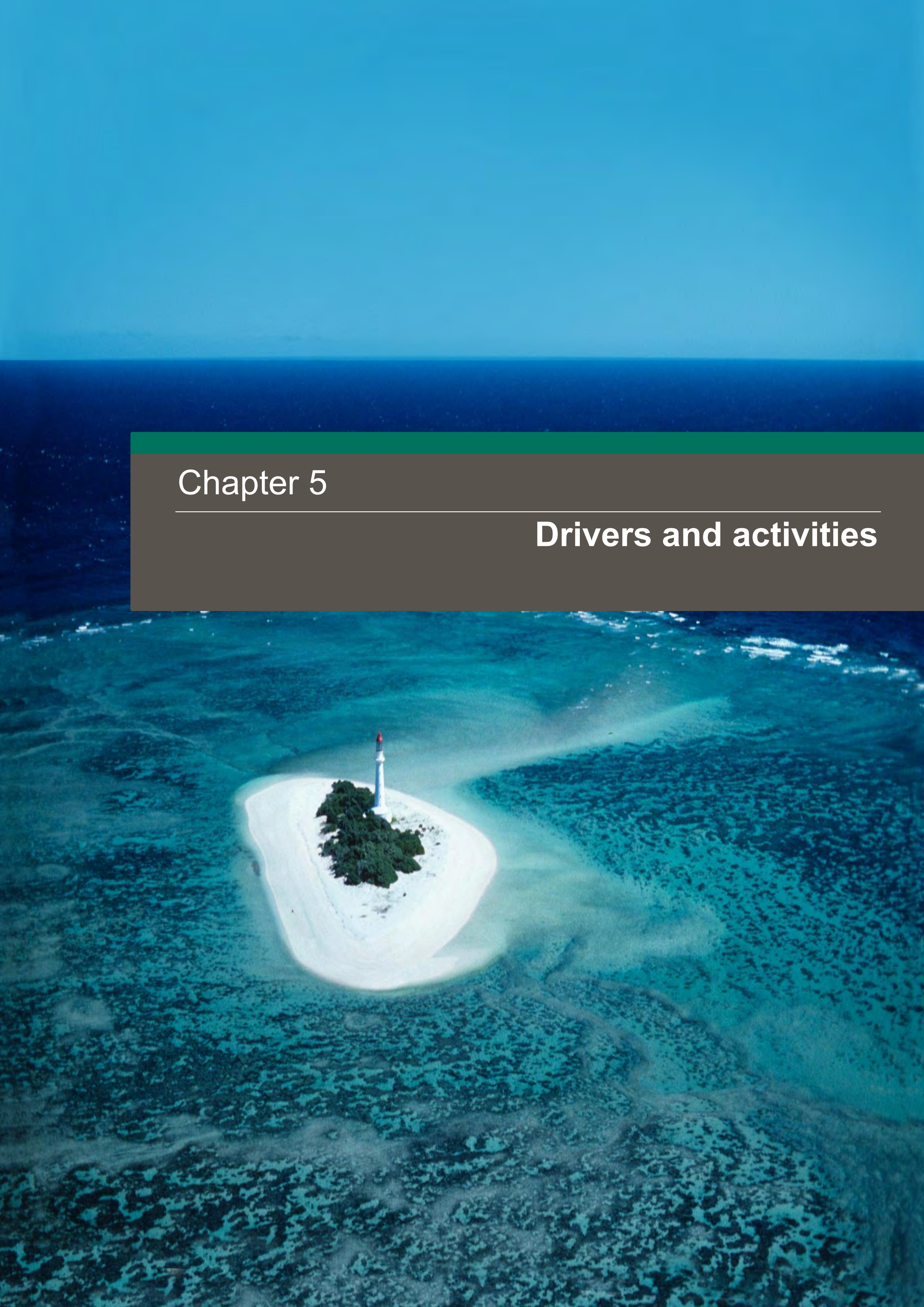
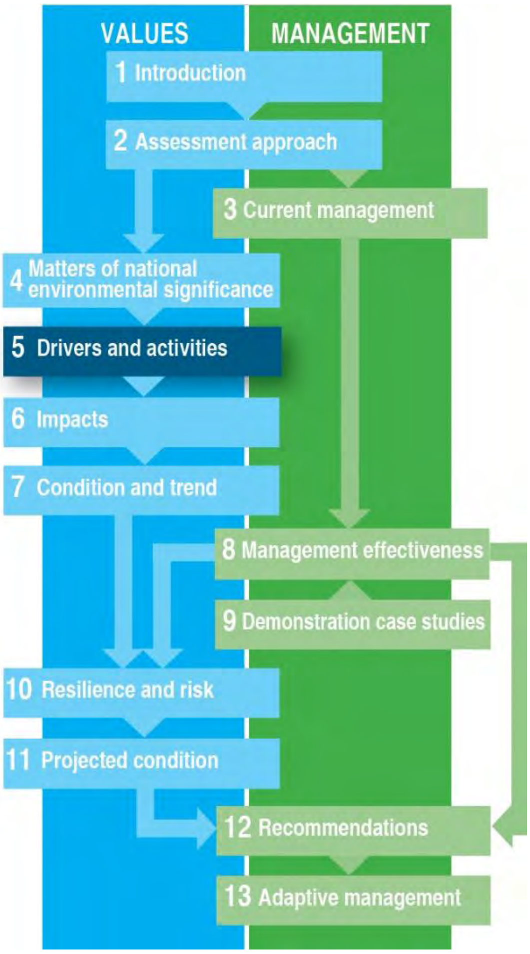


Chapter 5

Drivers and activities



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Cover page image: North Reef lighthouse on North Reef Island

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

3. Assessment of impacts on matters of national environmental significance

3.1 Actual and potential impacts

a) describe the environmental, social, cultural and economic drivers affecting the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area.

b) describe and analyse the actual and potential impacts on the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, in the strategic assessment area, including:

i. impacts from past, present and future activities

………

5 Drivers and activities

5.1 Background

As outlined in Chapter 4, the Great Barrier Reef Region (the Region) comprises a rich mosaic of biodiversity, geomorphology and heritage values. The condition of those values determines the quality of the cultural, social and economic benefits the community derives from the environment (such as aesthetics, income, appreciation and enjoyment). As a result of external drivers and activities both within the Region and beyond its boundaries, a number of impacts are diminishing the condition of the Region's values and attributes and the quality of the benefits they provide. This chain of cause and effect is illustrated in Figure 5.1.

Understanding these causal relationships helps forecast the future condition of the Region's values and attributes, including likely changes in the community benefits derived from the Region.

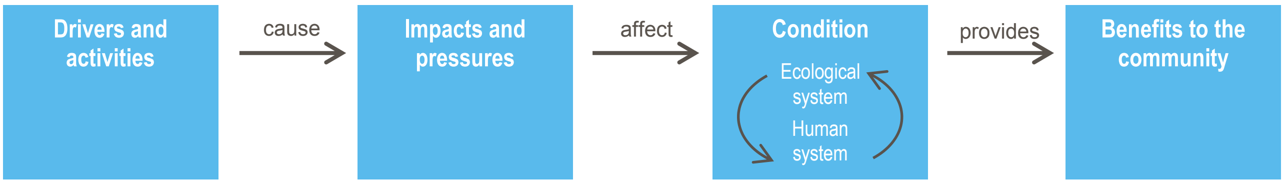


Figure 5.1 The influence of drivers and activities

5.2 Drivers of change

Drivers are overarching causes of change in the environment. They can affect the environment indirectly by changing the way people undertake activities that affect the environment (indirect drivers) or by directly changing conditions in the environment itself (direct drivers). They can also work in concert with one another and operate across a range of scales. An understanding of their positive and negative effects is fundamental to understanding the past, present and future condition of the values and attributes underpinning matters of national environmental significance.

5.2.1 Drivers relevant to the Region

The drivers most relevant to the Great Barrier Reef Region were identified by examining the *Australia State of the Environment 2011*[1] and relevant peer-reviewed literature, and through input from key Great Barrier Reef natural and social scientists. The five drivers analysed are:

- climate change
- economic growth
- population growth
- technological developments
- societal attitudes.

Climate change is a 'direct driver' that has direct and ongoing effects on the environment as well as indirect effects mediated by other processes or activities. The other four drivers are 'indirect drivers', influencing people's activities that in turn affect the environment. There are links between all these drivers with each one influencing the others. For example, technological developments can play a role in climate change, economic growth, population growth and societal attitudes. Similarly, population growth affects climate change, economic growth and societal attitudes.

This description of drivers relevant to the Region has been informed by the CSIRO's recent analysis of the environmental, social and economic conditions that are predicted to substantially change the way people live (megatrends).[2]

5.2.2 Climate change

The Earth's climate has always been changing. Ice ages ending, glaciers melting and sea levels changing are natural phenomena, as is climate variability from year to year. However, changes in the Earth's climate have typically occurred over millennia. In fact, the stable climate over the past 1000 years has in part enabled the rapid expansion of human populations and development.

It is now almost certain that the climate is changing at a rate unprecedented in the geological record.[3] A rapidly changing climate poses substantial risks and challenges for individuals, societies and nations and the ecosystems that support them.

Increased concentrations of greenhouse gases (particularly carbon dioxide) in the atmosphere result in more heat being trapped, increasing the Earth's temperature. Atmospheric carbon dioxide is at a concentration unprecedented within the past 650,000 years.[4,5] The rapid increase in emissions of carbon dioxide and other greenhouse gases since the Industrial Revolution has amplified their natural role in retaining heat within the earth's atmosphere.[3]

The science of carbon dioxide concentrations and coral reefs

The pre-industrial concentration of atmospheric carbon dioxide was approximately 280 parts per million.[6] Since then, the concentration of atmospheric carbon dioxide has been increasing and reached 396 parts per million in March 2013.[7]

Figure 5.2 shows atmospheric concentrations since the 1960s and the increasing annual mean growth rate in carbon dioxide from one of the global observatories. In addition to changing the climate, an increasing concentration of carbon dioxide in the atmosphere leads to ocean acidification.

Coral reefs are sensitive to climate change and ocean acidification. The consequences of rising concentrations of atmospheric carbon dioxide put reefs at increasing risk of serious decline. When the global atmospheric carbon dioxide concentration exceeded approximately 320 parts per million, widespread temperature-induced mass coral bleaching (leading to mortality) began to be observed by the scientific community.[8] Bleaching began on most reefs worldwide when carbon dioxide concentrations reached approximately 340 parts per million.[8]

If carbon dioxide concentrations reach 450 parts per million, scientists predict reefs will be in rapid and terminal decline worldwide as the result of multiple synergies arising from mass bleaching, ocean acidification and other environmental impacts.[4] It is predicted that damage to shallow reef communities will become extensive with consequent reductions of biodiversity followed by extinctions.[1] Reefs will cease to be large-scale nursery grounds for fish, threatening food security for millions of people around the world, and no longer provide the same community benefits. There will be knock-on effects to ecosystems associated with reefs, to other pelagic and benthic ecosystems, to coastal protection and reef-dependent industries and communities.[4,8]

Based on a current predicted trajectory, a concentration of 550 parts per million of carbon dioxide could be reached by about 2100.[3] Emissions are continuing to grow, and on the current trend 450 parts per million carbon dioxide could be reached by about 2040.

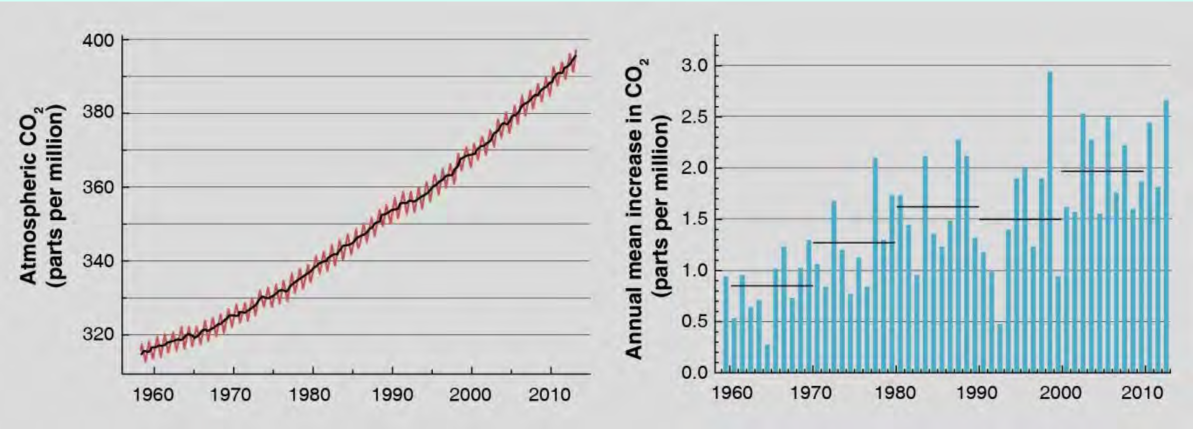


Figure 5.2 Mean atmospheric concentrations and the annual mean increase of carbon dioxide, 1960 to 2013

The data collected from Mauna Loa, Hawaii. This the longest record of direct measurements of carbon dioxide concentrations in the atmosphere. In the second graph, mean annual increase is the difference between the start of January and the end of December of that year. Decadal averages of growth in carbon dioxide concentrations are represented by the horizontal black bars. (Source: NOAA and Scripps Institution of Oceanography[9])

Trends

Increases in the concentration of greenhouse gases in the Earth's atmosphere are driving changes in a number of variables that can affect the Region's values. Variables of particular significance are:

- sea temperature
- ocean acidity
- sea level
- ocean currents
- tropical storm intensity
- weather variability — rainfall, wind, droughts and flooding.

The indicative trends in these variables and the uncertainties around these trends are summarised in Figure 5.3 and described in detail in the relevant parts of Chapter 6.

The climate change variables listed do not work in isolation from one another. For example, as more carbon dioxide is released into the atmosphere, air and sea temperatures rise. This warming causes ice to melt and thermal expansion in the oceans which, in turn, causes the sea level to rise.

Implications for the Region's values

Climate change is a direct and indirect driver for coral reef ecosystems such as the Great Barrier Reef, and there have already been some serious effects on the Region's biodiversity values, for example coral bleaching in 1998 and 2002.[10] The future implications for biodiversity values depend on the rate and extent of increases in greenhouse gas concentrations because this is the factor driving the change.

Potential climate change effects for species groups and habitats have been considered in *Climate change and the Great Barrier Reef: a vulnerability assessment,*[11] and in many recent scientific studies.[12,13,14] The effects, both individually and combined, are likely to have far-reaching consequences for the Region's environment. The 2013 Water Quality Scientific Consensus Statement concluded that "*key Great Barrier Reef ecosystems are showing declining trends in condition due to continuing poor water quality, cumulative impacts of climate change and increasing intensity of extreme events"*.[15]

The projected vulnerability of a number of the Region's habitats and species presented in Figure 5.3 shows not all components of the Great Barrier Reef are affected equally. Corals and seabirds are considered to be some of the most vulnerable species to the predicted changes. Many other species, however, will also be negatively affected. Molluscs, for example, will have a reduced capacity to develop hard shells due to ocean acidification.

Reef-building corals are highly vulnerable to several environmental factors driven by increasing greenhouse gas concentrations: increasing temperature, ocean acidification and increased frequency of severe storms. As the climate changes, the capacity of hard corals to grow and reproduce will be increasingly compromised with flow-on effects on other species dependent on coral reefs.

The frequency and severity of coral bleaching is predicted to increase under climate change, with potentially serious consequences for the Reef.[16,17,18,19] Coral bleaching can affect large areas (known as mass bleaching events). Bleaching is not always fatal for corals, but has been one of the main causes of coral death around the world in the past 20 years.[12,18,20]

Recent assessments predict that reefs could experience temperature-induced bleaching events twice per decade by about 2020, and annual bleaching events could occur by mid-century.[21] Patterns of bleaching will vary by location. In favourable conditions, recovery of corals following bleaching is likely, and reef habitats may recover if the frequency remains at fewer than about two events per decade. However, severe degradation of Great Barrier Reef corals and coral reef habitats is likely to occur before, rather than after, the time when bleaching events occur annually, since there are a large number of additional pressures and impacts on coral reefs.[12,21,22]

Implications for the Region's values at different concentrations of atmospheric carbon dioxide can be summarised as:

- **350 parts per million:** Optimum limits for coral reef ecosystems are at or below this concentration. This would require a lowering of global carbon dioxide concentrations.

- **400 parts per million** (close to the current concentration)**:** The frequency of severe bleaching is likely to increase, with rising summer temperatures leading to the dominance of thermally tolerant species. While coral reef ecosystems are likely to be affected by a number of impacts related to climate change, they are expected to remain coral dominated in many areas. This concentration of atmospheric carbon dioxide is only slightly above the average level reached globally in March 2013,[7] and there is already evidence of effects on the Reef, such as declining calcification rates, that are suggested to be caused by temperature stress and ocean acidification.[23]
- **450 parts per million:** It is predicted that the diversity of corals on reefs will decline under the combined effects of elevated temperatures and ocean acidity.[1] Ocean acidification is likely to further affect the growth of most calcifying organisms.[1,24] This level of atmospheric carbon dioxide poses an extreme risk for coral reef ecosystems and tropical coastal habitats.

The major impacts of climate change are described in further detail in Chapter 6.

Implications for activities and industries

Reef-dependent activities, including tourism, fishing, recreation and traditional use, are vulnerable to the negative effects that ocean acidification, sea level rise, more frequent extreme weather and warming sea temperatures may have on Reef condition.[11,25]

The Reef-based tourism industry is very concerned about the impacts of climate change on its businesses and livelihoods, including degradation of reef sites, poor recovery of bleached sites as a result of other stresses, and a loss of marketing appeal as a high-quality reef destination.[26]

It is likely fishing activities will be highly sensitive to climate change, including projected changes in fish abundance, survivorship[27,28,29], size and distribution, disruptions to shallow water nurseries and loss of coral reef habitats, as well as changes in cyclone and storm activity[11,30,31].

Traditional Owners are concerned about rising temperatures altering the seasonality and availability of marine resources, as well as the potential loss of totemic species and the possible displacement of their coastal communities due to rising sea levels.[30]

Climate change science is a rapidly expanding field and there is improved understanding of the implications for the Great Barrier Reef and Reef-dependent industries.[32] Tools are being developed and applied to help communities and industries recognise their vulnerabilities and adaptation needs. For example, a climate change vulnerability assessment of the East Coast Otter Trawl Fishery[33] has been published and key stakeholders have been engaged in a climate change adaptation planning process.[34]

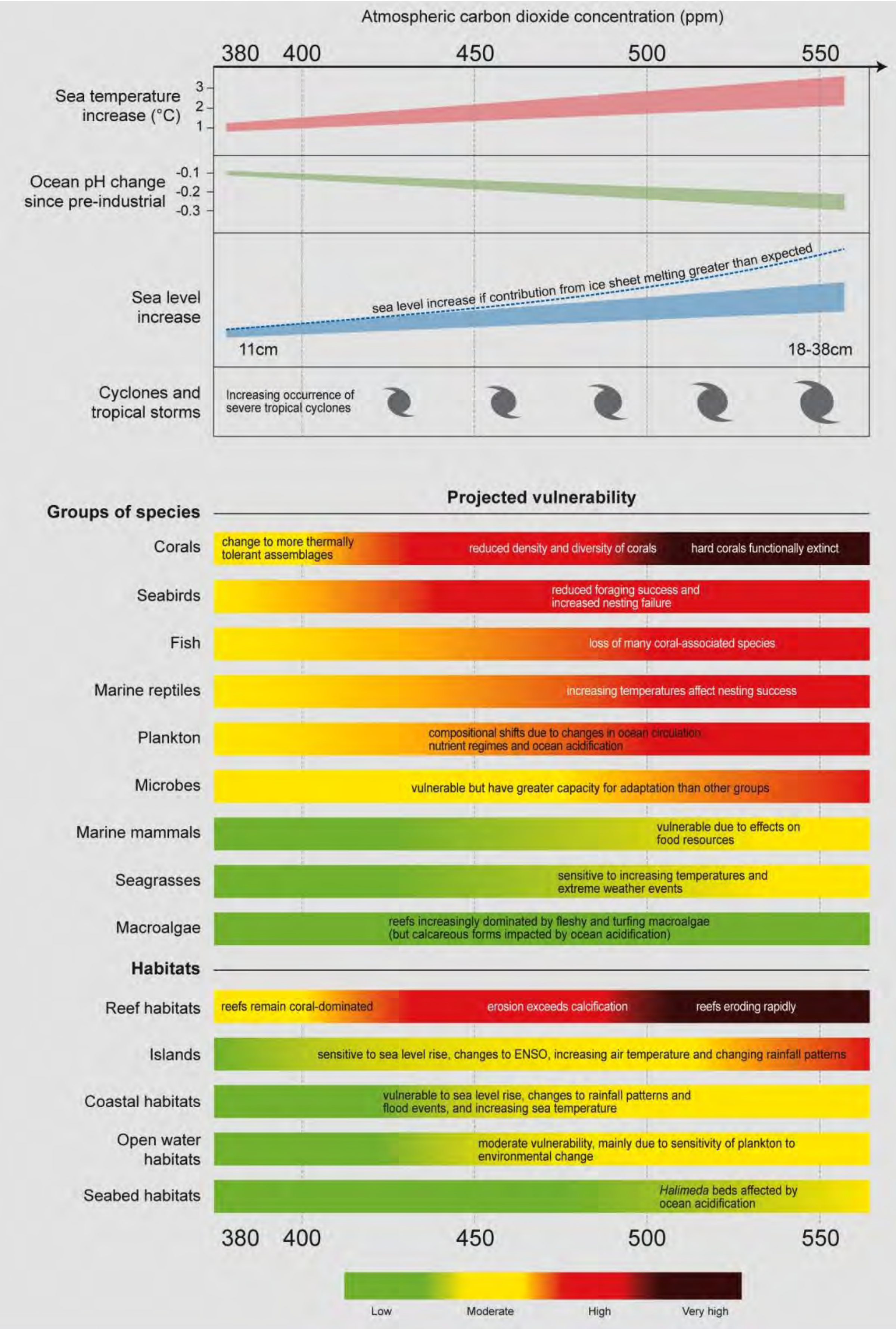


Figure 5.3 Projected trends in climate change variables and the Region's biodiversity values

The average monthly global carbon dioxide concentration reached 396 parts per million (ppm) in March 2013.[35] A concentration of 550ppm carbon dioxide is predicted to be reached by about 2100.[3,7] Concentrations could potentially exceed this value, resulting in even more serious effects on the Region's ecosystem.

Tourism industry addressing climate change

Recognising the threat that climate change poses to the health of the Great Barrier Reef, industries that depend on it are proactively taking action to tackle climate change. Innovators within the marine tourism industry, tourism industry associations and key tourism agencies worked with the Authority to form the Great Barrier Reef Tourism Climate Change Action Group in 2006 to encourage industry action on climate change. Implementation of the Group's *Great Barrier Reef Tourism Climate Change Action Strategy 2009–2012*[36] has delivered a range of products specific to the Great Barrier Reef and its tourism industry, including a carbon emissions calculator, climate change case studies, and climate change operator workshops.

The emissions calculator assists Great Barrier Reef tourism operators to reduce their emissions and adapt to climate change. The online calculator allows operators to calculate their carbon footprint, access information on how to reduce their emissions and track the results of any changes they make.

Lady Elliot Island Eco Resort, on the Region's southernmost island, is showcased in the climate change case study on sustainable island resorts. The resort's operators were inspired to make operational changes in response to climate change. After undertaking an energy audit, they replaced diesel generators with a large hybrid solar power system in 2008. A follow-up audit in 2009 showed they had reduced the resort's non-renewable energy use by 32 per cent. By mid-2012, they had reduced the resort's diesel consumption by almost 70 per cent.

In 2007, the Authority's Reef HQ Aquarium set out to achieve a 50 per cent reduction in energy usage, motivated by concerns about climate change. By raising the air-conditioning temperature, undertaking minor building works and improving lighting arrangements, the aquarium has substantially reduced energy consumption. By June 2012, power usage had been cut by 27 per cent.

A rooftop photovoltaic system has also been progressively installed, and now totals 1230 square metres of solar panels. Reef HQ has become a registered solar power station and its 205 kilowatt peak system should offset about 20 per cent of the aquarium's current power use. This initiative, combined with the installation of a new stored chilled water air conditioning system, means the target of a 50 per cent reduction by the end of 2013 is expected to be met.

Solar panels on the roof of Reef HQ Aquarium

An examination of the extreme weather events in the summer of 2010–11 highlights the potential impacts on communities and industries from the predicted increased frequency of these events. As a result of cyclone Yasi and the central Queensland floods, the summer's extreme weather damaged 27 per cent of Queensland's road network and 4750 kilometres of the state's railway lines.[37] It was also responsible for 11 port closures.[38] Many resorts, jetties and marinas were damaged, along with more than 4000 houses.[38]

Two Reef-dependent industries were particularly affected by that season's cyclones and floods.[39] A survey of 145 commercial fishers and 62 marine tourism operators showed the most significant impacts across each industry were the three to four months of lost operations after the extreme weather. Many fishers were unable to fish because of the large amounts of debris and sediment remaining in the water and the reduced catchability[31] of some Reef-associated target species. Tourism operators were far less able to attract tourists to their destination due to the perception that tourism experiences had been affected Reef-wide.[39]

Flooding rains, intense cyclones and rising sea levels may have serious impacts on regional industries regardless of whether they are directly dependent on the Reef. However, the people who depend on the Reef for their activities may face additional vulnerabilities linked to deteriorating Reef condition. Patterns of use may also change in the wake of extreme weather and climate change, with the potential to create new 'hotspots' of pressure on the Great Barrier Reef ecosystem.[40]

5.2.3 Economic growth

Queensland's economy is currently worth $260 billion per annum, and is principally based on mining, construction, tourism and agriculture.[41,42]

Queensland has had the highest long-term average economic growth rate of any Australian state or territory for over 20 years.[41] The state has had an average annual growth rate of 4.2 per cent over the last decade and has outpaced the economic growth rate of both the rest of Australia and the Organisation for Economic Co-operation and Development group of nations for the past 20 years.[41]

Much of Queensland's economic activity takes place in the Great Barrier Reef catchment, although this activity is mostly not dependent on the Reef environment. The state's strong export trade is dominated by mining and agriculture. Three-quarters of Queensland's exports go to Asia, the most populous region in the world, with new trading opportunities opening up in Latin America and the Caribbean region. Japan is the state's largest trading partner, followed (in order) by China, India, South Korea and Taiwan.[41] About 80 per cent of the world's seaborne metallurgical coal exports are from Queensland[41], shipped through the Great Barrier Reef.

Reef-dependent industries in the catchment and the World Heritage Area — tourism, commercial fishing, recreation and research activities — make a significant contribution to the state and national economy, especially in terms of employment. In 2012, these uses combined contributed $5.7 billion to the Australian economy and employed almost 69,000 people (see Table 7.9 in Chapter 7).[43] These Reef-dependent industries provide benefits to associated industry sectors through demand for services such as vessel manufacture and maintenance, catering and retail.

In 2011, most people living in the catchment were employed in retail trade; health care and social assistance; or construction. Over the past six years, there have been fewer catchment residents employed in manufacturing, agriculture, forestry and fishing; and more employed in the mining and minerals sector, particularly in the Gladstone and Isaac local government areas.[41,43]

Future trends

According to the 2013–14 Queensland State Budget,[44] growth in the gross state product in 2011–12 was mainly driven by increased business investment. Since 2010–11, business investment has been dominated by the start of construction of three coal seam gas-to-liquefied natural gas projects with a combined capital expenditure of more than $60 billion. The staged completion of the three projects is projected to mean that business investment will fall in each year from 2013–14 to 2015–16. The first liquefied natural gas exports are scheduled for 2014–15 and export volumes are expected to increase substantially in the following year, driving double digit growth in exports in 2015–16. Although business investment is forecast to decrease in 2013–14 and 2015–16, investment conditions are forecast to improve outside the resources sector, based on projected improvements in global economic conditions and projected depreciation of the Australian dollar.

The state budget forecast is that coal exports will continue to grow, supported by strong demand from China and the completion of the Eagle Downs and Grosvenor (Phase 1) coal mines. It also notes that major risk surrounds the timing and rate of liquefied natural gas investment. Growth in other sectors of the Queensland economy may not be enough to prevent Queensland's economic growth slowing more rapidly than currently expected, especially in 2014–15.

The Queensland Government has indicated its aim is to continue growth in the state's economy by doubling the value of agricultural production by 2040,[45] expanding the resources industry, growing the construction sector through expedited planning processes, and enhancing tourism through marketing campaigns and the development of new tourism destinations and products.[41]

For agriculture in the catchment, it has been forecast that the pastoral sector is likely to grow and further intensify.[42] On the other hand, further large-scale changes from low-intensity agriculture to sugar production are forecast to be relatively unlikely in the medium to long term. In recent years, growth in intensive production of fruit and vegetables (horticulture) has generally exceeded demand.[42] While strategies are being developed to export product, their perishable nature and the expense of processing and transport will likely constrain large-scale growth.[42] As with other sectors of the Queensland economy, there is a degree of uncertainty around future trends in agriculture, especially in relation to global economic trends and the value of the Australian dollar.

There are a number of resource development projects proposed or under assessment. Changing economic circumstances mean it is difficult to predict the number that will reach construction and production. Growth in the mining and resources sector in and adjacent to the Region's catchment would more than likely require expanded port capacity and associated infrastructure along the coast adjacent to the southern half of the Region (see Figure 5.4).[41]

In particular, Queensland has 98 per cent of Australia's proven coal seam gas reserves and economic activity associated with the development of coal seam gas projects has grown substantially over the last decade (Figure 5.5). A Bureau of Resources and Energy Economics report anticipates that Australia will become the world's largest liquid natural gas exporter by the end of the decade.[46] Curtis Island, within the World Heritage Area, is the site for the world's first project converting coal seam gas to liquefied natural gas.[41]

The continued and increasing global demand for coal[47] has resulted in mine expansions, new mines and additional mine proposals. The projected export volumes for coal in 2025 range from 267 to 383 million tonnes for thermal coal and 260 to 306 million tonnes for metallurgical coal. Over this period, production of both thermal and metallurgical coal is projected to increase significantly in the Bowen, Surat and Galilee basins in Queensland which export coal through the Great Barrier Reef. [46]

It is recognised that the recent slowing of the resources sector and the uncertainties around the realisation of potential projects mean that growth in the sector may not be as substantial as has been forecast.

Changing global market trends also influence commercial fishing patterns in the Great Barrier Reef, especially the nature and level of demand for wild-caught product and the worldwide expansion of aquaculture fisheries.[25] Market conditions, price trends and competition have not been favourable enough to trigger widespread expansion of aquaculture in the Region's catchment.[42]

Tourism was identified in the early 2000s as having the greatest capacity for growth and that may occur as the global financial situation improves.[48] The Queensland Government recognises tourism as a pillar of the state's economy and has identified a number of actions as catalysts and drivers for tourism investment, infrastructure and access. Actions of particular relevance to the Region and its tourism industry are:

- developing a Commercial Aviation Plan and a Queensland Drive Tourism Strategy
- ensuring a strategic approach to cruise shipping and superyacht priorities, infrastructure and supply chains
- including tourism in the State Planning Policy
- encouraging local governments to provide for appropriate tourism opportunities in their planning schemes (for example, a regional plan for Cape York)
- working with agencies to ensure tourism is considered in developing government plans and programs of economic and community infrastructure priorities
- developing a Queensland Ecotourism Plan.[49]

The value of tourism and commercial fishing in the Great Barrier Reef has remained relatively stable over the past six years.[43] It is difficult to predict future trends given uncertainty about the value of the Australian dollar, long-term implications of the global financial uncertainty and trends in Reef condition. Some onshore tourism sectors are expected to benefit from growth in the resources sector, particularly business-related travel, however these benefits may not flow on to the marine sector.

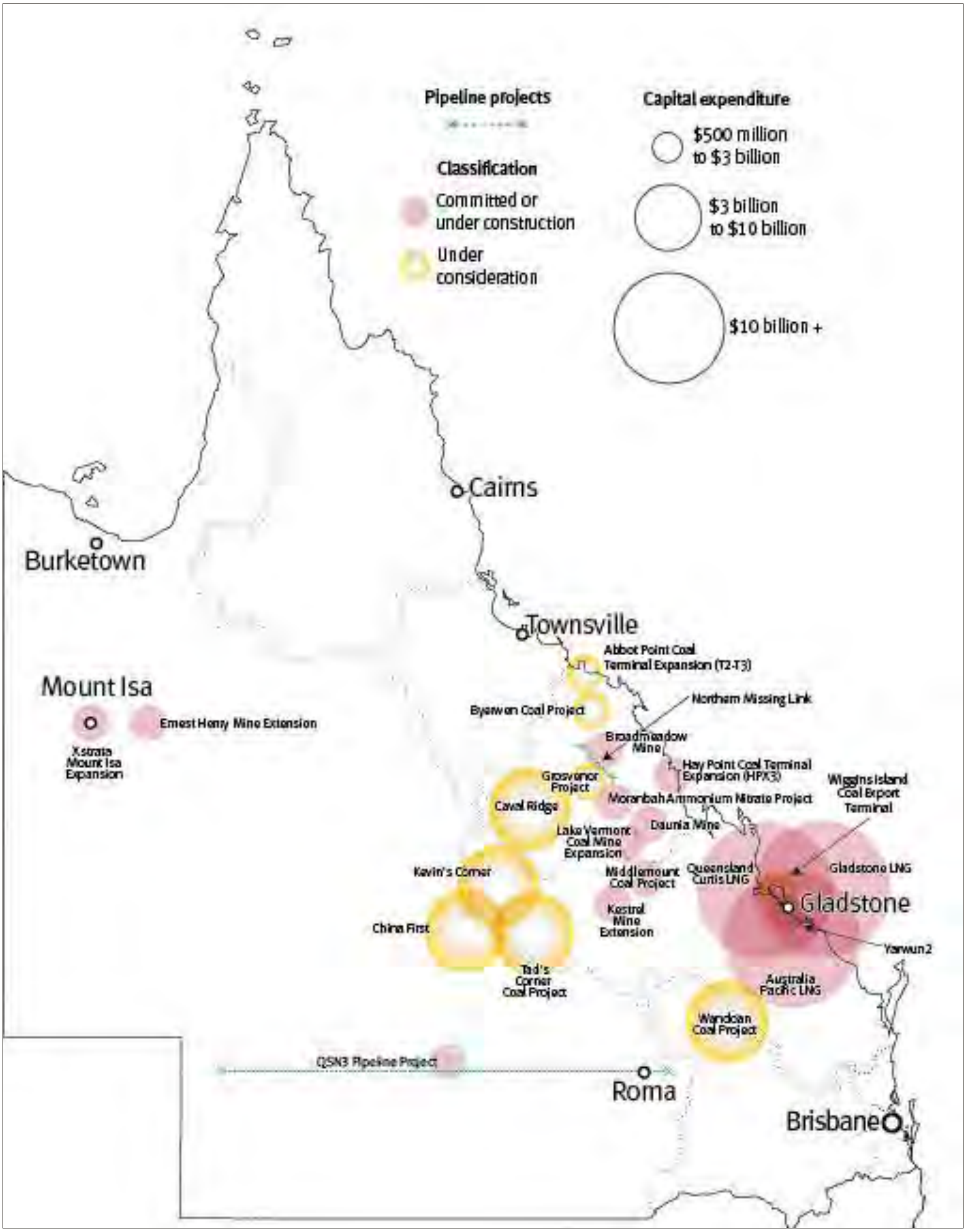


Figure 5.4 Major resource projects planned or underway in Queensland[41]

There are number of major projects planned or underway that would greatly expand the volume of cargo handled by ports adjacent to the Region.

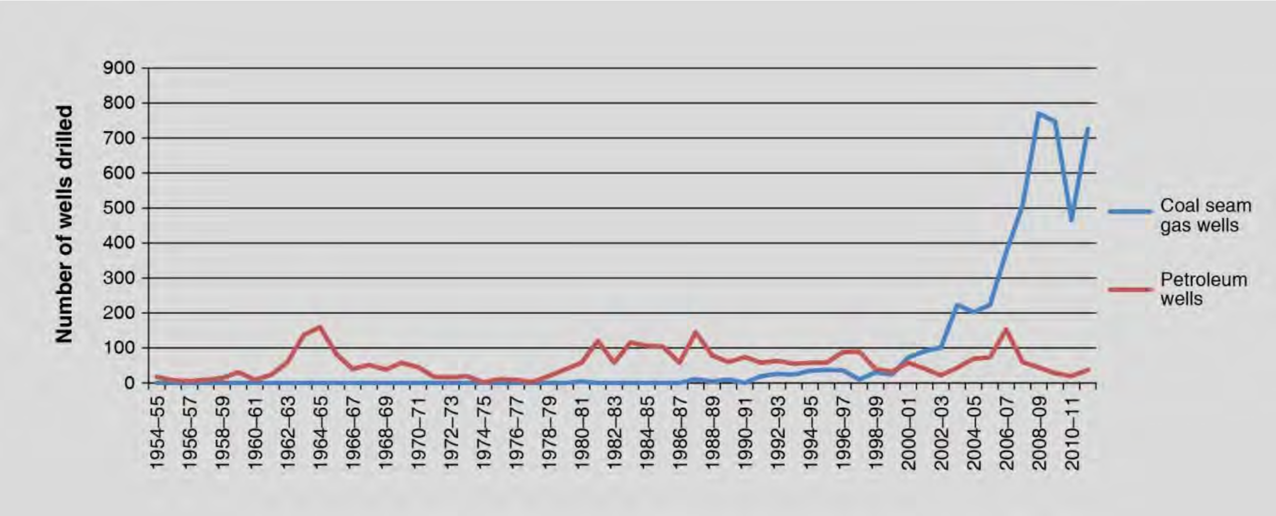


Figure 5.5 Wells drilled in Queensland, 1954–2011[50]

Implications for the Region's values

The scale and scope of the resources boom has led to changes in land use with the Great Barrier Reef catchment, particularly in the Fitzroy, Burdekin and Mackay–Whitsunday areas. It has also created unprecedented demands for water, power and new infrastructure including roads, railways and large-scale ports.[51] Any expansions to ports and associated infrastructure would result in the need for increased dredging and shipping in the Region (see Sections 5.3.5 and 5.4.6). If not properly managed, increased industrial development can result in impacts to coastal and marine systems, adversely affecting the Region's productivity, biodiversity, connectivity and aesthetics at regional scales.[51]

5.2.4 Population growth

Indigenous Australians have lived in the Great Barrier Reef catchment for thousands of years, using its marine and coastal resources for food, shelter and cultural activities. European settlement commenced more than 150 years ago, resulting in an increased number of people living in the catchment. The estimated total population of the Great Barrier Reef catchment was 1,138,532 people as at 30 June 2011, which is approximately 25 per cent of Queensland's total population of 4,474,098.[52]

The far northern part of the catchment (from north of Port Douglas and Mossman to Cape York) is sparsely populated. The two largest communities are Cooktown with 2339 residents and Hope Vale, 45 kilometres further north, with 858 persons.[52] The southern part of the catchment from Port Douglas to Bundaberg is more heavily populated, including six major urban centres with populations of between 50,000 and 190,000 people. The largest of these is Townsville, with an estimated population of 189,931 people, growing at an average of about 2.2 per cent every year.[52] This compares to a Queensland average growth rate of 1.7 per cent and a national average of 1.4 per cent.[53]

A profile of each of the catchment's natural resource management areas is presented in Table 5.1, including total population, average age and income of residents, and number of dwellings. The highest income earners live in the Mackay–Whitsundays natural resource management area, corresponding with higher resource-based activity. This coastal area also supports large numbers of fly-in fly-out miners.

Table 5.1 Population, housing and income within natural resource management areas of the Great Barrier Reef catchment, 2011[54]

Natural resource management area	Population	Average age	Number of dwellings	Average individual income
Cape York	8,396	34	3,730	$37,794
Wet Tropics	186,514	37	85,352	$39,311
Northern Gulf	43,729	41	20,374	$33,628
Burdekin (also known as Burdekin Dry Tropics)	237,758	36	103,031	$44,222
Mackay Whitsunday	112,796	37	45,665	$47,831
Fitzroy	211,341	36	92,829	$45,344
Burnett Mary	273,260	42	128,317	$31,626

Future trends

Much of the Great Barrier Reef catchment is expected to experience annual population growth rates of 1.6 per cent or higher in coming years.[52] In contrast, the national rate of population growth is expected to slow from 1.4 per cent to 1.2 per cent per annum over the next 40 years. Growth is forecast to be focused in the major regional centres (Figure 5.6) and many of the state's fastest growing local government areas are within the catchment, mostly in southern areas[55] (Figure 5.7). The Gladstone and Isaac local government areas are expected to expand particularly rapidly, due to increased activity in the resources sector.

As well as employment opportunities, lifestyle and amenity factors are likely to be attracting people to live in coastal areas.[56]

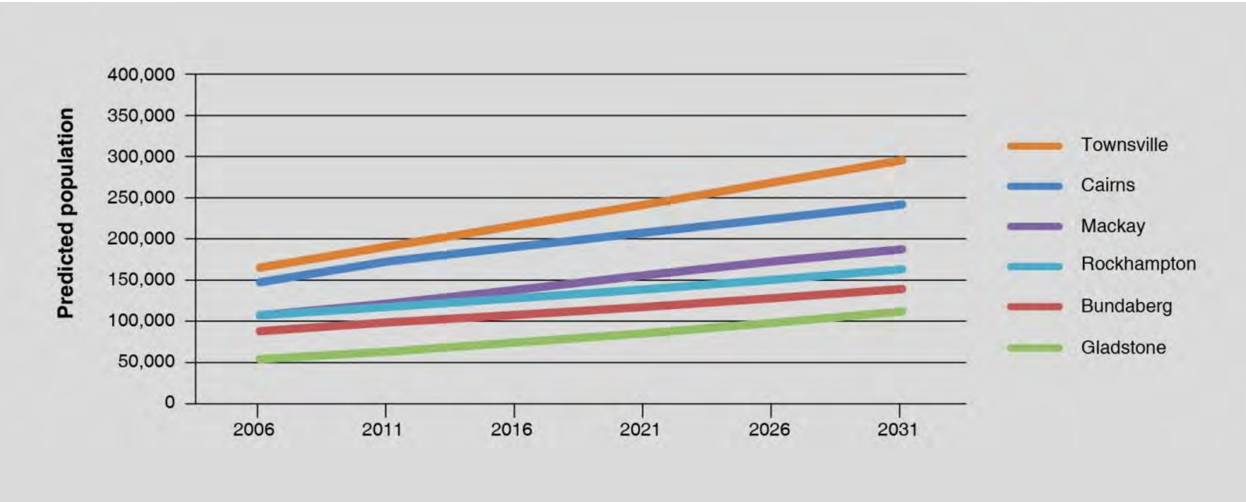


Figure 5.6 Predicted population growth in regional centres of the catchment, 2006–2031[52]

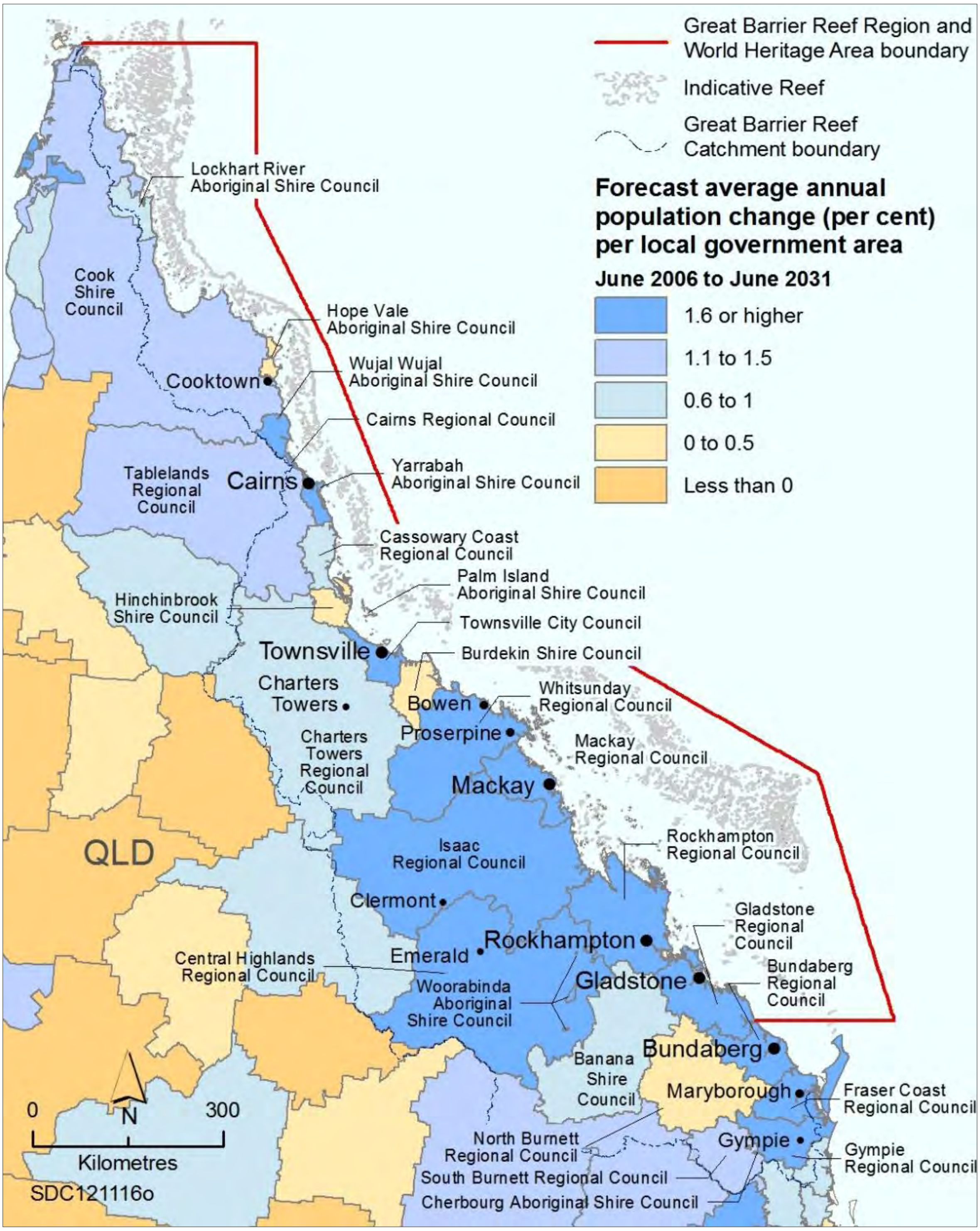


Figure 5.7 Forecast average annual population growth by local government area 2006–2031[55]

Implications for the Region's values

Population growth in the catchment is likely to drive changes in a number of activities relevant to the Region and its values. These will range from more direct use of the Region to widespread impacts on coastal habitats that support the Great Barrier Reef.

With an increasing population comes an expanded urban footprint required to accommodate the increasing number of residents. Although urban development occupies only a small proportion of the catchment, its footprint has more than doubled in the last decade, especially in coastal areas.[51] This development — including its supporting infrastructure and services, such as roads, water, sewerage and power — affects catchment habitats that support the Great Barrier Reef and has implications for the Region's values at a local level.

With regard to direct use of the Region, it is likely the trend of increasing recreational vessel ownership[57] will continue in the catchment. This is predicted to include faster growth in vessel numbers in the more southern parts of the catchment (see Sections 5.4.5). The trend towards people owning larger, better equipped vessels increases the potential for recreational users to access the outer reefs of the Region.

With increasing use of the Region comes increasing demand for coastal infrastructure (for example, roads, marinas and boat ramps) including in new sections of the coast. High demand and long wait times at popular access points can result in use being spread to adjacent, less popular areas as people choose to spend more time travelling and less time queuing.[58]

The movement of people into areas adjacent to the Region results in a higher proportion of new residents who may have less knowledge of its management arrangements than longer-term residents. However, there is evidence that some of the people moving to the catchment are 'tree-changers' and 'sea-changers' and that they have deliberately chosen to live adjacent to the Great Barrier Reef, often for amenity or lifestyle reasons rather than income.[56] These new residents are likely to become engaged with the Reef and its management.

Global population increases and demographic shifts are also likely to drive changes relevant to the Great Barrier Reef, ranging from increased emissions, pollution and marine debris to increased demand for seafood and increased shipping of export cargo through the Reef.

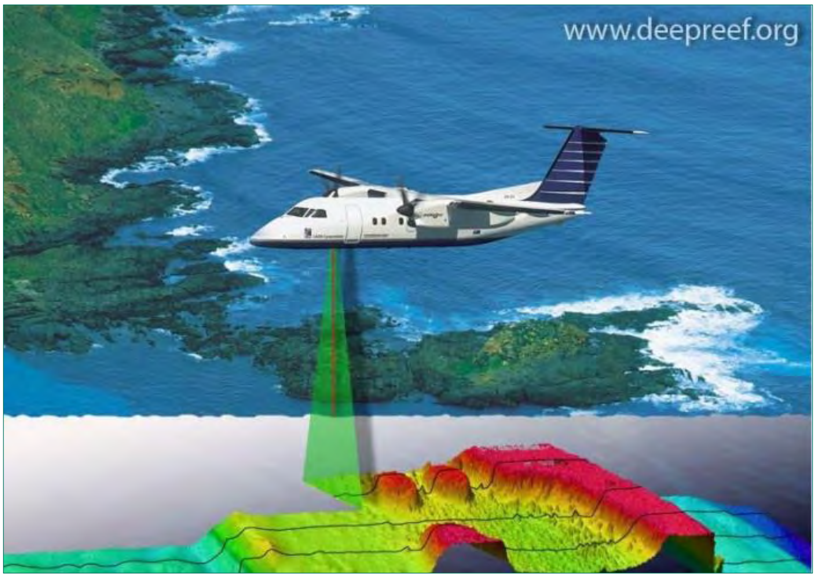
5.2.5 Technological development

Technological development is the application of scientific knowledge to create tools to solve specific social, economic or environmental problems. Technological advances have brought major changes to the way people communicate, work, learn, travel and spend leisure time.

Technology has changed the way we learn about, manage and use the Region and its resources. Examples of its influence include:

- Reef managers, visitors, tourism operators, commercial and recreational fishers, researchers, students and teachers all benefit from the latest maps and satellite imagery of the Reef.
- Information about the Reef can be communicated instantaneously through social media such as Facebook, Twitter, blogs and online news reporting.
- The public can become involved in campaigns about the Reef through online advocacy organisations.
- Reef HQ Aquarium's videoconferencing facility enables students around the world to learn about the Great Barrier Reef.
- Global positioning systems allow safer navigation of the Reef and the ability to more reliably locate sites and share locations with others. This technology also provides opportunities for sharing spatial information about the Reef and how it is used.
- Satellite-based vessel monitoring systems are used to track large ships and some commercial fishing vessels moving through the Great Barrier Reef.
- Satellite telemetry and acoustic arrays enable greater understanding of the movements and habitat use of species of conservation concern and those of economic importance.[59,60]
- Researchers use state-of-the-art satellite imagery, oceanographic instruments, laboratory equipment and portable weather stations to better understand, explain and predict changes in Reef condition, significantly improving understanding of the Region and contributing to its management.
- Light detection and ranging (lidar) mapping from low-flying aircraft delivers fast, high resolution bathymetry mapping in areas that are too shallow for vessel-based multibeam mapping.[61]
- Advanced diving technologies and remotely operated vehicles enable scientists and others to explore the length, breadth and depth of the Great Barrier Reef like never before.
- Development of antifouling alternatives that are lower in tributyltin (TBT) and copper reduce shipping impacts.

- Turtle excluding devices on the suction openings of dredges reduce the effects of dredging on large mobile marine animals.[62]
- Improvements in fishing gear have reduced bycatch in trawl nets (for example, through turtle excluder devices and other bycatch reduction devices) and improved seafood product quality.[62]
- Technological developments have increased the efficiency of fishing operations to catch target species.[63]
- Newer engines, mobile refrigeration, depth sounders, side scanning sonar and positioning systems have increased the range, endurance and efficiency of boat and shore-based fishing.
- The combination of depth sounders and global positioning systems have improved fishers' ability to find fish and accurately relocate previous fishing sites and target deep shoals and fish aggregation areas.
- Reef-based tourism relies on technological advances such as the latest dive gear, digital cameras and global positioning systems to provide high quality visitor experiences.
- Low emission engines which are more fuel efficient and less polluting are increasingly being used by Reef users. Combined with more efficient hull designs, this is increasing vessel range.
- Web-based emissions calculators, such as those developed by the Great Barrier Reef Marine Park Authority (the Authority), guide Reef-dependent industries in ways to reduce carbon emissions.
- Island resorts use new technologies such as solar power and sewage treatment to reduce their ecological footprint.
- In the catchment, advances in farming technology are reducing the use of fertilisers and pesticides, helping to slow and reverse negative trends in Reef water quality.[64]
- In the resources sector, new technologies are advancing mineral exploration and mining across the catchment, resulting in new mine sites and the reopening of mines that were not profitable using older technology.



Lidar mapping uses low-flying aircraft to scan laser beams across the seafloor and generate depth soundings in water too shallow for vessel-based surveys Image courtesy of www.deepreef.org.au

Future trends

Relationships between industry, government and community form and change over time, responding to and driving technological change, and altering land use and infrastructure development. New technology emerges from a combination of innovation, political imperatives, public acceptability and societal uptake. Future changes in technology and consumer demand will undoubtedly drive changes in the way people use the Region, the areas they want to use and the types of infrastructure installed;

however, the nature of these changes is unclear. As an example, greater interest in renewable energy may prompt applications for wind turbines over the ocean or infrastructure using wave or tidal power. Changes in consumer demand and engineering advances may alter plans for tourism infrastructure.

Implications for the Region's values

The development and spread of scientific knowledge and technologies can have significant implications for ecological systems, human use and wellbeing. New technologies can drive both positive and negative changes relevant to the Region's environment.

Technologies which better guide and monitor shipping traffic, enhance visitor experiences, reduce carbon emissions, monitor Reef use and contribute to our collective understanding of the Reef, enable the Region's values to be better protected and managed. Rapid improvements in spatial technology are providing an increasing number of spatial datasets for management. Changing vessel and navigational technology is likely to change the spatial patterns of fishing, tourism and recreational use, including allowing vessels to travel further offshore and better focus their use on preferred locations.

5.2.6 Societal attitudes

Societal attitudes operate at international, national and local scales, and are shaped by cultural and social norms, institutional arrangements, economic imperatives and politics. They may be strongly influenced by external sources, particularly the mass media.[65] Societal attitudes significantly influence the potential for an individual, group or community to take action to help conserve natural assets such as the Great Barrier Reef.

Societal attitudes about the Reef have changed dramatically in the past and will continue to do so into the future. For thousands of years, societal attitudes about the Reef were those held by the Traditional Owner clan groups whose customary estates include sea country within the Region. Their culture and lore was reflected in ongoing stewardship and custodianship of the Reef environment. Traditional Owners continue to maintain a close and dynamic connection to their sea country, which integrates nature, heritage and culture.

The attitudes of early European explorers were principally shaped by their anxiety about being shipwrecked, due to the sheer size and complexity of the coral reef system. By the late 1800s, non-Indigenous Australians saw the Reef as a bountiful resource to exploit through whaling, dugong and turtle harvesting, pearling and commercial fishing. It was not until the early part of the twentieth century that they also began to explore its natural wonders in earnest, through science, recreation and tourism. This appreciation of the Reef flourished during the 1940s, 1950s and 1960s, and continues today.[66]

By the mid-1960s, Australians were beginning to express concerns about the future of the Great Barrier Reef, particularly with respect to outbreaks of crown-of-thorns starfish and the possibility of drilling for oil.[66] This growing public affinity for the Reef and sense of responsibility for its future led to the establishment of the *Great Barrier Reef Marine Park Act* (the Act) in 1975 and subsequent progressive protection of the Great Barrier Reef as a marine park.

Legislation such as the Act, non-regulatory incentives for behaviour change and international agreements and conventions (for example, the World Heritage Convention, the Kyoto Protocol and trade agreements) reflect societal attitudes and play a major role in shaping the condition of the Great Barrier Reef.

Future trends

Future trends regarding dominant societal attitudes are difficult to predict. International, national and local leaders who understand the issues and what is at stake can exert a strong influence on people's attitudes. Societal attitudes can also gradually change with persistent targeted messages reaching all sectors of society.[65]

Awareness of threats to the Reef and willingness to accept responsibility for maintaining and restoring Reef health are important pre-conditions for behavioural change towards the Reef.[67] Connections with the environment, feelings of trust, notions of fairness and respect also have a great influence on the way people respond to management initiatives and policies. Examples of social variables that may drive different outcomes for the Region include:

- national and state legislation
- international, national and state agreements, policies or guidelines
- mass media messages

- perceptions of the need for and fairness of environmental regulations
- perceptions of Reef condition
- feelings of empowerment to effect change
- individual and collective participation in environmental initiatives
- personal willingness to change behaviour towards the environment
- personal sense of place and attachment to local environments
- societal attitudes towards illegal or harmful activities on or adjacent to the Reef.

Before a person is willing to change activities or behaviours which have adverse impacts on the environment, they first have to recognise there is a problem. A study of the public's perception of the Reef found there is a high level of acceptance that the community has a responsibility to look after the Reef.[68] Thirty-nine per cent of residents in Queensland coastal communities believe their activities at home impact on the Reef, while 23 per cent believe their activities at work impact on the Reef.[69]

Implications for the Region's values

Changes in societal attitudes on a global scale through to attitudinal changes in a coastal community can all drive changes in activities relevant to the Region's environment.

Stewardship actions driven by community and industry are critically important for changing prevailing attitudes and supporting management initiatives to maintain and enhance the Region's values. Stewardship is a central tenet of many of the management programs for the Region, and the growing interest in these programs reflects shifts in thinking towards ecologically sustainable development, human wellbeing and a healthy, vibrant Great Barrier Reef.

5.3 Activities adjacent to the Region

This section examines activities within Great Barrier Reef catchment that are likely to be causing impacts or pressures on the values of the Region (Figure 5.8). The activities described are:

- agriculture
- aquaculture
- urban development
- industrial development (including mining)
- port activities (undertaken in both the catchment and the Region)

The summary includes an examination of trends and indirect impacts on the Region's values.

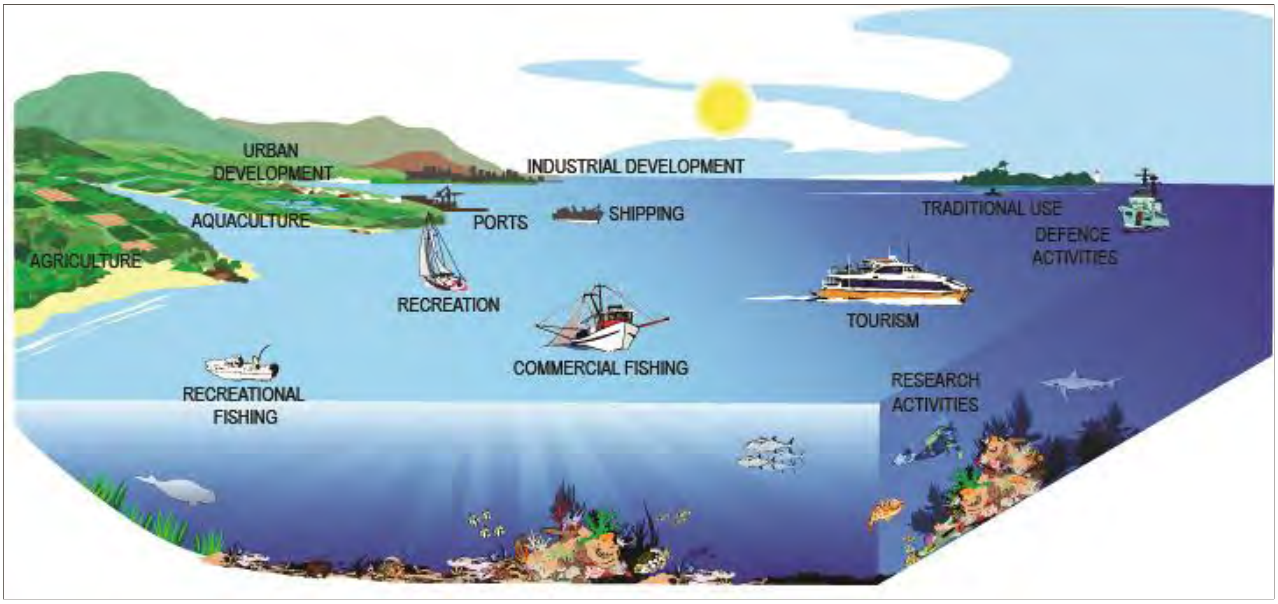


Figure 5.8 Activities within and adjacent to the Region

5.3.1 Agriculture

Agriculture within the Great Barrier Reef catchment is an important producer of food and, to a lesser extent, fibre. In 2010–11, Queensland's agriculture had a total gross value of $9.5 billion[70], much of which would have been derived from the catchment. The Great Barrier Reef catchment was first developed for agriculture when cattle and sheep grazing were introduced at the time of European settlement in the 1850s.[71] Intensive agriculture (sugar cane) started about 10 years later.[71] However, it was probably not until the early to mid-1900s and the introduction of heavy machinery that land clearing accelerated and intensification of the use of the coastal zone began in earnest.[71] This change in the use of the catchment has been recorded in sediments and coral cores taken in the Great Barrier Reef as changes in the sediment signatures[72], in nutrients[73] and in coral communities.[74] Today, more than 80 per cent of the catchment supports some form of agriculture (Figure 5.9).

Grazing is the most extensive land use, occurring in more than 74 per cent of the catchment. It is particularly extensive in the larger dry tropical catchments of the Fitzroy and Burdekin rivers but is a significant portion of most catchments, even in the Wet Tropics. It is the dominant land use in Cape York, covering about 50 per cent of the Great Barrier Reef catchment in that area (Figure 5.9).

Intensive agriculture occurs in about five per cent of the catchment. It is largely confined to the lower coastal floodplain of the Great Barrier Reef catchment, south of Port Douglas. The coastal plains with the most intensive agricultural production are the Mackay Whitsunday, Wet Tropics and Burnett Mary regions. Extensive grain and cotton areas in the upper Fitzroy catchment and, to a lesser extent, mixed cropping on the Atherton Tableland in the Barron catchment and upland parts of the Mary catchment are the exceptions where intensive agriculture is inland of the coastal plain (Figure 5.9).

Trends

Over the 160 years of European settlement in the catchment, agricultural use has become more widespread and more intensive. Historically, broadscale land clearing and intensive cropping on the coastal floodplain have affected coastal habitats and the processes that support the Great Barrier Reef environment.

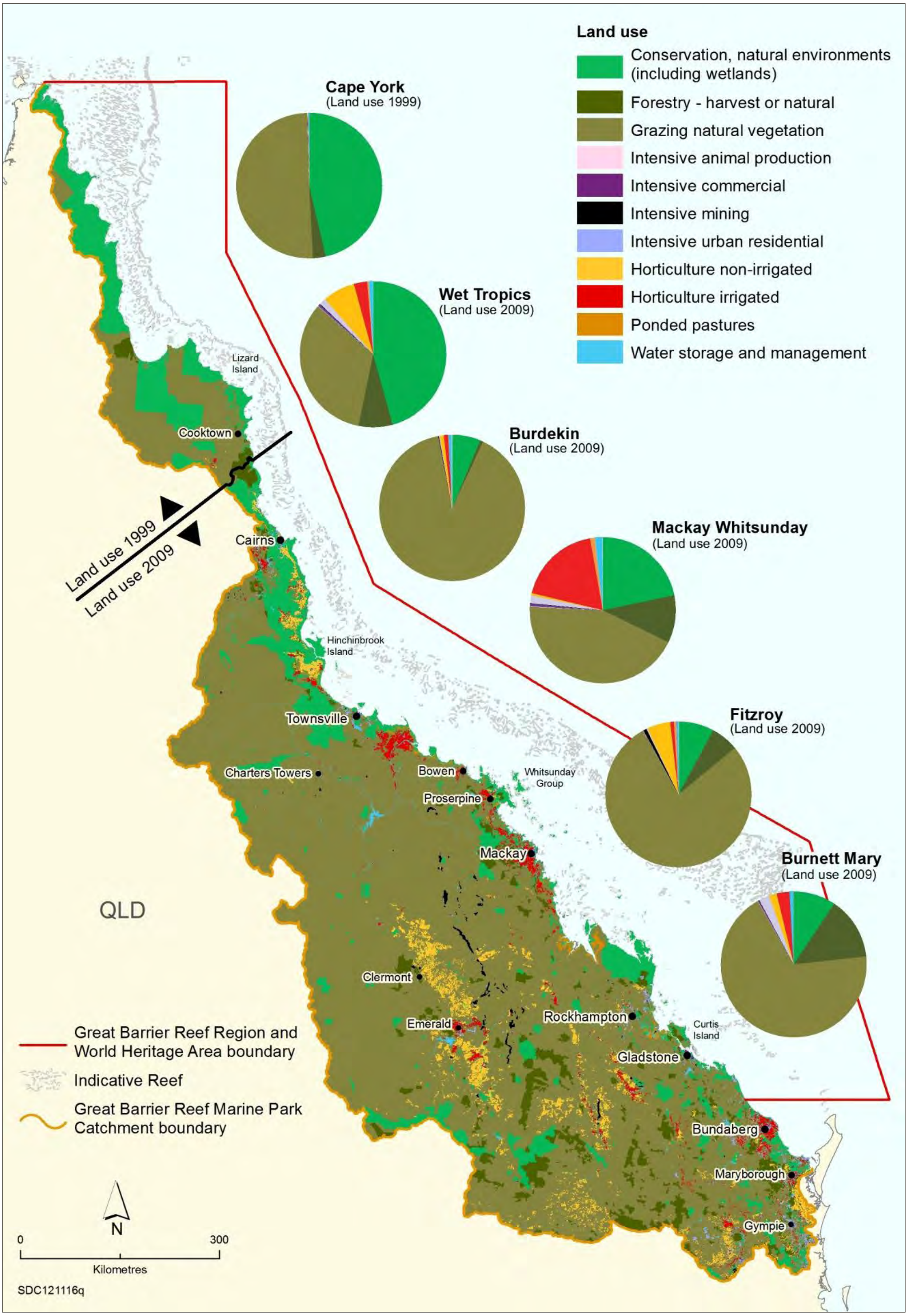


Figure 5.9 Land use in the Great Barrier Reef catchment, 2009 and 1999[51]

Grazing is the predominant land use in the catchment. Intensive agriculture is confined to a relatively small area, mainly close to the coast. For much of the catchment, comprehensive land use mapping was undertaken in 2009. For the Cape York natural resource management area, the most recent information is from 1999.

Between 1990 and 1999, the area under sugar cultivation grew by 30 per cent from 323,000 to 424,000 hectares. In the same period, there was also rapid growth in banana cultivation, mainly in the Tully and Johnstone River catchments, south of Cairns, with the area under cultivation more than doubling so that the area now produces most of Australia's bananas.[71] This expansion in intensive agriculture correlates strongly with the peak of broadscale tree clearing. The rates of broadscale clearing in Queensland increased until the late 1990s (around 750,000 hectares per year in 1999–2000) when the *Vegetation Management Act 1999* (Qld) was introduced. By 2007–08, implementation of this legislation had significantly reduced the rate of clearing to about 123,000 hectares per year and, with policies for wetland protection, led to greatly reduced rates of loss of coastal ecosystems. The overall loss of wetlands, however, has been significant in the coastal floodplain, with more than 80 per cent lost in many Great Barrier Reef basins[51] — noting that the rate of wetland loss has slowed in recent years. The full ramifications of these losses on the health of Great Barrier Reef ecosystems remain to be quantified. Recently, the Queensland Government proposed a suite of changes to the Vegetation Management Act which includes repealing regulations that apply to clearing high value regrowth on freehold and Indigenous lands, and promoting self-assessment of areas that contain remnant or high value regrowth.[75]

There is also a strong relationship between agricultural chemical inputs (for example fertilisers) and increasing intensification of agricultural activity (for example, moving from grazing to cropping). The use of fertilisers throughout the southern and central sections of the Great Barrier Reef catchment increased exponentially from the 1940s to about 2000 (Figure 5.10). After this period, it began to decline.[76] There are a number of factors contributing to a decline in fertiliser use. The issue of water quality decline in the Great Barrier Reef came to the fore in the early 2000s with the release of the Authority's Water Quality Action Plan.[77] This plan highlighted the need for significant reductions in nutrient inputs to the Great Barrier Reef and led in 2003 to the joint Australian and Queensland government *Reef Water Quality Protection Plan* (Reef Plan). The early 2000s also saw two major multi-million dollar Australian Government funding programs in the Great Barrier Reef catchment: the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality. Both these programs supported Reef Plan actions and provided assistance to farmers and other land managers through, for example landcare groups or local government, to improve land management activities and water quality. This focus on improving land management and identifying issues around excess fertiliser application led to an improved attention by industry on best practices and a general and sustained reduction in application rates.[78] Additionally, as noted above, the Queensland Vegetation Management Act, which came into effect in early 2000, significantly reduced the rate of broadscale tree clearing in the state.[76] More recently, Australian Government initiatives such as Caring for Our Country and the Queensland Government's regulatory measures and extension programs have been aimed at improving land management practices by farmers and graziers.

Land use data shows the area under intensive agriculture (that is, where fertiliser applications are made) remained stable with little or no increase between 1999 and 2009.[51] There were a number of market forces that put downward pressure on fertiliser use and potentially led to a drop in fertiliser application rates, including worldwide declines in sugar prices through the early 2000s and increasing costs of fertiliser.[78,79]

As reported in Section 5.2.3, it is forecast the pastoral sector is likely to grow and further intensify in the catchment in the medium to long term, but that large-scale changes to sugar production are relatively unlikely. Large-scale growth in intensive production of fruit and vegetables (horticulture) is predicted to be unlikely.[42]

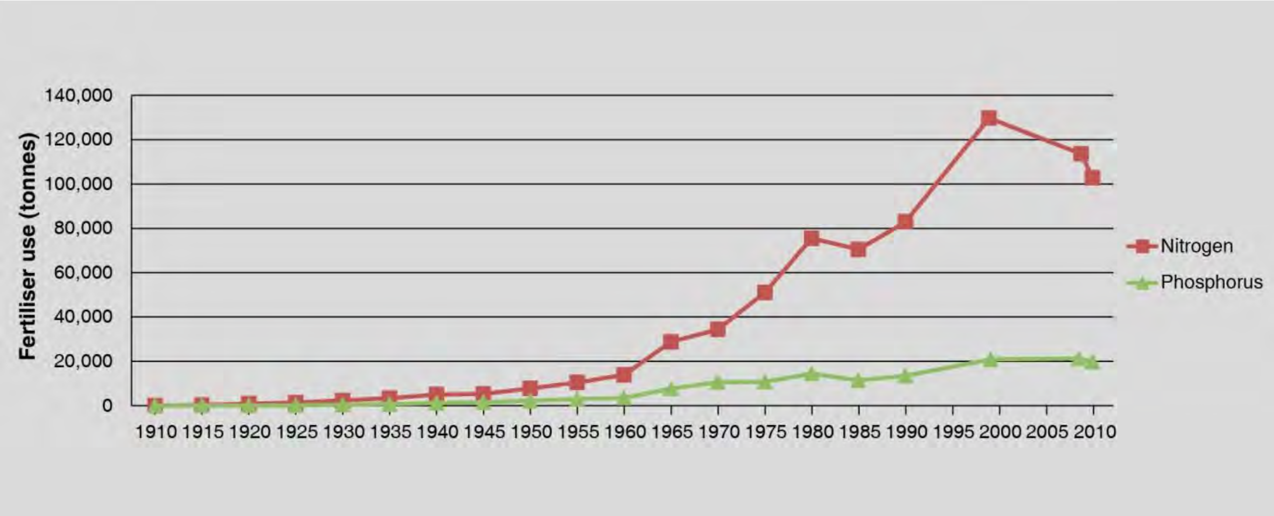


Figure 5.10 Fertiliser use in the Great Barrier Reef catchment

After decades of increasing fertiliser use in the Great Barrier Reef catchment, calculations indicate the amounts used are now declining. The 1910 to 1990 data was derived from Pulsford.[80] The 1999, 2009 and 2010 data points were estimated using Queensland Land Use Mapping Program data[81], the Fertilizer Industry Association of Australia application rates for different land uses[82] and Incitec Pivot published figures[83].

Impacts

Over the years, agricultural development in the catchment has resulted in significant loss, modification and fragmentation of terrestrial habitats that support the Great Barrier Reef which has affected the health of the Reef's inshore ecosystems.[51] Extensive broadscale clearing of forests, woodlands and forested floodplains has increased erosion and, therefore, sediment loads in rivers, streams, freshwater wetlands and, ultimately, the Great Barrier Reef. [51] A significant area of forested floodplain and wetland habitats has been lost or modified for intensive agriculture.[51] In addition to flow-on effects to the Region from clearing these habitats, activities such as infilling and building channels, levees and bunds have affected many ecological processes that support the Great Barrier Reef such as water flow, groundwater recharge and discharge, nutrient and sediment cycling, and connectivity.[84]

Diffuse source pollution from agriculture is the main source of excess nutrients, fine sediments and pesticides, including herbicides, entering the Great Barrier Reef Region.[15] The trends in loads of these pollutants entering the Great Barrier Reef steadily increased with agricultural development of the catchment. In 2012, nutrient and sediment loads were estimated to be about 5 or 6 times natural levels.[85]

Together, increased sediments, nutrients and pesticides have had serious impacts on marine ecosystems, particularly coral reefs and seagrass beds. For example, recent research has shown the timing of shifts or degradation of coral communities on inshore reefs is strongly correlated with increases in terrestrial run-off.[74] Furthermore, there is increasing evidence of a link between increased nutrients and crown-of-thorns starfish outbreaks[86] and degradation of seagrass meadows[87]. In some cases, agricultural activities have also resulted in the exposure of acid sulphate soils.[88]

Recent improvements in land management and agricultural practices are recognised in the 2013 Water Quality Scientific Consensus Statement[15] which concluded that "*the use of improved land and agricultural management practices is proven to reduce run-off of suspended sediment, nutrients and pesticides at the paddock scale*". These improvements will potentially mean reduced future impacts on the Region's ecosystems.

5.3.2 Aquaculture

Aquaculture refers to an operation for the propagation, rearing, keeping or breeding of an aquatic organism. It is Australia's fastest growing primary industry.[89] Although there has been limited marine-based aquaculture within the Region and no facilities are in operation at present, land-based aquaculture occurs in the catchment, principally for prawns, barramundi, redclaw and freshwater fish.[90,91]

Aquaculture operations are located close to the coast in a number of areas in the southern half of the catchment, typically where there is access to good water supplies.

Trends

While over the last decade there has been little spatial expansion of land-based aquaculture adjacent to the Region, overall production has increased.[90] Before 2010–2011, prawn aquaculture experienced strong annual production increases; however in 2010–11 production fell by 25 per cent mainly due to cyclones.[90] Several marine-based aquaculture operations have been proposed or have begun over the past two decades (fish, pearls, sponges) but none are in operation at present, primarily due to economic or environmental sustainability issues.

Impacts

The potential impacts on the Great Barrier Reef environment associated with land-based aquaculture facilities include: increased loads of sediment and nutrients (nitrogen and phosphorus) in discharged wastewater; clearing or modifying coastal habitats; modifying hydrologic processes; disturbing acid sulphate soils; introducing marine species; genetic pollution; and introducing disease.[92]

The Great Barrier Reef Marine Park (Aquaculture) Regulations were introduced in 2000 to ensure the discharge of waste from land-based aquaculture facilities did not significantly impact the plants and animals of the Marine Park.

5.3.3 Urban development

Urban development refers to the construction or expansion of a town or city including buildings, houses, roads, water and electricity supply. The six major population centres within the Great Barrier Reef catchment — Cairns, Townsville, Mackay, Rockhampton, Gladstone and Bundaberg — account for about 42 per cent of the population. They are the areas of most intensive urban development.

Trends

Population growth in the Great Barrier Reef catchment continues to occur at rates faster than the Australian average, especially along the coast (see Figure 5.7). The catchment's current population is expected to grow by approximately 44 per cent to 1.74 million by 2031.[93] The majority of this population is expected to live on or near the coast. Population growth in the regional centres of the catchment (see Figure 5.6) is driving expansion of its urban footprint. For example, Townsville is projected to grow from approximately 191,000 to 300,000 by 2031. As a result, the number of dwellings in Townsville is predicted to increase from 74,205 in 2011 to 121,914 in 2031.[93]

Impacts

Although urban development occupies only a small proportion of Queensland's total land area, it can be a source of impacts in relation to the Region's values at a local scale.

By its very nature, urban development in coastal areas modifies the local habitats that support the Great Barrier Reef ecosystem — this includes clearing and infilling, modifying water flow and changing aquatic connectivity between coastal and marine habitats.[51]

Local councils continue to work to minimise the amount of pollutants entering the Region's waters from urban areas, however these areas remain a localised source of nutrients, pesticides and litter entering the marine system.[94] Such pollution can enter the Region via sewage, stormwater and wastewater discharge. While the contribution of sewage discharge to the Region's overall nutrient loads is relatively small, it often occurs in more disturbed areas already subject to multiple other impacts. In 2002, the Queensland State Coastal Management Plan[95] identified the need for improving sewage management for environmental and human health reasons. It required that all sewage treatment plants discharging into coastal waters that enter the Marine Park be upgraded to remove excess nutrients by 2010. This involved significant investment by the Queensland Government and local councils, with assistance from the Australian Government, to upgrade facilities in major population centres. It has resulted in significant reductions in the nutrient load from urban areas.

There remains a number of smaller communities along the coast that discharge secondary treated sewage to waterways that lead to the Great Barrier Reef, or that are serviced by septic systems. In these communities, it is currently not considered to be economically viable to upgrade to tertiary treatment.[96] As Queensland's population continues to grow along the coast, this is likely to be an increasing issue for water quality.

All island resorts discharging sewage from marine outfalls into the Marine Park meet tertiary standards.[25]

Other local-scale impacts from urban development include exposure of potential acid sulphate soils[51], increased light[97] and atmospheric pollution, increased noise and visual disturbance.

Land-based sewage management in the Great Barrier Reef and its catchment

In 1991, the Authority introduced a policy requiring tourism resort operators to have a permit to discharge sewage into the Marine Park and to have upgraded their sewage treatment plants to tertiary treatment standard by 2002. This decision was based on the best science at the time which had begun to identify issues with changes in the nutrient and sediment concentrations in coastal waters of the Region. It was also in response to a specific case of seagrass communities expanding because of the retention of diluted effluent on the reef flat around a resort and localised effects on coral reefs adjacent to other resorts.[98,99,100]

An assessment of sewage discharges into the Region undertaken in 2000 identified 16 other sewage treatment plants that discharged into coastal waters in or adjacent to the Marine Park that needed upgrading to achieve the Authority's tertiary treatment policy.[101]

In parallel, the Queensland Government implemented a process for improving coastal management and identified critical issues, such as the need to improve management of sewage discharges, with the release of its position paper on managing the coast.[102] This led to the first Queensland State Coastal Management Plan which came into effect in August 2002 and required all sewage treatment plants discharging into coastal waters that enter the Marine Park to upgrade facilities to a tertiary treatment standard by 2010.[95]

Northern wastewater treatment plant, Cairns

Over the subsequent decade, about $620 million was invested in upgrading sewage treatment plants to a tertiary treatment standard in the three largest coastal cities adjacent to the Great Barrier Reef — Cairns, Townsville and Mackay. All levels of government and the coastal communities have contributed to these initiatives. Most population centres that discharge sewage via waterways that lead to the Reef now treat their sewage to tertiary standard.[25] Until 2011, the Queensland Government had provided about 50 per cent of the capital expenditure to fund these upgrades. Some upgrades are still underway in smaller population centres (for example, Sarina is undergoing a $40 million upgrade). The Australian Government has supported local governments in some of these upgrades, for example contributing $40 million to the Townsville City Council as part of the $170 million redevelopment of the Mt St John sewage treatment plant. Most of the remaining funds for upgrading or building new sewage treatment plants have come from the coastal communities themselves through local government rates.

While inputs of nutrients from sewage treatment plants accounted for only a small percentage of the overall nitrogen load entering the Great Barrier Reef from its catchment (less than four per cent of the total nitrogen load and less than one per cent of the of the total phosphorus load[25]), the reduction of loads at localities adjacent to high population centres is substantial. For example, in the Townsville local government area, introduction of tertiary treatment reduced the total nitrogen and total phosphorus loads by 81 per cent[103] which equates to an approximate 42 per cent load reduction from the Black and Ross rivers catchment. A reduction in the nutrient load from these facilities is likely to improve the overall ecosystem resilience of these areas to cumulative impacts.

In total, the upgrades have removed an estimated 834 tonnes of nutrients per annum (approximately 80 per cent of the original total nutrient load from this source) that would otherwise have entered the Region.

5.3.4 Industrial development

For the purpose of this report, industrial development refers to the construction, operation or expansion of commercial industries, excluding agriculture, ports, tourism, fishing and aquaculture. Historically, there have been extensive small-scale mining operations through much of the catchment, including gold, tin, nickel and uranium mines.[104] Much of the supporting infrastructure for mining and industry is located in coastal areas and, in the past two decades, major State Development Areas have been declared in Gladstone (1993), Townsville (2003), Abbot Point (2008) and Gladstone–Curtis Island (2008).[105] State Development Areas are defined areas established to promote economic development in Queensland.

Trends

Trends in industrial development in the catchment are described earlier in Section 5.2.3.

Impacts

Mining and industrial development can lead to increased pressure for expanded urban and service infrastructure to cater for more workers.[106] With regard to resource extraction, although the footprint of a mine or well may be relatively small, installation of the supporting infrastructure can lead to fragmentation, modification or loss of local coastal ecosystems.[51] If not properly managed, industrial development adjacent to the Great Barrier Reef can also result in localised impacts such as the exposure of potential acid sulphate soils; light pollution[97]; atmospheric pollution; artificial barriers to estuarine flow; discharge of pollutants; coastal reclamation; and marine debris.[51,107] Coastal industrial development can also diminish aesthetic values for users of the Region.[108]

5.3.5 Port activities

As an island nation, Australia is dependent on maritime trade. Consequently, ports and their associated infrastructure are of significant economic and social importance to Australia. A number of Queensland's ports, including those in the Region, are considered nationally significant for cargo throughputs and contributions to the national economy.[109]

There are 12 trading ports in the World Heritage Area, managed by four port authorities — all Queensland Government-owned corporations. Of these, eight are located at least partly in the Region and only the minor ports of Cooktown and Quintell Beach in Cape York are located within the Marine Park (Table 5.2). In 2011–12, ports within the Great Barrier Reef Region accounted for 76 per cent of the total throughput for all Queensland ports combined. This amounted to 199.8 million tonnes of imports and exports through the Region (Figure 5.11).[109]

Table 5.2 Trading ports located within, or partly within, the Great Barrier Reef World Heritage Area, Region and Marine Park

A trading port refers to a port that is associated with a pilotage area managed by Maritime Safety Queensland.

Port	Great Barrier Reef World Heritage Area	Great Barrier Reef Region	Great Barrier Reef Marine Park
Quintell Beach	●	●	●
Cape Flattery	●	●	
Cooktown	●	●	●
Cairns	●		
Mourilyan	●		
Lucinda	●	●	
Townsville	●	●	
Abbot Point	●	●	
Mackay	●	●	
Hay Point	●	●	
Port Alma	●		
Gladstone	●		

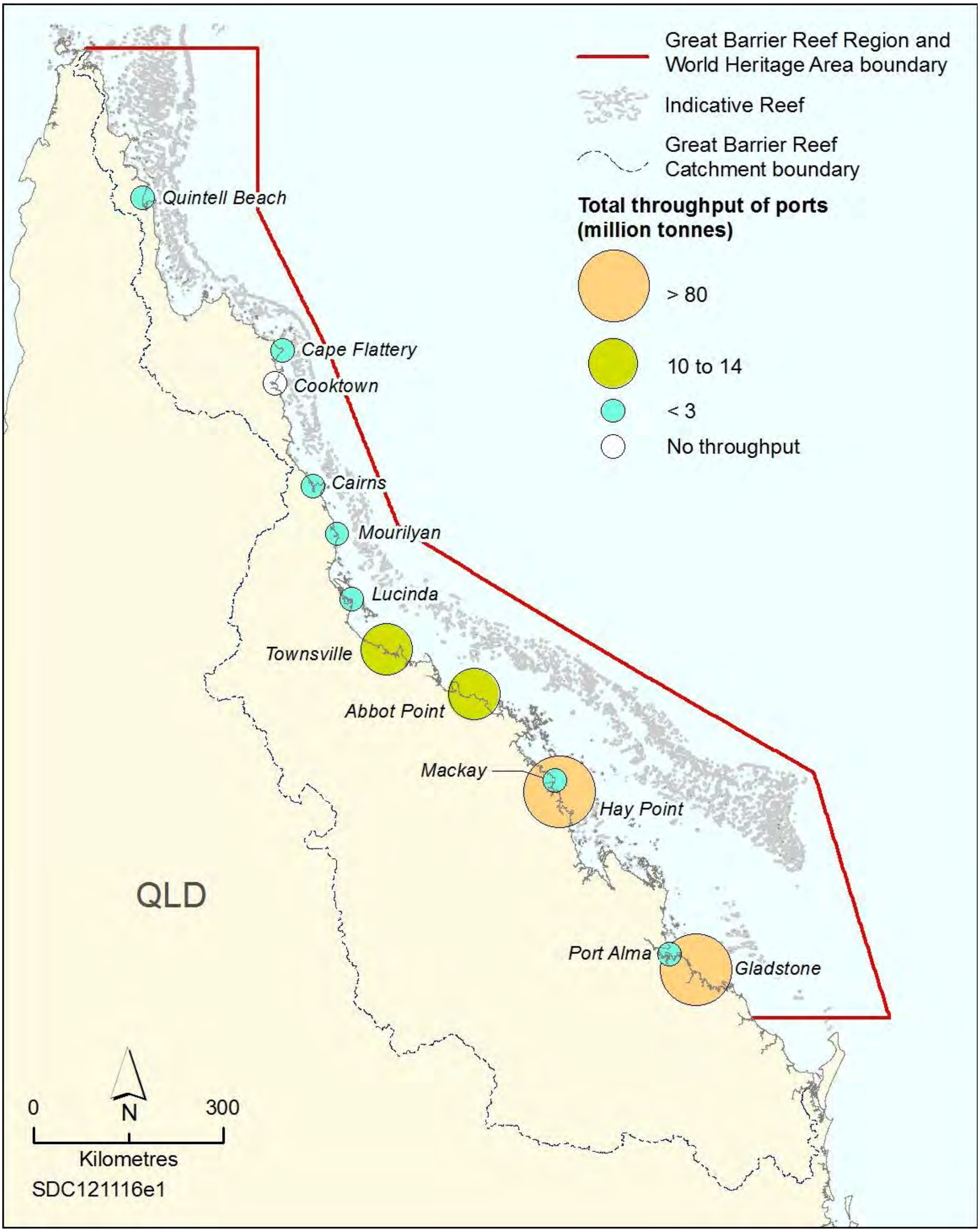


Figure 5.11 Queensland trading ports in the Great Barrier Reef World Heritage Area, Region and Marine Park and their throughput, 2011–12[109]

In terms of infrastructure, operational capacity and size, the largest ports on the Region's coast are Abbot Point, Gladstone, Hay Point and Townsville. The Gladstone, Abbot Point and Hay Point ports are major hubs for the export of coal.[46] Hay Point is one of the largest coal export terminals in the world,[110] handling more than 80 million tonnes of coal in 2011–12.[109] During 2010–11, it had the highest value of coal exports among all Queensland ports at $18 billion.[47]

The land and ocean-based activities associated with ports include:

- rail and road networks
- terminals, loading and unloading facilities
- land reclamation
- trestle structures
- dredging and sea dumping of dredge material
- storage and waste facilities, cargo holding facilities, stockpiles
- safety and navigational aids and lighting
- monitoring buoys
- tug boat and shipping berths
- ship departure channels and anchorages.

Activities associated with ports cut across many of the jurisdictional boundaries relevant to the Region, occurring on land, as well as in the World Heritage Area, the Region and the Marine Park.

Figure 5.12 illustrates the jurisdictional boundaries relevant to the operation of ports around Mackay.

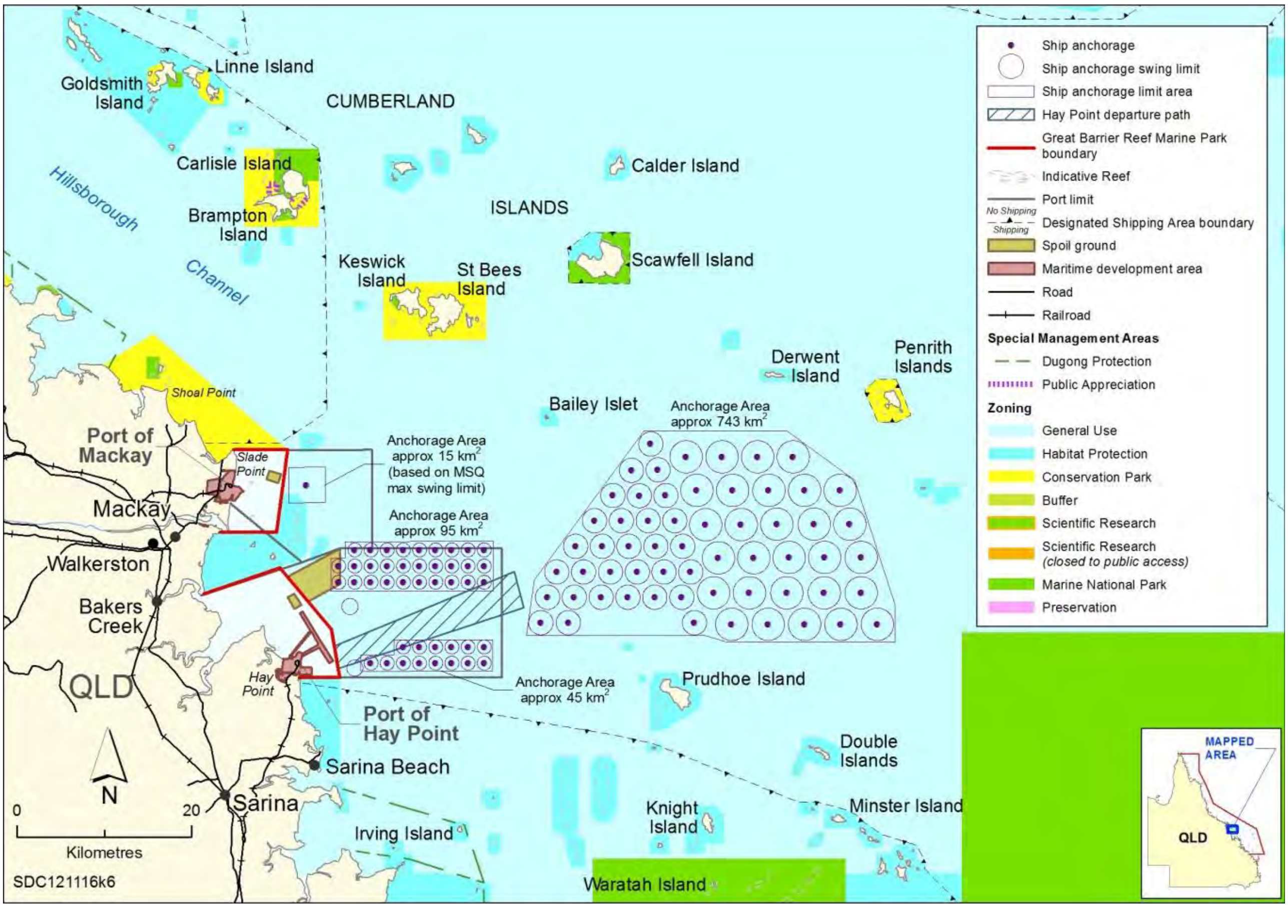


Figure 5.12 Port infrastructure at Mackay and the Port of Hay Point

Using Mackay and Hay Point as examples, the facilities and management arrangements relating to the operation of Great Barrier Reef ports often cut across the boundaries for the World Heritage Area, the Region and the Marine Park.

Trends

There has been major expansion of ports on the Region's coast over the past two decades. Between 1988–89 and 2010, total export tonnage from these ports grew by 297 per cent.[111] In the same period, the value of the exports increased by 550 per cent. Increases in bulk commodity exports from these ports are driving increases in shipping.

As at June 2013, five of the 12 commercial ports (Cairns, Townsville, Abbot Point, Hay Point and Gladstone) had active proposals for port expansions, driven mainly by growth in the resources sector. There are also proposals for two new ports (Wongai in Cape York and the Fitzroy terminal project) adjacent to the Region. A proposal to develop a port on Balaclava Island has been withdrawn and it is noted that not all the current proposals may proceed.

A Bureau of Resources and Energy Economics report[46] found the total capacity of planned infrastructure projects progressing through the approval process exceeds the projected volumes of commodity exports out to 2025. However, a lower than expected ability to make use of this capacity was identified as a key risk; with predictions that further capacity expansion may be required to compensate for the lack of consistent throughput. This finding is similar to a recent study by the Queensland Department of State Development, Infrastructure and Planning that found Queensland's three major coal ports (Hay Point, Gladstone and Abbot Point) operated at only 52 per cent of their combined capacity in 2011–12[112] and that Abbot Point only operated at one quarter of its total capacity.[112] The exception is liquid natural gas where the Bureau of Resources and Energy Economics report predicts that under a high market share scenario, there is insufficient time to build adequate capacity by 2020, despite planned infrastructure capacity exceeding projected export volumes.[46]

The draft of ships is a significant factor limiting navigable waterways, and the worldwide trend towards longer, deeper draft ships[113] affects port access requirements. In order to accommodate deeper draft ships, some ports may require more capital and ongoing maintenance dredging into the future.

Impacts

Dredging to improve vessel access and the installation, operation and maintenance of infrastructure is affecting habitats and species.[114,115] Ports and associated access channels have been dredged since their establishment, well before the Marine Park was declared. Today, both capital and maintenance dredging are undertaken within and adjacent to the Marine Park. Sites for the disposal of dredge material (sediments from the seafloor) may be at sea or on land. Existing ocean disposal sites are located within and adjacent to the Marine Park. Most large-scale dredging and dredge material disposal are associated with the larger and busier ports such as Cairns, Townsville, Abbot Point, Hay Point and Gladstone.[47]

The dredging itself, plus the disposal of dredge material and its later resuspension, can have direct effects on the environment. These include: removal of existing habitats such as seagrasses;[114] disturbance to the seabed; increased underwater noise;[116] reduced water quality; transport and resuspension of contaminants and nutrients; burial and smothering of life on the seafloor both at the disposal site and in surrounding areas after resuspension; [117] and increased turbidity.[117,118]

Impacts to the marine environment from the installation and maintenance of port infrastructure and general port activities may include: clearing, modifying and fragmenting coastal habitats; reclamation of marine areas; exposure of potential acid sulphate soils; creation of artificial habitats; alteration of natural coastal processes; the risk of large and small chemical and oil spills; marine debris; injury or death of marine wildlife; altered light regimes; displacement of other Marine Park users; and diminished aesthetic values for users and nearby communities. The impacts of ports are also directly linked to impacts associated with shipping and ship anchorages.

5.4 Activities within the Region

This section examines activities within the Great Barrier Reef Region that are likely to be causing impacts or pressures on the values of the Region (see Figure 5.8). The activities described are:

- traditional use of marine resources
- tourism
- fishing — commercial
- fishing — recreational
- recreation
- shipping
- defence activities
- research activities.

Some of the activities are directly dependent on the Region's natural resources (Reef-dependent) and other are carried out regardless of the natural environment (not Reef-dependent). Examples of Reef-dependent activities are traditional use of marine resources, tourism, fishing (commercial and recreational), recreation and research activities. Reef-dependent activities are likely to be more sensitive to changes in the condition of the Region's values.[119]

5.4.1 Traditional use of marine resources

Traditional Owner connection to sea country within the Region continues to be practiced and maintained according to traditional customs and spiritual lore, reflecting the ongoing stewardship and custodianship.

Traditional use of marine resources is the undertaking of activities as part of Aboriginal and Torres Strait Islander people's customs or traditions, for the purpose of satisfying personal, domestic or communal needs. It includes fishing, collecting (for example, shellfish) and hunting, as well as looking after cultural and heritage sites.

Marine resources have distinct cultural uses. Traditional Owners use these resources to practice their living maritime culture, provide traditional food for their families and educate the younger generation about traditional and cultural rules, protocols and activities in sea country.

For more than 40,000 years, the traditional use of marine resources has been conducted sustainably. Impacts such as coastal development, habitat degradation, boat strikes, pollution, netting and sedimentation as well as legacy impacts have affected Traditional Owners' use of the marine environment. Traditional Owners are now working in partnership with the Authority to conserve and protect species and ecosystems critical to the health of people, culture and country, including through development and implementation of Traditional Use of Marine Resources Agreements.

For example, since European settlement in Australia, the dramatic reduction in species such as marine turtles and dugongs has reduced the capacity of these populations to withstand the multitude of impacts that affect them, such as habitat degradation, boat strikes, pollution, netting, sedimentation and the effects of coastal development. In recognition of the pressures on these species, some Traditional Owner groups have taken steps to reduce, temporarily suspend or cease traditional hunting of them. In their Traditional Use of Marine Resources Agreement, the Woppaburra Traditional Owners of the Keppel Island region have specified that green turtle harvest will be limited and there will be no take of dugong at all:

> *"We are fulfilling our customary obligations by taking an active role in managing the marine resources in our sea country for the future. Under our Dharumbal–Woppaburra Traditional Use of Marine Resources Agreement, we have agreed to limit green turtle harvest in specific areas under a traditional authority system, and to not harvest dugongs. We recognise that marine turtles and dugongs are under threat from many pressures and we are committed to the conservation and protection of these and all marine species. We are proud of our sea country and welcome you. We work in partnership with the Australian and Queensland governments, and we ask you to help keep our shared sea country healthy by following zoning rules and doing all you can to minimise the impacts of your visit."*[120]

Other Traditional Owner groups — such as the Gooreng Gooreng, Gurang, Taribelang Bunda and Bailai peoples who have an agreement covering the Port Curtis Coral Coast — have voluntarily agreed not to hunt dugongs for five years from 2011, in response to that year's extreme weather and the number of dugongs that were stranded dead in eastern Queensland.

Trends

Traditional Use of Marine Resources Agreements, and one marine Indigenous Land Use Agreement, apply to approximately 13 per cent of the Great Barrier Reef Marine Park. Due to the success of the Authority's Reef Rescue Land and Sea Country Indigenous Partnership Program, other Traditional Owner groups are currently working to develop their own agreements, which will result in a significant increase in the area covered. With increased development in remote areas and changes to infrastructure, there is potential for the level and type of traditional use along the coast to change.

Benefits

The continuing sea country management and custodianship of the Great Barrier Reef by Aboriginal and Torres Strait Islander Traditional Owners provides immeasurable benefit.

Many Traditional Owners use marine resources to practice their sustainable 'living maritime culture'; provide traditional food for families; and educate younger generations about traditional and cultural rules, protocols and activities in sea country.

Traditions are of high cultural importance, while social sharing during special events that require traditional resources is also critical to maintaining culture. Traditional Owners hold many cultural, economic and spiritual connections to the Region; establishing effective partnerships with them helps protect cultural and heritage values, conserve biodiversity and enhance the resilience of the Great Barrier Reef.

Impacts

Any impacts attributable to traditional use of marine resources undertaken according to customs and traditions are considered to have only minor or localised effects on values. This is distinct from any illegal poaching of species of conservation concern undertaken without the customary approval of the relevant Traditional Owners.

There have been some recent examples of disputes in multiple-use areas where the activities of tourism operators and visitors conflicts with Traditional Owner cultural use of marine resources in the sea country areas where they express their native title rights.[121]

5.4.2 Tourism

In this report, tourism is defined as the commercial activities that provide transport, accommodation or services to people who are visiting the Region principally for enjoyment. Non-commercial recreational activities are discussed in Section 5.4.5.

Australia's rich natural resources and high number of natural world heritage sites, based on a comparatively pristine natural environment, are recognised as some of the nation's tourism strengths.[122] For the Region, its long-term attractiveness as a tourism destination is largely based on the Great Barrier Reef's reputation as the world's largest and best known coral reef ecosystem — one that has spectacular and diverse species — combined with a high standard of tourism operations and protected area management. The Region's tourism industry is almost exclusively nature-based, with coral reefs and islands as the focus. There are opportunities to see iconic wildlife such as whales, turtles, sharks and seabirds — many of which are matters of national environmental significance — and to go boating, diving, snorkelling, fishing, sailing, hiking, camping or enjoy various water sports.

The industry offers a wide range of tourism experiences, from cruise ships and live-aboard vessels to day trips on high speed catamarans, fishing charters and kayaking tours. While tourism visitation occurs across most of the Great Barrier Reef, activity is consistently focused on a small portion of the Marine Park, with more than 85 per cent of all tourism activity management occurring in about seven per cent of the Region (Figure 5.13).[123]

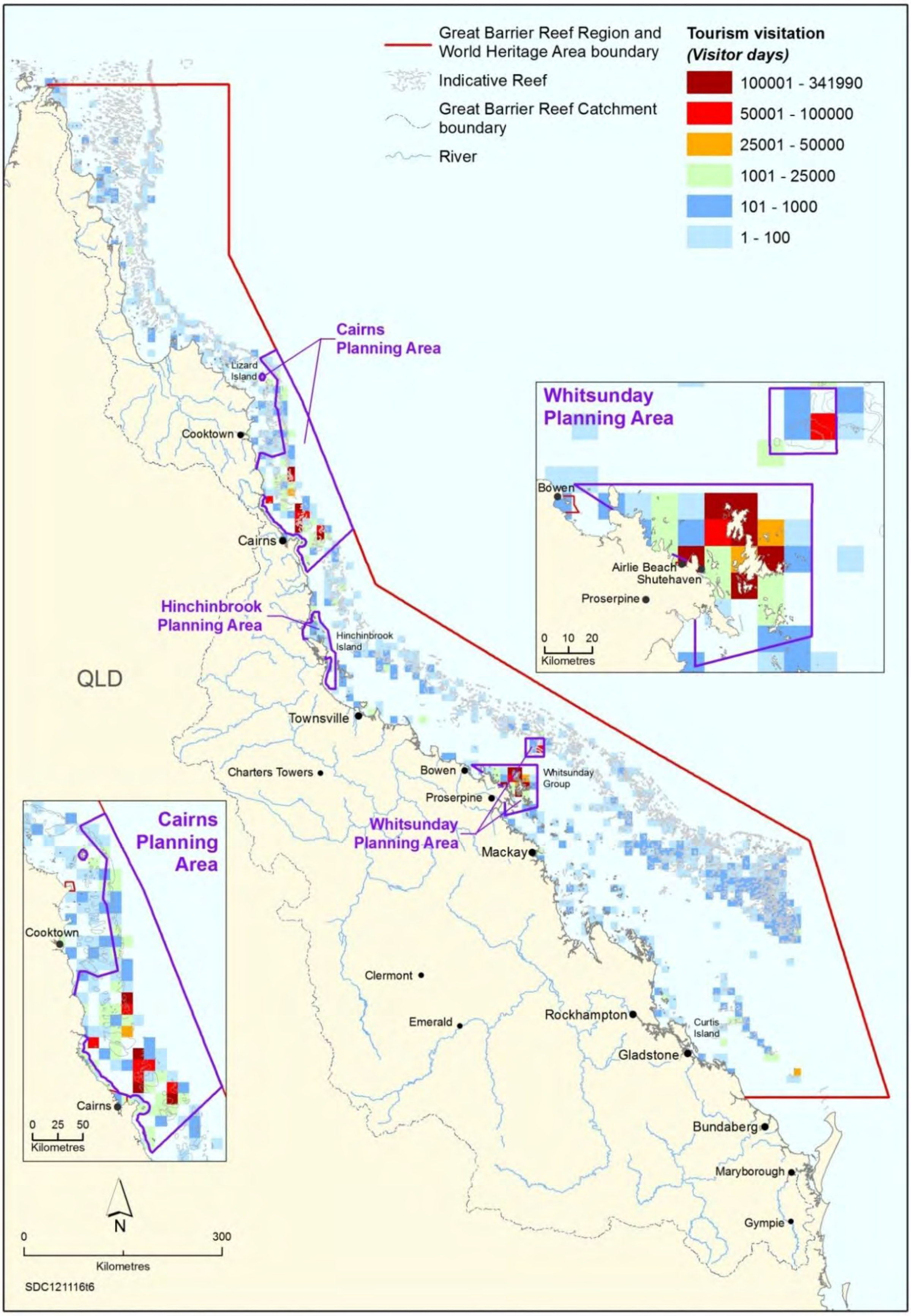


Figure 5.13 Distribution of tourism activity in the Great Barrier Reef Marine Park, 2012[123]

Tourism use of the Great Barrier Reef is strongly focused on the areas offshore from Cairns and Port Douglas and around the Whitsunday islands. The map shows full day visits (visits of more than three hours) and part day visits (visits of less than three hours), including those that are exempt from paying the Environmental Management Charge. Visitation from stand-alone coral viewing activities, scenic flights or passenger transfers to and from islands are not mapped.

Trends

Commercial tourism began on the Great Barrier Reef in the 1890s. Since that time vessels and technologies available for viewing the Reef environment and enjoying the Region have changed substantially. The number of visitors has increased, along with the size and geographic distribution of the industry.

Total tourism visitation to the Great Barrier Reef Marine Park in 2011 was 1.842 million.[123] Tourism visitation rose gradually over the 10 years prior to 2005 and has subsequently declined by about eight per cent per year (Figure 5.14). The declines have been attributable to a range of factors, including the high exchange rate of the Australian dollar, increased competition from international destinations, extreme weather events and the global financial crisis. In 2012, there were signs of a recovery in tourism visitation, however it was patchy in its extent. Visitation to the Whitsundays — previously a strongly performing region — is still depressed.[123]

The forecast outlook is for a slow recovery bolstered by the emerging markets of China and India (Figure 5.15), recent improved availability of airline capacity on some Asian airline routes and a strengthening domestic market.

The Authority works in partnership with the tourism industry to improve standards for the protection and presentation of the Great Barrier Reef. Operators who are independently certified with Ecotourism Australia's ECO Certification Program at Ecotourism and Advanced Ecotourism levels and who meet best practice standards when undertaking their tourism operations are invited by the Authority to be recognised as high standard operators. The High Standard Tourism program began in 2004 with 19 tourism operators. The number of operators involved has steadily increased to 60 in 2012. During that year, these operators carried 66 per cent of tourists visiting the Reef (Figure 5.16).

Increased economic activity associated with the resources industries throughout Australia has resulted in competition in sourcing labour for the tourism industry.[124] This has the potential to affect the level of expertise of tourism crew and their knowledge and understanding about the Great Barrier Reef, its values and its management arrangements. It may also affect the industry's ability to source adequate capital.[124]

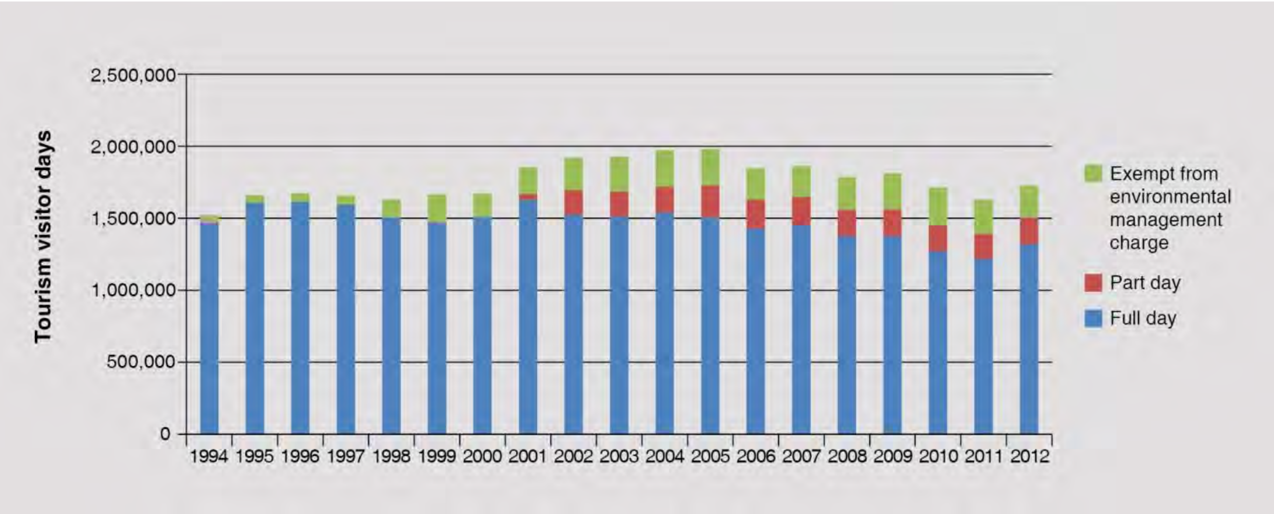


Figure 5.14 Number of tourism visitor days to the Great Barrier Reef Marine Park, 1994–2012 [123]

A 'visitor day' is a visit by one tourist for one day. For overnight visits, each day is counted separately (e.g. a three-day visit by a tourist represents three visitor days). A half-day visit refers to visitors who undertake a trip of less than three hours, and exempt from the environmental management charge includes young children and trade familiarisations. Ongoing improvements in the way the environmental management charge information is recorded has progressively allowed more accurate differentiation of visitation. This figure does not include stand-alone coral viewing activities and scenic flights, estimated at more than 0.2 million. It also does not include the estimated 2.3 million passenger transfers conducted each year through the Region to and from islands.

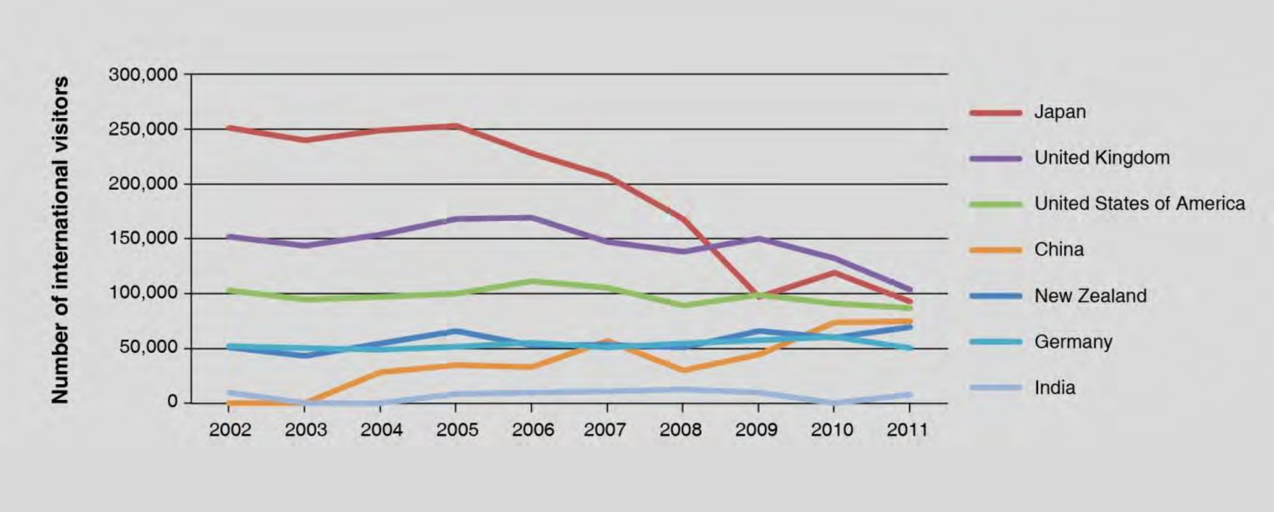


Figure 5.15 International visitation to the Great Barrier Reef catchment, 2002–2011[125]

There has been a marked decline in Japanese visitors to the Reef catchment over the last decade. Visitation by Chinese tourists is increasing.

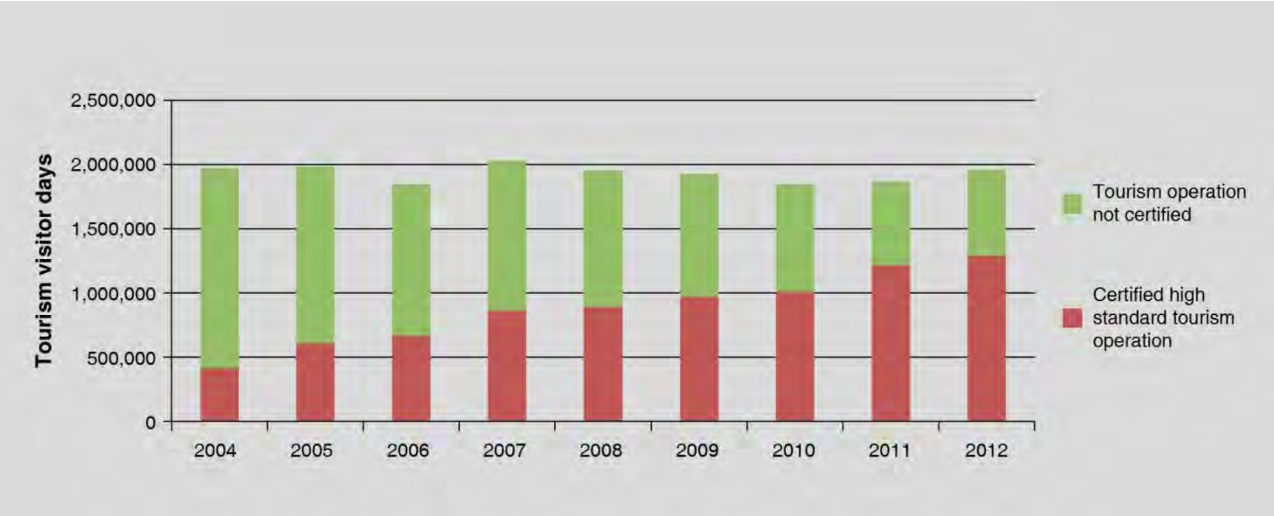


Figure 5.16 Percentage of visitors to the Marine Park carried on high standard tourism operations, 2004–2012

Since the Authority's High Standard Tourism program began in 2004, the increasing number of recognised high standard tourism operators has resulted in a higher proportion of tourists using these operators to visit the Reef. (Visitor numbers shown includes coral viewing and scenic flights.)

Benefits

Tourism is the most significant direct use of the Region — both in terms of economic value and employment (see Table 7.9 in Chapter 7). In 2012, tourism in the Reef catchment and World Heritage Area generated approximately $6.4 billion in direct expenditure, $5.2 billion value-added (that is, profit generated) and an equivalent of more than 64,000 full time jobs.[43]

The tourism industry is a key partner in the Reef's protection and management. On behalf of the Authority, the industry collects about $7 million each year from tourists through an environmental management charge (see Chapter 3).[123] These funds directly contribute to management of the Great Barrier Reef Marine Park.

Tourism operators are actively involved as stewards of the Reef. Through the High Standard Tourism program, operators are increasingly working to voluntary best practice standards in their activities. In addition, tourism operators are leading the way in responding to climate change by reducing and mitigating their carbon emissions. The Association of Marine Park Tourism Operators, in partnership with the Authority, has undertaken targeted control of crown-of-thorns starfish. All these actions improve the sustainability of the industry and the health and resilience of the Reef.

Many operators also participate in research and monitoring programs, such as the Eye on the Reef environmental monitoring program, the Sightings Network and visitor surveys. Despite the financial pressures experienced through the downturn in tourism, 23 tourism operators continued to actively gather reef health data in early 2012 through different components of the Eye on the Reef program, including the water quality data presented in Figure 6.15 in Chapter 6.

Importantly, the tourism industry makes much of the vast area of the Great Barrier Reef accessible to visitors, and without it, many visitors simply would not be able to enjoy or experience the Region's values. The industry, therefore, plays a key role in fulfilling Australia's world heritage obligation to 'present' the Great Barrier Reef World Heritage Area. Most tourism programs involve education and interpretation activities, aimed at increasing appreciation and understanding of the natural environment and sustainable practices that support the Reef.

Impacts

Concern about tourism impacts in the Great Barrier Reef arose during the 1980s and 1990s because of rapidly increasing tourism visitor numbers, forecasts of exponential future growth and widely reported damage to popular reefs and adjacent islands. With the introduction of more intensive management of popular areas, limits on the number of vessels and group sizes, an increase in supporting infrastructure and the adoption of best practices by operators, many of these concerns have been avoided or mitigated. As a result, the impacts associated with tourism activities today are generally regarded as low risk and are concentrated in a few intensively managed areas.[25,126]

Tourism can cause localised impacts through anchor damage to coral reefs and seagrass meadows, poorly supervised activities, such as diving and snorkelling, and disturbance to wildlife including whales, marine turtles and seabirds, some of which are matters of national environmental significance. These impacts have been largely reduced by regulation (for example, whale approach distances), site management arrangements (such as group size limits at locations, use of moorings, seasonal seabird closure areas); permit arrangements (for example, fish feeding guidelines); education; and the adoption of best practices for activities (such as diving and snorkelling).

In recent years, reduced profitability across the industry has increased the risks associated with tourism-related structures in the Region (such as pontoons, jetties, underwater observatories and moorings). As structures age, they require more investment in maintenance to ensure they are not a threat to the surrounding environment and do not impact on amenity and presentation values of a location. In addition, coastal development, marinas and ancillary services associated with marine tourism can result in flow-on impacts on the environment within the Region, including dredging and dumping of dredge material, clearing or modifying coastal habitats and decreased water quality.

Tourism use of the Region also has the potential to impact on or displace other users, such as commercial fishers, Traditional Owners and recreational users, particularly in high use areas. There have been some recent examples of conflict between the activities of tourism operations and those of Traditional Owners exercising their traditional hunting rights.[121] There are also potential conflicts between sectors within the industry, such as charter fishers and site-based tourism. In areas experiencing growth or peaks in visitation, some users also express concern about popular sites being crowded because of intensive tourism activity[127].

To minimise impacts on biodiversity, sewage discharge standards for all users, including tourism operations, have been improved. Currently, discharge at sea (more than one nautical mile from any reef or island and the mainland) remains necessary for many tourism operations as there are insufficient land-based facilities to service the fleet's pump-out requirements.

A number of compliance incidents involving the tourism industry are reported annually, particularly from the more intensively used Cairns and Whitsunday areas. Reports are typically about breaches of marine parks permits, unpermitted activity, plan of management offences (such as undertaking activities not in accordance with group and vessel size limits), issues around payment of the environmental management charge, groundings and moorings offences. Tourism-related compliance incidents have been relatively stable over recent years, with about 140 reported each year since 2009–10.[128]

5.4.3 Fishing — commercial

The Great Barrier Reef supports a diversity of fisheries including commercial, recreational, charter and Indigenous fisheries and is a major part of Queensland's fishing activity. Fishing is the major extractive use of the Region. Recreational fishing targets many of the same species as commercial fishing and is considered separately in Section 5.4.4. The activities of charter and Indigenous fishers in the Region account for a relatively small component of the overall fisheries take.

Commercial fishing is widespread across the Great Barrier Reef (Figure 5.17). Of the major commercial fisheries in the Region, trawl, net, line and pot are the largest (Table 5.3).

The Authority has a regulatory role in the management of commercial fishing through its Zoning Plan, Regulations and permits for a limited number of fisheries. Zoning provides the framework for extractive use of the Marine Park, delineating areas available for fishing and the types of activities that can occur. Within this framework, direct fisheries management is primarily the responsibility of Fisheries Queensland within the Queensland Department of Agriculture, Fisheries and Forestry. Gear and size restrictions apply, as well as other rules such as controls on fishing effort or total allowable catch to manage catch in some commercial fisheries. The Authority has an advisory role to other agencies in relation to the management of commercial fisheries in the Region.

The East Coast Trawl Fishery is Queensland's largest and most valuable commercial fishery, with about 400 licensed vessels producing more than 7000 tonnes of seafood product from the state's east coast. About 60 per cent of the fishery is undertaken in the Region.[129] The trawl fleet operates in coastal, lagoon floor and upper continental slope habitats of the Great Barrier Reef. Prawns make up most of the trawl fishery's catch (85 per cent by weight of the targeted catch in 2010).[129] The fishery also retains and markets scallops, Moreton Bay bugs, squid and various incidentally captured by-product species such as some species of fish, crabs, octopus and cuttlefish. Bycatch (catch that is unintentionally caught) in the trawl fishery can comprise hundreds of species, many of which are caught very infrequently.[130] Queensland fisheries provisions are used to manage the trawl fishery (as for other fisheries in the Region), and trawling is restricted to the General Use Zone (light blue) in the Marine Park.

The commercial component of the East Coast Inshore Fin Fish Fishery is Queensland's third most valuable commercial fishery and is conducted in the tidal waters of the east coast between the northern tip of Cape York and the Queensland–New South Wales border. Large mesh netting is the predominant fishing method of this fishery, targeting a range of inshore bony fish and tropical shark species. Some species are also taken commercially by hook and line. In 2009–10, the Queensland east coast catch included shark species (453 tonnes); mullet species (1754 tonnes); whiting (339 tonnes); barramundi (234 tonnes); bream (165 tonnes); blue threadfin (152 tonnes); school mackerel (136 tonnes) and king threadfin (135 tonnes).[131] Bycatch has previously been estimated at less than 20 per cent for netting operations that target mullet, whiting, small mackerels, barramundi and mixed estuary species.[132] However, the need to continue to reduce the bycatch of species of conservation concern such as sawfish, dugongs, marine turtles and inshore dolphins (most being matters of national environmental significance) is recognised and is a high priority for industry and management. Changes since 2009 in management of the fishery have included new net fishing arrangements such as improved attendance requirements, changes to managing the take of sharks, and new and amended possession and size limits.

More than 125 bony fish species are caught by line from reef habitats in the Great Barrier Reef, but only a few of them are specifically targeted by the quota-managed commercial sector of the Coral Reef Fin Fish Fishery.[133] These include coral trout species for the international live food fish trade (commercial catch of 797 tonnes in 2010–11), red throat emperor (commercial catch of 256 tonnes in 2010–11), and a range of other reef fish such as red emperor and several cod species (commercial catch of all other reef fish species of 426 tonnes in 2010–11).[133] Other reef fish species not targeted commercially can be caught incidentally and are either retained (by-product) or discarded.

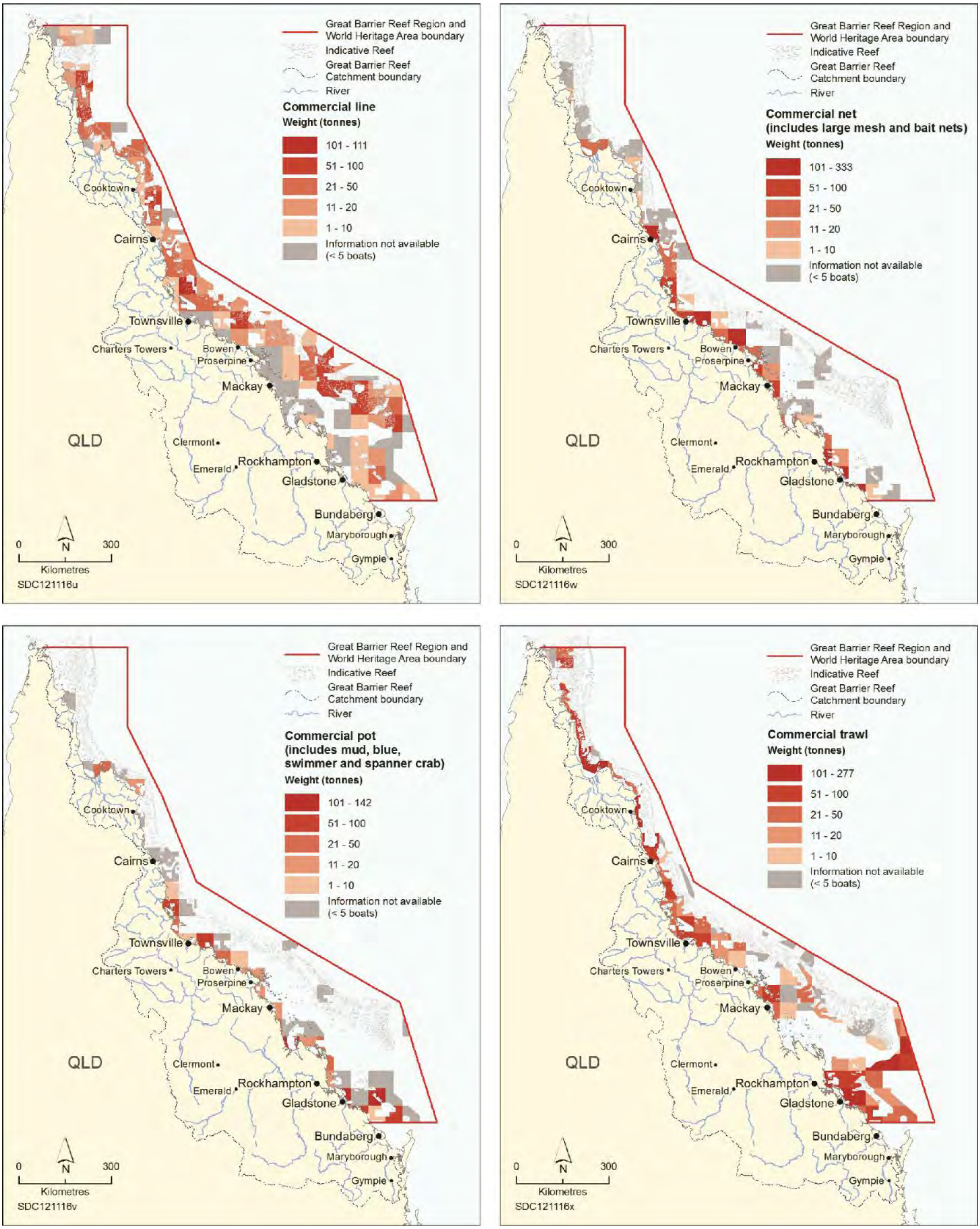


Figure 5.17 Spatial distribution of catch by commercial line, net, pot and trawl fisheries, Great Barrier Reef Region, 2011[134]

The amount of fisheries product taken from different areas in the Great Barrier Reef varies for each of the major fisheries. Net and pot fisheries are undertaken close to the coast, whereas line fishing and trawling extend further offshore. The tonnages shown are for each fisheries 'grid' (a 30 nautical mile square), excluding the zones closed to fishing. Note: commercial bait netting data includes Conservation Park Zones (other netting is restricted in these areas).

Table 5.3 Commercial fisheries of the Great Barrier Reef Region, 2011

Type of fishery	Fishery	No. of active primary licences (Great Barrier Reef component)	Estimated proportion of Qld fishery within Great Barrier Reef	Retained commercial catch in the Great Barrier Reef, 2011	Main target species
Otter trawl on or near seabed	Trawl (otter)	196	~60%	3602 tonnes	prawns, scallops, Moreton Bay bugs, squids
Net (mainly large mesh net)	East Coast Inshore Fin Fish (net component)	224	~40%	1787 tonnes	barramundi, sharks, grey mackerel, threadfin salmons, bait species
Line	Mainly the Coral Reef Fin Fish, Spanish Mackerel, and East Coast Inshore Fin Fish (line component)	270	Reef~95%, Inshore~50%	1741 tonnes	Reef: coral trouts, cods, emperors and snappers Spanish mackerel inshore: barramundi, sharks, mackerels, cobia, pelagics
Pot	Mud crab, blue swimmer crab and spanner crab	212	Mud and blue swimmer~65%; Spanner <20%	1012 tonnes	mud crab, blue swimmer crab, spanner crab and three-spot crab
Collection	Coral	25	99%	~68 tonnes	'live rock' and potentially hundreds of species including hard and soft corals
	Marine aquarium fish	27	~60%	~78,000 fish, mostly juveniles	potentially hundreds of species but mostly damselfish and anemone fish, wrasses and angelfish
	Trochus	-	100%	no reported catch	large herbivorous gastropod
	Tropical rock lobster	7	100%	141 tonnes	ornate rock lobster
	Sea cucumber (beche-de-mer)	6	100%	387 tonnes	sea cucumbers (mainly white teatfish and burrowing blackfish)

Reef sharks may be caught incidentally while fishing for reef fish and are generally discarded.[135] A number of species of sharks may also be targeted for their fins, however in the Region there are landing requirements that the carcasses must be retained with their fins to ensure full use of the shark. Seven fish species are prohibited from commercial take for conservation reasons, iconic values or ciguatera (poisoning) concerns, including humphead Maori wrasse and Queensland grouper. In accordance with the Great Barrier Reef Marine Park Regulations 1983*,* all groupers over one metre in length are protected from fishing in the Marine Park.

The commercial fishery for Spanish mackerel uses line gear and is a highly selective fishery for this, the largest mackerel in Queensland. Spanish mackerel are known to aggregate in large numbers to spawn at particular reefs in the Region. The main commercial catch is from these reefs, between Ingham and Bowen. A quota system caps the commercial catch from Queensland's east coast at 544 tonnes per year.

Other commercial fisheries that use line gear and partly occur in the Region are the Rocky Reef Fin Fish Fishery (this predominantly targets snapper) and the Deepwater Fin Fish Fishery.

Trends

Global fisheries trends influence those for the Great Barrier Reef. As wild-caught fisheries throughout the world continue to be fully exploited or over exploited,[136] the economic value of the Region's fisheries resources and the pressure to exploit them (legally and illegally) may increase.[25] International demand for wild caught Queensland seafood may increase the targeting of additional species or increase demand for intensive aquaculture within the Region and its catchment.[25] Expected growth in aquaculture around the world (for example, aquaculture-raised coral trout are expected to be commercially viable in the near future[137]) may also lead to diversification in the reef line fishery and increased targeting of other species.

The commercial Coral Reef Fin Fish Fishery has reported significantly reduced catch rates of coral trout in areas affected by cyclones such as Hamish in March 2009 and Yasi in early 2011, which can have flow on effects to other areas. For example, after Cyclone Hamish in 2009 some active commercial live coral trout fishers moved northward to escape cyclone impacted areas where lower catch rates were being experienced.[31]

Fishing effort in the Region's otter trawl fishery has been relatively constant for the past five years at about 20,000 boat days.[129] The peak trawl fishing effort was in 1997 (more than 73,400 boat days) (Figure 5.18). Total fishing effort is nominally limited by a cap which is distributed among licensed operators in tradeable effort units. There is, however, a significant amount of latent effort in the fishery, with approximately 40 per cent of the available total effort units not used in 2010.[129] This means trawl fishing effort could rise substantially under current management arrangements in response to more favourable economic conditions such as lower foreign exchange rates.

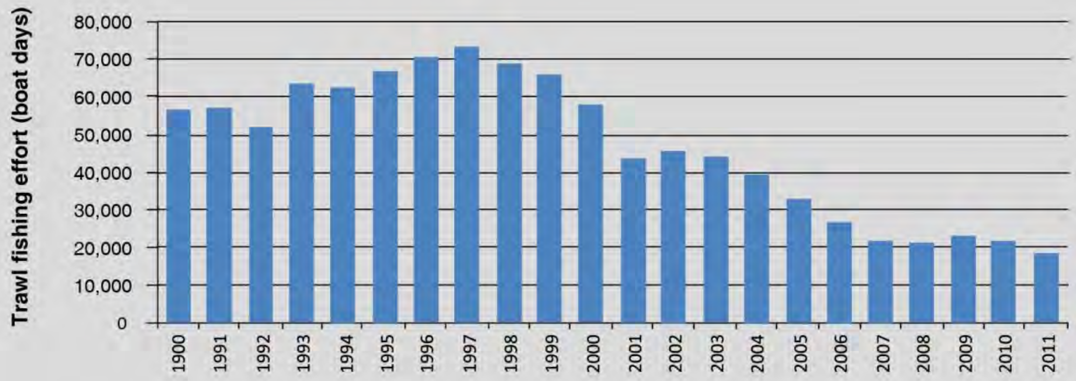


Figure 5.18 Annual trawl fishing effort in the Great Barrier Reef Region, 1990–2011[129]
Data is based on fisher logbook records.

Some fisheries (such as trawl) already catch a substantial amount of their product in the far north of the Region (see Figure 5.17), and have done so for many years. Fishing effort in other fisheries may spread northwards to take advantage of catch availability and improving market access (due to improved infrastructure), or to offset other factors such as impacts of extreme weather and recreational uses displacing some commercial fishers close to urban areas.

Economic factors influence patterns of commercial fishing operations. For example, recent increases in fuel prices[138] have affected profitability and in some cases methods and areas of operation of Great Barrier Reef fisheries. The strength of the Australian dollar has also put pressure on commercial fisheries. In this economic environment, exported product is less profitable and there is increasing competition in the local market from cheap imports. Fishing business owners also have to compete for crew with the resources sector.

Benefits

Fisheries product from the Region is important to local communities, as well as domestic and international markets. It is a major component of the total seafood catch from the Queensland east coast, representing about 95 per cent of the reef line fishery, 60 per cent of the trawl fishery and 40 per cent of the net fishery.[25] In a 2008 survey of catchment residents, 92 per cent had eaten seafood in the previous 12 months. The vast majority of those who bought seafood preferred to buy fresh seafood caught in Queensland.[139]

Commercial fishing is a multi-million dollar industry in the Region. In 2011–12, the economic contribution of the commercial fishing industry and aquaculture to the national economy was estimated to be $160.3 million dollars.[43] This value-added figure is the gross value of production minus tax on production and other factors such as operating costs and labour. Separate recent valuations of the major fishery sectors (calculated on the price paid to fishers at the first point of sale) reported the value of the East Coast Inshore Fin Fish Fishery to be about $19.6 million a year[131], the reef line fishery at about $31 million a year[140] and the trawl fishery at about $110 million each year.[141] In 2012, commercial fishing in the Region was estimated to have generated the equivalent of 975 full-time jobs[43]**,** although data on employment is limited and estimates for secondary employment are lacking.

Fishers have a high attachment to their industry, and most have been involved in the industry for a long time (more than 20 years).[39,142] They are also generally very reliant on the industry, with most fishers receiving more than 75 per cent of their household income from fishing.[39,143] Fishing is more than just a job for most fishers. In a 2008 survey of inshore fishers in the Region, 63 per cent preferred to be at sea than on the land; 98 per cent stated they liked being a fisher; 93 per cent stated fishing is a lifestyle, not just their job; and 79 per cent felt proud to tell others they were a commercial fisher. Seventy per cent also stated they would still be fishing in three years.[142]

Although commercial fishers pay annual fees to the Queensland Government for their licence, commercial fisheries in Queensland are not managed on a cost recovery basis.

Impacts

Commercial fishing is the largest extractive use of the Region. It also has other direct impacts such as the death of discarded catch and physical impacts on habitats. The total commercial catch retained by line, trawl, net and pot fisheries from the Great Barrier Reef Region was about 8100 tonnes in 2011, using more than 60,800 days of commercial fishing effort.[134]

Commercial fishing effort is not uniformly distributed in the Region (see Figure 5.17). The areas fished depend on many factors including zoning, licence conditions, distance from shore, weather, access to distribution networks, distribution of the target species and fishers' preferences. This can result in a concentration of fishing effort and any associated impacts in popular areas open to fishing and close to the coast.

While all commercial fisheries have made significant progress towards achieving better sustainability outcomes as a result of improved management arrangements, illegal fishing activities continue to undermine these outcomes. Based on knowledge gained through compliance and enforcement activities and on intelligence received, illegal commercial fishing within the Great Barrier Reef Marine Park remains a serious concern. Priority areas for enforcement include non-compliance with zoning requirements within the Coral Reef Fin Fish Fishery, and with net attendance requirements in the East Coast Inshore Fin Fish Fishery. Reliable information from individuals who work within the commercial fishing industry indicates illegal activity in the reef line fishery continues to be significant despite the recent low number of offences detected. A number of skippers and dory operators in the commercial Coral Reef Fin Fish Fishery continue to be non-compliant, even after receiving court-imposed fines — many of which remain unpaid. Those fishers who are intent on illegal activity continually modify their behaviour and employ surveillance avoidance tactics.[128]

There are particular concerns about non-compliance in the commercial netting special management areas which are critical to species of conservation concern and matters of national environmental significance such as dugongs and the Australian snubfin dolphin. The remoteness of some of these locations makes enforcement particularly challenging, for example in the Princess Charlotte Bay Special Management Area which is an area with significant populations of dugong and inshore dolphins — both species of conservation concern and matters of national environmental signficance.[144,145] Management issues in relation to Princess Charlotte Bay are discussed in the relevant demonstration case study (Section 9.6).

The stock status of a number of key targeted species, including grey mackerel and king threadfin, are classified as uncertain or undefined, while snapper are classified as overfished in Queensland.[146] There are also community and/or scientific concerns about the population status of some targeted species, including some mackerels[147,148], snapper[149] and coral trout[150]. Between 1989 and 2003, some 300 to 620 tonnes of coral trout were estimated to have been discarded annually by the commercial Coral Reef Fin Fish Fishery in the Region.[151] Though the ecological significance of this level of discard is unknown, declines in some Reef predatory species, including coral trout, suggests predation in reef-related food webs may have altered significantly.[25]

The paucity of information about the stock status of sharks in the East Coast Inshore Fin Fish Fishery is of particular concern as the fishery takes a wide range of shark species, each with a different productivity and susceptibility to fishing.[152] Collection of basic information about the take of different shark species in this fishery has improved over the past five years, and many of the species taken are not considered at high risk from fishing, though some still are, such as the scalloped hammerhead. Information on interactions with rarer species (such as bignose and mako sharks) is difficult to obtain and the population status of these species is largely unknown.

Concerns about overcapacity in some Reef-related fisheries[153,154] and the assessment that some species are overfished or that their stock status is uncertain indicates that there remain some ecological risks and unsustainable impacts on some retained species.

Management changes have led to a significant reduction in the ecological impacts of the trawl fishery (see Section 9.10), however some concerns remain, particularly for 11 species of rays and skates, two species of Balmain bugs, two species of sea snakes and a poorly known upper continental slope habitat in the south-east of the Region.[155] The amount of effort is the main determinant of impacts on the Great Barrier Reef ecosystem from the trawl fishery, and risks could increase if effort levels rise.[155]

The main impacts on the Region's values from commercial net fishing are entanglement of species of conservation concern and bycatch.[156] The fishery is known to interact with dugongs, dolphins (particularly inshore dolphins), whales, marine turtles, crocodiles and green and freshwater sawfish — all of which are matters of national environmental significance.

Any death of a species with depleted populations, such as dugong, Australian snubfin dolphin and sawfish, are of particular concern. Commercial fishers are required to report interactions with such species — records of marine wildlife strandings in Queensland confirm fishing interactions continue to be a cause of death of marine wildlife in the Region.[157] Under-reporting by some commercial fishers of interactions is a recognised issue.[154] Discards of fishery species and most bycatch are not required to be reported. While there are a number of research projects providing important fisheries information[130,152], there is currently no independent fishery observer program in the Region to complement the research.

Information to develop harvest strategies for the sustainable use of many target species is limited. The *Privacy Act 1988* limits the disclosure and use of some commercial fisher logbook data on catch and effort. This makes it difficult to develop an accurate representation of all fishing in the Region, particularly fine-scale patterns of use, and to assess cumulative impacts of all activities in a local area.

Several major research programs and studies have improved our understanding of the environmental effects of fishing, including on the broader ecosystem.[158,159] This information has informed reviews of management arrangements for commercial fishing activities.

5.4.4 Fishing — recreational

Recreational fishing is one of the most popular activities on the Great Barrier Reef. Statewide, an estimated 703,000 residents went fishing in the 12 months prior to June 2010.[160] Residents living adjacent to the Reef fished for a total of approximately 2.6 million days in the 12 months between October 2010 and September 2011. Approximately 100,000 of these fisher days were concentrated in Mackay coastal waters.[160] Recreational fishing is also popular with visitors areas adjacent to the Region, however little is known about their activities.

In Queensland, the most common recreational fishing method (80 per cent) is line fishing (including the use of hooks and lures), followed by fishing with pots (13 per cent).[160] Together, fishing with cast nets, hand collection, pumps and spades, diving using spears, and hand collection comprised only seven per cent of all fishing effort. In the Great Barrier Reef Region, coral trout, red throat emperor, tropical snapper, morwong and sweetlip are commonly targeted by recreational fishers.[160] Hundreds of other species of bony fish, sharks and other animals are also caught.[156,160]

Trends

Queensland-wide, the number of people fishing fell between 2000 and 2010, however numbers remained about the same for those areas where residents are likely to be accessing the Region, that is the Fitzroy, Mackay, Northern and Far North[160] (Figure 5.19).

The popularity of fishing in the Region is reflected in participation rates. Information collected during a 2010 statewide recreational fishing survey[160] showed 28 per cent of residents who have lived for five years or more in the Mackay region (including Bowen, Mackay, Proserpine and the Whitsunday Islands) fished in the 12 months prior to the survey. This was the highest participation rate for any region in Queensland and much higher than the statewide average of 17 per cent. Other regions adjacent to the Great Barrier Reef also had relatively high participation rates of 20 to 23 per cent. Most of the fishing was in local marine waters from boats.

The 2010 survey indicated that people are catching fewer fish for a similar level of effort compared to a decade ago.[160] This may reflect lower abundances of some target species after many decades of fishing pressure.

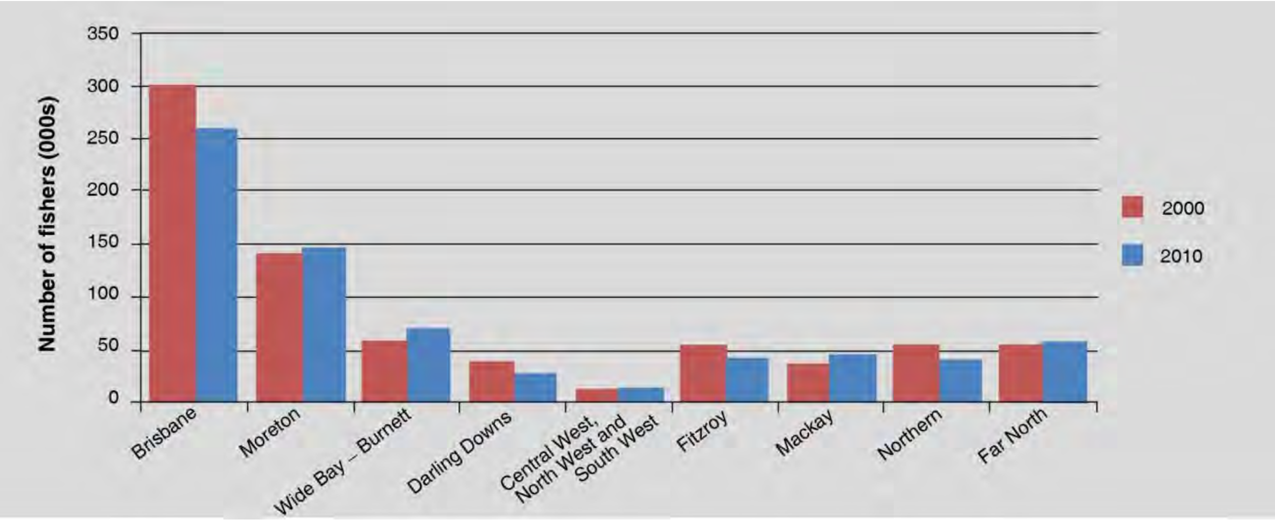


Figure 5.19 Number of recreational fishers by Queensland residential region in 2000 and 2010[160]
A recreational fisher is defined as anyone who fished once or more in the 12 months prior to April 2000 or June 2010.

A typical fishing trip is less than 20 kilometres, and often involves boating to a location and staying there to fish. However, some fishing trips cover hundreds of kilometres and last for several days.[161] A trend towards larger, more powerful, more fuel-efficient vessels,[161] combined with improvements in safety, mean recreational fishers may be likely to fish further from the mainland. Recreational fishing in the remote far north of the Region is increasing, due to factors such as improved road access, catch availability and infrastructure improvements. In addition, improved navigation and positioning systems make it more likely that fishers will be able to relocate specific fishing sites and increase their effectiveness at catching fish.

Benefits

Recreational fishing provides economic and social benefits to Queensland's communities.[162] For generations, fishing on the Great Barrier Reef has been an important recreational activity for coastal residents and visitors. Most people indicate that relaxation, socialising, catching fish and excitement are their reasons for fishing recreationally.[162] In 2008, more than half of all people visiting the Great Barrier Reef for recreational purposes went fishing.[25]

Economic contributions from recreational fishing are difficult to estimate. In 2012, all recreational activities (including fishing) were estimated to generate $330 million and employment equivalent of 2724 full-time jobs (see Table 7.9 in Chapter 7).[43] It is likely that a significant portion of this economic activity is related to recreational fishing.

Many recreational fishers have contributed to research, monitoring and management programs, for example the CapReef program in the Central Queensland area.[163] Recreational fishers also contribute to caring for Australia's waterways and fish stocks, including those in the Great Barrier Reef Region.[164] There can be considerable health and wellbeing benefits for individuals who fish for recreation.[165] There is also some contribution to management costs, with $17.75 from each vessel registration in Queensland going to Fisheries Queensland for enhancing recreational fishing.[166]

Impacts

Recreational fishing is a significant extractive use of the Region, removing marine animals from various parts of the food chain. In 2010–11, an estimated 13.3 million fish were caught by recreational fishers who reside in Queensland, plus 8.3 million animals of other species including crustaceans (such as crabs, prawns and lobster) and cephalopods (for example, squid and octopus).[160] A substantial, but as yet unquantified, portion of these total catches occurred in the Region, and for some species most of the catch was taken there. The main target species are coral trout and cod, emperor, tropical snapper, barramundi, bream, mackerel, whiting, crab, lobster and bait fish.[25]

While the impacts resulting from each recreational fishing visit are relatively minor, the large number of participants is likely to contribute to a cumulative effect on Great Barrier Reef values. Technological improvements (for example, widespread use of positioning systems and sounders) have also allowed more efficient and targeted fishing by recreational fishers. Further, the species targeted by recreational fishers are mostly the same as those targeted by commercial fishers, increasing cumulative impacts on those species. Recreational fishery harvest levels have contributed to concerns about the population status of some species. Recreational fishing activities contribute to other impacts on values such as the death of discarded species, including some species of conservation concern. This includes drowning of marine turtles in poorly designed crab pots, bycatch of sharks and rays and incidental catch of seabirds. The recreational catch of sharks is highest in the northern part of the Region.[160]

A large proportion of the recreational catch is subsequently released (for example, 60 per cent for inshore fishing), either through the increasingly popular practice of 'catch and release' or because they are undersized or unwanted species.[58] High release rates have been reported for snapper, barramundi, stripey snapper, Australian bass, sharks, and cod and groper; the highest rates are for sharks with 94 per cent released.[160] Survival rates of the released species vary.[167]

The ecosystem effects and cumulative impacts of recreational fishing are poorly understood, but are likely to be most concentrated in inshore areas close to major population centres and a relatively small number of offshore reefs. Local depletion, particularly of some inshore species, is of concern in some areas.[25] Increasing numbers of seasonal recreational fishers may increase the pressure on specific species and locations, but these impacts are also largely unquantified.

With regard to physical damage to the environment, the most likely impact resulting from recreational fishing is localised anchor damage at popular fishing grounds. This damage is likely to be more significant on fragile fringing reefs or nearshore islands. Fishing gear may also damage fragile species such as corals. Discarded fishing gear (from all fishery sectors) contributes to marine debris in the Region, and can entangle or kill marine animals[168,169], including species of conservation concern.

Illegal recreational fishing continues to be of concern — activities in no-take zones are a priority for enforcement. Illegal fishing has the potential to impact on the Region's values, including eroding the resilience benefits of the network of no-take marine reserves.[170] Recreational fishing in protected zones continues to be the most frequent type of offence, particularly in those areas close to large population centres. Detected recreational fishing offences across all zones are increasing (Figure 5.20). Incident information shows most recreational fishers detected illegally fishing are resident in communities adjacent to the Marine Park and that there are some fishers targeting no take (green) zones at night.[128]

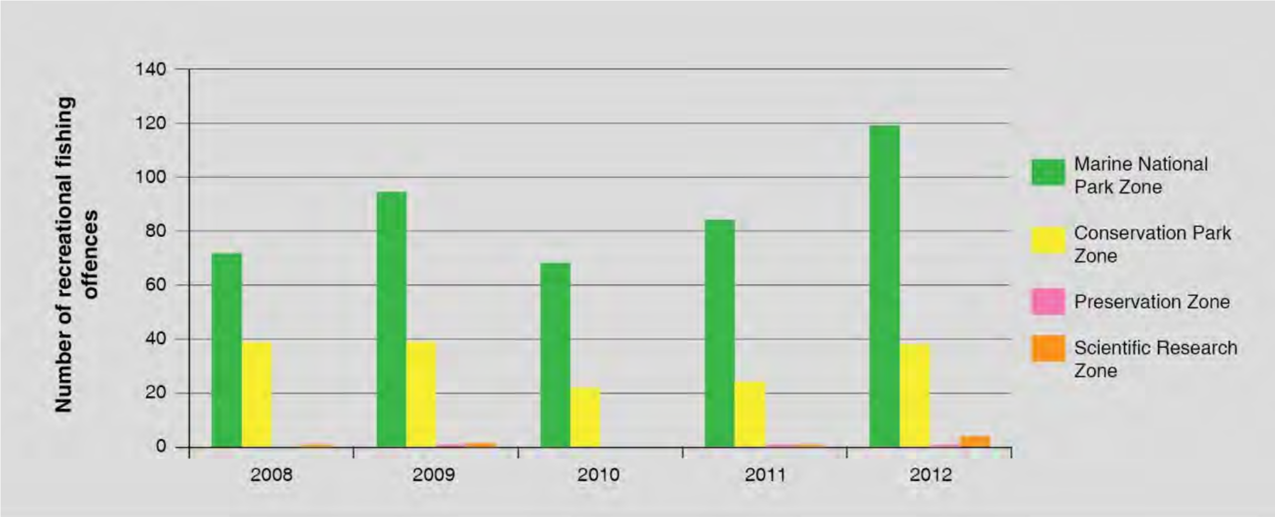


Figure 5.20 Recreational fishing compliance incidents by marine park zone, 2008–2012
Each incident many include multiple offenders and/or multiple offences.

5.4.5 Recreation

Recreation is defined as an independent visit to the Region for enjoyment that is not part of a commercial operation. It is distinct from tourism where a visitor pays to use a commercial operation (see Section 5.4.2 above).

People living adjacent to the Region, as well as domestic and international visitors, use the Region for a wide range of recreational activities, including swimming, motorised boating and fishing, snorkelling, sailing, diving and jetskiing (Figure 5.21). The fisheries aspects of recreation are addressed in Section 5.4.4 above.

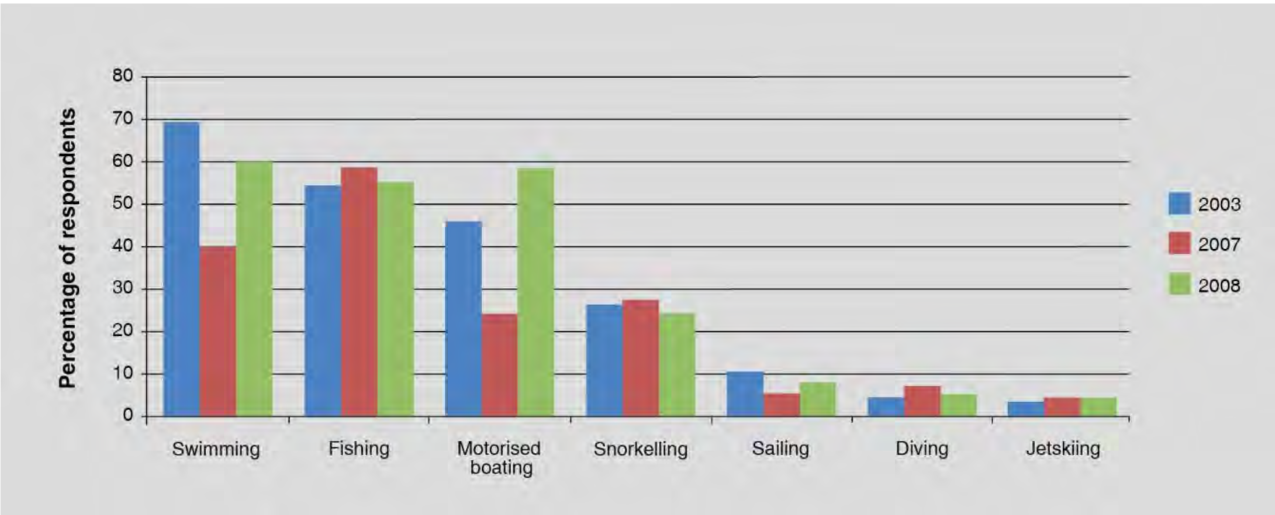


Figure 5.21 Main activities of visitors to the Great Barrier Reef[58]

A study in 2008 estimated there were more than 14 million recreational visits to the Marine Park by catchment residents every year.[171] This does not include visits by independent travellers from outside the catchment (such as retired, long-term holiday makers ('grey nomads') and cruising yachtsmen).[58]

Because most recreational vessels are less than five metres in length, recreational use is concentrated in inshore areas close to urban centres. The most popular destinations are islands, followed by reefs, shoals, cays and wrecks (Figure 5.22). In 2008, almost half the vessel-based trips departed from the area between and including Cairns and Townsville.[171] Cairns, Townsville and Mackay have the highest numbers of boat registrations in Queensland (Figure 5.23).

Trends

The number of recreational visits from residents in the catchment appears to have risen substantially in recent years, most likely as a result of three factors: population growth, an increase in the proportion of the population visiting the Region and a rise in the average number of visits each person makes.[171]

The average number of visits by residents from the Great Barrier Reef catchment increased from 14 visits per person per year in 2003 to 15.5 in 2008. Half of those who visit from the catchment do so more than seven times in a year, while 17 per cent visit more than once a week.[171] Increasing recreational vessel ownership in the catchment (Figure 5.24) is likely to be contributing to the growing proportion of residents visiting the Region.

The relative popularity of different recreational activities has changed in recent years. Motorised boating has become more popular and the proportional use of sailing boats has fallen (Figure 5.21 above).[171] Activities like shell collecting and reef walking are now far less popular than in the early 20th century.[172]

Between 2003 and 2008, the number of visits to destinations such as reefs, shoals and wrecks increased while visits to islands declined (Figure 5.22).[171] Visiting creeks, inlets and rivers also became more popular. These trends are likely to continue.

Benefits

The opportunity to enjoy the Region's environment is of enormous social and cultural value to Queensland residents, other Australians and international visitors.[58] The Great Barrier Reef is viewed as beautiful, pristine and unique by those who have already visited the Reef and those who are yet to visit.[25]

In 2012, recreational activities (including fishing) was the second largest direct use of the World Heritage Area, generating $330 million and the employment equivalent of 2724 full-time jobs (see Table 7.9 in Chapter 7).[43] Most of the contribution associated with recreational activity was derived from expenditure on equipment, largely reflecting the purchase of boats and maintenance or repair of recreational equipment.

Recreational users contribute to protection and management of the Marine Park through programs such as Clean up Australia Day, Order of Underwater Coral Heroes Volunteers (OUCH, a non-profit organisation based in the Whitsundays), the Strandings Hotline and the Sightings Network.

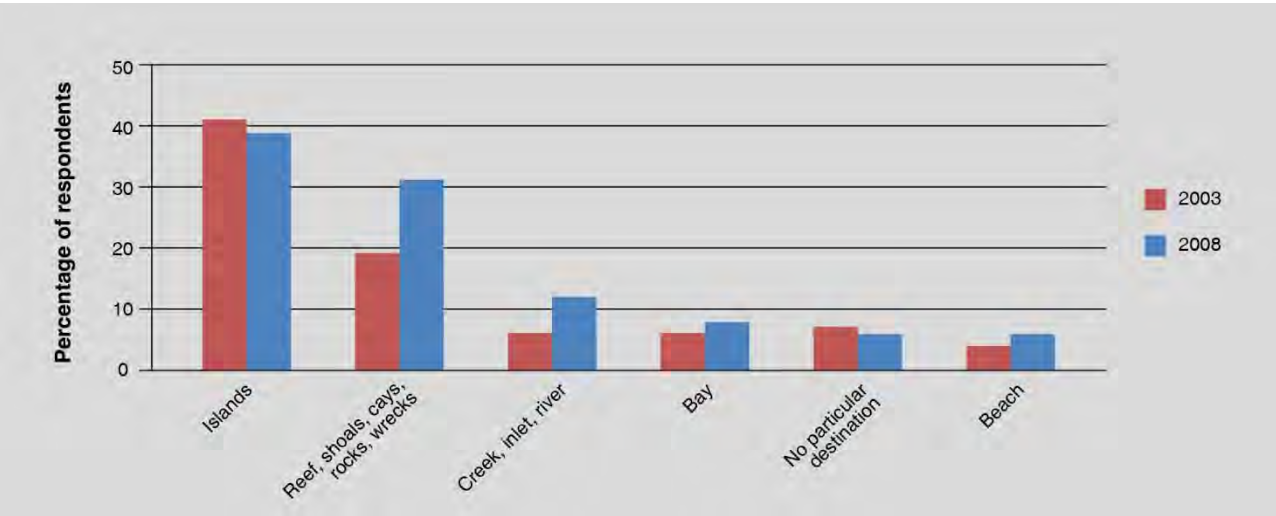


Figure 5.22 Main destinations of recreational vessel-based trips, 2003 and 2008[171]
Most people who visit the Region for recreation go fishing or visit islands, reefs, shoals, rocks or wrecks.

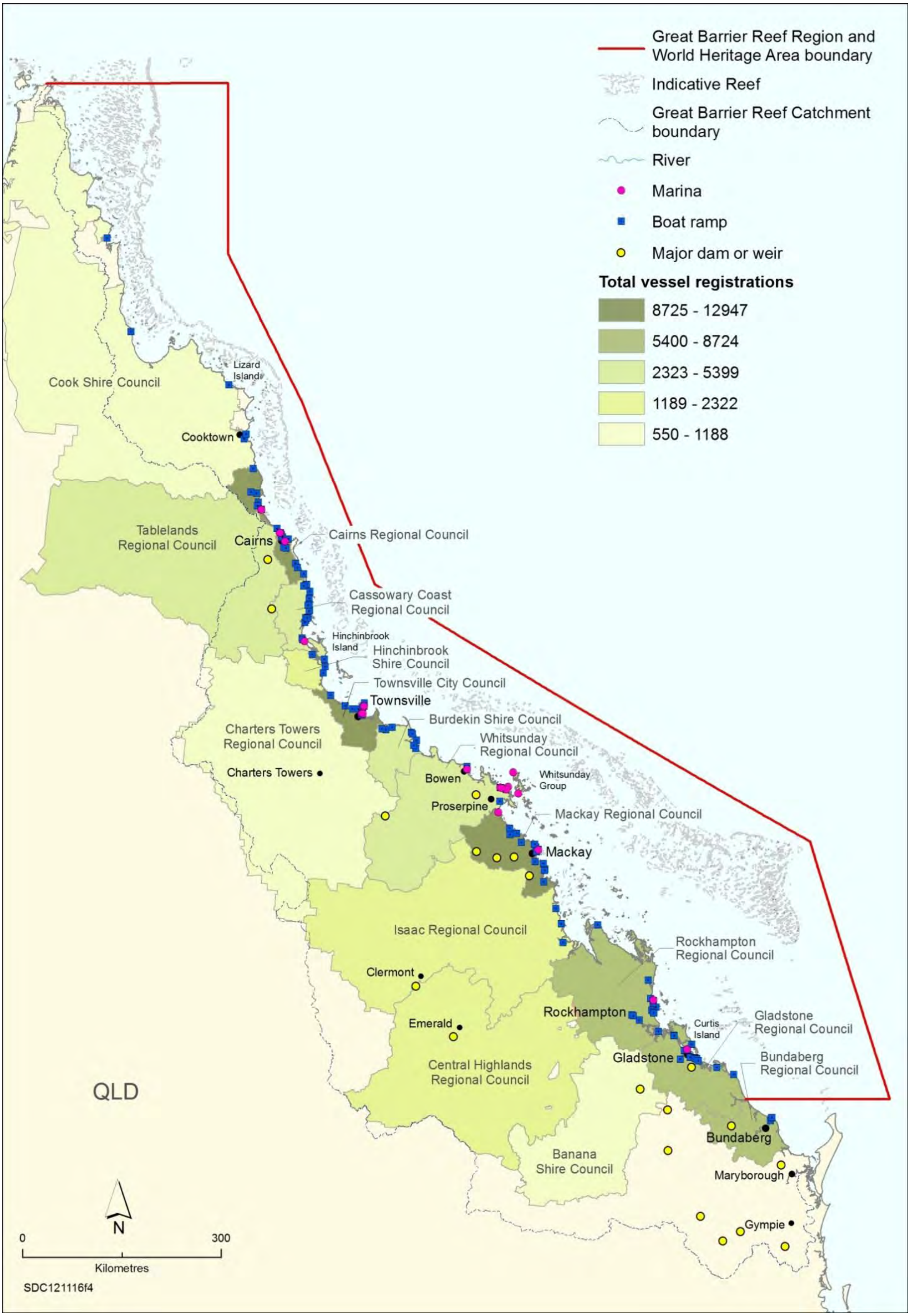


Figure 5.23 Vessel registrations in the Great Barrier Reef catchment, 2011
The number of vessel registrations is shown by local government area.

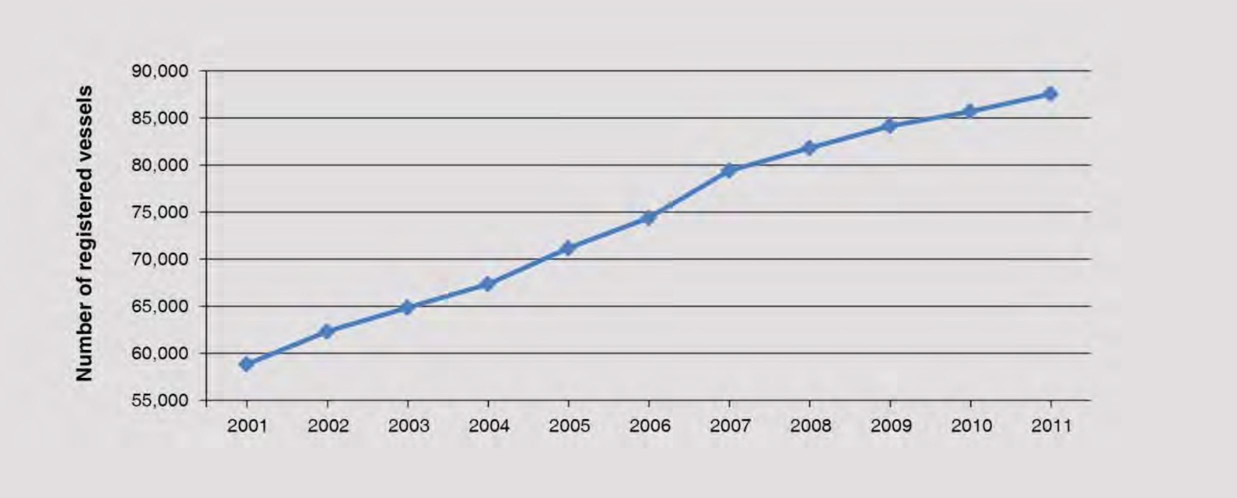


Figure 5.24 Number of recreational vessels registered in the Great Barrier Reef catchment, 2001–2011[57]

Impacts

The *Great Barrier Reef Outlook Report 2009* lists the likely impacts of recreational use as "localised but frequent anchor damage to corals and seagrass meadows…..along with littering, boat strikes on marine mammals and turtles, and damage to corals when snorkelling and diving. There is some risk of introducing species through fouling on recreational vessels, especially those from overseas".[25] There are also potential impacts from the grounding of small vessels, oil and chemical spills, vessel sewage discharge and disturbance of wildlife.[58] Recreational use on islands can result in disturbance of seabirds and other wildlife, trampling of coastal vegetation and the introduction of weeds and feral animals.[58] Given the concentration of recreational use near the coast and regional centres, it follows that the main impacts are also likely to be in those areas.

There is the potential for Indigenous and historic heritage values to be affected by recreational use.[58] For example, Traditional Owner connections to their sea country, including access to resources, are being interrupted at least partly because of increasing recreational use.[58] Previously, some historic shipwrecks have been disturbed and artefacts removed, particularly during the 1950s to the 1970s.

While management arrangements have significantly reduced the likelihood of conflicts of use between recreational and other users in popular areas, there continues to be some localised negative interactions.

With increasing use of the Marine Park comes an increasing demand for coastal infrastructure to access the area (for example, roads, marinas and boat ramps). Construction and operation of these facilities can affect the Great Barrier Reef ecosystem through damage to coastal habitats, dredging, dumping and resuspension of dredge material, reclamation and adverse effects on water quality. These facilities can also result in changes to patterns and intensity of use within the Region.

Queensland's Shark Control Program, established in 1962, aims to reduce the number of potentially dangerous sharks at popular swimming beaches and, thereby, lower the likelihood of shark bites. A combination of 338 drumlines and 37 mesh nets is currently deployed across 84 beaches in Queensland.[173,174] Thirty of these beaches are within the World Heritage Area, located at: Cairns (seven beaches); Townsville and Magnetic Island (eight beaches); Mackay (five beaches); Capricorn Coast (nine beaches); and Gladstone (one beach). In addition to catching targeted shark species, nets and drumlines catch non-target species, including other shark and rays species, marine turtles, dugongs, whales and dolphins — some of which are matters of national environmental significance. Drumlines tend to catch more loggerhead turtles. Nets tend to catch more marine mammals and green turtles. The effects of these nets on dugongs are described in the dugong demonstration case study (Section 9.3) and on the snubfin dolphin in Section 7.1.5.

Compliance incidents associated with recreational activities, other than fishing, include vessel groundings and sinkings, pollution discharges, entering restricted areas or zones, approaching whales too closely and island national park offences such as camping without a permit, lighting campfires, taking domestic animals ashore and using generators.[128] The annual number of reported offences (excluding recreational fishers) has steadily declined over recent years from 130 in 2009–10 to 82 in 2011–12.[175]

5.4.6 Shipping

Thousands of domestic and international ships transit the Region every year, carrying export goods, servicing coastal and inland communities and transporting passengers. Shipping, as described in this report, includes vessels greater than 50 metres in overall length or carrying specialised product regardless of length (for example, oil tankers, chemical or liquefied gas carriers). It includes cruise ships and superyachts.

Shipping cargo includes coal, sugar, iron ore, timber, oil, chemicals, live cattle and general cargo. The four busiest ports in relation to commercial vessel visits in 2011–12 were the ports of Gladstone (1453 visits), Hay Point (809), Townsville (747) and Cairns (720) (Figure 5.25). Although Cairns is one of the busiest ports on the Great Barrier Reef coast, it is not considered a major port due to the relatively small throughput (refer Section 5.3.5). Gladstone, Hay Point, Townsville and Abbot Point are considered the major ports due to their relatively high annual throughput.

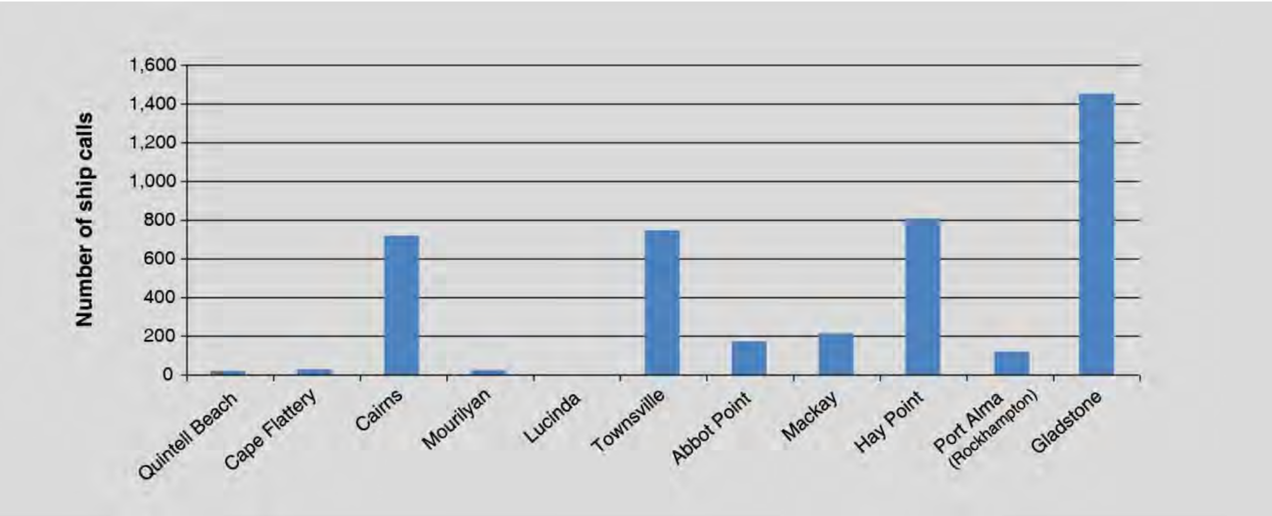


Figure 5.25 Total commercial vessel calls to ports adjacent to the Region, 2011–12[109]

The graph represents total commercial vessel visits, excluding those made by cruise ships. Note: A vessel or ship 'call' relates to an arrival at port; whereas 'movements' include all reportable movements within the Great Barrier Reef, including movements on the way to and within the port.

The Region is one of the world's most regulated shipping areas. The Authority, together with the Australian Maritime Safety Authority and Maritime Safety Queensland, works closely to protect the marine environment from the potential adverse consequences of shipping operations. The Reef was designated a Particularly Sensitive Sea Area by the International Maritime Organization in 1990 and shipping traffic is confined to a Designated Shipping Area (Figure 5.26) unless otherwise permitted by the Authority.

Within the Designated Shipping Area, anchoring a ship does not require a permit from the Authority. Maritime Safety Queensland has designated 154 ship anchorages adjacent to some of the ports along the Region's coast (Figure 5.26). All but 12 are within the Marine Park. Including swing room, the anchorages cover about 1200 square kilometres. They confine the impacts arising from anchoring for these ports, such as disturbance to wildlife, physical damage to benthos, light pollution, waste discharge from a vessel, exotic species and diseases, noise pollution, user conflict and aesthetic impacts on the seascape.

Measures to increase navigational safety and reduce the risk of ship groundings and collisions have included compulsory pilotage, recommended pilotage, an automatic identification system and mandatory vessel reporting and monitoring. These management arrangements mean there have been few shipping incidents relative to the large number of ship movements in the Region.[25]

In response to the *Shen Neng I* incident in 2010 when a large coal carrier grounded on a reef, the capabilities of the Great Barrier Reef and Torres Strait vessel traffic service were extended to the southern boundary of the Region.

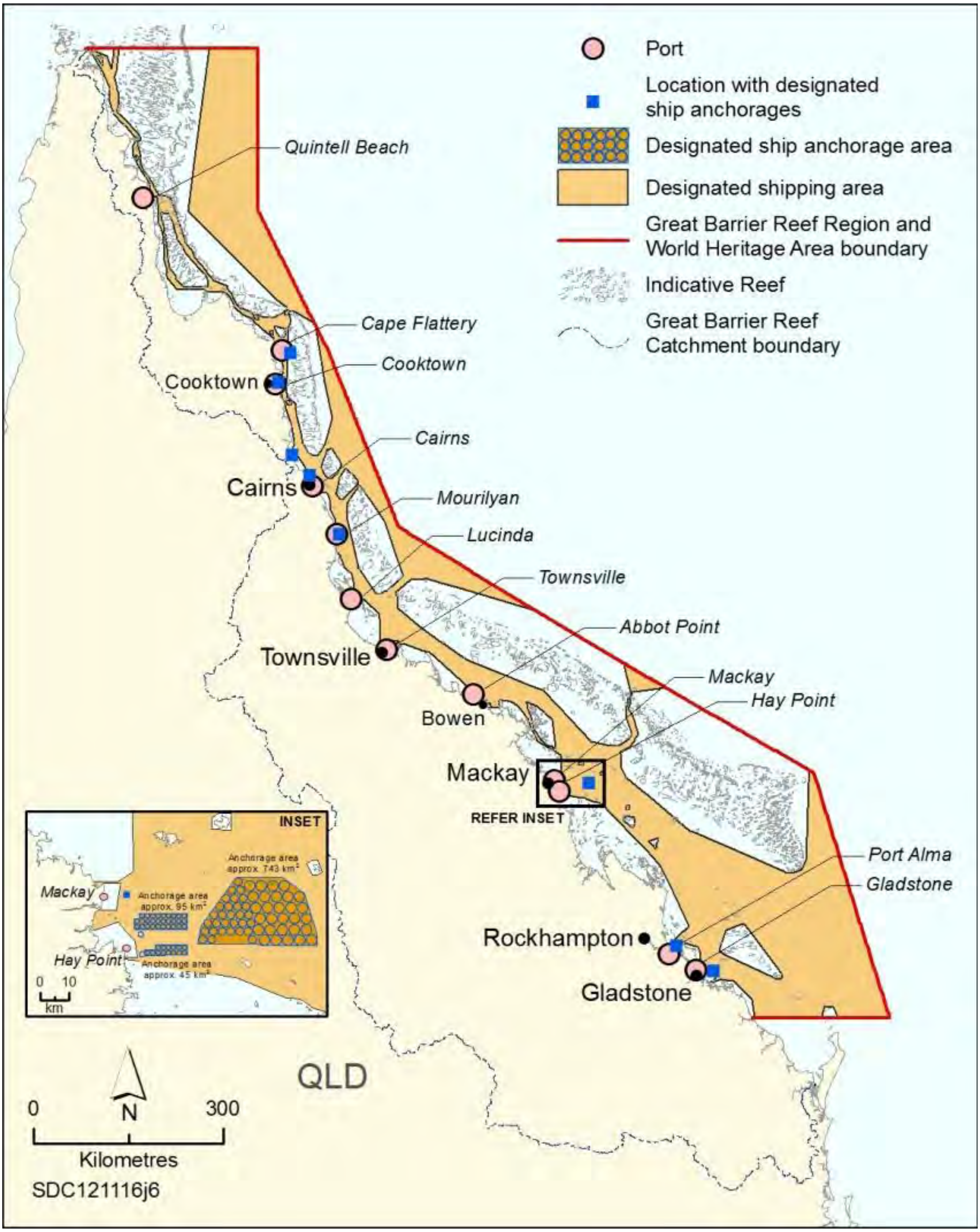


Figure 5.26 Designated Shipping Area and designated ship anchorages, Great Barrier Reef Region
Over 150 ship anchorages have been designated by Maritime Safety Queensland adjacent to some of the ports along the Great Barrier Reef coast.

Trends

The number of ship voyages undertaken through the Region has increased substantially over the past 10 years (see Figure 5.27 and Figure 5.28), driven mainly by industrial and mining activity. In 2011–12, Ports Australia estimated that more than 4300 ships called at Great Barrier Reef ports.[109]

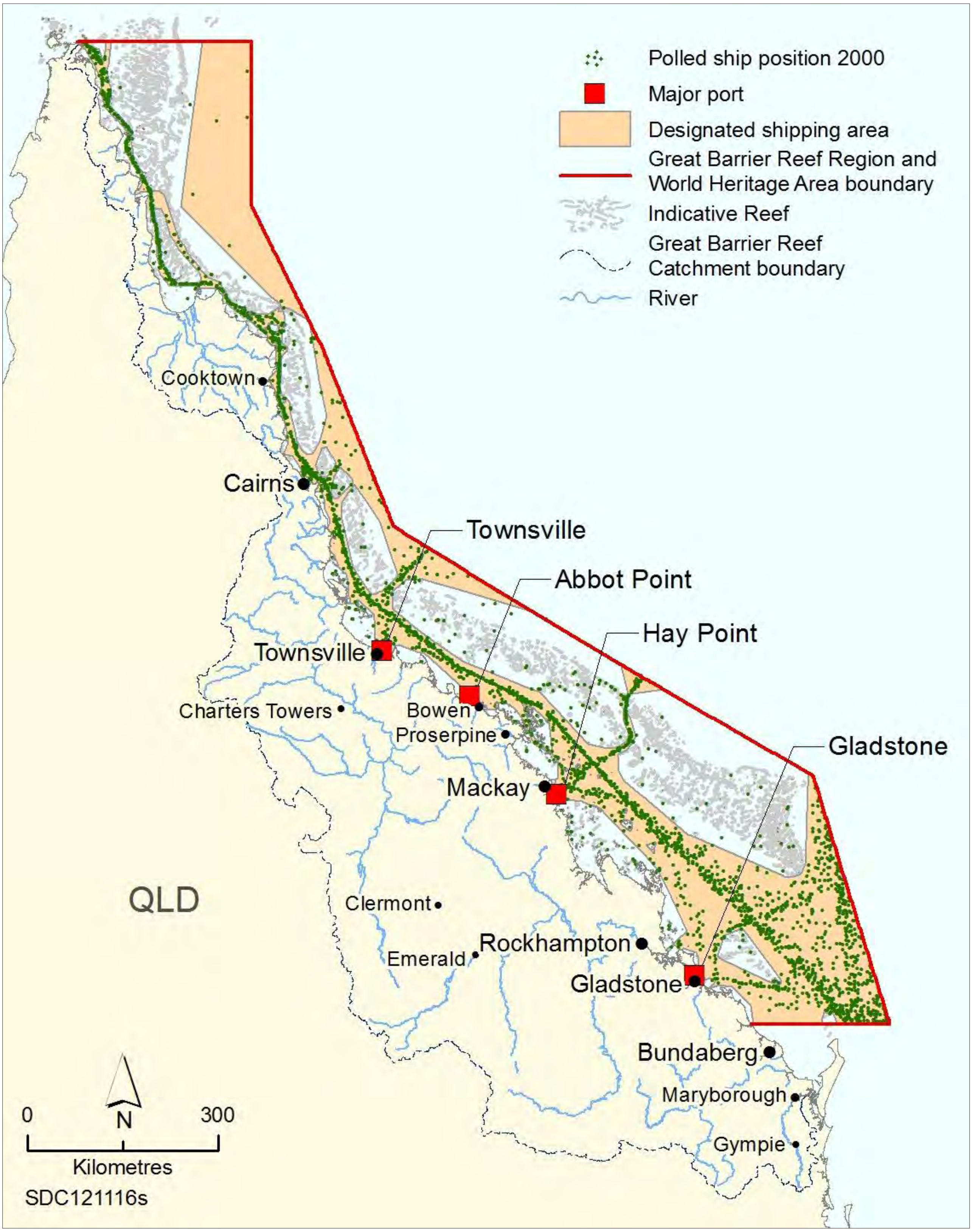


Figure 5.27 Polled ship positions, Great Barrier Reef Region, 2000[176]

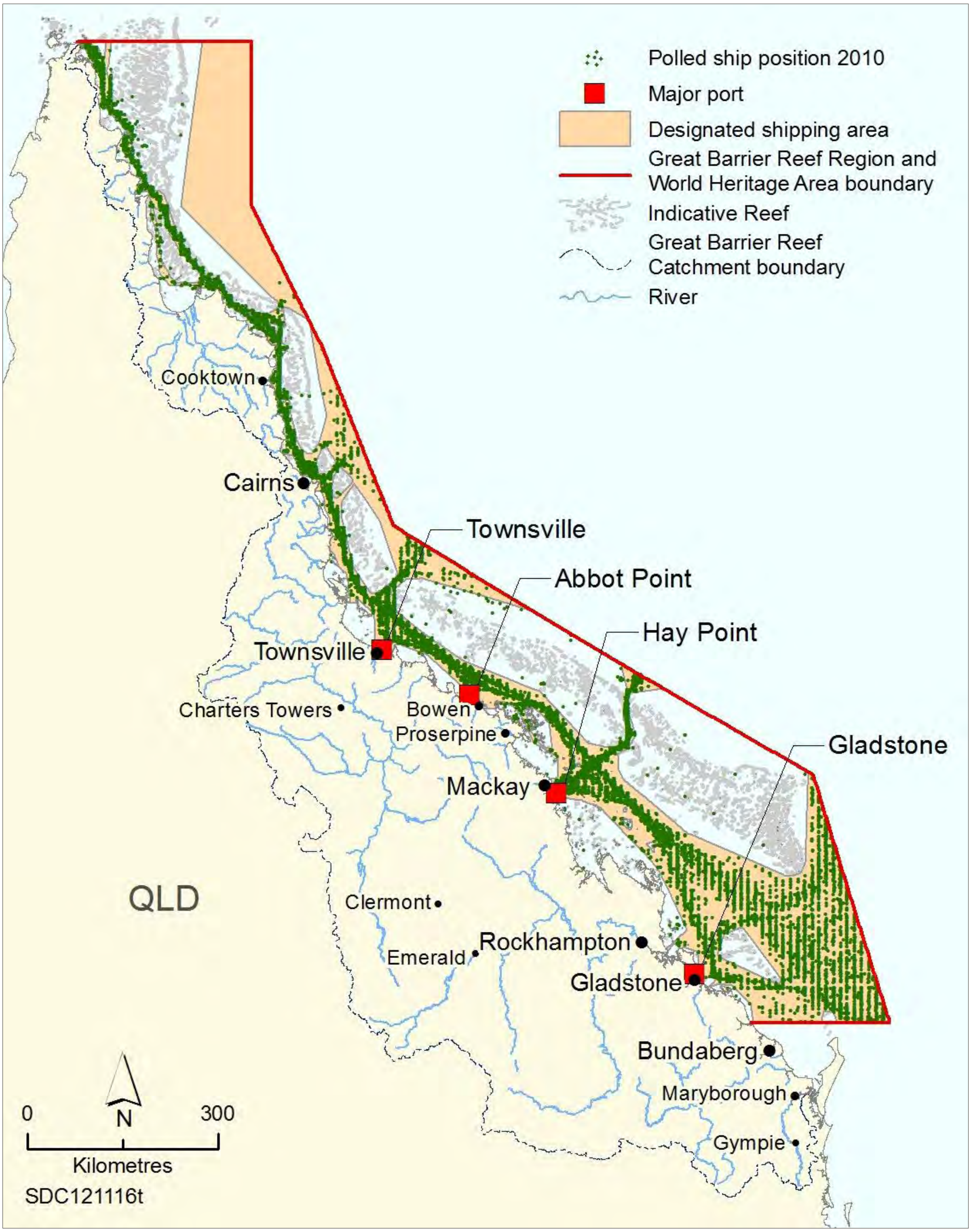


Figure 5.28 Polled ship positions, Great Barrier Reef Region, 2010[177]

In recent years there have been various forecasts of shipping activity in and adjacent to the Region.[46,178,179] Based on projected export capacities, information from existing development proposals and predictions for the Region's four major ports, shipping in the Region is forecast to significantly increase over the next 10 to 15 years (Figure 5.29). This is likely to be driven by growth in the mining and liquefied natural gas industry, port expansions and increases in trade.[47]

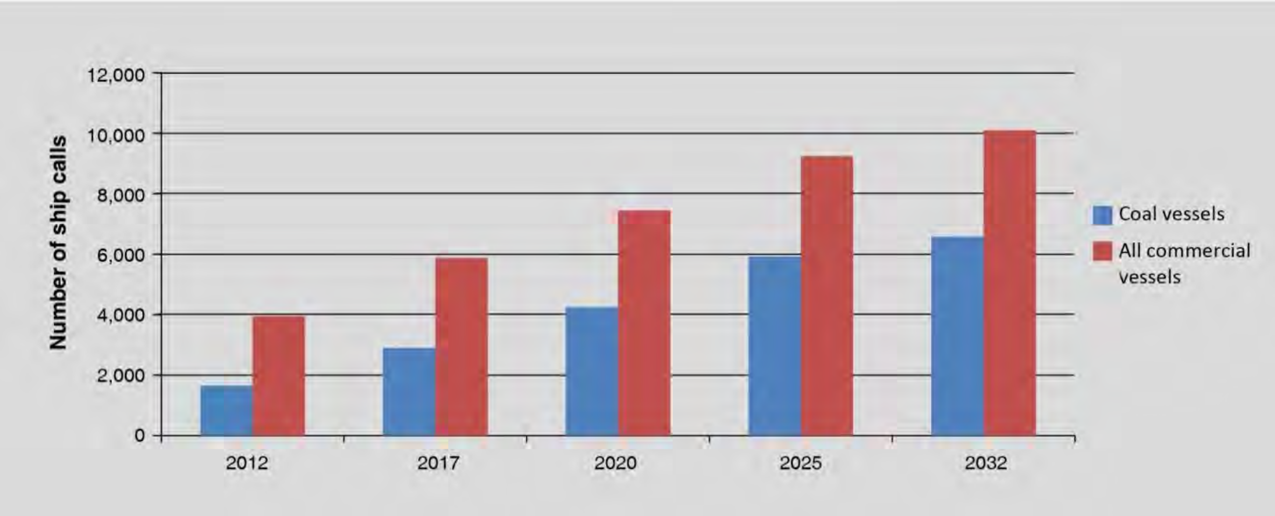


Figure 5.29 A projection of shipping increases at major ports adjacent to the Great Barrier Reef Region, 2012–2032[178]

The category 'all commercial vessels' includes coal carriers, bulk carriers, container carriers, vehicle carriers, general cargo ships, tankers and cruise ships. Fishing, other tourism and recreational vessels are not included. All commercial vessel projections are based on 4.8 per cent annual growth. Coal vessel projections are based on 7.2 per cent annual growth. It is recognised that these projections may be higher than the eventual shipping traffic, depending on variables such as economic conditions.

The dynamic nature of shipping and the industries it services means there is likely to be continual changes in the types of bulk and packaged cargo carried through the Region. This is likely to include a greater range of substances that are noxious or hazardous to the environment. There is also a global trend towards longer, deeper draft ships.

The draft North-East Shipping Management Plan[180] released in August 2013 examines shipping-related risks in the Great Barrier Reef, the Torres Strait and the Coral Sea (within Australia's Exclusive Economic Zone) and identifies protective measures to address them. It is a collaborative plan developed by the Australian Maritime Safety Authority in cooperation with other responsible government agencies, including the Authority.

Cruise ships comprise a minor component of the commercial vessels transiting the Region. In 2011–12, cruise ships represented only 1.5 per cent of the commercial vessel calls to Great Barrier Reef ports.[109] The cruise shipping industry is predicted to grow over coming decades.[181]

Benefits

Ships that transit the waters of the Great Barrier Reef provide a service to communities adjacent to the Region, transporting export and import cargo as well as cruise ship passengers. An estimated $38 billion of Australia's export trade is carried annually through the Region.[182] The economic activity generated by this shipping traffic provides a range of social and economic benefits to catchment communities and beyond.

Proactive and collaborative planning for increased shipping

Driven primarily by Queensland's industrial and mining activity, shipping in the Region is projected to increase by about 150 per cent by 2032, resulting in approximately 10,097 commercial vessels calling at Great Barrier Reef ports[178] (see Figure 5.27). Australia is currently the world's largest exporter of black coal, and Queensland supplies more than 75 per cent of Australia's metallurgical coal resources.[46] During the first decade of this century, Australian coal exports increased from 195 million tonnes in 2000–01 to 284 million tonnes in 2010–11.[46] Continued growth in shipping activity through the Region presents an increased risk of incidents, including ship-sourced pollution and damage from groundings.[180]

In anticipation of the increased risk, government agencies with jurisdiction over shipping activities in the north-eastern waters of Australia have developed the draft North–East Shipping Management Plan.[180] The draft plan applies to the Great Barrier Reef, the Torres Strait and the Coral Sea (within Australia's Exclusive Economic Zone). It examines known, potential and cumulative shipping-related impacts such as collisions, groundings, release of air emissions and other pollutants, marine pest introduction, wildlife disturbance, altered aesthetic value, and wildlife collisions, as well as impacts on Indigenous, cultural and social values.

The draft plan demonstrates a proactive approach to addressing the projected increased risks from shipping, outlining the safety and environmental standards that need maintaining or improving. It identifies a number of measures to reduce risks from shipping, including:

- additional areas for consideration of **pilotage requirements**
- increased resources for **port state control inspections** to ensure all ships meet the applicable standards
- increased focus on areas related to **navigational risk** (such as fatigue, passage planning and navigational equipment)
- **additional protection for the Coral Sea** through seeking categorisation as a Particularly Sensitive Sea Area and implementing associated protective measures such as ship reporting and routing requirements
- using emerging **ship tracking technology** to improve awareness of shipping movements in the Coral Sea and to provide early alerting of ship breakdowns
- more active management of traffic such as a '**traffic organisation service**' to minimise collision risk, particularly in confined waters such as Hydrographers Passage
- working with industry to introduce the need for trading ships to be equipped with **Electronic Chart Display and Information Systems**, an alternative to paper nautical charts which assist with navigation through ship position monitoring and alarms alerting navigation officers when a ship exceeds pre-defined safety boundaries
- working with industry to introduce the need for trading ships travelling through protective locations to be equipped with **bunker oil tanks** which reduce the risk of an oil spill.

The current Great Barrier Reef and Torres Strait vessel traffic service is considered effective at preventing shipping incidents — almost 11,000 ship movements were monitored in 2011–12 without significant incident.[180]

Impacts

There are many factors that increase the likelihood of impacts as a result of shipping activity in the Region. These include:

- limited (but improving) navigational facilities
- extensive areas of shallow water
- strong trade winds, cyclones and complex tidal streams
- reduced visibility during storm conditions
- some narrow shipping lanes.[111]

To date, the impacts of shipping have mainly related to: grounding of large vessels with the associated physical damage and pollution from toxic antifoulant paint; small chemical spills; large and small oil spills; increased noise; vessel strikes on wildlife; vessel-based waste discharge; the introduction of exotic marine species; and marine debris.[47] The increasing prevalence of ships anchoring off ports is likely to increase disturbance to the seabed, visual disturbance, potential for pest introduction, light pollution, interference with species behaviour and the displacement of others such as recreational users and commercial fishers.[179]

There is emerging evidence of additional impacts from ship operations worldwide, for example the leaching of biocides from ships' antifouling coatings, vessel-animal interactions including collisions, and loss of 'communication space' for marine animals as a result of vessel noise.[183]

As a result of the comprehensive management arrangements in place, incidents involving ships are relatively infrequent, with annual totals of 10 or fewer in recent years, and no obvious trend.[25] However, given the projected increases in shipping activity it is critical that management arrangements keep pace with growth in the industry. Of major concern is the potential for ship groundings, major oil or chemical spills and the introduction of invasive marine species.[184] While the likely frequency of serious incidents is very low, the location and nature of an incident could mean that its environmental effects are very high, causing long-term damage to the Region's environment on a local and regional scale, and the social and economic benefits derived from it.

5.4.7 Defence activities

The Australian Defence Force has operated and trained in the Great Barrier Reef Region for more than 100 years, and the Region is predicted to increase in importance as a defence training area over the next 25 years.[185] The Authority is notified of all defence activities in the Region and can issue directions to the Australian Defence Force to minimise risks to the Great Barrier Reef.

Operational activities in the Region include ocean surveillance, maritime search and rescue missions, and hydrographic survey and charting. Defence forces also provide critical support for border protection activities such as environment and fisheries protection, immigration controls, and biosecurity. Australian Navy, Army and Air Force bases at Cairns and Townsville serve as the key platforms for defence operational activities in the Region.

Training activities are regularly undertaken in designated areas of the Region, covering less than four per cent of the area (Figure 5.30). While most of the designated defence training areas within or adjacent to the Region are small, the Shoalwater Bay Defence Training Area near Rockhampton is one of Australia's largest and is regularly used. Every other year, Shoalwater Bay and other defence training sites in the Region host the combined Australia and United States of America training exercise called Talisman Sabre, which is Australia's largest defence training exercise.

The Australian Defence Force has a moratorium on the use of high explosives in the World Heritage Area except in the Shoalwater Bay training area, where they continue to be used intermittently and in major training exercises. Stringent environmental procedures are followed when high explosives are used, including a requirement to maintain a safety zone for marine mammals and reptiles. There are dedicated shipboard and aerial observers who communicate any marine wildlife sightings to other participants.

Trends

The Australian Defence Force is currently enhancing its capabilities in amphibious landings and other ship-to-shore or coastal manoeuvres, including the acquisition of new landing vessels.[186] The key amphibious training areas in or adjacent to the Region are Shoalwater Bay and Cowley Beach, and the Army's major deployable force is based in Townsville. As a result, more frequent and intensive amphibious training exercises are expected in the Region in the coming years. Additional training areas may also be required to develop and maintain this new amphibious capability. An increase in near-shore vessel movements increases the risk of a vessel grounding and subsequent oil spill, as well as creating more sediment disturbance which can affect nearby seagrasses or corals. It also has the potential to result in increased disturbance to wildlife.

The United States of America has recently shifted its global military focus to enhance its capabilities in the Asia-Pacific region.[186] As a result, combined training exercises between Australian and U.S. forces are expected to increase in frequency and intensity. Shoalwater Bay and other sites in the Region will therefore increase in importance for major exercises such as Talisman Sabre. While U.S. forces operate under Australian Defence Force instructions during combined training exercises, any visiting foreign force increases the complexity of communications and therefore the risk of impacts.

The Australian Defence Force is increasingly aware of its contribution to greenhouse gas emissions, with the Royal Australian Navy trialling renewable fuels for ships. It is expected to introduce alternative, low-carbon fuels as suitable replacements become commercially available and where consistent with operational needs.

While defence training activities are well-managed and have negligible impacts on the Great Barrier Reef, the predicted intensification of defence activities in the Region coincides with a decline in the Region's ecosystem health caused by a range of other pressures. The Australian Defence Force is working with the Authority to review the risks posed by defence activities in light of new information about the Region's declining ecosystem resilience and cumulative impacts.

Benefits

Defence activities in the Region directly contribute to the training and operation of Australia's defence services. In addition, the acquisition of Shoalwater Bay in 1965 has provided environmental benefits. The land component remains largely undisturbed and is able to maintain natural environmental processes. It also supports high biodiversity, including internationally significant migratory species and wetlands, and has stunning landscape features.[187] Operational activities can also help, directly and indirectly, to achieve management objectives for the Region including hydrographic surveys, and fisheries and border protection patrols.

Defence bases at Cairns and Townsville strongly support these regional economies. Little is known of the economic benefits of small-scale defence training activities to the coastal communities adjacent to the Region, although Talisman Sabre 2013 was predicted to contribute $4 million to the Rockhampton economy and $200,000 to the Townsville economy.[188] Periodic visits from U.S., New Zealand and Singapore naval ships to ports at Townsville and Cairns also generate short-term economic benefits, related to increased visitation and tourism.[189]

Impacts

Defence activities are well planned and well resourced, so incidents causing environmental harm to the Marine Park are rare. Standard operating procedures and contingency plans cover all defence activities, and any incidents are promptly reported and closely investigated.

However, by their nature, defence activities do pose risks which must be continually monitored and managed. The potential impact of greatest concern is the introduction of marine pests. The Australian Defence Force employs stringent quarantine measures to reduce this risk.[190]

Other impacts that may be of concern at a local or regional scale include:

- debris and residue from expendable stores, such as bullet casings or sonar buoys
- death, injury or disruption to marine life from explosives
- disturbance to marine animals from loud or low-flying aircraft
- discharge of sewage, food scraps and other wastes from ships
- oil spill from a ship grounding or collision
- loss of civilian life or property, particularly if civilians stray into defence training areas when exercises are taking place.

There is a range of legacy impacts associated with past defence activities. Most significant is the presence of large amounts of unexploded ordnance (such as shells, missiles and bombs) and chemical warfare agents which were deliberately dumped at sea at the end of World War II.[191,192] The largest post-war dumpsites were offshore from Cairns and Townsville, however dumps occurred throughout the Region.[185] Chemical warfare agents were also dumped off Bowen and Proserpine in the late 1940s.[185] Some records were kept about the locations of these dumpsites, but the details are not reliable in terms of precise locations, quantities and types of materials dumped. In addition to dumped materials, Australia laid thousands of sea mines in the Great Barrier Reef during World War II. Mine sweeping activities after the war resulted in the Great Barrier Reef being declared safe for shipping by 1948[193] but navigational charts still note former mined areas which may be unsafe for bottom activities such as trawling or anchoring. Encounters with World War II sea mines are extremely rare, and it is likely that they now pose a very low risk to humans or the environment. However, mines are occasionally discovered and require Defence and Authority resources to neutralise, most recently in 2013 at Night Island near Lockhart River and in 2002 at Sudbury Reef near Cairns[194].

These legacy issues are increasingly important to the Australian Defence Force. A pilot study is currently underway at John Brewer Reef offshore Townsville to evaluate the risks posed by unexploded ordnance. The Australian Defence Force is also working closely with researchers worldwide to evaluate the risks posed by World War II era sea mines in tropical environments. The Authority will continue to work with the Australian Defence Force to address the risks posed by both historic and contemporary defence activities.

Figure 5.30 Defence training areas relevant to the Region

5.4.8 Research activities

The Great Barrier Reef is an area of high scientific interest because of its biological and ecological diversity, geomorphology and cultural heritage. Scientific research has made a substantial contribution to the way the Reef is understood, managed and used. Monitoring also plays a key role in tracking trends in the Region's values and effects on those values.

Research programs range from small, independent student projects to large, multi-agency collaborative programs with teams of world-leading scientists.[43]

A network of six island research stations located at Lizard Island, Low Isles, Green Island, Orpheus Island, Heron Island and One Tree Island has been integral to research activities on the Reef. Eighty per cent of scientific research has been conducted around Lizard, Heron and Orpheus islands.[195]

Trends

The amount of research conducted in the Region and the focus of that research is determined by a number of variables including: the priorities of funding bodies such as the National Environmental Research Program and the Australian Research Council; the priorities of research end-users such as government agencies; and the research interests and capacities of scientists in universities and research institutions. There is a strong history of research programs which inform and help improve management of the Region.[196]

Although past research focused primarily on studying the biophysical environment, there is also a history of social and economic studies. This recognises that effective natural resource management requires an understanding of social and economic systems as well as natural systems.

Technological advances continue to change the way research is conducted, for example DNA mapping allows greater use of non-lethal sampling methods[197] and remotely-sensed data reduces the need for field science.[198,199]

Benefits

Research and monitoring of the Great Barrier Reef environment continues to contribute to global knowledge about individual species, coral reef systems and tropical marine ecology. An improved understanding of the Region's environment and how its components interact and respond to changing conditions has contributed substantially to its protection and management. In addition, the results of targeted and applied research are providing managers with information to better measure the outcomes of management initiatives.

A range of academic institutions and government agencies undertake research about the Great Barrier Reef. In 2012, more than $98 million of revenue was generated through the conduct of scientific research into the World Heritage Area, supporting more than 881 full-time equivalent jobs[43] (see Table 7.9 in Chapter 7). This is likely to be an underestimate of the total economic contribution of research activities as it is derived from only four major Australian research institutions involved in Great Barrier Reef research, namely the Australian Institute of Marine Science, James Cook University's ARC Centre of Excellence in Coral Reef Studies, the Heron Island Research Station operated by the University of Queensland, and the Lizard Island Research Station operated by the Australian Museum.

The activities of other research institutions and government agencies make significant additional economic contributions. In 2010, research funding for Reef-related projects from Australian Research Council grants alone totalled more than $8 million.[200]

Because the Great Barrier Reef is accessible and diverse, it provides a valuable training ground for researchers — supporting domestic and overseas students.

Impacts

The concentration of research activities, such as sampling, around research stations, has the potential to contribute to local depletion of some species and some minor, localised impacts on habitats. Little is known about the cumulative impacts of research activities at any particular location, however, given the scale of activities, overall impacts are likely to have only localised effects.

5.5 Summary of outcomes

Key drivers directly and indirectly influencing the Great Barrier Reef Region are:

- **Climate change**. Reef-dependent values and activities are vulnerable to the negative effects on Reef condition of ocean acidification, sea level rise, more frequent extreme weather and warming sea temperatures. The frequency and severity of associated impacts such as coral bleaching are predicted to increase, with serious consequences for the Reef likely before mid-century.
- **Economic growth**. Queensland's economy continues to grow rapidly and much of its economic activity takes place in the Great Barrier Reef catchment. Predicted growth in Queensland's economy relies on expansions in port capacity, shipping, coastal infrastructure and urban utilities adjacent to the Region.
- Annual **population growth** in the Reef catchment is 1.6 per cent compared with Australia's growth rate of less than 1.4 per cent. Combined with economic growth, population growth will increase pressure on the Region's environment, with potential effects on biodiversity, connectivity and aesthetics. An increasing population will likely mean increased recreational use of the Region.
- **Technological developments** contribute to our understanding of the Reef and enable the Region's values to be better protected and managed. They also improve access to previously remote areas for fishing and recreation, placing additional pressure on vulnerable habitats, and targeted fish and other species.
- Prevailing **societal attitudes** play a key role in people's use of and attitude towards the Reef. Stewardship actions implemented by community and industry are critically important for influencing attitudes and supporting management initiatives to maintain and enhance the Region's values.

Activities that affect the Region's values may be undertaken within the Region (direct uses) or beyond its boundaries.

- **Agriculture** within the catchment is an important producer of food and, to a lesser extent, fibre. Over the 160 years of European settlement in the catchment, agricultural use has become more widespread and more intensive. Land clearing and altering water courses have affected many ecological processes that support the Reef. There have been significant improvements in agricultural land use practices in recent years, such as those supported by the implementation of the *Reef Water Quality Protection Plan*.
- Although there is no marine-based **aquaculture** within the Region, there are land-based operations in the catchment. Within a local area, these may increase sediment and nutrient loads in discharged wastewater, modify hydrologic processes, introduce marine species or diseases and cause genetic pollution.
- **Urban development.** The six major population centres within the Great Barrier Reef catchment — Cairns, Townsville, Mackay, Rockhampton, Gladstone and Bundaberg — account for about 42 per cent of the population. While urban areas occupy only a small proportion of the catchment, development of housing and associated utilities increases land clearing, modifies water flows and affects connectivity between coastal and marine habitats.
- **Industrial development.** Much of the supporting infrastructure for mining and industry is located in coastal areas adjacent to the Region and, in the past two decades, four major State Development Areas have been declared in the catchment. If not properly managed, industrial development adjacent to the Great Barrier Reef could result in the discharge of pollutants, potential acid sulphate soils, artificial barriers to estuarine flow and coastal reclamation.
- There are 12 trading **ports** in or adjacent to the Region. Many are of economic importance, especially to export industries such as mining and agriculture. Over the past two decades, total export tonnage has grown by about 300 per cent. Five ports currently have active proposals for port expansions, and there are proposals for two new ports. Port operations and infrastructure can lead to impacts such as clearing, modifying and fragmenting of coastal habitats, reclamation of marine areas, alteration of natural coastal processes, as well as requiring capital and maintenance dredging.
- **Traditional use of marine resources.** Traditional Owners use coastal and marine resources to practice their living maritime culture, provide traditional food for their families and educate the

younger generation about traditions, rules, protocols and activities. Impacts such as coastal development, habitat degradation, vessel strikes on wildlife, pollution, netting and sedimentation affect Traditional Owners’ use of the Reef.

- **Tourism** is the most economically significant direct use of the Region, with about 2 million tourists visiting the Region each year. It offers a wide range of tourism experiences, focused on a small portion of the Region, and plays an important role in presenting the Region’s world heritage values. Many tourism operators are active stewards of the Reef and more than 60 per cent of visitors travel to the Reef with a certified high standard tourism operator. The impacts associated with tourism activities, such as localised anchor damage and wildlife disturbance, are generally regarded as low risk, concentrated in a few intensively managed areas.
- The Great Barrier Reef supports a diversity of **fishing** activities including commercial, recreational, charter and Indigenous fisheries. Fisheries product from the Region is important to local communities, as well as domestic and international markets. Reef-based commercial fishing is mainly comprised of trawl, net, line and pot fisheries and is widely distributed across the Region. Net fishing impacts include bycatch and entanglement of species of conservation concern. Trawl bycatch can comprise hundreds of species, however many are caught infrequently. Many species are targeted by both recreational and commercial fishers, increasing cumulative impacts on those species. Illegal fishing continues to be of concern as it erodes the benefits of no-take marine reserves.
- **Recreation other than fishing** includes swimming, motorised boating, snorkelling, sailing, diving and jetskiing. The most popular destinations are islands, reefs, shoals, cays and wrecks. Potential recreational impacts include localised anchor damage, littering, boat strikes on wildlife, and damage to corals when snorkelling and diving.
- **Ships** transiting the Reef carry export goods, service coastal and inland communities and transport passengers. The Region is one of the world's most regulated shipping areas. While the number of ship voyages increased substantially over the past 10 years — driven mainly by industrial activity — improvements in management arrangements have meant there have been relatively few shipping incidents.
- The Great Barrier Reef is a critical part of Australia’s **defence** training programs. Training activities are regularly undertaken in a few designated areas of the Region, covering less than four per cent of its area. Recognising the potential for impacts such as noise, anchor damage and disturbance to wildlife, defence activities have undergone rigorous environmental assessments resulting in environmental management plans and protocols.
- **Research activities** contribute to global knowledge about Reef species and tropical marine ecology. An improved understanding of the Reef and how its components interact and respond to changing conditions contributes substantially to the Region’s protection and management. Any impacts are minor and localised, mainly around research stations.

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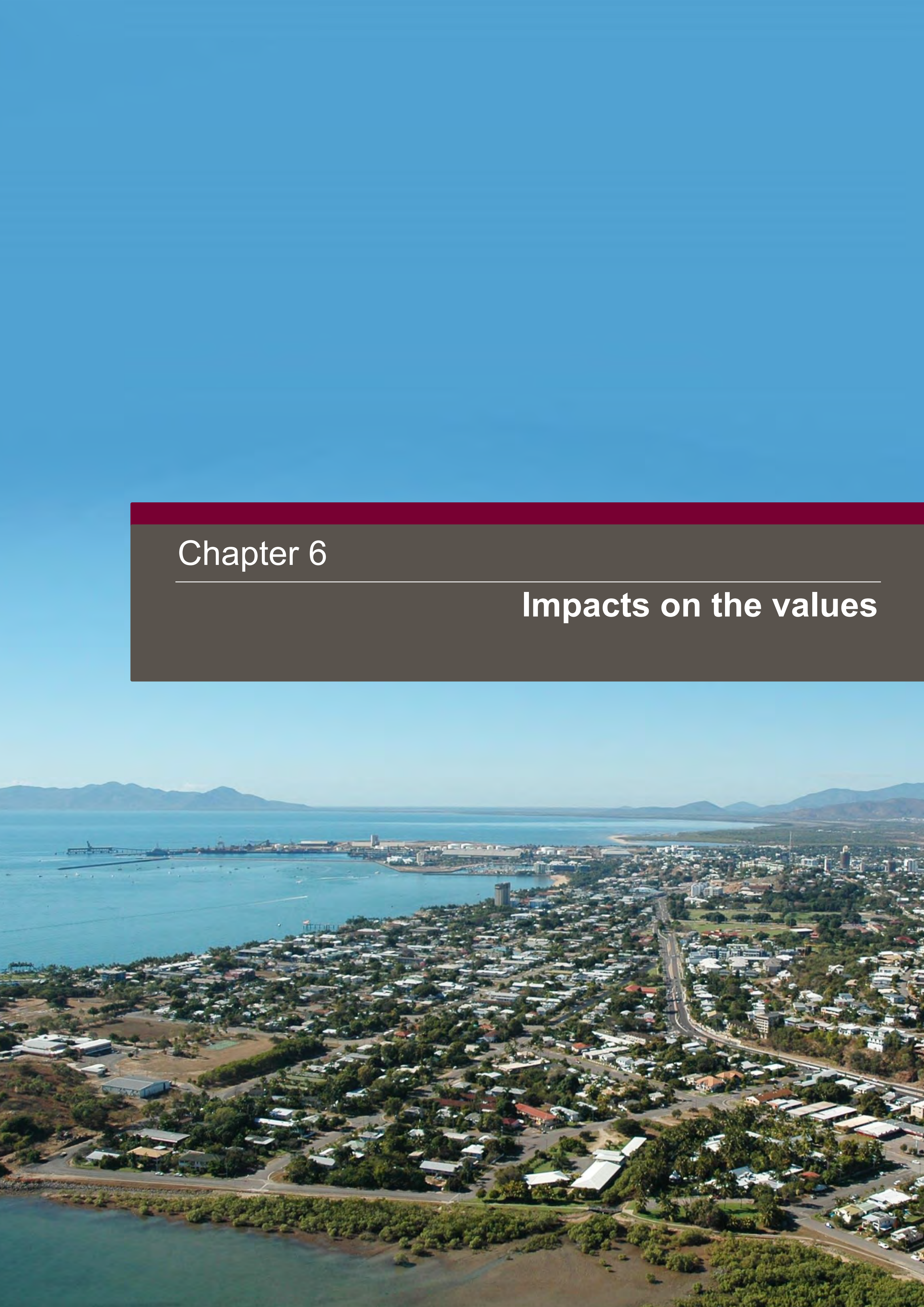


Chapter 6

Impacts on the values

Table of contents

Cover page image: Aerial view of Townsville

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

3. Assessment of impacts on matters of national environmental significance

3.1 Actual and potential impacts

……….

b) describe and analyse the actual and potential impacts on the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, in the strategic assessment area, including:

i. impacts from past, present and future activities

ii. direct, indirect, consequential and cumulative impacts

iii. the likely impacts of climate change

c) describe the spatial and temporal scale at which impacts and their effects on the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, are occurring or are likely to occur

d) identify key information gaps and processes to address critical information needs.

6 Impacts on the values

6.1 Background

6.1.1 Context

The Great Barrier Reef Region is a large and complex natural system with multiple uses that is subject to many impacts. The state of the Region's biodiversity, geomorphological features and Indigenous and historic heritage values, and the benefits derived from the environment, are constantly changing in response to a complex suite of interactions between drivers, activities and impacts.

To develop a full understanding of the impacts and their effects on the Region's values the individual and cumulative effects of all impacts are considered in the chapter. The focus is on the impacts on the ecological system (that is, its biodiversity values) as this is fundamental to the matters of national environmental significance in the Region. An assessment of the impacts on key biodiversity values informs the assessments of impacts on geomorphological features and Indigenous and historic heritage values. Flow-on effects on the community benefits derived from the environment are also described.

To date, understanding of cumulative impacts in the Region has been limited. The assessment of management effectiveness for the *Great Barrier Reef Outlook Report 2009* identified the extent to which cumulative impacts are being addressed as "the weakest indicator across the entire management effectiveness assessment"[1]. The independent review of the Authority's current management arrangements, carried out as part of the strategic assessment process (refer to Chapter 8), arrived at the same conclusion and further stated that processes to address cumulative impacts were "problematic for most issues". Both qualitative and spatial modelling are employed in this chapter to consider cumulative impacts (see Section 6.8).

6.1.2 Challenges in assessing impacts

Specific challenges in assessing impacts, and cumulative impacts in particular, in the Great Barrier Reef Region include:

- the diversity of values and attributes underpinning matters of national environmental significance relevant to the Region
- the availability of information on the condition and trend of a number of values and attributes to allow development of a 'baseline' for the assessment
- the complex interactions, processes and relationships of the hugely diverse species, habitats and bioregions that make up the ecosystem

- the number of drivers, activities and impacts acting on the values and attributes
- limited understanding of the relationships between the ecological and human systems
- the multiple scales at which processes and impacts occur and interact with ecological and human systems
- limited understanding of the cause-and-effect relationships of multiple or 'compounding' impacts on the Region's values
- the dynamic nature of systems and the rapid pace of change
- the delayed response time of species, habitats and systems to change
- a limited understanding of the thresholds for species, habitats and ecosystem health.

6.1.3 Terminology

In describing and assessing impacts, the following types are considered, adapted from *A guide to undertaking strategic assessments*[2]*:*

- Direct impacts — where the loss or modification of values is a direct result of an action within the strategic assessment area (for example, dredging and disturbing wildlife).
- Indirect impacts — can be either:
  - from actions outside the strategic assessment area with 'downstream' effects in the area (for example, modifying supporting terrestrial habitats, urban and industrial discharge)
  - as a result of another direct impact (for example, an oil spill resulting from the grounding of a ship).
- Consequential impacts — where the impact arises from an action made possible by an initial direct impact (for example, anchor damage from ships now able to visit an area after dredging).
- Cumulative impacts — the successive and combined effects of impacts on the environment, taking into account direct, indirect and consequential impacts and the incremental and compounding effects of these impacts over time.

Direct, indirect and consequential impacts are diagrammatically represented in Figure 6.1.

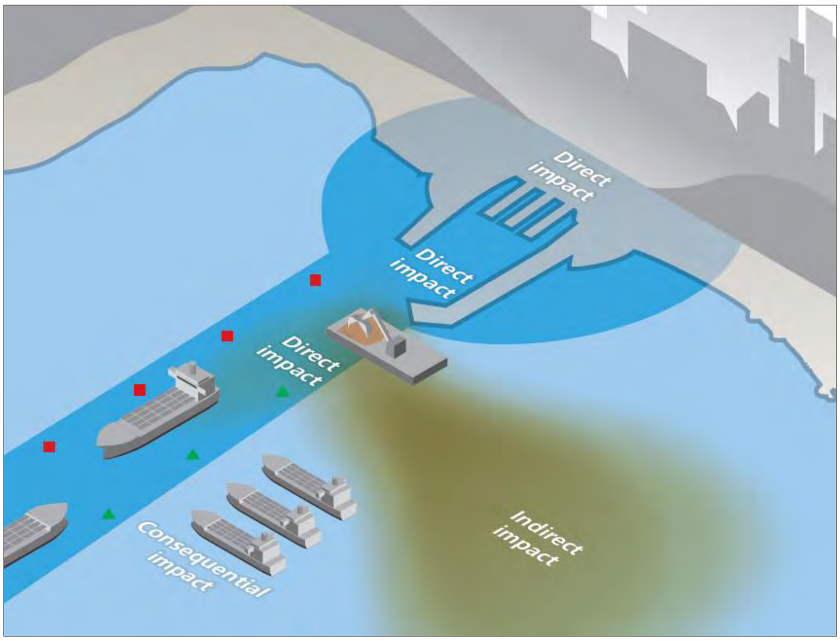


Figure 6.1 Direct, indirect and consequential impacts

The strategic assessment considers all types of impacts on the Region's values. Using ports and shipping as an example: dredging to deepen a port channel is a direct impact, a plume of sediment from that dredging is an indirect impact, and any anchor damage to the seafloor as a result of a ship visiting the port following the dredging is a consequential impact.

6.2 Impacts considered

6.2.1 Identifying likely past and present impacts

The set of past, present and future impacts affecting or likely to affect the Region's values was developed by consolidating the outcomes of:

- the Outlook Report 2009[1]
- the analysis of drivers and activities within and adjacent to the Region presented in Chapter 5
- workshops involving managers and technical experts in relation to future monitoring needs for the Region.

The descriptors used are based on those used in the Outlook Report 2009, with some amendments and updates. The final 40 impacts considered are listed in Table 6.1 and matched to their likely causes, either direct drivers or activities, in Table 6.2.

Each of the impacts is individually assessed in relation to its effects on biodiversity (Section 6.4), geomorphological features (Section 6.5) and Indigenous and historic heritage values (Section 6.6). The flow-on effects on community benefits, including aesthetics, is discussed in Section 6.7. The focus is on the impacts on the ecological system (that is, its biodiversity values) as this is fundamental to the matters of national environmental significance in the Region.

It is important to recognise that there is great variation in the spatial extent of the impacts — some operate in only a few areas within the Region, while others are, or have the potential to be, widespread. These variations are indicated in Table 6.1 and discussed throughout the assessment.

As demonstrated in Table 6.2, the past and present impacts can be grouped into four broad categories:

- climate change
- catchment runoff
- degradation of coastal ecosystems
- direct use.

Although some of the impacts fall into more than one category, they have been grouped this way to help structure the assessment.

The most significant legacy impacts on the Region from historic activities, both within the Region and the catchment, are described in Section 6.3. The continuing influence these impacts have on the condition of the Region's values is taken into account in the assessments later in the chapter.

Table 6.1 Impacts considered in the assessment

Note — Scale refers to Reef-wide: likely to cause effects through much of the Region; Regional: likely to cause effects in extended areas; and Local: likely to cause effects in small areas (for example a reef or bay).

Abbreviated title	Impact	Scale
Acid sulphate soils	Exposure of potential acid sulphate soils	Local
Altered ocean currents	Altered ocean currents due to climate change or anomalies related to the El Niño-Southern Oscillation, and altered coastal water movement at a local scale	Reef-wide
Artificial barriers to flow	Artificial barriers to riverine and estuarine flow including breakwalls, weirs, dams, gates, ponded pastures, and weeds causing changes to hydrology, groundwater and ecological connectivity	Regional
Atmospheric pollution	Atmospheric pollution, including coal dust	Local
Coastal reclamation	Coastal land reclamation, including for ports and groynes	Local
Cyclone activity	Cyclone activity	Regional
Dredging	Dredging of the seafloor	Local

Abbreviated title	Impact	Scale
Dumping and resuspension of dredge material	Sea dumping of dredge material including smothering, loss and modification of seabed habitats and resuspension	Regional
Exotic species and diseases	Introduction of exotic species and diseases from aquaculture operations, hull fouling, ballast release, imported bait and release of aquarium specimens to the Region, plus the introduction of weeds and feral animals to islands	Regional
Extraction — death of discarded species	Death of non-retained species from fishing, collecting, hunting, scientific sampling and Queensland's Shark Control Program	Regional
Extraction — fishing in spawning aggregations	Fishing in unprotected fish spawning aggregations	Regional
Extraction — herbivores	Retained take (extraction) of herbivores through commercial, recreational and traditional use	Reef-wide
Extraction — lower order predators	Retained take (extraction) of lower order predators (e.g. coral trout and snapper) through commercial, recreational and traditional fishing	Reef-wide
Extraction — lower trophic orders	Retained take (extraction) of lower trophic orders (e.g. scallops, sea cucumbers and prawns) through commercial, recreational and traditional fishing	Reef-wide
Extraction — top order predators	Retained take (extraction) of top order predators (e.g. sharks) through commercial, recreational and traditional fishing and the Queensland Shark Control Program	Reef-wide
Illegal fishing and poaching	Illegal fishing, collecting and poaching (foreign or domestic) including of species of conservation concern	Reef-wide
Increased freshwater inflow	Increased freshwater inflow from prolonged or heavy rainfall including flood events, and from changes to catchment ecosystems; resulting in reduced salinity	Regional
Increased sea temperature	Increased sea temperature due to climate change	Reef-wide
Light impacts (artificial)	An increased amount of artificial light	Local
Marine debris	Manufactured material discarded, disposed of or abandoned in the marine and coastal environment (including discarded fishing gear and plastics)	Reef-wide
Modifying supporting terrestrial habitats	Clearing or modifying supporting terrestrial habitats such as wetlands, saltmarshes, mangroves and sand dunes — this also includes trampling and damage from recreational vehicle use	Regional
Noise pollution	Noise from human activities, both below and above water	Local
Nutrients from catchment run-off	Nutrients entering the Region in run-off from the catchment	Reef-wide
Ocean acidification	Increasing acidity of the Region's waters	Reef-wide
Outbreak of crown-of-thorns starfish	Outbreak of crown-of-thorns starfish (i.e. when the density exceeds about 30 starfish per hectare)	Regional
Outbreak of disease	Outbreak of naturally occurring diseases	Local
Outbreak or bloom of other species	Outbreak of naturally occurring or native species, excluding crown-of-thorns starfish	Local
Pesticides from catchment run-off	Pesticides (including herbicides, insecticides, fungicides) entering the Region in run-off from the catchment	Regional
Physical damage — fishing	Physical damage to marine habitats from fishing, such as the effects of trawling on or near the seabed	Reef-wide

Abbreviated title	Impact	Scale
Physical damage — other	Physical damage to coral reefs and seafloor habitats including from anchoring of vessels of any size, grounding of small vessels, diving and snorkelling. Does not include physical damage for fishing or ship grounding	Local
Physical damage — ship grounding	Grounding of ships including physical damage and the dislodging of antifoulants	Local
Rising sea level	Rising sea level	Reef-wide
Sediments from catchment run-off	Sediments entering the Region in run-off from the catchment	Reef-wide
Spill — large chemical	Chemical spills that trigger a national or regional response or are more than 10 tonnes	Regional
Spill — large oil	Oil spills that trigger a national or regional response or are more than 10 tonnes	Regional
Spill — small chemical and oil	Chemical and oil spills that do not trigger a national or regional response and are less than 10 tonnes	Local
Urban and industrial discharge	Point and diffuse-source land-based discharge of pollutants from urban and industrial land use and mining, including polluted water, sewage, wastewater and stormwater	Local
Vessel strike on wildlife	Death or injury to wildlife as a result of being struck by a vessel of any type or size	Local
Waste discharge from vessels	Waste discharged from a vessel into the marine environment	Local
Wildlife disturbance	Disturbance to wildlife including from snorkelling, diving, fish feeding, walking on islands and beaches, and the presence of boats	Local

Table 6.2 Impacts and their sources

Broad categories used in the assessment are shown (on left), however impacts may fall into more than one category. * indicates impact is likely to be the result of a variety of activities.

		Direct driver	Activities in the Region: Activities in the catchment												
	Impacts	Climate change	Agriculture	Aquaculture	Urban development	Industrial development	Port activities	Traditional use	Tourism	Fishing — commercial	Fishing — recreational	Recreation	Shipping	Defence activities	Research activities
Climate change	Altered ocean currents	●			●		●								
	Cyclone activity	●													
	Increased sea temperature	●													
	Ocean acidification	●													
	Rising sea level	●													
Catchment run-off	Increased freshwater inflow	●	●		●	●									
	Nutrients from catchment run-off		●	●	●	●									
	Outbreak of crown-of-thorns starfish		●		●	●				●	●				
	Pesticides from catchment run-off		●		●	●									
	Sediments from catchment run-off		●	●	●	●	●								
	Urban and industrial discharge			●	●	●	●								
Degradation of coastal ecosystems	Acid sulphate soils		●	●	●	●	●								
	Artificial barriers to flow		●	●	●	●	●								
	Atmospheric pollution		●		●	●	●						●		
	Coastal reclamation				●	●	●		●	●	●	●			
	Light impacts (artificial)				●	●	●						●		
	Modifying supporting terrestrial habitats		●	●	●	●	●		●	●	●	●			
Direct use	Dredging				●	●	●						●		
	Dumping and resuspension of dredge material						●						●		
	Exotic species and diseases*			●					●	●	●	●	●		
	Extraction — death of discarded species									●	●				●
	Extraction — fishing in spawning aggregations									●	●				
	Extraction — herbivores							●		●	●				●
	Extraction — lower order predators							●		●	●				●
	Extraction — lower trophic orders							●		●	●				●
	Extraction — top order predators							●		●	●				●
	Illegal fishing and poaching									●	●				
	Marine debris*		●		●	●	●		●	●	●	●	●		
	Noise pollution					●	●						●	●	●
	Outbreak of disease*		●				●								
	Outbreak or bloom of other species*		●										●		
	Physical damage — fishing									●					
	Physical damage — other							●	●	●	●	●	●	●	●
	Physical damage — ship grounding								●	●			●		
	Spill – large chemical				●	●	●						●		
	Spill – large oil					●	●						●		
	Spill – small chemical or oil				●	●	●		●	●	●	●	●		
	Vessel strike on wildlife						●		●	●	●	●	●	●	
	Waste discharge from vessels							●	●	●	●	●	●	●	●
	Wildlife disturbance						●		●	●	●	●	●	●	●

Impacts identified by Traditional Owners and stakeholders
During development of the strategic assessment, the Authority sought advice from a range of stakeholders and Traditional Owners (see Section 2.11 and Appendix 5) regarding impacts on the Region's values.

Participants at stakeholder and Traditional Owner workshops identified the impacts considered to be affecting the Region's values. Those mentioned consistently across all workshops were:

- climate change
- extreme weather events
- declining water quality
- coastal development, including urban development and increased industrialisation of the coast
- port development and associated increases in shipping
- mining
- overfishing.

Key impacts identified by Traditional Owners in particular included:

- dispossession from country and loss of access to traditional grounds
- unauthorised entry to sites of cultural significance
- coastal development
- vandalism, including damage and graffiti
- marine debris and litter
- ships and boats cutting across storylines
- over fishing
- declining water quality
- extreme weather events.

In a follow-up survey completed by 118 participants, climate change was rated as the most serious threat by 34 per cent of respondents, water quality by 23 per cent, while 12 per cent considered extreme weather the most serious.

6.3 Legacy impacts

Direct legacy impacts
Some activities previously undertaken within what is now the Great Barrier Reef Region and on the islands have had severe and long-lasting impacts on the values of the Region (Table 6.3). The legacy of these past activities is still affecting the Reef ecosystem and contributing to cumulative impacts in the Region.

Of the past activities directly undertaken in the Region, the most significant legacy impacts have resulted from large-scale commercial harvesting, especially of long-lived species. Past commercial harvesting of dugongs, green turtles, crocodiles and humpback whales has had major effects on the populations of these species. Historic reductions in dugong, green turtle and hawksbill turtle populations have substantially affected those species' ability to bounce back from more recent impacts.[3,4,5]

The east Australian humpback whale population is now showing strong recovery more than 50 years after harvesting stopped, and it is estimated that the population may be 50 to 75 per cent of its pre-whaling size.[6,7]

Table 6.3 Past activities resulting in direct legacy impacts on Region's values

Activity		Time period
Commercial harvesting	Harvesting humpback whales	1952–1962[8]
	Harvesting dugong — meat, bones, hide, oil	1847–1969[8]
	Harvesting hawksbill turtles — tortoise shell	1871–1940s[5,8]
	Harvesting green turtles	1867–1962[4,8]
	Farming green and hawksbill turtles	1970–1979[8]
	Harvesting estuarine crocodiles	1945–1974
	Trawling without bycatch reduction devices	1950s–2001
	Trawling sensitive lagoon floor communities [9]	1960s–2000
Physical destruction of coral	Mining coral for limestone	1900–1940[8]
	Dynamiting coral reefs[8]	Unknown, but pre-1970s
	Constructing transit channels across reef flats[8]	Unspecified
Collecting (commercial and recreational)	Unrestricted collecting of coral	Ceased in 1933[10]
	Collecting shells — pearl shell, trochus	From late 1800s[8]
	Collecting seabird eggs	Unspecified
	Collecting black teatfish	Ceased in 1999[11]
Islands	Deliberate introduction of exotic plants and animals on islands, e.g. goats for hunting and food[8]	Unknown, but pre-1980s
Mining and exploration	Mining guano and rock phosphate	1860–1940[8]
Defence	Widespread activities during World War II and subsequent bombing and shelling during military target practice	1943–1965[8]

Dugongs were commercially harvested from 1847 until 1969 in the Moreton Bay area (south of the Region) and for shorter periods at other locations on the Queensland coast, including sites within the Region.[12] In the first 50 years, the number taken was so high that the industry was initially closed in 1890 due to a scarcity of dugong.[12] This, combined with large harvests especially between the 1930s and 1969, has increased the vulnerability of dugongs to subsequent impacts.[3] Populations have subsequently failed to recover due to a combination of conservative life history traits and exposure to multiple impacts either directly and through habitat degradation.

Commercial use of green turtles began in the 1860s and continued until 1962. The harvest was primarily to supply turtle meat and soup for export. It was focused in the Capricorn Bunker group, but occurred as far north as Raine Island.[12] It is estimated thousands of mature females were taken during this period.[12] Given green turtles are long-lived, late maturing and display a high degree of fidelity to their foraging grounds and nesting areas, this species is highly vulnerable to overharvesting.[4] Long-term monitoring of the green turtle nesting population in the southern Great Barrier Reef shows this stock is now recovering, increasing at an average of about 3.8 per cent per year for the past four decades.[13] However, the northern Great Barrier Reef stock is at best stable and may be showing early signs of a population in decline.[4] The northern stock is mainly affected by harvesting of adult and near-adult turtles throughout much of the foraging range, as well as climate and habitat-related loss of hatchling production.[4]

Hawksbill turtles were also harvested commercially for many decades, primarily as a source of tortoiseshell. This activity was concentrated in the northern Great Barrier Reef where hawksbill turtles were abundant. By 1900, the hawksbill turtle had been already heavily exploited by Europeans; harvesting has had lasting impacts on the species.[5,12] Current population trends for the Torres Strait–northern Great Barrier Reef hawksbill turtle stock suggests the stock has been declining at three to four per cent each year since at least 1990, which projects to an expected reduction of greater than 80 per cent in the breeding female population in less than one generation.[5] The most obvious large source of mortality is the continuing harvest of hawksbill turtles for food and tortoiseshell in the broader Coral Sea region. [14]

Otter trawling in the Region dates back to the 1950s. The effect of high intensity prawn trawling may be substantial, locally removing about 70 to 90 per cent of seabed animals.[15] Although very few areas of the Region were fished so intensively, scientific evidence shows historical patterns and the amount of trawl fishing effort resulted in substantial effects and changes to seabed habitats and species at a Great Barrier Reef-wide scale.[9,15,16] Science also shows that over the last decade these impacts have been arrested and reversed by a sequence of management interventions implemented by the Queensland Government and the Authority.[17]

Historically, otter trawling also caused marine turtles to drown in the trawl nets. This activity was one of the major causes of marine turtle mortality in the Region and contributed to their population decline (especially for the endangered loggerhead turtle).[18] The mandatory use of turtle excluder devices since the early 2000s has largely mitigated this impact.[1,17,18,19]

Indirect legacy impacts
Past broadscale land clearing, principally in the southern two-thirds of the Great Barrier Reef catchment, has indirectly caused major changes to the Region's environment, affecting habitats and species. Clearing began in the 1870s and was undertaken to allow more intensive agricultural use. It further increased when intensive cropping on the coastal floodplain began in the early 1900s and again in the 1930s and 1940s when heavy machinery made clearing easier. The rate of clearing continued to increase until the late 1990s when controlling legislation was introduced.[20]

The resultant loss and modification of habitats has led to significant increases in pollutants, principally nutrients and sediments, entering the Great Barrier Reef lagoon[20] which has reduced the ecosystem's ability to bounce back after impacts (resilience), especially in southern inshore areas.[21] In addition, freshwater coastal habitats are important to numerous marine species, including the freshwater sawfish which is now threatened, in part, due to habitat loss.[22]

The previous construction of dams (for example, Fairbairn Dam in the 1970s and Burdekin Falls Dam in the 1980s) has led to lasting changes in the hydrological processes in the Great Barrier Reef catchment, in turn affecting the Region's values and reducing connectivity between coastal and marine environments.[23] Levees, bunds, drains and other impediments to flow have also had negative legacy effects on habitats, species, connectivity and hydrology.[23]

6.4 Impacts on biodiversity values

This section contains an analysis of how each impact identified in Table 6.2 affects the Region's biodiversity values as set out in Chapter 4. It is based on the best available information, including input from stakeholders and Traditional Owners. It concludes with an assessment of the relative effect of each impact on the Region's biodiversity values.

6.4.1 Climate change impacts

Altered ocean currents
Ocean currents play an important part in regulating heat, connecting biodiversity and supporting productivity.[24] They vary naturally and are now also being influenced by climate change.[25] The effects of such changes could be Reef-wide.

There is increasing evidence of intensified flow and accelerated warming in the East Australian Current adjacent to the Region's southern coast.[26] This current is transporting greater volumes of warmer water southward. There is little information about the Hiri Current travelling north along the coast in northern Great Barrier Reef waters.[24,26,27]

Changes to ocean currents have the potential to affect entire marine food webs from corals and sponges to top predators such as sharks. Altered ocean circulation patterns may affect the transport of eggs and larvae within and among coral reefs and other Great Barrier Reef habitats and the movement of hatchling marine turtles away from nesting beaches. Pelagic foraging seabirds are also highly vulnerable to changes in ocean currents, as many search for food in pelagic communities that follow upwellings, eddies and other sea surface temperature gradients.[28] Changes may also result in species being more widely distributed or occurring in different areas.

At a local scale, currents can be altered by coastal infrastructure (for example, groynes and marinas), and other coastal works (for example, coastal reclamation, beach replenishment, dredging and dumping of dredge material).[29] Historically, the development and location of coastal works and infrastructure has affected coastal water movement which has resulted in negative effects on beaches and islands.[30]

Cyclone activity

Cyclones are a natural part of the weather cycle in tropical areas. However, the global climate system is now warmer and moister than it was 50 years ago, and this is increasing the chances of more extreme weather events.[31] As cyclone activity is influenced by environmental conditions such as sea surface temperature, climate change predictions suggest an increase in the intensity of cyclones in Queensland, and therefore an increase in the frequency of severe tropical cyclones (categories three, four and five) and an extension of their southern range.[32] However, the overall frequency of cyclones of all five categories is predicted to decrease.[33] Projections for the period 2051 to 2090, relative to 1971 to 2000, suggest an approximate 50 per cent decrease in frequency, a small decrease in duration (0.3 days), and a 100 kilometre southward movement in where they occur.[33]

Over the last decade, particularly between 2005 and 2012, there have been a number of severe cyclones in the Region (Figure 6.2).

Severe tropical cyclones can damage the Region's habitats such as coral reefs on a regional scale.[34] It is estimated that they have been responsible for about half of the total coral cover loss since 1985.[35] One effect has been high intensity waves damaging underwater habitats and coastlines (Figure 6.3). Most of the Region is likely to have experienced damaging waves at least once during the last decade; the area between Cairns and Townsville has been particularly affected (Figure 6.3).

Tropical habitats such as coral reefs, seagrass meadows and islands have a natural resilience to physical disturbances such as cyclones. Severely damaged reefs have shown strong signs of recovery within about five to 15 years if there are few other stresses to impede regrowth, recruitment and survivorship of corals.[36,37,38] It is thought the effects of cyclones on vulnerable habitats are becoming more severe and persistent due to a reduction in the resilience of the Reef.[21,39] This has flow-on effects to other parts of the ecosystem.

In 2011 cyclone Yasi produced damaging winds and waves that affected much of the coastline between Cairns and Townsville.

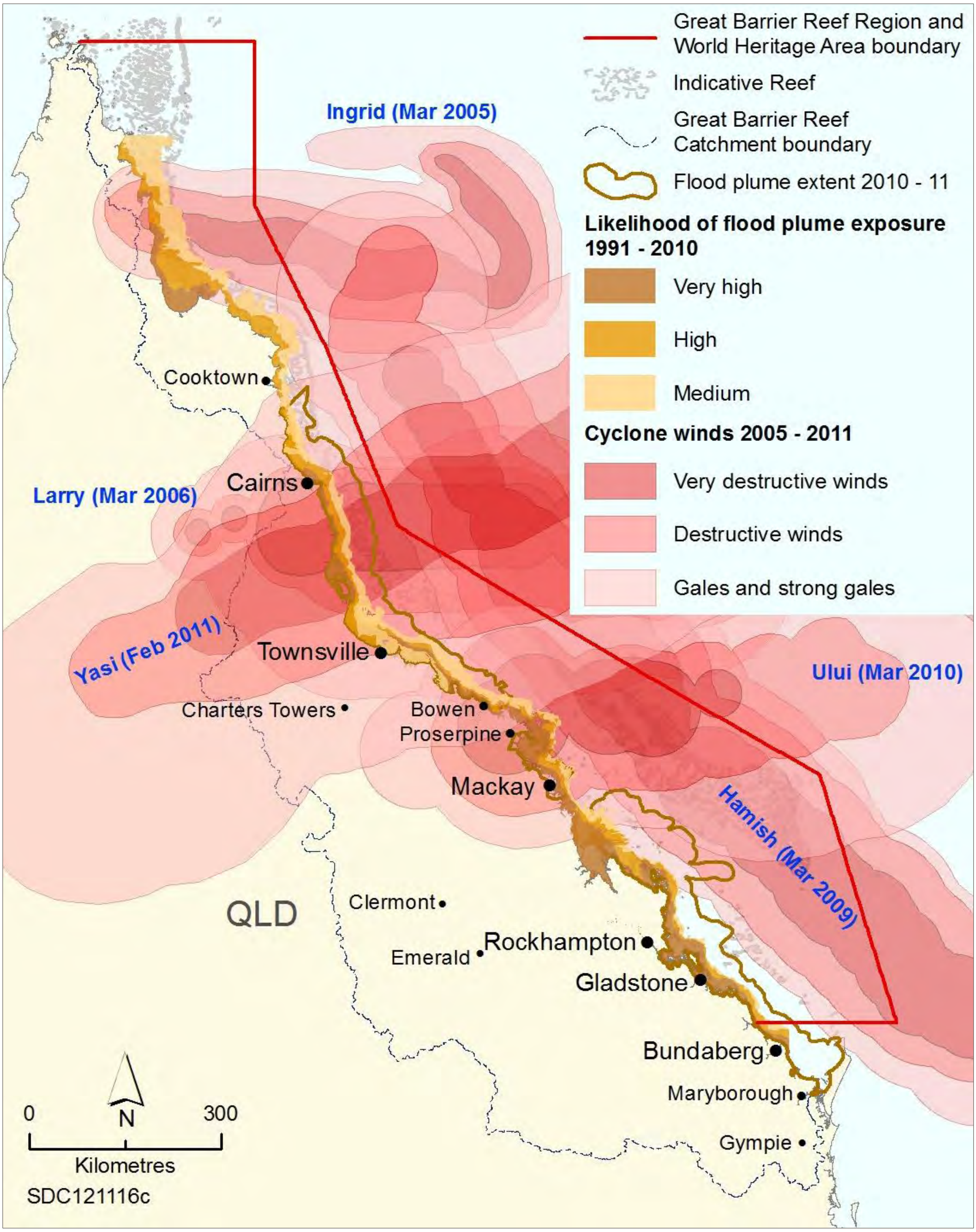


Figure 6.2 Cyclone winds (2005–2011) and flood plume exposure (1991–2011) in the Great Barrier Reef Region

The cluster of cyclones and flood events in recent years has seriously affected the condition of many Great Barrier Reef habitats and species. The likelihood of flood plume exposure (brown areas) is a cumulative assessment of multiple flood plumes based on remotely sensed conditions at the sea surface. The flood plume extent for 2010–11 (brown line) indicates the distribution of the flood plume as a result of the extreme weather events experienced over that summer.

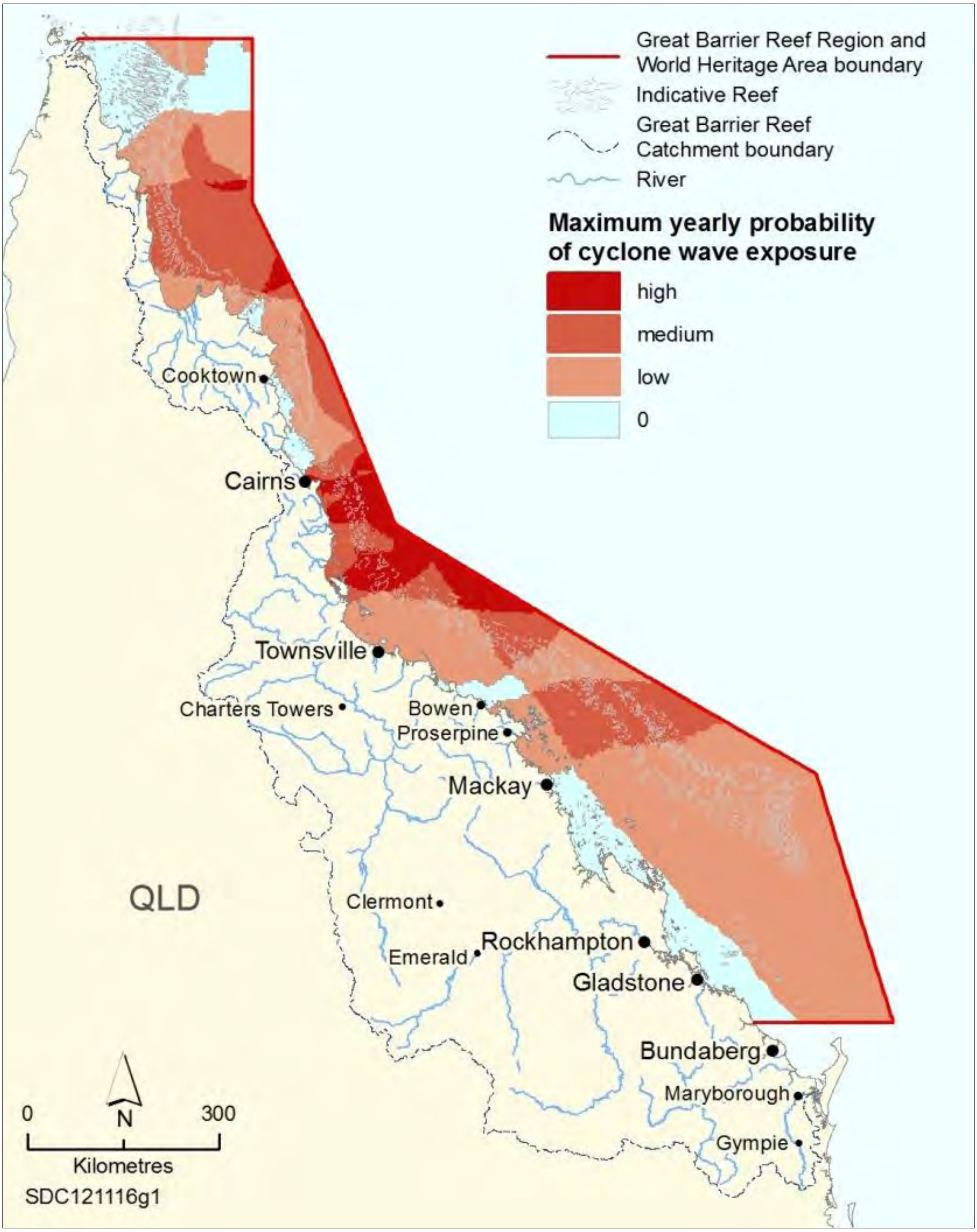


Figure 6.3 Cyclone wave exposure in the Region, 2000–2011[40]

The extent and severity of cyclone wave damage to corals and other biota (e.g. seagrasses) depends on the size and duration of cyclone generated waves, exposure of organisms to those waves, and the vulnerability of the organisms to wave action.[41] Therefore, the significant wave height (the average size of the largest one-third of the waves in a given sea) needed to damage coral or other biota varies by species and area.[42] For the Region, a significant wave height of four metres is likely to damage most species, and is used here. The map represents the probability that four metre significant wave heights formed for at least an hour in a given year over the period 2000 to 2011. Gradings are scaled between 0 and 1, based on a maximum yearly probability of 31.7 per cent: low (less than 11 per cent chance), medium (11 to 22 per cent chance) and high (22 to 31.7 per cent chance).

Increased sea temperature
In line with global ocean trends, surface waters in the Coral Sea, including the Region, have warmed substantially over the last century[32,43] and will likely continue to rise over the coming century.[44] The average summer (December to February) sea surface temperature anomalies (when the temperature is above the 1982 to 2000 summer maximum) in the Region for the 10 year period to 2011 for non-reef areas are presented in Figure 6.4.

Average ocean temperatures around Australia have warmed by 0.68 degrees Celsius since the period 1910 to 1929.[44] Within the 102-year instrumental record, 15 of the 20 warmest years have been in the past 20 years.[44] For many areas of tropical Australia, a new high for recorded sea surface temperatures occurred during October to December 2010.[44] Further records were set in the summer of 2012–13 when the hottest sea surface temperatures for the Australian region were recorded.[31] Whatever climate scenario is used, it is predicted that by 2035 the average sea surface temperature will be warmer than any previously recorded, and by 2100 sea temperatures off north-eastern Australia could be about 2.5 degrees Celsius warmer than the present average.[44]

Increasing sea temperatures are already affecting the Great Barrier Reef.[45,46,47,48,49,50,51,52] Further increases pose significant risks over the coming decades across the whole Region, influencing a range of physical, chemical and biological conditions and processes and, hence, many different habitats and species.[45] As temperatures rise past the temperatures at which an organism's metabolic processes perform best, its physiological efficiency decreases. This can cause stress and increase susceptibility to disease and predation. Higher temperatures also reduce the amount of oxygen available within the water. Projected increases in ocean stratification — the vertical layers in the water column — are predicted to affect the supply of nutrients and oxygen into deeper pelagic and benthic (seafloor) ecosystems with implications for their biodiversity.[46]

There have been a number of widespread coral bleaching events in the Great Barrier Reef. The two most severe coral bleaching events spanned the summers of 1997–98 and 2001–02[49,50,53], resulting from prolonged elevated sea temperatures. During both events, more than 50 per cent of reefs were affected to some degree by bleaching, with lasting damage to an estimated five per cent of reefs.[50] In 1997–98, coral bleaching affected reefs around the world. This coincided with observations of 500-year-old corals dying and, what was (at the time), the highest sea surface temperatures ever recorded on the Great Barrier Reef.[49] Another localised, but severe, bleaching event occurred in 2006 in the Keppel Bay region in the southern Great Barrier Reef. During this event, 40 per cent of corals died, but some recovery has since been observed.[37]

A future predicted increase of two degrees Celsius in the average sea temperature will likely lead to annual bleaching, with up to 97 per cent of reefs affected and almost certain regular large-scale coral mortality.[52,54]

Coral bleaching is a result of prolonged elevated sea temperature

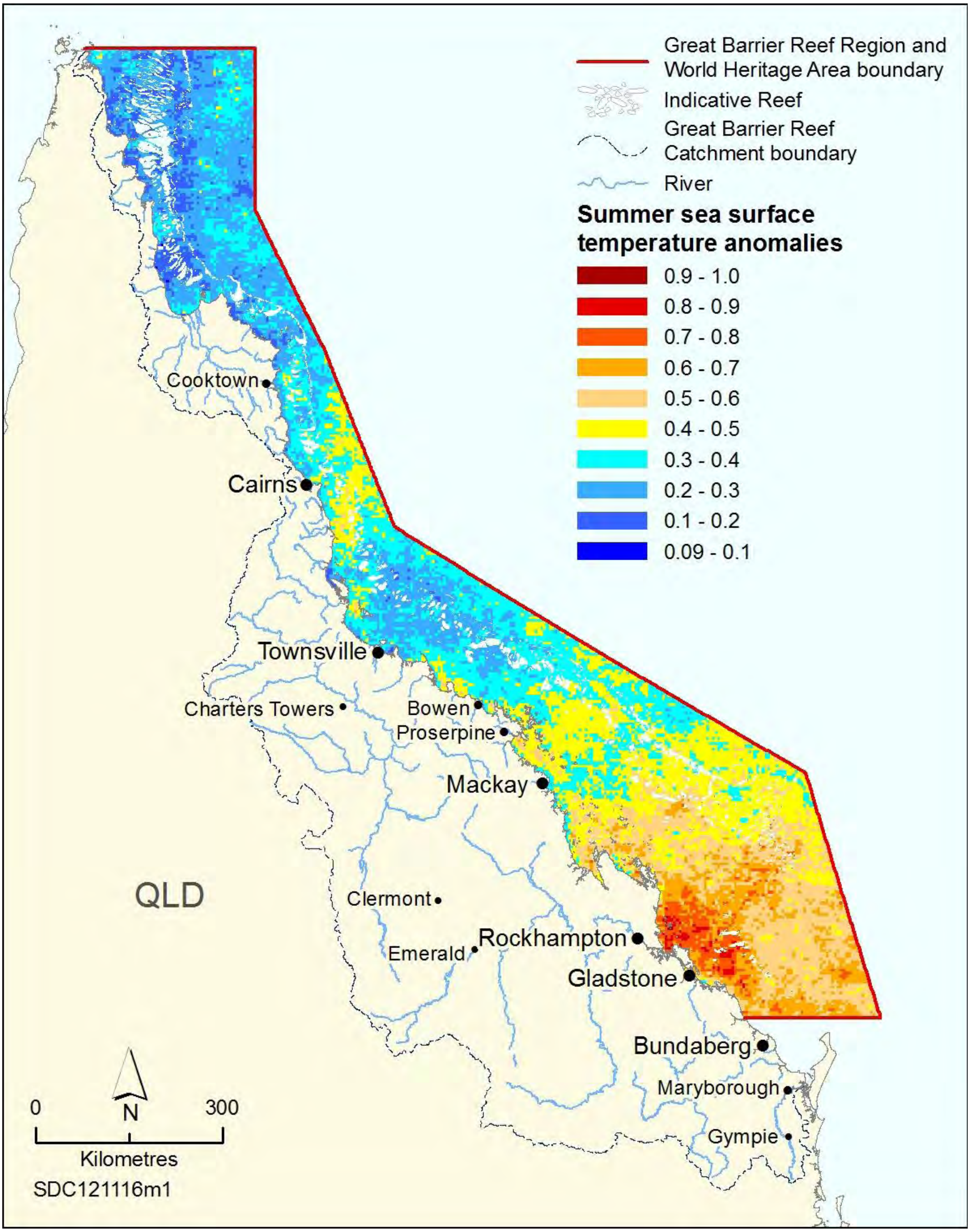


Figure 6.4 Summer sea surface temperature anomalies in the Region, 2001–2011[55]

The map was developed by scaling the sums of the average annual positive sea surface temperature anomalies for summer periods (December to February) between 2001 and 2011, for non-reef areas. Values are scaled from 0 to 1, based on the maximum value of 68.79 degree heating days.

Ocean acidification

A decline of 0.1 units in the pH of Great Barrier Reef waters has already been recorded, and further declines are expected. From a current pH of 8.2 (alkaline), it is predicted that the ocean could fall to a pH of about 7.6 by 2100, with slight regional variation.[46] While rates of decline are greater in southern areas of the Region, it is predicted that the ecosystem will be affected on a Reef-wide scale.

It is predicted that ocean acidification will ultimately affect most marine life through habitat destruction, food web deterioration and disruption of physiological processes. In addition, the effects of global warming and ocean acidification may magnify each other[56] and may not occur uniformly from place to place and over time.[57] Regardless of the rate of change, even relatively small increases in ocean acidity reduce the capacity of corals to build skeletons, which in turn reduces their capacity to create habitat for reef biodiversity in general.[58] Field observations at natural carbon dioxide seeps have found more acidic oceanic conditions (a decline in pH from 8.1 to 7.8) do not necessarily affect coral cover but reduce species diversity and structural complexity, and increase macroalgae and seagrass cover.[59]

The most immediate effects of ocean acidification may be on crustose coralline algae, a species vital to reef building. Increasing acidity is likely to reduce the capacity of coralline algae to cement reef debris into solid limestone, and in turn affect coral recruitment and establishment.[60] Other species such as molluscs, phytoplankton and foraminifera will also be affected by acidification.

Rising sea level

Sea levels are rising because of a combination of thermal expansion of the ocean and the addition of water volume to the ocean from melting glaciers and the ice sheets of Greenland and Antarctica. Globally, the sea level has risen more than 200 millimetres since 1880, and the rate of rise is increasing[61] (Figure 6.5). Sea level rose at a globally-averaged rate of about 1.7 millimetres per year during the 20th century as a whole and about 3 millimetres per year between 1993 and 2011.[61] Around Australia, the fastest rates of sea level rise are in northern Australia (Figure 6.6). In the Region, it continues to rise by about 3.1 millimetres per year on average.

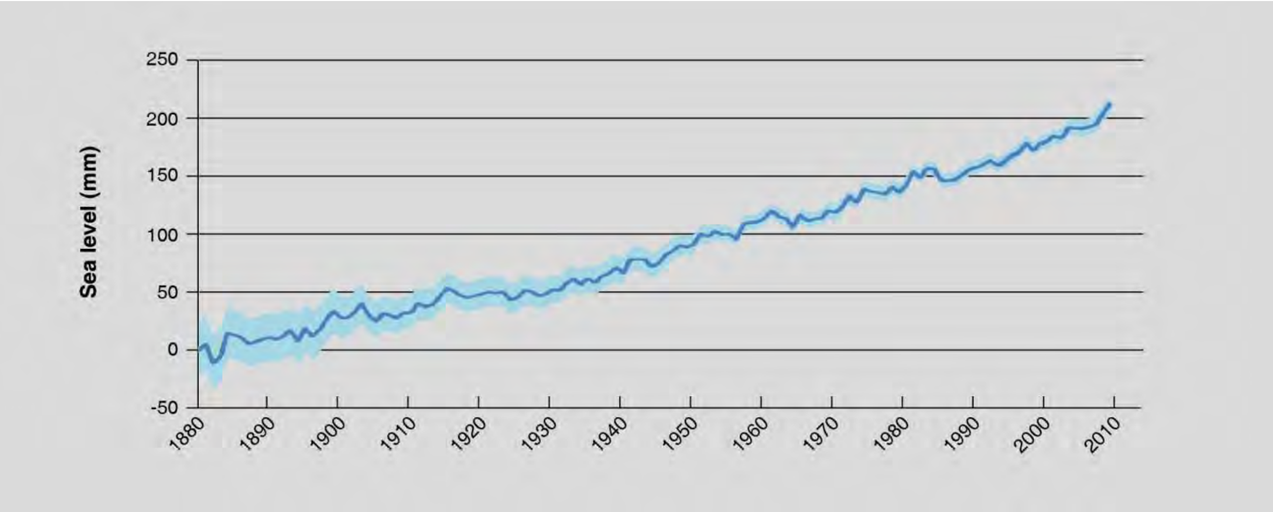


Figure 6.5 Global average mean sea level, 1880–2011[62]

Dark blue line shows sea level records collected from tide gauges with shading that provides an indication of accuracy.

Future responses of sea level to temperature increases are difficult to accurately predict. The Intergovernmental Panel on Climate Change predicts a rise of between 18 and 79 centimetres by 2095, from a 1990 baseline.[63] Sea levels are currently rising at near the upper end of these projections.[61]

Even modest rises in sea level may have substantial consequences throughout the Region when combined with natural variability arising from the El Niño Southern Oscillation and the Pacific Decadal Oscillation.

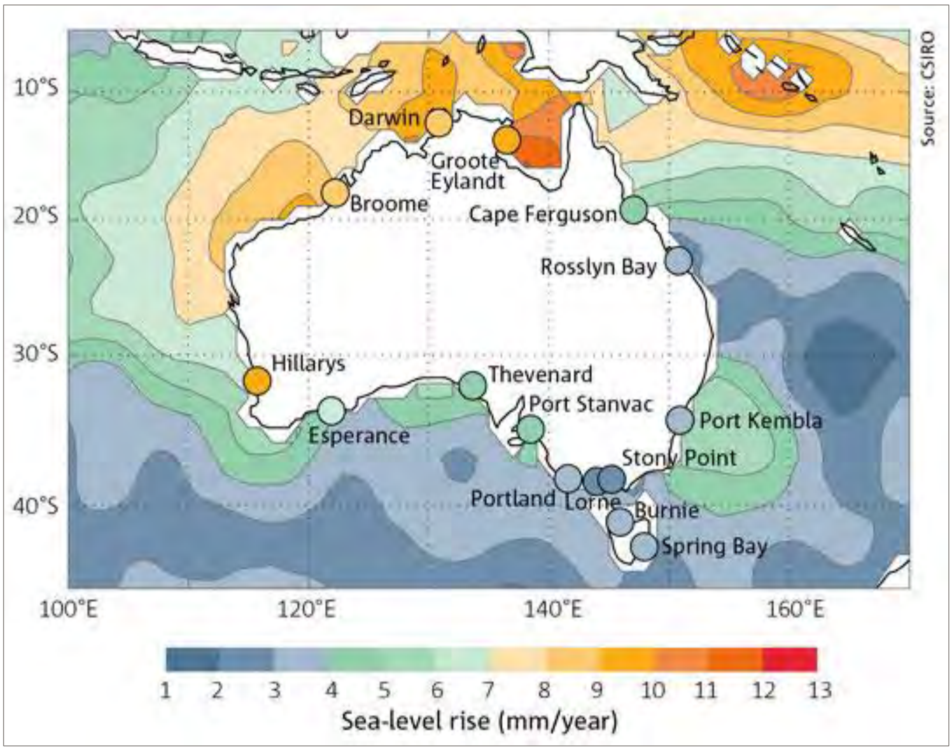


Figure 6.6 Rates of sea level rise in Australia[62]

Rises in sea level are important for the Great Barrier Reef ecosystem as some habitats are shallow and strongly influenced by sea level. In particular, because much of the land adjacent to the Great Barrier Reef is low lying, small changes in sea level will mean increased erosion and land inundation, causing significant changes in tidal habitats such as mangroves, and saltwater intrusion into low lying freshwater habitats.[1,64] Brackish saltmarsh habitats are being displaced by mangroves.[65] Turtle nesting beaches are particularly vulnerable to rising sea levels which exacerbate beach erosion[66] and inundate nests. Seabird nesting and shorebird roosting sites are also at risk.[67]

6.4.2 Catchment run-off

Increased freshwater inflow

Freshwater inflow to the marine environment from heavy or prolonged rainfall and flood events can reduce salinity and have a range of effects on marine life on a regional scale. Freshwater input is generally higher in the southern half of the Region, corresponding with the larger catchments. Recent La Niña conditions resulted in increased average annual rainfall and flood events between 2008 and 2012 (Figure 6.7). Much of the inshore areas of the Region have been exposed to freshwater over the last decade (Figure 6.8).

Across Australia, heavy rainfall events are likely to become more frequent as the temperature increases[31], with a tendency for more abnormally large freshwater inflows to the marine environment.

In a natural system, freshwater wetlands and the forested floodplain capture and slow freshwater flows. Changes to catchment ecosystems, such as infilling wetlands and constructing levee banks and drainage, have had major effects on the quantities of freshwater entering coastal seas.[68] At the same time, the clearing of forests and woodlands, and their replacement with grasslands for grazing, have substantially affected overland and groundwater flow.

Activities such as agriculture, urbanisation and industrial development can increase the magnitude and timing of freshwater inflows into the Region. For example, roads, stormwater drains and other urban infrastructure can increase the volume and speed of freshwater inflow, compared to natural vegetation and soil which retard water movement.[69] Stormwater drains release large quantities of fresh water into the sea that would normally percolate through the groundwater along shorelines and in riparian areas.

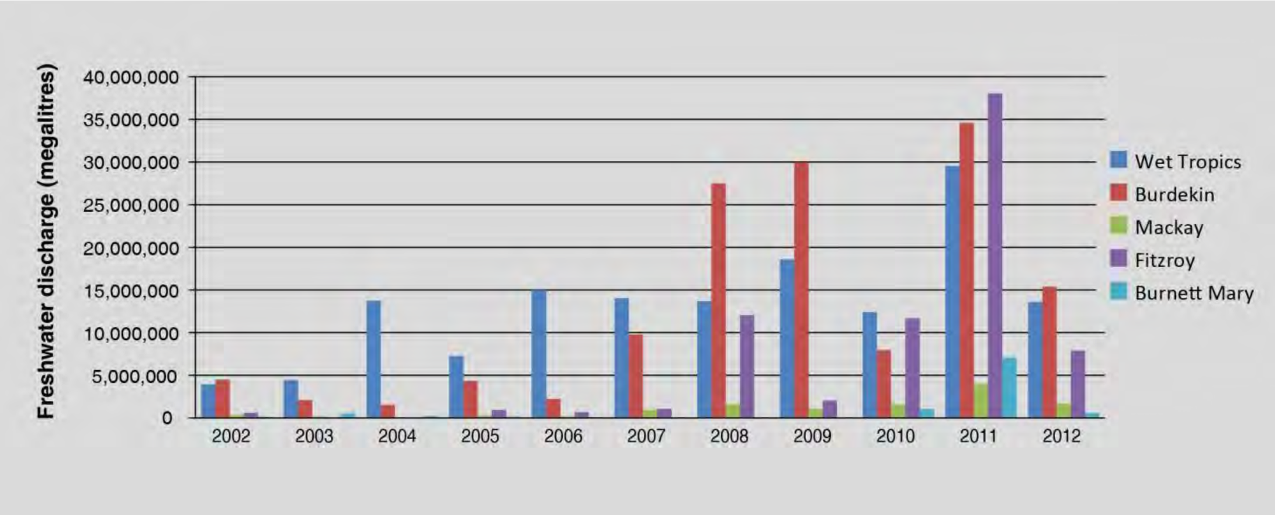


Figure 6.7 Annual freshwater discharge from the major rivers of the Great Barrier Reef catchment, 2002–2012

Much greater volumes of freshwater entered the Great Barrier Reef lagoon between 2008 and 2012 compared to previous years. Higher than average annual freshwater discharges were recorded for many of the major rivers, especially in southern catchments. In 2011, discharge volumes in the Fitzroy and Proserpine Rivers were the largest ever recorded. In the Herbert River, the volume was equal to the biggest ever recorded, while the Burdekin River experienced the third biggest. For each year, the inflow is for the 12-month period starting in October of the previous year. Data for 2012 is up to August of that year. (Figure compiled from data provided by the Australian Institute of Marine Science[70]).

Generally, natural freshwater flows enhance estuarine productivity, provide connectivity between freshwater habitats and the sea, and improve fish recruitment and growth.[71] Maintaining natural freshwater flows can have positive effects, for example on breeding and recruitment of estuarine and marine fish of commercial and recreational value including barramundi and king threadfin.[72,73] Abnormally large freshwater inflows can have negative effects, for example low salinity bleaching and mortality in corals[74] or widespread damage to seagrass meadows[39].

Increased freshwater inflow during flood events also carries with it pulses of nutrients, sediments, pesticides and other pollutants from catchment run-off, which has significant effects on inshore Great Barrier Reef habitats and species[75] (see relevant impacts in this chapter).

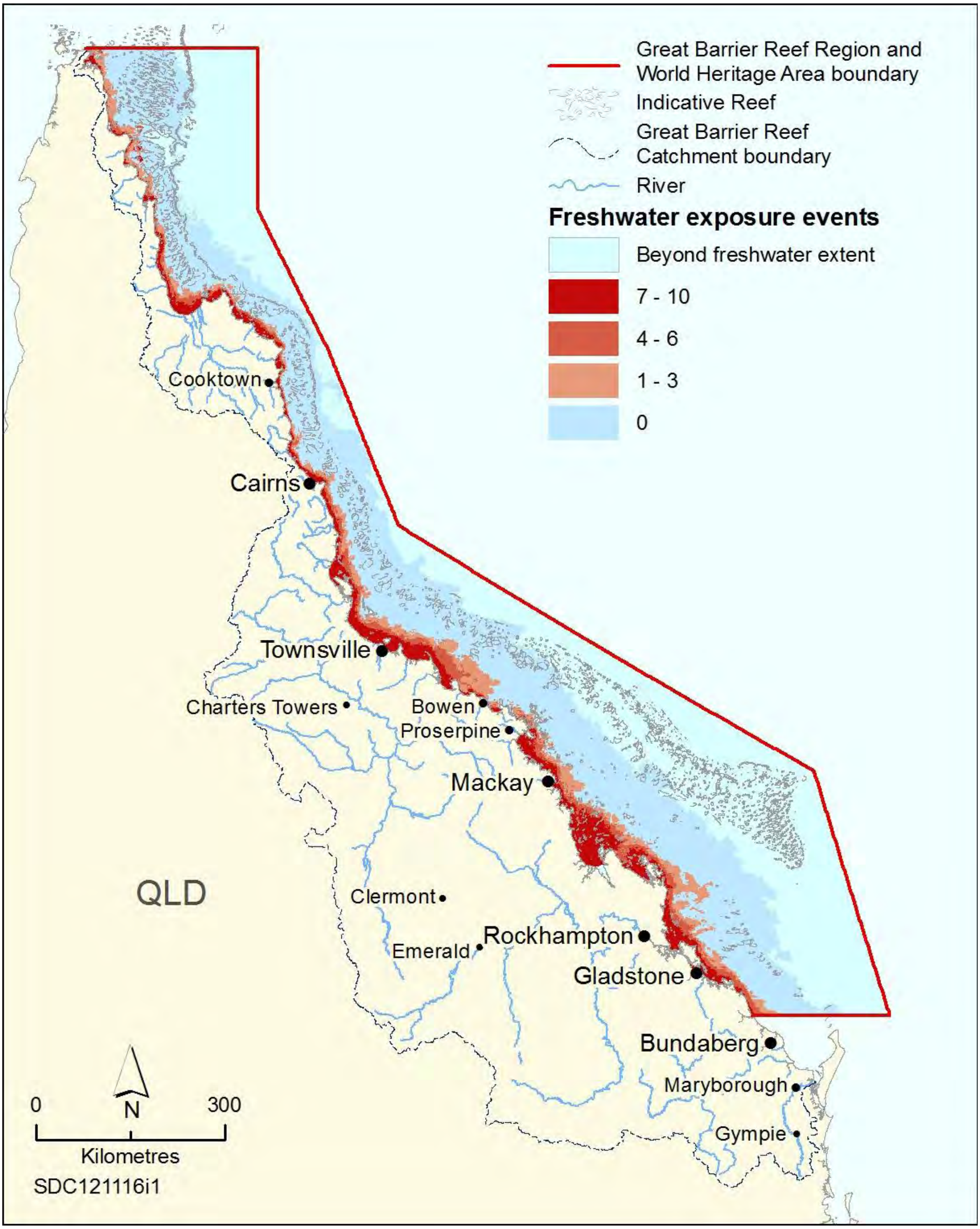


Figure 6.8 Freshwater exposure in the Region, 2001–2011[55]

Observed frequency of freshwater plumes between 2001 and 2011 modelled from remotely sensed concentrations of dissolved organic matter (a proxy for freshwater), provided by CSIRO Land and Water. Gradings are based on the number of times a freshwater plume with a measured concentration of salinity less than 30 (+/- 4) parts per thousand was observed in any given year over the 10 year period. Gradings were expressed as: low (1–3 events), medium (4–6 events) and high (7–10 events) where the maximum frequency of events observed was 10.

Nutrients in catchment run-off

The majority of coral reef habitats in the Great Barrier Reef evolved over thousands of years in nutrient-poor waters. The symbiosis between corals and the algae that live inside them evolved as a response to this lack of nutrients, allowing corals to harvest energy from photosynthesis by the algae.

The changes in land use since European settlement, including clearing and the application of fertilizers, have significantly altered nutrient concentrations in the inshore waters of the Great Barrier Reef lagoon to the extent that it is one of the most significant factors affecting Reef health.[1]

Dissolved inorganic nitrogen and phosphorous continue to enter the Great Barrier Reef ecosystem at greatly enhanced levels compared to those prior to European settlement. Estimates suggest the total nitrogen discharge into the Great Barrier Reef ecosystem has increased from 14,000 tonnes annually before European settlement (late 1800s) to 80,000 tonnes annually in the early 2000s — an almost six-fold increase, ranging from a doubling in some catchments to an almost twenty-fold increase in others.[76] Similarly, it is estimated that almost nine times more phosphorus is entering the ecosystem compared to pre-European settlement, with some catchments as high as 30 times more.[76]

Sources for nutrients into the Great Barrier Reef system include river discharges[77], urban run-off[78,79], atmospheric input[80], nitrogen fixation by marine organisms[81], deep ocean supply from upwellings[82], deposition of dust from storms and wind[83], and resuspension of nearshore sediments[84,85]. Of these, the single largest source is river discharges[86], largely driven by the application of fertilisers and the subsequent loss of dissolved inorganic nutrients into the water column. Nutrients are also transported as part of the sediment load bound to particulates (particulate nutrients).[87] More than 90 per cent of these river discharges occur during the wet season.[79,88,89]

While the coarser-grained sediments and their bound particulate nutrients initially settle out of the water column close to river mouths, nutrients bound to clay and sediment fractions travel much further and dissolved nutrients disperse widely in the Great Barrier Reef lagoon.[87,90]

Changes to catchment ecosystems from human activities can also contribute to nutrients in catchment run-off through altering processes such as nutrient and chemical cycling.

Nutrients in the marine environment can be assessed by measuring chlorophyll concentrations, as the amount of planktonic algae containing chlorophyll in the water column is proportional to nutrient concentrations. Monitoring and modelling indicate that chlorophyll concentrations in up to 10 to 15 per cent of the Region have exceeded the *Water Quality Guidelines for the Great Barrier Reef Marine Park* in the last decade.[91,92] For much of the southern nearshore environment, concentrations are frequently above the annual guidelines (Figure 6.9), with some areas more than double.

Once dissolved inorganic nutrients enter the marine system, they are taken up by phytoplankton, bacteria and benthic organisms such as macroalgae and seagrasses. This promotes growth in these organisms which in turn affects a variety of other species, habitats and processes. Imbalances in the nutrient cycle are having severe consequences for many of the Region's values. For example:

- Nutrients in flood discharges result in extensive, observable phytoplankton blooms and likely shifts in the species composition of phytoplankton.[87,93]
- There is strong scientific evidence that an increase in the frequency of crown-of-thorns starfish outbreaks is linked to increased nutrients in the open water. More nutrients lead to greater concentrations of phytoplankton, the food source of the planktonic larval stage of the starfish (see Figure 6.10).[94,95]
- The complex relationship between corals and macroalgae is affected by nutrient status. Higher nutrient concentrations may contribute to an increase in macroalgal abundance and a decrease in coral diversity. This drastically affects the overall resilience of the ecosystem, as a dominance of macroalgae reduces the chance for hard corals to recruit, establish and grow, which perpetuates the shift towards an algae-dominated ecosystem.[96,97]
- There is evidence that elevated nutrient concentrations may make corals more sensitive to temperature stress.[98,99]
- While seagrasses may benefit from small increases in nutrients in the water column, elevated concentrations can be detrimental to seagrass health and resilience. Lowered ambient light levels, as a result of increased growth of phytoplankton, macroalgae and algal epiphytes that compete for light, can reduce photosynthesis in seagrass, particularly in deeper waters.[100]

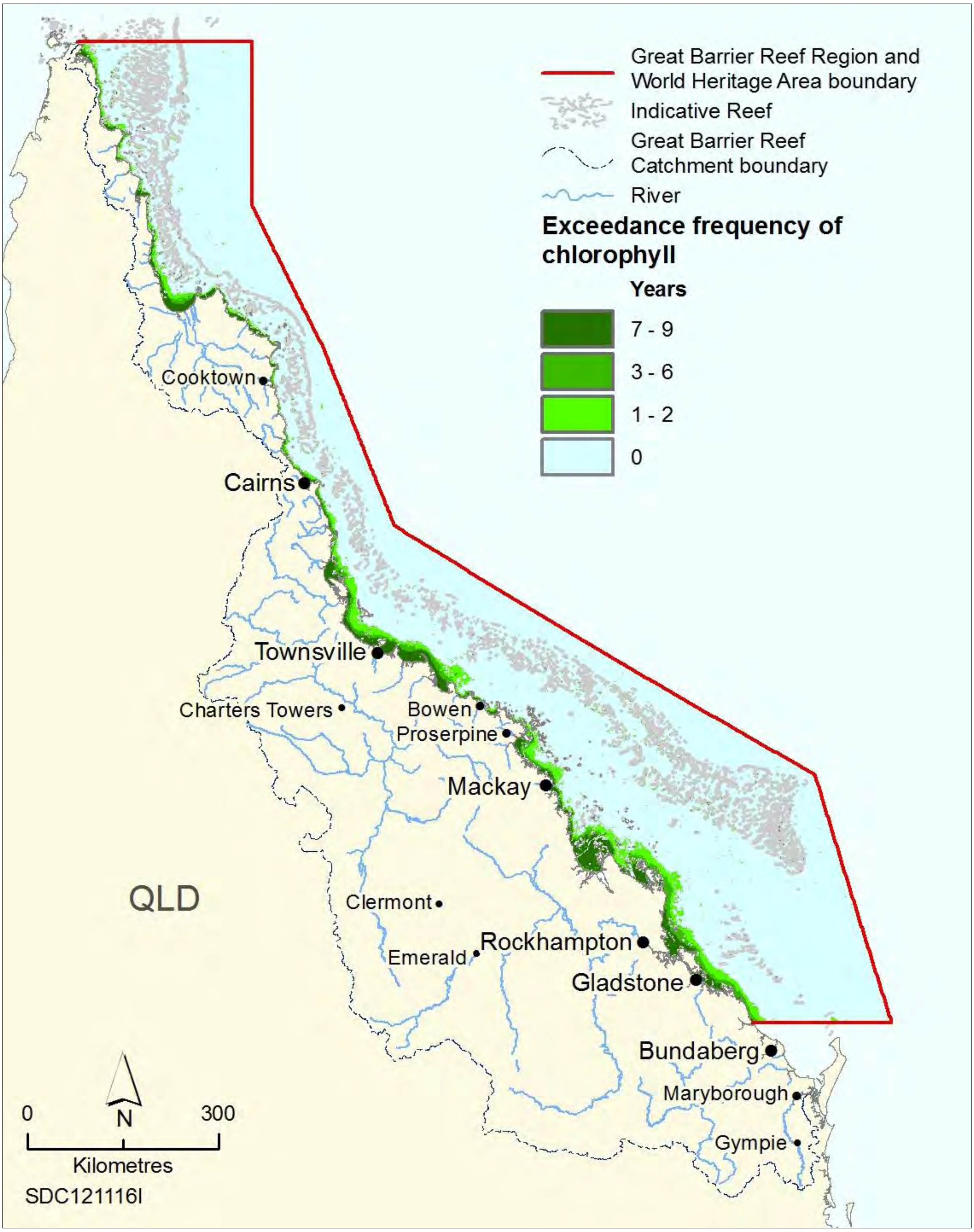


Figure 6.9 Years that chlorophyll concentrations exceeded the guidelines in the Region, 2003–2012[101]

The water quality guidelines for the Great Barrier Reef Marine Park use chlorophyll concentration as an indicator for nutrient concentrations in open waters. The guideline trigger value is an annual mean of 0.45 micrograms of chlorophyll per litre. The map shows the number of years that the guideline value was exceeded between 2003 and 2012.

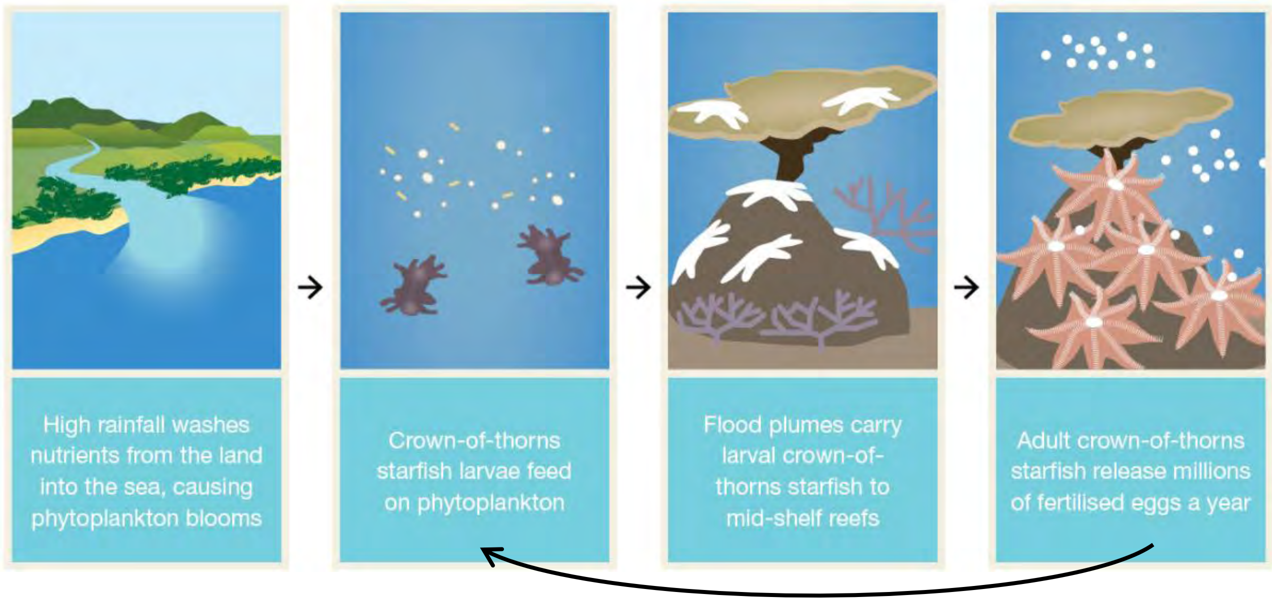


Figure 6.10 Role of nutrients in the population dynamics of crown-of-thorns starfish
Crown-of-thorns starfish are a major cause of loss of coral cover. There is evidence that their populations are significantly affected by the concentration of nutrients and, therefore, the amount of phytoplankton in Great Barrier Reef waters.

A key target of the *Reef Water Quality Protection Plan 2013*[102] (Reef Plan) is to achieve a 50 per cent reduction in nutrient loads entering the Great Barrier Reef by 2018. Total fertiliser use on farming lands in the catchment has been reduced in recent years (see Figure 5.10), and recent monitoring and modelling show current initiatives are successfully reducing nutrient concentrations in catchment run-off. The Reef Plan Report Card for 2011 reports that, through implementation of best management practices in sugar, grazing and horticulture industries, over the previous two years there was reductions in sediment load of six per cent, total nitrogen load of seven per cent and pesticide load of 15 per cent entering the Great Barrier Reef.[103] Early evidence shows reductions in the nutrient load entering the marine system has resulted in reduced nutrient concentrations in open waters.[104,105]

Elevated levels of another nutrient, dissolved organic carbon, can accelerate the growth of microbes on corals, which can cause coral death by oxygen depletion, accumulation of poisons and/or microbial predation on weakened coral.[106] In fact, it has been suggested that dissolved organic carbon causes more coral death than other more routinely measured water quality components (for example, nitrogen, phosphorus and ammonia).[106]

Outbreak of crown-of-thorns starfish

Crown-of-thorns starfish are a major predator of coral. Under natural conditions, it is likely that their populations increase to outbreak concentrations in a 50 to 80 year cycle.[95] However, there have been three major population outbreaks of crown-of-thorns starfish over the past 50 years.[95] These occurred from 1962 to 1976, 1978 to 1990, and 1993 to 2005.[94] An emerging outbreak was detected in 2011. An outbreak of crown-of-thorns starfish is considered to be occurring when they are at densities greater than about 30 starfish per hectare.[107,108]

Outbreaks appear to be initiated in the area between Lizard Island and Cairns, and gradually progress south over several years,[109] although independent outbreaks have been observed in the Swains Reefs in the far south (Figure 6.11). Each of these outbreaks has resulted in severe reductions in coral cover on a regional scale, particularly in the central area of the Region.[110] A crown-of-thorns starfish can consume up to 478 square centimetres of coral each day.[111]

Outbreaks of crown-of-thorns starfish have been one of the major causes of coral death and reef damage on the Great Barrier Reef since surveys began in the 1980s. Analysis of long-term monitoring data has estimated a decline in coral cover of more than 50 per cent in the past 27 years — 42 per cent of which has been attributed to crown-of-thorns starfish outbreaks[35] (see Section 7.1.2).

There is scientific evidence that, while occasional outbreaks are to some extent natural, human impacts have increased their frequency and severity.[95] There are indications that increased nutrient loads lead to crown-of-thorns starfish outbreaks due to increased food supply for their larvae [95,112,113] (see Figure 6.10). The reduction in populations of fish that prey on crown-of-thorns starfish may also have some effect, although this is still a matter of conjecture.[114,115] Importantly, the increased frequency of outbreaks, combined with other stresses on corals, means coral populations are unable to fully recover before the next outbreak occurs.

During 2009 and 2010, increases in local populations of crown-of-thorns starfish were beginning to be observed. By late 2011, tourism operators, fishers, rangers and researchers were reporting signs of an emerging outbreak of crown-of-thorns starfish in the northern Great Barrier Reef between Lizard Island and just south of Cairns. In June 2012, the Australian Government invested $1.43 million for targeted control of starfish in this area. The Authority contracted the Association of Marine Park Tourism Operators to undertake the control operations, with priority given to protecting sites of high value to the Reef tourism industry and, where possible, conducting broader scale control. Between August 2012 and May 2013, 63 reefs were visited out of 330 reefs in the area and 77,679 starfish were removed. A summary of the number of starfish removed to September 2012 is presented in Figure 6.12. In addition, the Queensland Government has invested $1 million to control crown-of-thorns starfish through the Skilling Queensland program. Work placement participants assist in small-scale control of crown-of-thorns starfish on selected coral reefs.

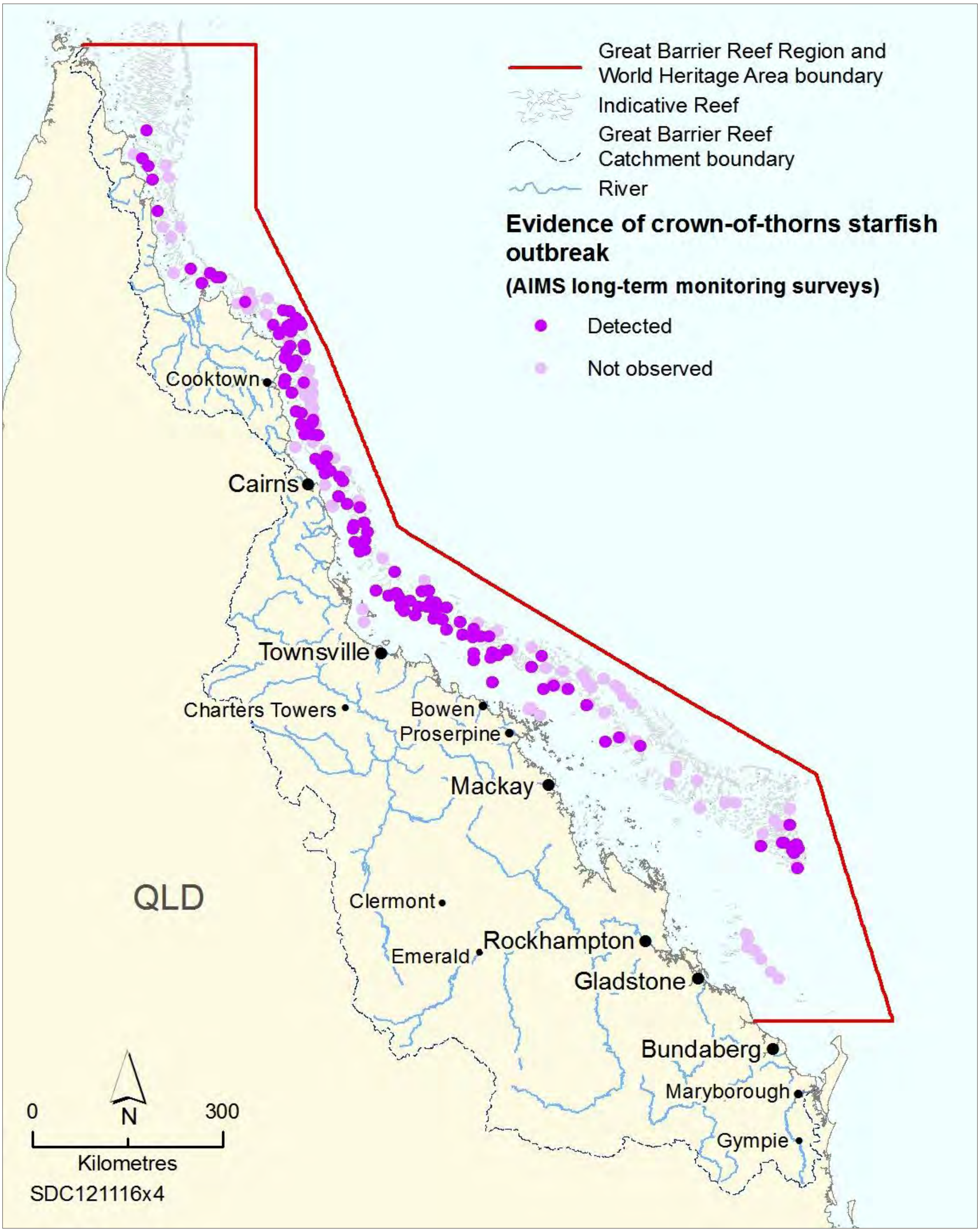


Figure 6.11 Extent of observed crown-of-thorns starfish outbreaks in the Region, 1986–2011[55]
The map shows areas where evidence of an outbreak has been recorded. This includes active outbreaks, incipient outbreaks or recovery from an outbreak.

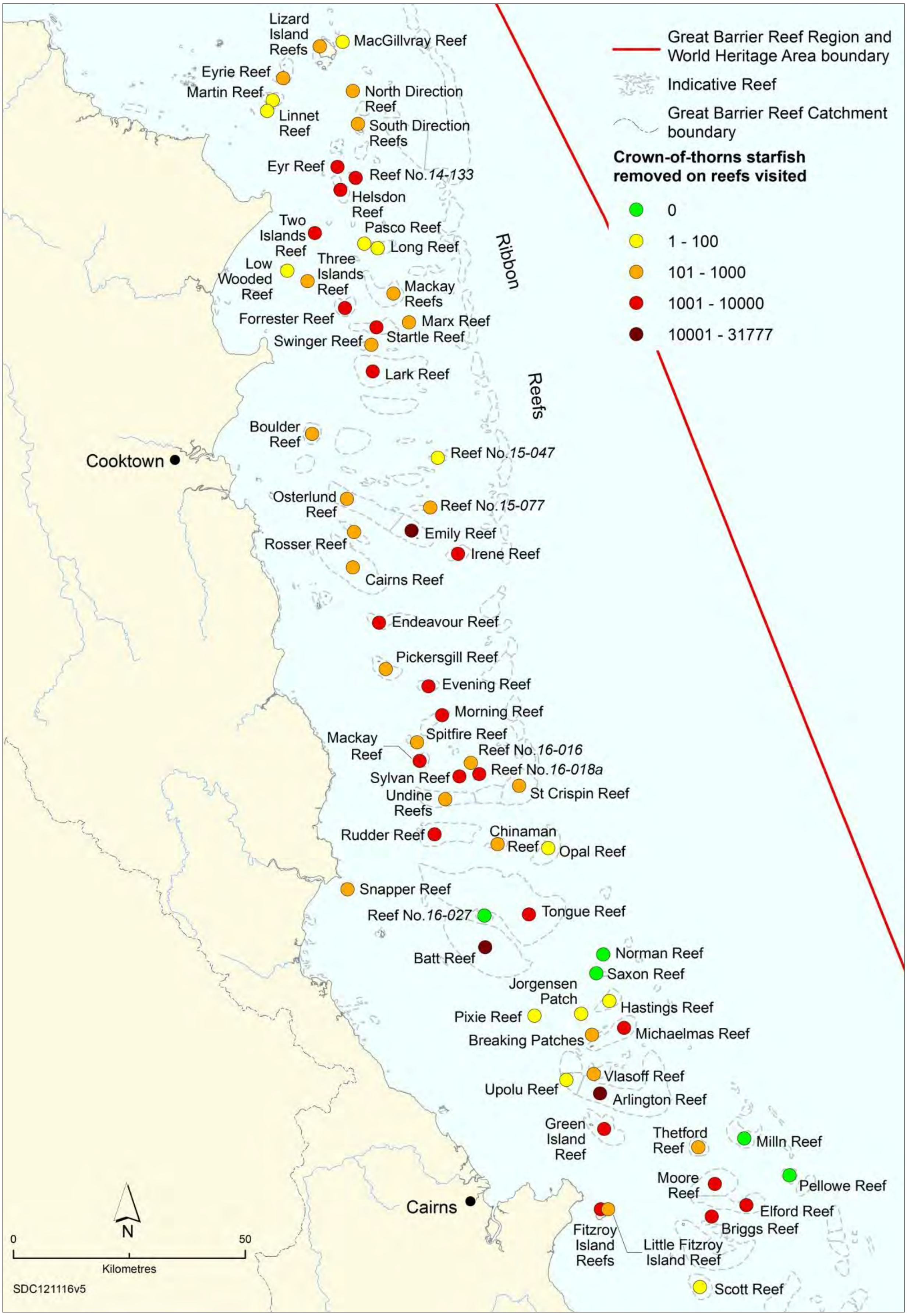


Figure 6.12 Removal of crown-of-thorns starfish, offshore Cairns, August 2012 to September 2013

Reefs where high numbers of starfish have been reported are targeted for repeat visits in the starfish control program. Effort is focused on one or more sites at each reef. The map shows the number of starfish removed from each reef over 39 10-day voyages. (Data provided by the Association of Marine Park Tourism Operators)

Pesticides from catchment run-off

Pesticides, including herbicides, insecticides and fungicides, are used to kill or control pests in agricultural and urban environments and would have been absent from the Region's environment prior to European settlement.[116] It is estimated that at least 28,000 kilograms of herbicides are now introduced into the World Heritage Area each year.[76] The total pesticide load is not accurately known as not all pesticides used in the catchment and draining into its waterways are currently monitored and not all locations can be easily sampled.[76,116] Recently, more systematic monitoring of pesticide residues[117] has shown widespread contamination by a range of pesticides in rivers, streams and estuaries draining to the Region[116], particularly areas south of Port Douglas. This includes frequent exceedances of the Australian and New Zealand Water Quality Guidelines for fresh waters[118] (often 10 to 50 times), for example atrazine and diuron.[119]

Elevated herbicide concentrations have been particularly linked with sugarcane cultivation in the adjacent catchment.[120,121,122] Irrigation shortly after herbicide application is a major mechanism of herbicide loss from farms.[123] The sugarcane industry has taken initiatives, many funded through the Reef Rescue program, to reduce the run-off of herbicides including precision application (band spray) of herbicides.[124]

Pesticides have been detected in inshore areas of the Region (Figure 6.13) and are of concern as they can have a negative impact on marine plants and animals.[119,120] Herbicide concentrations in flood plumes that extend into the marine environment can exceed concentrations shown to have negative effects on certain species of coral, seagrass and microalgae and present risks to marine mammals.[125,126,127,128,129,130,131] Estuarine areas and freshwater wetlands are more exposed to pesticides as they are closer to the source.

The risk from pesticide exposure is of particular concern for inshore areas in the Mackay Whitsunday Region, Bowling Green and Keppel bays and waters between Port Douglas and Cardwell [130] (Figure 6.13). Other nearshore areas are of low risk, and further offshore the risk might be considered insignificant or zero.

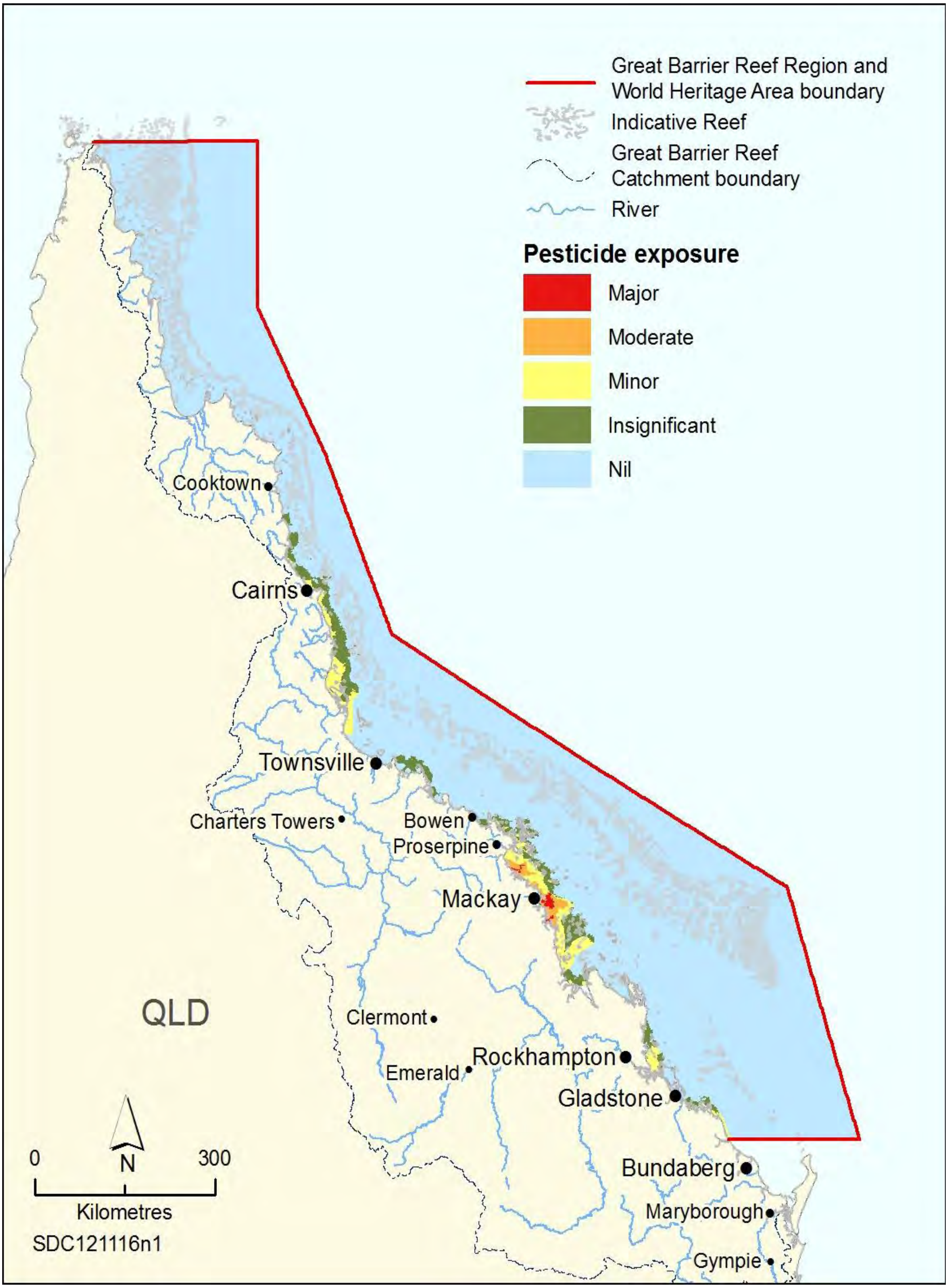


Figure 6.13 Risk areas of additive PSII herbicide residues modelled in the Great Barrier Reef Region[132]

The model calculated additive photosystem II inhibiting (PSII) herbicide concentrations using end-of-river monitoring data and applied the established relationship of concentration of dissolved organic matter to salinity to corresponding satellite images of flood plumes to predict the additive PSII concentrations. Conservative mixing processes in the Great Barrier Reef lagoon were assumed. Consequence categories are based on known toxicity data to coral and seagrass species and these thresholds, where they were reached, were mapped using the modelled concentrations.

Sediments from catchment run-off
Sediments from the catchment are mostly transported to the Region via coastal rivers during the wet season.[133,134]

It is estimated that since European settlement of the catchment in the 1850s, the average annual suspended sediment load entering the Great Barrier Reef has increased by 5.5 times from 3100 to 17,000 kilotonnes per year, with some catchments as high as 14 times more.[76] This is mainly due to increased soil erosion where areas have been cleared of native vegetation to establish pasture grasses for grazing. It has been exacerbated by poor land management practices. In addition, hardened surfaces and straightened channels, as a result of urban and industrial development and agriculture, mean run-off has more erosive power, exacerbating stream bank erosion.

Much of the inshore southern area of the Region is now frequently affected by increased suspended solids that often exceed water quality guidelines (Figure 6.14). Most sediment is confined to the inner shelf and settles out of the water column within five to 15 kilometres of the coastline[133,135,136] where it may be later resuspended by wind-generated waves and currents. However, during flood events, suspended sediment may be carried further offshore. For example, during the 2010–11 wet season, when the Burdekin River had highly elevated discharge over 200 days, most sediment initially settled within approximately 10 kilometres of the river mouth, but some fine silt and clay was carried as far as 100 kilometres northward.[137] These fine colloidal sediments also carry nutrients and other contaminants further into the Region.[138]

Increasing sediment loads have far-reaching effects on the Great Barrier Reef values. For example:

- The heavier erosion sediments, which flow more slowly through the system, are filling freshwater stream beds and deep waterholes. This degrades these habitats, affecting the distribution, abundance and recruitment of many freshwater species and some marine-related species such as sawfish.[139]
- Increases in suspended sediment significantly alter light regimes — lower light levels reduce primary production, both pelagic and benthic (including in the coral-algae symbiosis).
- As the increased sediment load settles, it can smother benthic organisms such as seagrass and corals, making it harder or impossible for them to grow, survive and reproduce.[140,141] This has significant flow-on effects to organisms and animals dependent on these habitats.
- The resuspension of sediments increases the turbidity of open waters and releases additional nutrients previously bound up or buried in sediments.[93,142,143]

Tourism operators voluntarily monitor the health of their tourism sites as part of the Eye on the Reef program. Six years of data collected from tourism sites (Figure 6.15) has found water clarity at some sites is diminishing, particularly in the southern Great Barrier Reef, which is consistent with results presented in Figure 6.14.

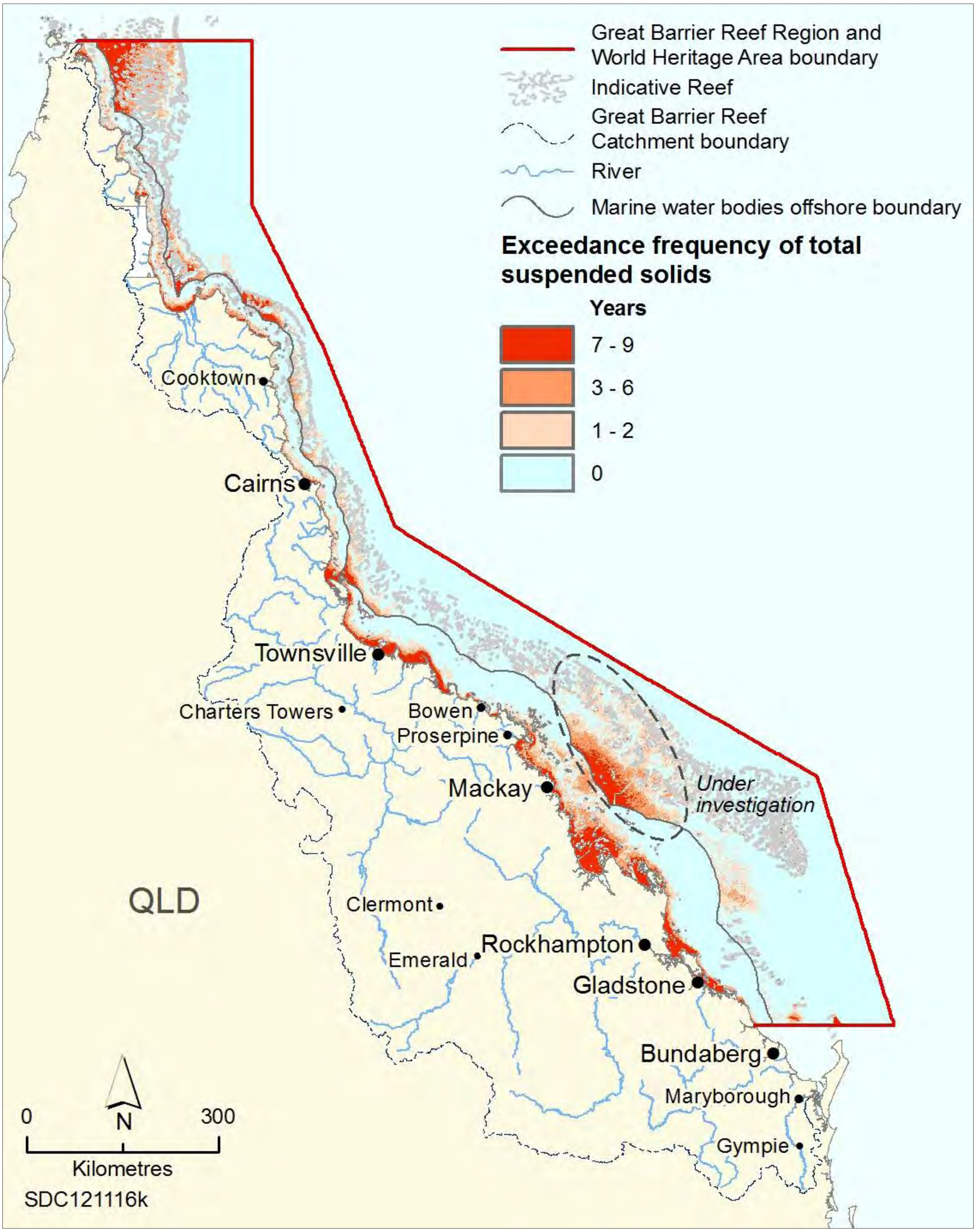


Figure 6.14 Years that total suspended solids exceeded the guidelines in the Region, 2003–2012[101]

The map shows the number of years that the relevant water quality guidelines value was exceeded between 2003 and 2012. The exceedances in offshoreareas, particularly the Mackay–Fitzroy region (indicated by the dashed line), are under investigation. They may be due to an overestimate of mean concentrations or may indicate a need to revise the boundaries and concentrations in the guidelines.

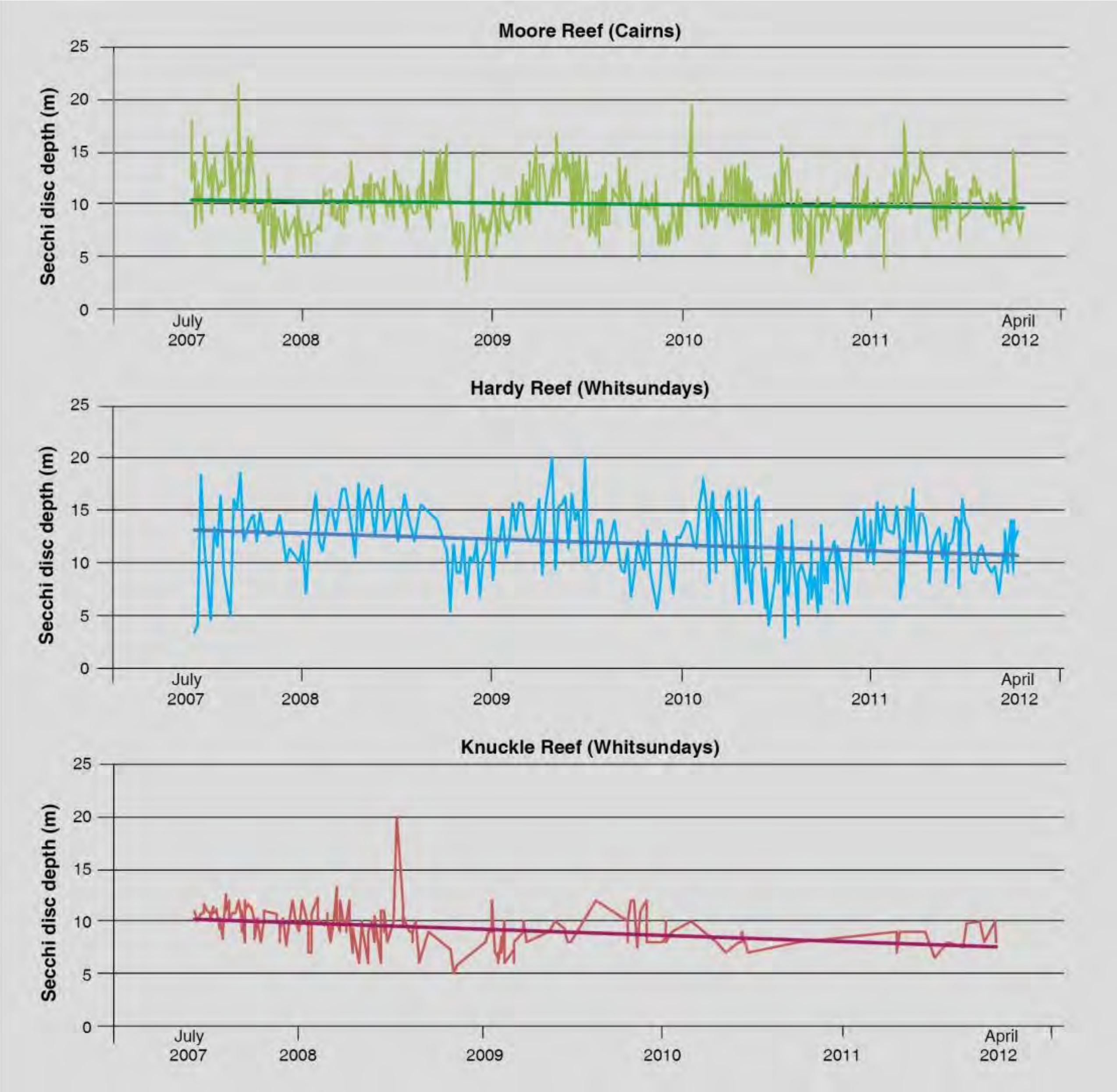


Figure 6.15 Water clarity at three tourism sites

Secchi disc depth data collected voluntarily by tourism operators as part of the Authority's Eye on the Reef program. The six year data series shows water clarity has declined slightly in the northern Great Barrier Reef. In the south, the rate of decline has been greater.

Urban and industrial discharge

Urban and industrial discharge refers to all pollutants that enter the Region from the land via pipes and drains. It includes sewage, industrial waste, stormwater and wastewater discharge. The contribution of key pollutants from urban sources is relatively small when compared to diffuse pollutant sources. These impacts can however be locally significant.[144]

There have been significant improvements in the management of sewage in major urban centres of the catchment (see 5.3.12) over the last decade. Large investments have been made in upgrading sewage treatment plants at the major coastal population centres of Cairns, Townsville, Mackay and Bundaberg to a tertiary treatment standard. Urban populations with fewer than about 3000 people generally use individual septic tanks at dwellings. The rapidly growing population in most coastal centres is placing increased pressure on local governments to maintain and improve sewage management.

Wastewater is treated at a treatment station before it is discharged to creeks or rivers or reused over land, and some (but not all) impurities are removed. Stormwater run-off receives no treatment (other than gross pollutant traps) and therefore any chemicals or rubbish it contains can flow directly into creeks or rivers and into the marine environment. To improve stormwater management, local councils are working with their communities and Queensland Government agencies to manage rubbish disposal and the use of chemicals, while documenting environmental values for their local rivers and streams.

Industrial discharge is subject to strict environmental controls. The discharge can release chemicals such as metals, metalloids and non-metallic inorganics in wastewater. There are national, state and Great Barrier Reef-specific water quality guidelines that identify trigger levels on the discharge of these chemicals.[1] However, many facilities were built decades ago, with long-term permits containing a variety of conditions.

Historically, there have been extensive small-scale mining operations through much of the catchment, including gold, tin, nickel and uranium mines.[145] Some operations have released toxicants which have had severe effects, at least locally, in streams and creeks, for example arsenic associated with tin mining near Herberton.[145] Sediment cores from inshore areas near Townsville have shown a spike in mercury of 25 times the background levels (before European settlement) that coincides with a period of intense gold mining in the adjacent catchment area (between 1870 and the early 1900s) when mercury was used in gold processing.[146]

Extreme flooding events can affect mines within the catchment. Recently, after widespread flooding, more than 30 temporary environmental programs were permitted in central Queensland to address mine flooding. The Queensland Flood Commission of Inquiry proposed a number of changes to the state's Regulations and recommended actions to address mining and water management issues.[147] These included further legislative changes regarding temporary environmental programs and associated permissions. A pilot program of allowing mine wastewater releases during flood conditions was implemented in the 2013 wet season.[148] The results of monitoring associated with these releases will improve understanding of the extent of any effects on water quality, including within the Region.

6.4.3 Degradation of coastal ecosystems

Acid sulphate soils

Potential acid sulphate soils often form where seawater (containing sulphides) mixes with land sediments that contain iron oxides and organic matter in a waterlogged condition without oxygen. In these conditions, the iron sulfides are stable and the surrounding soil is often weakly acid to weakly alkaline. However, when this soil is exposed to air (termed 'actual acid sulphate soils'), these soils produce sulphuric acid, often releasing toxic quantities of iron, aluminium and heavy metals.[149] Potential acid sulphate soils are often found in mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes.[150] Typically, they may be disturbed through coastal development (specifically the removal of coastal vegetation) and some activities associated with agricultural practices such as drain construction.[151] In drained wetlands, run-off from acid sulphate soils is known to travel through groundwater to estuaries during floods.[152] Modifying floodplains and wetlands can expose acid sulphate soils, resulting in mobilisation of large quantities of iron and aluminium through surface and groundwater, which has been linked to algal blooms such as the toxic *Lyngbya* species.[153]

Potential acid sulphate soils are found extensively in Great Barrier Reef coastal areas and islands.[154,155,156] There has been historical disturbance[157] and once disturbed, if not treated, acidic water and heavy metals can be released during rain events for decades to come. The combination of acid waters (often with a pH of between two and four) and high concentrations of heavy metals (usually toxic in trace amounts) will affect many species, both immediately and as accumulators in food chains. The impact of acid sulphate soils can affect a range of values such as beaches and coastlines, mangroves, seagrass meadows, invertebrates and fish at a local scale. The effects are often long term and difficult to reverse.[158,159]

Artificial barriers to riverine and estuarine flow

Artificial barriers, dams and other modifications to waterways, such as straightening of channels, affect the natural hydrology in the catchment and may affect Great Barrier Reef species that move between terrestrial and freshwater habitats and the sea.

Barriers to riverine and estuarine flow, such as weirs, dams, barrages, gates, levees, ponded pastures and weeds are widespread in the catchment. For example, 41 impediments to natural environmental flows have been identified as affecting the internationally listed Bowling Green Bay wetland[160], while in the Burdekin Dry Tropics natural resource management region there are estimated to be more than 1000 obstructions to fish passage.[161]

The interface between the estuarine and freshwater systems is a very productive component of the food chain. Estuaries and coastal waterways are also critical corridors for movement between ecosystems.[20] As many as 78 Great Barrier Reef marine and estuarine fish species use the freshwater systems for part of their life cycle[162] and can be affected by changes in water flow and the presence of artificial barriers.

The loss of 30 to 60 per cent of estuarine and brackish water habitats, largely saltmarshes and mud flats[20], is likely to have had effects on shorebirds and fish productivity and survival, particularly through the disruption of tidal systems.

Dams and weirs on rivers reduce freshwater flows in the wet season and often result in increased flows in the dry when the stored water is released.[145] The released water usually comes from deep in the dam, and its temperature and chemistry (for example concentration of dissolved oxygen) is significantly different to natural river flows. Dams also act as traps for sediments (mainly the coarse fraction). For example, the Burdekin Falls Dam captures 60 to 80 per cent of the sediment of the Burdekin River's upstream tributaries.[163]

Hardened surfaces and straightened channels, as a result of urban and industrial development and agriculture, mean there is greater run-off and less water retention on the land. Levees and other structures used to channel waters off the land have significantly modified hydrological processes in many parts of the catchment.[20,164,165,166]

Heavy, salty water sinks are a driver of ocean currents. Water extraction, plus barriers to river and groundwater flow, can increase the salinity of seawater in bays, modifying ocean currents. [167]

Atmospheric pollution

In general terms, atmospheric pollution refers to that from domestic, industrial and business activities. For the purposes of this report, this potential impact does not include the release of carbon dioxide and other greenhouse gases into the atmosphere — the effects of such pollution are covered in the impacts related to climate change (see Section 6.4.1) such as increasing sea temperature.

Atmospheric pollution is not a major issue for the Region's environment. Urban and industrial development is relatively minor and localised in the Great Barrier Reef catchment; however, future projections suggest an increase in both. If not properly managed, this could result in increased atmospheric pollution. Atmospheric pollution has the potential to affect the health of species living in the Region on a local scale, including birds and island plants. It could also affect aesthetic values.

Air pollution from coal dust can occur anywhere coal is handled, conveyed or open to erosion by the wind.[168] Coal dust tends to float[169] and can therefore remain on the water's surface, potentially reducing the amount of sunlight reaching seagrasses and corals and being captured by filter-feeding organisms. Coal dust particles can also aggregate and settle, potentially smothering benthic habitats. While trace elements can leach from coal particles into seawater — some of major concern include arsenic, mercury, lead, sulphur and boron[170] — Australian coal has relatively low trace element concentrations.[168]

Coastal reclamation

Coastal reclamation refers to the process of creating new land where there was ocean, wetlands, or other water bodies by filling the area with 'land fill' or infrastructure such as groynes and jetties. Reclamation projects can be for public open space, housing or commercial and industrial developments.

The total area reclaimed within the Region is approximately eight square kilometres, the majority of which is in the Gladstone area (approximately 5.5 square kilometres). The largest coastal reclamation projects have been for the development of ports, for example in Gladstone and Townsville.[1]

Land disposal of dredge material including reclamation can have localised effects on habitats critical to the Great Barrier Reef's health. Between 2000 and 2012, the total volume of material disposal to land (that is, areas above highest astronomical tide) from dredging activities occurring in the Great Barrier Reef Marine Park was 67,000 cubic metres. The volume of dredge material disposed to land from operations within the World Heritage Area is much larger. For some of the major ports in the last few years, the dredge material has been largely used for reclamation works in ports areas. For example, 14 million cubic metres of dredge material has been disposed to the Fisherman's Landing reclamation area in Gladstone Harbour as part of the development of Gladstone's port facilities.

Sand replenishment is a form of reclamation used to address beach erosion in order to protect coastal properties and preserve areas for recreational use.

Coastal reclamation can have local effects on the Region's environment, for example removing coastal habitats, covering marine habitats (such as seagrass meadows), altering small-scale local currents, impeding natural drainage from the catchments, altering groundwater levels, and diminishing local aesthetic values. If not properly managed, reclamation works can affect water quality in the adjacent waters and potentially expose acid sulphate soils. Coastal reclamation may also alter the mainland boundary of the World Heritage Area — defined by mean low water.

Light impacts (artificial)

The presence of artificial light in those localised areas of the Region's coast where there are ports, industrial developments, urban areas and resorts affects some species. Clearing vegetation and flattening dune systems can also reduce natural light cues and increase impacts from artificial light.[171]

Altered light regimes can disrupt animal behaviour, for example the nocturnal orientation of both adult marine turtles and their hatchlings.[18,172] Artificial lighting can disorient nesting females and turtle hatchlings by reducing the effect of natural lighting and altering topography horizons which are used as guidance mechanisms.[173,174] Seabird fledglings have been found to be attracted to artificial light, causing them to land and stay in urban areas.[175] Some fish and marine invertebrates are attracted to light. Pelagic fish have been shown to be deterred by artificial light, making them disperse and migrate to deeper waters.[176] This response may also lead to consequential impacts on inshore food webs.

Modifying supporting terrestrial habitats

Since European settlement, there have been significant losses of and modifications to terrestrial habitats that support the Great Barrier Reef ecosystem (Figure 6.16 and Figure 6.17, see pages 6-36 and 6-37). For the purposes of this report, this potential impact is focused on changes to their ecological function for Reef species and effects on environmental processes. It does not include hydrology or degradation of water quality as those effects are covered in the impacts related to catchment run-off (Section 6.4.2) or artificial barriers to flow (in this section).

Overall, approximately 60 per cent of pre-clear vegetation — classified as remnant vegetation — remains intact in the Great Barrier Reef catchment.[20] However, the status of coastal ecosystems varies greatly across regions and basins. Generally, human development and the modification of supporting terrestrial habitats intensifies from north to south in the catchment and closer to the coast. For example, much of Cape York's catchment ecosystems remain intact and these make up around one-third of the total area of currently intact ecosystems within the Great Barrier Reef catchment.[20] By contrast, in the Wet Tropics natural resource management region there has been substantial loss of native grasslands and freshwater wetlands across the entire region (greater than 55 per cent) and a high loss of forests and woodlands in several basins, especially on the coastal floodplain.[20]

The loss of functional ecosystems (such as forested floodpains and estuaries) close to the Reef is having significant effects on the feeding and reproduction of many marine species, as well as diminishing dry season refuges, has been diminished as these habitats have been lost or modified. For example, where forested floodplains have been lost through changes in land use, the areas no longer provide nesting habitat or roosts for waterbirds and shady migratory pathways for aquatic species with connections to the Great Barrier Reef.[20] Another example is the replacement of coastal grasslands with intensive agriculture or urban settlements, reducing breeding habitat for many bird and reptile species, including saltwater crocodiles.[20]

Some coastal habitats such as sand dunes are highly sensitive to trampling associated with recreational activities and damage from recreational vehicle use. Damaged coastal vegetation and compacted dune sands influence soil moisture, run-off, erosion, vegetation and micro-organisms. Some animals may also be affected by these activities. For example, shorebirds are highly sensitive to intensive use of beaches, and frequent disturbance results in reduced feeding times, lower survival of chicks, and ultimately population declines.

6.4.4 Direct use

Dredging
Dredging involves the extraction of parts of the seafloor (predominantly sand and fine silt, but also harder substrate such as rock) to deepen an area and allow increased access for navigation. It is usually associated with ports, shipping channels, marinas and boat ramps. The term 'capital' dredging is used to refer to dredging that is undertaken to create, lengthen, widen or deepen channels, berth areas, swing basins, marinas and harbour areas. 'Maintenance' dredging refers to dredging which is undertaken to ensure that previously dredged depths are maintained (that is, removing accumulated silt from the channel). The disposal or 'dumping' of dredge material from the dredge site to a disposal site is dealt with separately in the section below.

Both capital and maintenance dredging is undertaken at the majority of trading ports (see Figure 5.11) and a number of marinas within and adjacent to the Region.

Proposals currently under assessment (as at May 2013) would involve an estimated maximum of approximately 54 million cubic metres of dredging in the World Heritage Area.[177] Decisions are yet to be made in relation to these applications and it is important to note that a change in economic circumstances may result in applications being withdrawn or modified. While it is difficult to predict whether all pending applications will proceed through the full assessment process, projected increases in economic and population growth over the next 25 years (see Chapter 5) clearly demonstrate that there will be aneed for Great Barrier Reef ports to handle increasing volumes of exports and imports and therefore a future need for both capital and maintenance dredging.

Consideration of dredging impacts requires an understanding of: values or attributes likely to be affected by dredging activities, including their current condition; the scale (zone of influence), duration and frequency of dredging activities; non-dredging impacts affecting values or attributes within the dredge zone of influence and the likely combined (or cumulative) effects of dredging and non-dredging impacts on values and attributes; and ecosystem thresholds for health.

The effects of dredging activities are well documented and include: seabed disturbance[178]; removal or modification of habitats[179,180]; loss of species, including benthic organisms[181] and injury or mortality to species of conservation concern[178,182]; changes in species behaviour[183]; degradation of water quality[179,184] including increased turbidity levels[180]; changes to hydrodynamics and coastal hydrology[180]; increased underwater noise[185]; and an increased risk of oil spills[183].

Dumping and resuspension of dredge material
Once material is extracted from the seafloor during dredging, it requires disposal. Disposal sites may include ocean disposal sites, near-shore reclamation areas and land-based receiving facilities. The National Assessment Guidelines for Dredging[186] require an evaluation of alternatives to ocean disposal including the environmental, social and economic impacts of each disposal option. When disposal sites are ocean-based, the disposal is referred to as 'sea dumping'.[181]

This potential impact considers sea dumping — land disposal is considered under impacts related to degradation of coastal ecosystems (see modifying supporting terrestrial habitats and coastal reclamation in Section 6.4.3).

Between 2000 and 2012, the total volume of dredge material (from both capital and maintenance dredging) disposed in the Great Barrier Reef World Heritage Area was approximately 26 million cubic metres (Figure 6.18). An additional 13 million cubic metres has been approved for disposal within the Region, but has not yet been disposed (Figure 6.18). The largest quantity of dredge material disposed in the Marine Park in a single campaign was 8.6 million cubic metres associated with the Port of Hay Point in 2006. As noted above, if all dredge and disposal proposals currently under assessment were to be approved, up to approximately 54 million cubic metres of dredge material would need to be disposed, either on land or at sea, over coming years.

Potential effects of sea dumping depend on a number of factors including the: volume and composition of the dredge material; oceanographic conditions in and around the disposal location; proximity of the disposal location to sensitive species and habitats; and the timing and frequency of dredge material disposal.

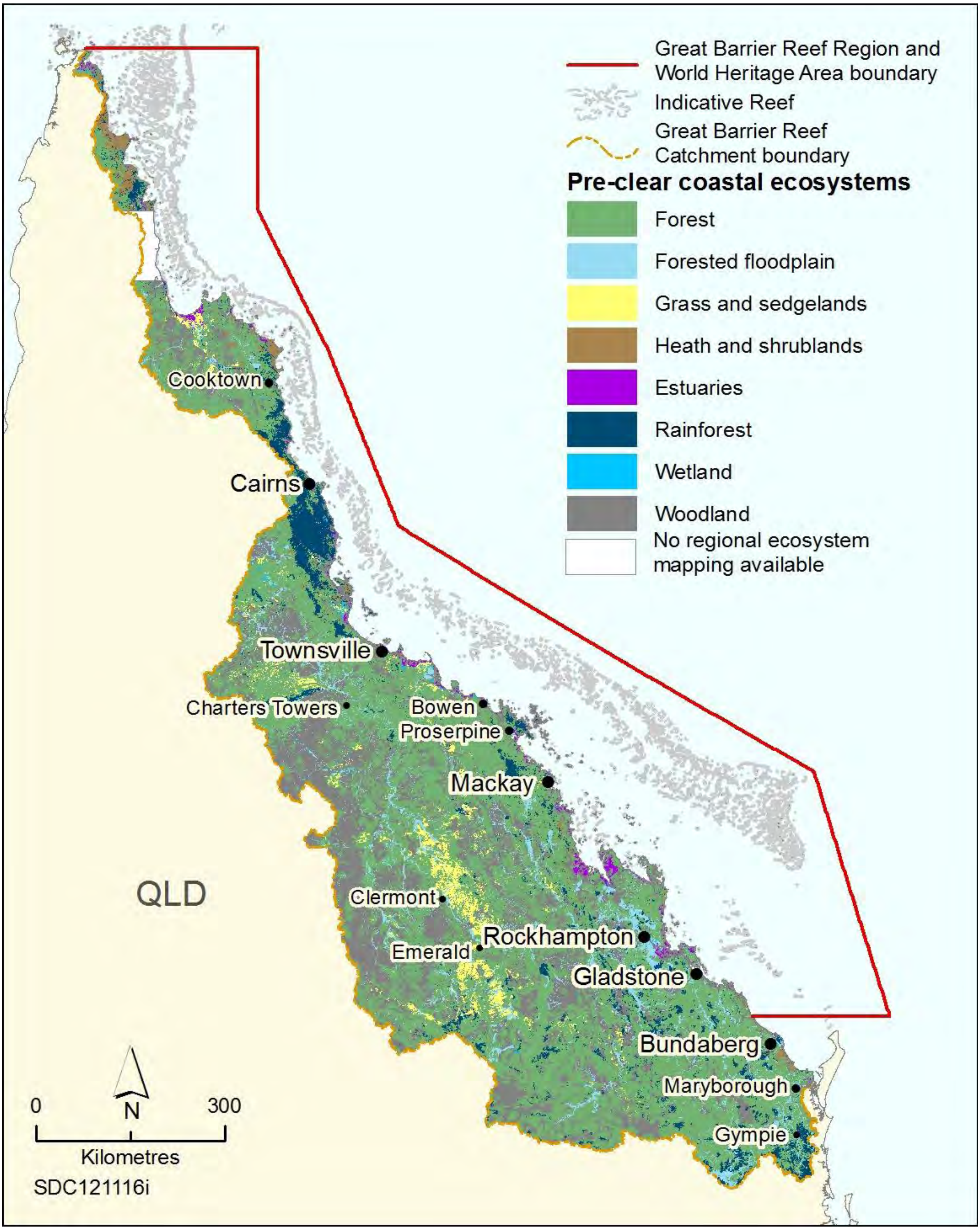


Figure 6.16 Coastal ecosystems of the Great Barrier Reef catchment before European settlement[20]

Before European settlement there were extensive areas of forests, woodlands and forested floodplain interspersed with wetlands and other aquatic habitats across much of the catchment, supporting the Great Barrier Reef ecosystem.

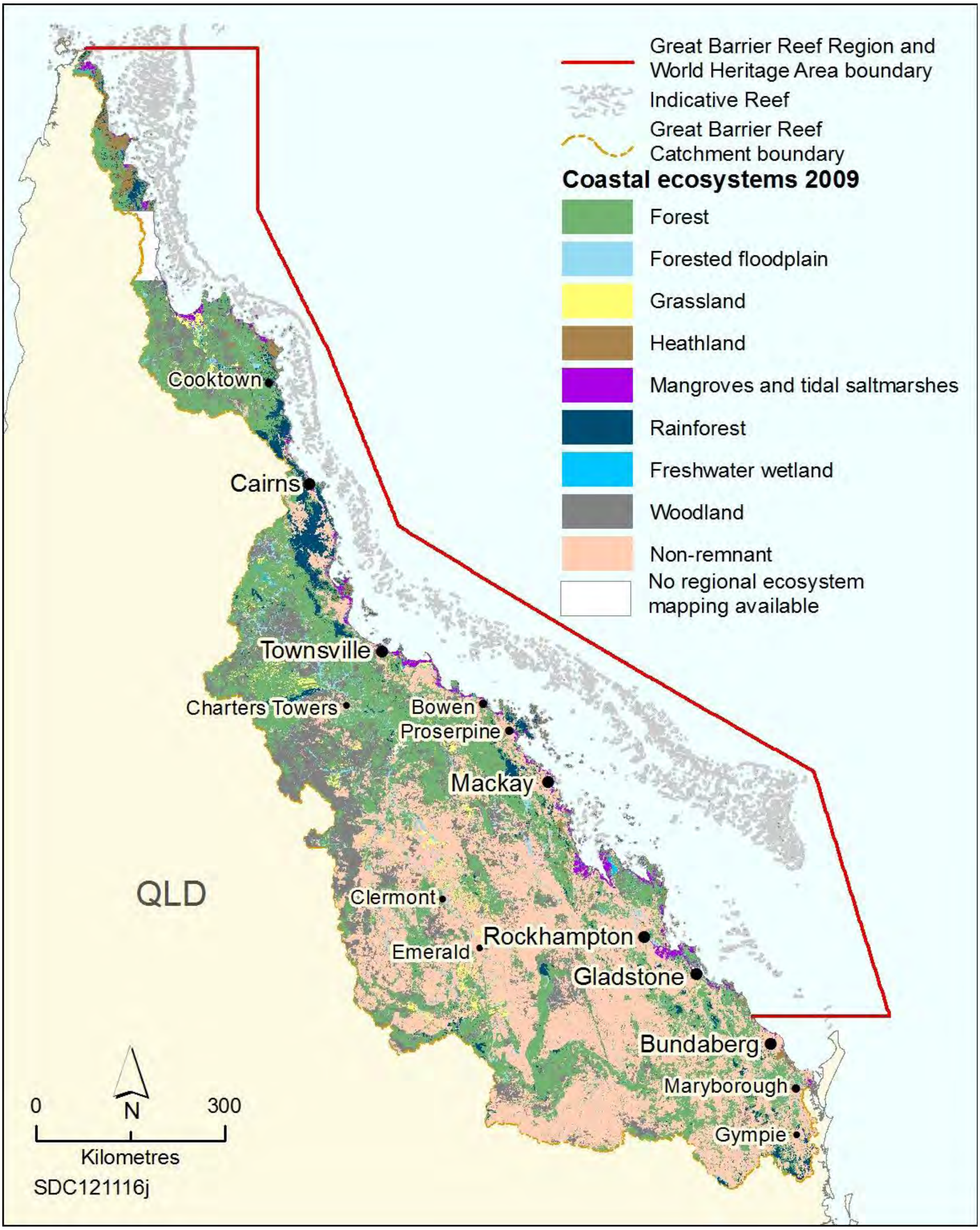


Figure 6.17 Coastal ecosystems of the Great Barrier Reef catchment as they are today[20]

The majority of vegetation in the catchment is classed as 'non-remnant', that is it has been modified to the extent that it is no longer recognised as a functioning habitat. Much has been changed from forest to grassland for grazing purposes.

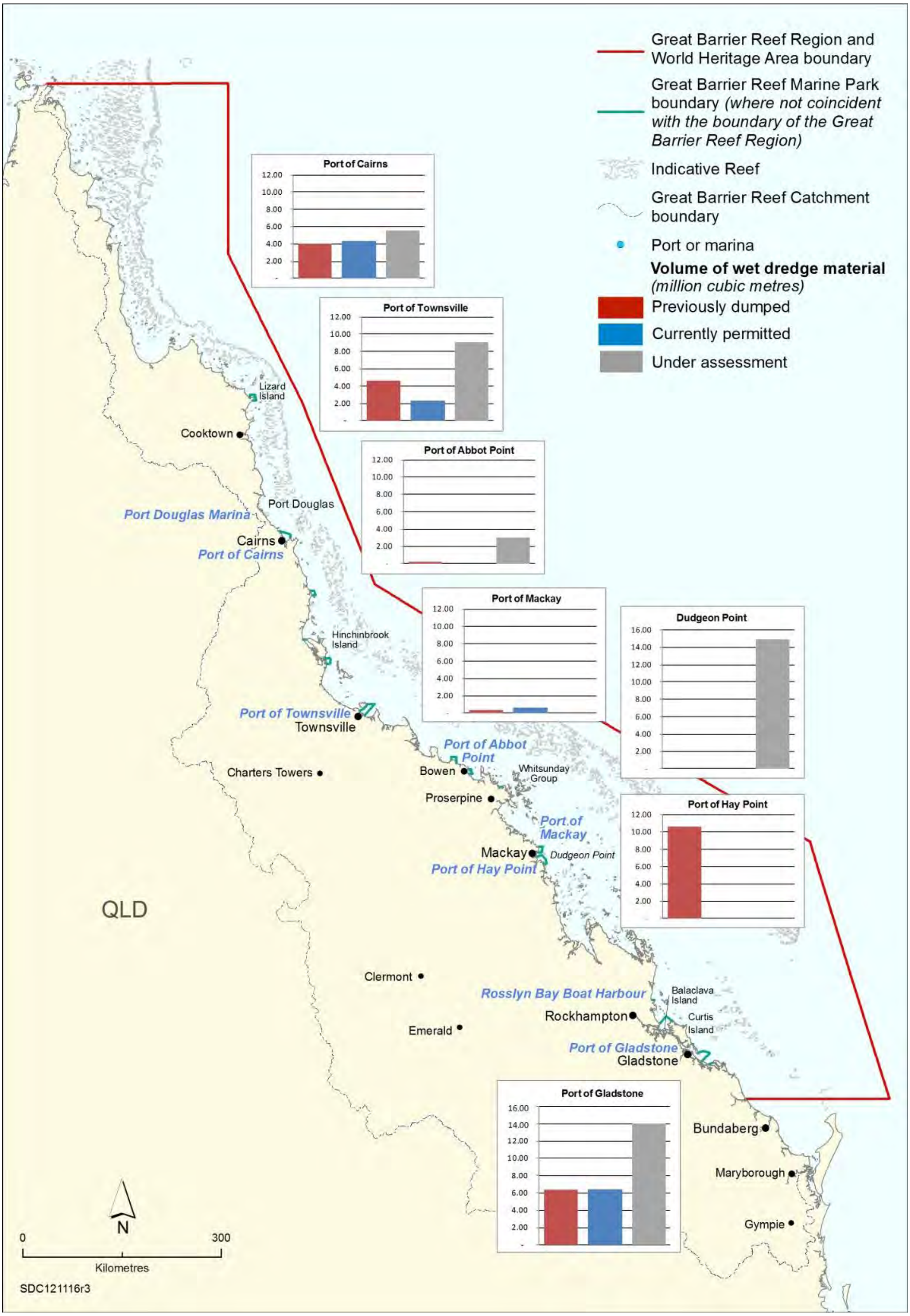


Figure 6.18 Dredge material disposed to date, approved for disposal or being assessed, by port

Actual dumping volume of dredge material originating from ports within the Great Barrier Reef World Heritage Area. The graphs indicate the amount of dredge material dumped between 2000 and 2012 (red bar), the remaining dredge material yet to be dumped under current permits (blue bar) and the amount of dredge material requested to be dumped in future pending a permit assessment process. Data for Rosslyn Bay (previously dumped: 107,023 ; currently permitted: 63,130; under assessment: 40,000 cubic metres) and Port Douglas marina (previously dumped: 22,000; currently permitted: 0; under assessment: 50,000 cubic metres) was not plotted due to the relatively low amounts compared with other ports. Data derived from the International Maritime Organization sea dumping reports, referrals under the *Environment Protection and Biodiversity Conservation Act* and Marine Park permit applications.

The localised effects at the sea dumping site are well documented and are similar to those listed above for dredging. Major impacts include the burial or smothering of benthic fauna and flora[179,184], degradation of water quality[181], and losses and modification of habitat[180]. As at January 2012, the combined area of dredge spoil disposal grounds in the Great Barrier Reef World Heritage Area where localised effects are concentrated was 66 square kilometres.

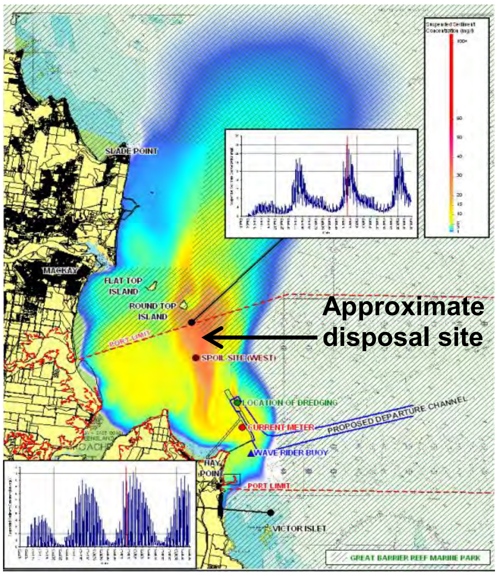
Less well understood are the broader regional and cumulative effects of sea dumping on inshore biodiversity. There is evidence that material disposed at existing dredge disposal grounds does not remain within the defined disposal area[187,188] and that previous modelling of predicted sediment plumes has significantly underestimated the dispersal and direction of sediments and thus the full extent and potential magnitude of potential impacts (Figure 6.19).

While dredging and sea dumping do not introduce additional loads of sediments or nutrients to the Great Barrier Reef World Heritage Area, these activities remobilise, redistribute and resuspend sediments and nutrients. It is the effect of the redistribution and resuspension of significant quantities of fine sediments which is a key concern. Increases in turbidity result in decreases in light penetration, affecting seagrass habitats and species such as dugongs and marine turtles which rely on seagrass as a food source.[180] This is particularly significant if these effects happen during periods critical for seagrass survival, growth and reproduction. Increased turbidity also affects coral growth, structure and survival.[184,189]

Increases in turbidity are predominantly caused by fine sediments. Fine sediments can potentially travel large distances (more than 100 kilometres)[137] and remain suspended for long periods of time[190], affecting the light available for photosynthesis of marine plants over significant areas of the Region's inshore waters. The exact fraction of finer sediment in dredge material will vary. On average, about 30 per cent of capital dredge material is known to be finer sediments such as silts and clays,[190] while riverine inputs typically contain a higher proportion of finer sediments (approximately 70 per cent)[137].

Modelling and monitoring of riverine plumes clearly demonstrate that suspended sediments travel over large distances.[187] Consequently, it is not surprising that a recent modelling study, *Improved dredge material management for the Great Barrier Reef Region,* has found dredge material placed at sea has the potential to migrate over greater spatial and temporal scales than previously understood.[190] The study was a screening-level sensitivity analysis of the relative merits, if any, of potential alternative material disposal areas and was intended for comparative purposes only. It was the first to incorporate the effects of regional oceanic currents in modelling dredge material and found they are a key factor in the migration or resuspension of dredge material over the long term (12 months). The study also highlighted inter-annual variations of large-scale currents at each of the five ports examined (Figure 6.20), which in turn would influence sediment migration patterns. While the study had a number of limitations (for example, modelled plumes were not field validated and plumes were modelled for an energetic year) and its outcomes cannot be used in project-specific assessments, it highlighted the need for future modelling to take into consideration large-scale currents (and their inter-annual variability) and greater temporal and geographic scales to better predict the extent of dredge material dispersion.

a.

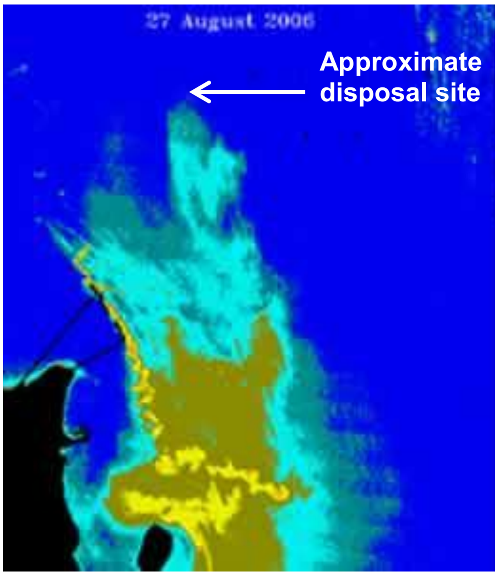


The predicted extent and level of concentrations of suspended sediment expected at Round Top Island after 31 days of constant dredging at Hay Point.[187]

b.

True colour image of the sediment plume produced by dredging and disposal operations at Hay Point. Image taken 27 August 2006 (Geoscience Australia) showing the sediment plume moving predominantly south.

c.



Landsat satellite image showing total suspended sediments in the area of Hay Point during dredging and disposal operations on the 27 August 2006 (Geoscience Australia) showing the sediment plume moving predominantly south.

Figure 6.19 Modelled and actual dredge plume dispersion during a dredging campaign for the Port of Hay Point

The 2006 Port of Hay Point dredging campaign was one of the largest dredge projects to date in the Region — 8.6 million cubic metres. A comparison of predicted modelling (showing movement predominantly to the north) with satellite images of the dredge plumes (showing movement predominantly southwards) shows the highly variable nature of sediment movement. This highlights the need to improve modelling of dredge material movement.
Note: Map (a) is a different scale.

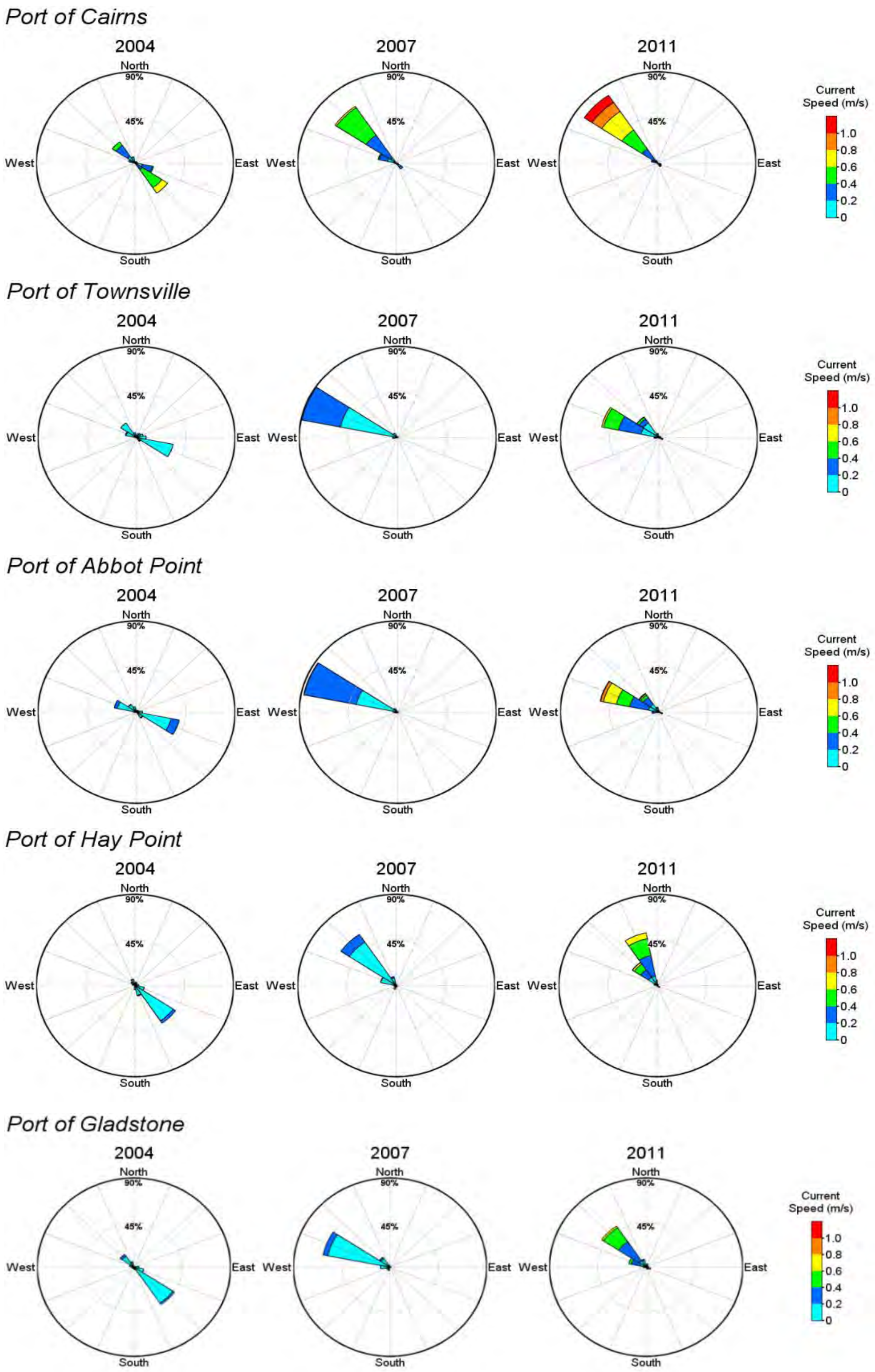


Figure 6.20 Surface large-scale currents for El Niño (2004), neutral (2007) and La Niña (2011) conditions at major ports

The rose diagrams show the variability of large-scale currents around the major ports, both in any one year and across years. Data was generated closest to the existing material placement sites.[190]

Exotic species and diseases

Exotic species and diseases can be introduced through vessel ballast discharge, hull fouling, imported bait and aquaculture operations; in cargo; and by intentional releases (for example, unwanted aquarium fish, dogs and cats). They can travel on all types and sizes of vessels from yachts to cargo ships. Species may be transferred on external and internal surfaces of vessel hulls and on equipment which makes contact with the water (for example, propellers, ropes, chains and intake grates). It is estimated that about 7000 different marine species, including viruses, bacteria and small marine invertebrates, are transported around the world in ballast water every day[191] and more than 150 million tonnes of ballast water is discharged into Australia's major ports each year[191]. More than 250 introduced marine species have been documented in Australia. While most have been relatively harmless, some, such as the northern Pacific seastar, have become aggressive pests in temperate waters.

Introduced marine species have been found in ports along the Great Barrier Reef coastline (for example, Asian green mussel and Caribbean tubeworm in the Cairns port), although none have been recorded beyond these ports. Any introductions in the future would likely have regional effects on the ecosystem — the nature of those effects would depend on the species introduced.

Land-based introduced species, such as rats and dogs, affect seabird and marine turtle nesting. Feral foxes and pigs are known to dig up turtle nests, and foxes have been implicated as one of the significant factors in the recent decline of loggerhead turtle numbers in Queensland[192]. Feral cats are known predators of green turtle hatchlings in the Seychelles.[193] Although no reports are known for Queensland, feral cats are known to occur on turtle nesting beaches (for example on The Strand, Townsville).

On some Great Barrier Reef islands, insect invasions have caused declines in *Pisonia* forests which are major nesting sites for several seabird species.[1] Weed species have been introduced to islands within the Region.[194]

Extraction — death of discarded catch

A range of marine species are captured but not retained during fishing activities in the Region. Species include those targeted by the fishery that are discarded due to size or catch restrictions, low market value or 'catch and release' practices, or unwanted species that have been unintentionally captured (incidental catch) and discarded. The largest amount of discarded (non-retained) catch is in the commercial sector (Figure 6.21) and results mainly from trawling activities (Figure 6.22).

Discarded catch in the trawl fishery includes several groups of species of conservation concern, including sea snakes, marine turtles, seahorses, and sharks and rays.[195] Hundreds of other non-target marine species, many of which are infrequently caught, may be injured or killed by trawling activities. Management requirements in the trawl sector, such as the requirement to install bycatch reduction devices and turtle excluder devices, combined with lower trawl fishing effort have reduced the death of discarded catch in the fishery.[196,197,198] The current risks from trawling to target and non-target species and to the broader environmental values and integrity of the World Heritage Area have been assessed as low or intermediate–low,[195] with a few remaining high risks to species of conservation concern — skates, rays and sea snakes. [195,198] There is no certainty that the level of risk for other species will not increase in the future, as there is potential for trawl fishing effort to increase substantially in the Region under current management arrangements.

The commercial inshore net fishery can unintentionally catch a number of species of conservation concern that are injured or killed in the nets (for example, marine turtles, dugongs, inshore dolphins, sharks and sawfish), many of which are matters of national environmental significance. While strict rules for the use of nets are in place, and Marine Park zoning and Dugong Protection Areas assist to reduce the risks, there is still concern about continuing interactions with these species. Even low levels of mortality may cause population declines and compromise the ability of depleted populations to recover.

Some species may be affected by activities in several fisheries, for example interactions with marine turtles occur in three of the main fisheries (Figure 6.22).

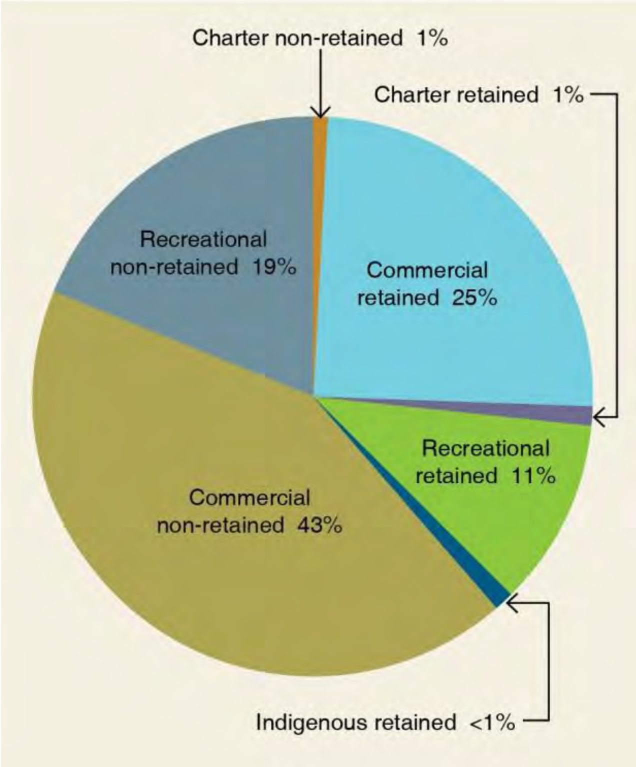


Figure 6.21 Retained and non-retained fisheries catch, Great Barrier Reef, 2007[199]

A high proportion of the weight of fisheries resources caught in the Great Barrier Reef each year is discarded (non-retained). The survival rates of the discarded species vary and are poorly understood. In the recreational and charter sectors catch and release is increasingly popular.

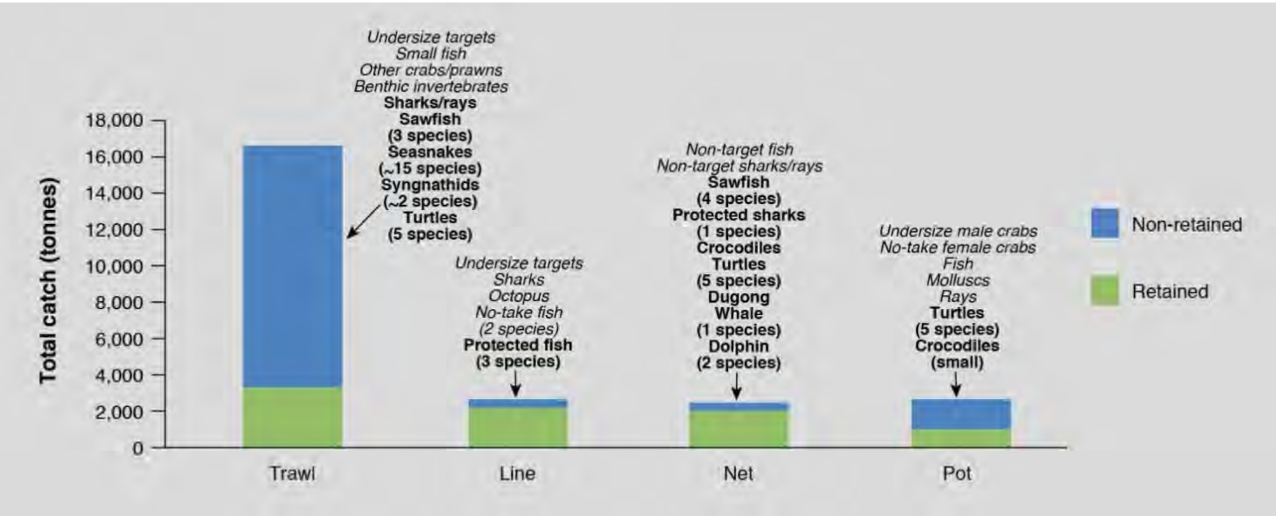


Figure 6.22 A breakdown of commercial fisheries non-retained catch, Great Barrier Reef, 2007[199]

Trawling is responsible for most of the commercial non-retained catch. The continuing interactions between the net fishery and species of conservation concern are of ecological concern. The species and groups of species listed in the figure are those most commonly caught but not retained. Species of conservation concern are in bold type. Syngnathids includes seahorses and pipefish.

A wide range of species is unintentionally captured during the Queensland Shark Control Program, including some sharks, rays, sawfish, dugongs, whales, dolphins and marine turtles (Table 6.4). Some, such as grey nurse sharks, whale sharks, marine turtles and humpback whales, are listed threatened and listed migratory species under the *Environment Protection and Biodiversity Conservation Act* (EPBC Act). Not all bycatch is identified to species level so the actual effects on some species of conservation concern are unknown.

Table 6.4 Marine species captured in the Queensland Shark Control Program, 1993–2003[200]

List compiled using catch data from the former Queensland Department of Primary Industries and Fisheries for 1992–2003.
† species is a 'target shark species' and euthanased upon capture
* common name is inclusive of several species

Sharks		Rays, sawfishes, stingrays	
Blind shark	Common blacktip whaler	Australian cownose ray	Narrow sawfish
Grey nurse shark	Creek whaler	Devil ray*	Queensland sawfish*
Great hammerhead †	Dusky whaler †	Manta ray	Shark ray
Scalloped hammerhead †	Graceful whaler	Eagle ray*	White-spotted guitar ray
Smooth hammerhead †	Grey reef whaler	Bull ray	Shovelnosed ray*
Winged hammerhead †	Hardnose whaler	White-spotted eagle ray	Eastern shovelnosed ray
Port Jackson shark	Long nose whaler †	Electric ray*	Giant shovelnosed ray
School shark	Mangrove whaler	Ray*	Reticulate whipray
Grey carpet shark	Milk shark	Sawfish*	
Great white shark †	Pigeye whaler †	**Other marine species**	
Mako shark †	Sandbar whaler †	Australian fur seal	Lobster*
Tawny shark	Sharptooth shark †	Barramundi	Mackerel*
Tropical sawshark*	Silky whaler †	Black kingfish	Marlin*
Fossil shark	Sliteye shark	Blue groper	Mud crab*
Weasel shark	Spot-tail shark	Bonita*	Puffer fish*
Whale shark	Spot-tail whaler	Catfish*	Queenfish
Australian blacktip shark	Tiger shark †	Cobia	Queensland groper
Australian sharpnose shark	Whaler shark*	Cod*	Sand crab
Bignose whaler	Whitetip reef shark	Conga eel*	Snapper
Blacktip reef whaler	Tasselled wobbygong	Crayfish*	Swordfish
Blue shark	Zebra shark	Estuarine crocodile*	Toad fish
Bronze whaler	*Unknown shark**	Dugong	Tuna*
Bull whaler †		Fish*	Yellowtail kingfish
Whales and dolphins		**Marine turtles**	
Bottlenose dolphin	Spinner dolphin	Flatback turtle	Leatherback turtle
Common dolphin	Unknown dolphin*	Green turtle	Loggerhead turtle
Snubfin dolphin	Whale*	Hawksbill turtle	Olive ridley turtle
Indo-Pacific humpback dolphin	Humpback whale		

Extraction — fishing in spawning aggregations

A fish spawning aggregation is a repeated concentration of fishes, gathered for the purpose of spawning, that is predictable in time and space.[201,202] The density or number of individuals participating in a spawning aggregation is at least four times that found outside the aggregation.[202] This makes the fish easier to catch. Such aggregations are in decline globally, with many decreasing or wiped out due to overfishing.[202] Loss of fish spawning aggregations leads to declines in fish populations with negative ecological consequences.[203] Fish spawning aggregations are classed by the International Union for Conservation of Nature as 'wildlife spectacles'.[203]

Numerous bony fish species in reef and inshore habitats are known to form transient spawning aggregations in the Region. Spanish mackerel are known to aggregate in large numbers to spawn in the Region. During the 1970s, aggregations of spawning Spanish mackerel were reported between Lizard Island and Townsville. In recent years, these aggregations have been reported over a much smaller area on several reefs east of Ingham.[204] A central Great Barrier Reef spawning aggregation site for flowery cod and camouflage grouper has occasionally been targeted by commercial fishers in the past, and the current status of this aggregation is unknown.[205,206] Monitoring shows a coral trout spawning aggregation site near Cairns has persisted for at least 20 years.[206]

Some fish spawning is protected by Queensland legislation, for example through the Coral Reef Fin Fish Fishery spawning closures and the protection of barramundi during its main spawning season. The protection of representative examples of habitat types in the Marine Park, while not a direct aggregation protection strategy, includes six known fish spawning aggregation sites for coral trout, Spanish mackerel and javelin fish (barred grunter) within no-take areas.[207]

Extraction — herbivores

Herbivory (feeding on plants) is a major ecological process in the Great Barrier Reef ecosystem, performed by a number of species, including many fishes, dugongs and green turtles. Herbivory is a key process in structuring plant communities on coral reefs.[208] Removing herbivores from the ecosystem can lead to unintended ecological consequences for these communities.

On coral reefs around the world, regional reductions in herbivores have underpinned shifts from coral to macroalgae dominance — increases in macroalgae supress coral growth by competing for space, thus affecting coral recruitment and growth.[96] Extraction of key herbivorous fish can lead to deleterious effects on coral reefs that are hard to reverse[208,209] and it is predicted these effects would be extremely serious should climate change impacts lead to more frequent reef disturbances (such as mass bleaching). Such disturbances would result in widespread algal overgrowth, which a diminished herbivore population may not be able to remove, resulting in limited space for corals to grow and recover.[209,210,211,212]

Currently, there is a relatively small take of herbivorous fish in the Region, and there is a range of management controls that limit the capacity for it to significantly expand. However, any increased demand for herbivorous fish in the future may affect the amount of take and possibly lead to effects higher up in the food chain, and may affect the process of herbivory on coral reefs.

Historically, there has been substantial extraction of the large herbivores — dugongs and green turtles — in the Great Barrier Reef ecosystem (see Section 6.3). The effects on seagrass ecosystems in particular from the reduced grazing pressure are unknown. The resulting reduction in turtle and dugong numbers has reduced the capacity of these species to withstand the current multiple impacts on them.[12]

Traditional Use of Marine Resources Agreements, which are developed by Traditional Owner groups in partnership with the Authority and based on the best available science and expert opinion, set limits to the traditional take of dugongs and turtles. Many Traditional Owner groups have taken steps to reduce or stop traditional hunting of turtle and dugong in the wake of recent extreme weather events which heightened concerns about these species (see Section 5.4.1).

Extraction — lower order predators

Lower order predators are species that occupy the middle ranks of the food chain. These species prey upon other species (for example, small fishes and crustaceans) but are also eaten by top order predators (for example sharks). In the Great Barrier Reef ecosystem, lower order predators include predatory fishes such as coral trout, king threadfin, snappers and emperors, groupers and cods, small sharks and stingrays.

Many of these lower order predators are targeted in the Region's fisheries (Figure 6.23) and the abundance of some target fishes is lower in fished areas.[115,213] Some lower order predators may live for a long time and are thus more vulnerable to pressures (for example, the flowery cod can live for up to 42 years[214]) and several could be vulnerable to fishing in inshore or reef areas.[214,215] Loss of predatory reef fish could change the types of species present in groups of juvenile fish [216] which would affect overall reef fish populations. Long-term monitoring has found reduced numbers of predatory fishes may leave coral reefs more susceptible to outbreaks of crown-of-thorns starfish.[114] Changes in predator abundance and behaviour causes changes throughout trophic levels which modify food webs, indirectly acting upon herbivore populations that maintain coral substrates.[210]

Some stingrays and groupers may help to physically shape marine habitats and create micro-habitats for other species.[217,218] Declines in these species could affect habitat formation.

Extraction — lower trophic orders

Lower trophic orders include omnivores, particle feeders and detritivores, for example some fish species, scallops, prawns, lobsters, crabs, sea cucumbers and corals. Herbivores are considered separately in the section above.

The commercial fisheries that extract lower trophic order species for seafood or to supply aquariums include trawl, net, pot, tropical rock lobster, beche-de-mer (sea cucumber), marine aquarium fish and coral collection. Recreational and traditional fishers also take some lower trophic order species such as crabs, prawns and lobsters. Particle feeders and scavengers taken in the trawl and pot fisheries made up more than half of the retained commercial catch from the Great Barrier Reef in 2007 (Figure 6.23).[1] These include valuable seafood species such as eastern king prawns, tiger prawns, endeavour prawns and mud crabs.

The hawksbill turtle is omnivorous, and historic commercial harvesting (Section 6.3) has had lasting effects on this species. Australia supports an internationally significant hawksbill nesting population.[5]

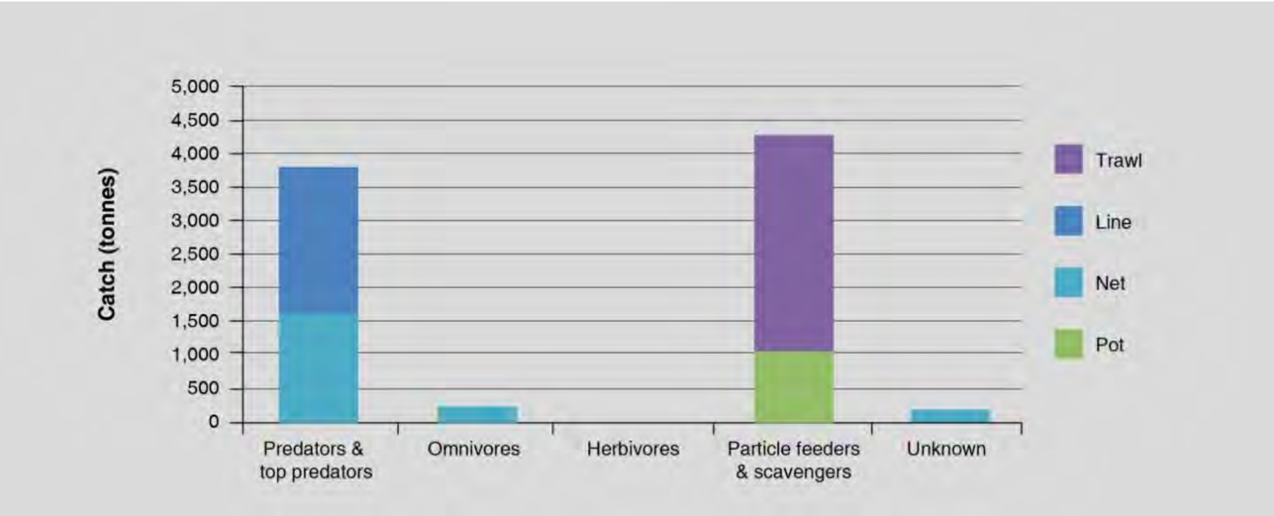


Figure 6.23 Ecological groups retained by commercial fishing, Great Barrier Reef, 2007[199]
Most species caught are carnivores (top predators and predators) or particle feeders. Herbivores are not generally targeted on the Great Barrier Reef.

Extraction — top order predators

Top predators are species that live near or at the top of the food web. In the Great Barrier Reef ecosystem, these species include sharks, very large fishes such as marlin, swordfish, potato cod and Queensland groper, some seabirds, whales, dolphins and the estuarine crocodile.

Many top order predator species are extracted during fishing operations in the Region, either as targeted species (Figure 6.23) or as non-target catch. Some, such as the grey reef shark, whitetip reef shark and several species of sawfishes, have declined.[219,220,221,222] While many top predators are not directly targeted by fishing activities in the Great Barrier Reef, some are unintentionally caught and retained, and several sharks and rays are at high risk from fishing.[215] Many top predators are extracted as part of Queensland's Shark Control Program (Table 6.4 above). In the last decade, between 521 and 716 sharks have been removed each year throughout Queensland as a result of the program.[223]

Predators play a key role in maintaining a healthy ecosystem and reductions in their populations can have long-term effects[224], including direct and indirect effects on the food chain.[210]

Illegal fishing and poaching

Illegal fishing and poaching activities occur Reef-wide and include fishing in no-take zones, the use of fishing equipment or methods where they are not permitted, the incursion of foreign fishing vessels and hunting contrary to legislative requirements. In 2011–12, a total of 305 possible offences involving fishing or collecting (commercial and recreational) and hunting were reported across the World Heritage Area.

Under the Field Management Program's (see Chapter 3 for a description of this program) coordinated risk-based compliance framework for the World Heritage Area, priority is placed on high impact offences such as illegal coastal mesh netting and its incidental impacts on vulnerable species, trawling and commercial reef line fishing. Recently there has been a significant increase in the detection of recreational fishing offences, with 250 recorded between July and December 2012, in part due to the increase of compliance effort on this activity.[225] Incident information shows some fishers are targeting no take (green) zones which has effects on the Region's biodiversity and resilience as well on benefits to other fishers.

The wide geographical range of high priority compliance issues and the growing use of surveillance avoidance tactics by commercial and recreational fishers increases concerns about illegal activity in the Region.

Illegal hunting of dugongs and marine turtles (poaching) in the Region is known to occur, and all reports received are investigated. In recent years, most reports have been found to be legal hunting activities undertaken by Traditional Owners or by people from Indigenous communities hunting with Traditional Owners.

Marine debris

There is a massive amount of man-made material accidentally or deliberately released into the marine environment. Common items found within the Region are plastic bags, discarded fishing gear, plastic and glass bottles, rubber thongs, aerosols and drink cans.[226] The annual global demand for plastics has continually grown over recent years. In 2011, it was estimated to be 245 million tonnes.[227] Plastic is the most prevalent type of debris found on beaches worldwide, comprising between 50 to 90 per cent by number of all debris items recorded.[228,229,230] Plastic debris poses a significant threat to wildlife which can choke on the material and starve, absorb chemicals, or ingest items that have degraded into microplastics.[231] In Australia, plastic waste, including discarded fishing gear (nets, lines and ropes), is potentially one of the most harmful types of debris to marine wildlife because of ingestion and entanglement.[232,233,234,235] Marine debris is identified as a key threatening process under the EPBC Act and can affect species and habitats throughout the Region. Marine debris from the catchment appears to accumulate and remain confined within the lagoon system of the Reef but with a northward movement.[226] At the southern end of the Reef, debris appears to be more ocean-sourced.[226]

Noise pollution

Greater shipping and boating activity, the use of sonar, activities associated with coastal development including pile driving, and defence activities all contribute to increased underwater noise on a local scale. Sound is extremely important to many marine animals, playing a role in communication, navigation, feeding, orientation and the detection of predators.[236] Concerns about the impacts of man-made sound on marine animals has grown over recent decades and is now considered a significant stressor on marine life worldwide.[237] Sounds can have a range of effects, depending on the acoustic frequency animals are able to detect and produce (Figure 6.24) and their proximity to the source. Effects to marine life range from detection with no adverse impacts, to significant behavioural changes, to hearing loss, physical injury and mortality.[236]

While there is a national policy addressing the acoustic impacts of seismic surveys on whales[238], there are no specific standards for the range of noise pollution affecting Great Barrier Reef species. Given the increases in man-made underwater noise and the observed effects on marine life around the world[237], there is an urgent need for a greater understanding of the ecological impacts of noise within the Region and for guidance on measures to avoid or mitigate these impacts.

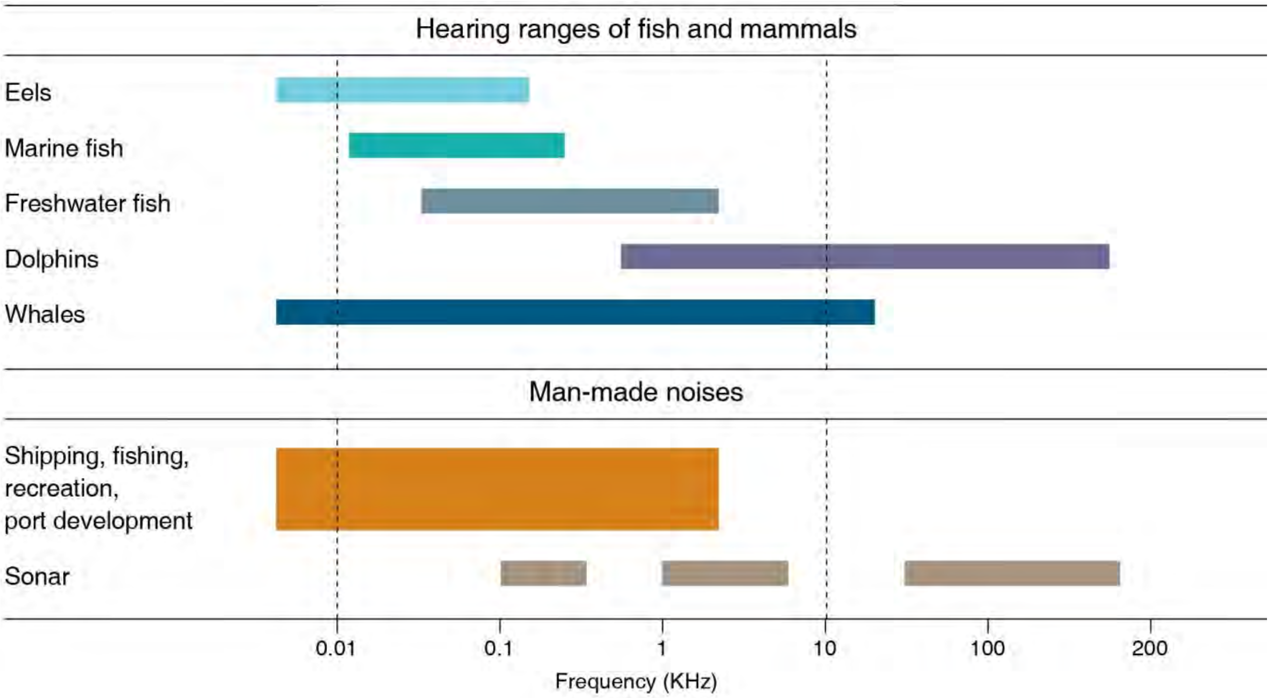


Figure 6.24 Man-made noise sources and the hearing ranges of marine mammals and fish[239]

There has been no comprehensive study of the effect of man-made noise on Great Barrier Reef species. This research from North America demonstrates that, for many groups of species, their hearing range overlaps with noises introduced into the environment by human activity. The dotted lines show the range of human hearing in air.

Outbreak of disease

Whether natural or introduced, disease outbreaks are a clear indicator of stress. They have affected a range of the Region's species in recent years, including corals, green turtles and the Queensland groper. In other countries, coral reef ecosystems that have become much degraded are characterised by a high incidence of diseases. For example, mass coral bleaching in Florida and the Caribbean are usually accompanied by disease outbreaks, probably resulting from low energy reserves in surviving corals.[240] This phenomenon is being increasingly observed on the Great Barrier Reef and is likely to cause major impacts in the future.[241,242] For the naturally occurring white syndromes disease, major outbreaks have been recorded after especially warm years on reefs with high coral cover, indicating a potential link between coral disease and increasing sea temperatures as a result of climate change.[241,243] Coral disease has been identified as a key indicator of coral reef resilience due to its prevalence in disturbed areas,[244] such as those exposed to flood events, [245] and higher levels of turbidity and sedimentation[246].

Fibropapilloma lesions on green sea turtle, Edgecombe Bay, near Bowen. (Photo: Ellen Ariel)

Outbreaks of disease in species of conservation concern are of particular concern. Green turtle fibropapillomatosis (see photo) was first reported in Australia more than 40 years ago[247] and the frequency of recorded cases increased up to the early 1990s[248]. In the Queensland population, fibropapillomas are rare on green turtles from offshore reefal environments, but prevalent from turtles in semi-enclosed bays.[4] There is overseas evidence of a link to land use practices.[249] The overall effect on the Region's population from this disease currently appears to be low,[250] and a few green turtles have been shown to recover naturally[4,251].

Necropsies conducted on deceased dugongs reported within the Queensland Marine Wildlife Strandings and Mortality Database indicate disease was the cause of death for between 20 and 25 per cent of the 298 animals examined between 1996 and 2010 for which the cause of death was determined.[252] In 2011, after extreme weather, 30 dugongs died of disease or ill health in Queensland. Twelve dugongs died after extended ill health and had poor body condition. Pneumonia was associated with the deaths of three dugongs, and a further 15 died of unidentified disease.[253]

There is little monitoring of the health of other species.

Outbreak or bloom of other species
An outbreak of a species refers to a rapid increase in abundance, biomass or population of naturally occurring marine plants and animals. Outbreaks of crown-of-thorns starfish and exotic species are examined above. Outbreaks and blooms can be harmful or lethal to other marine species as they can compete for resources such as food, sunlight and oxygen.

In 2002, a bloom of *Lyngbya majuscula*, a toxic cyanobacteria that can smother seagrass, was observed in Shoalwater Bay, an important feeding ground for green turtles. While the bloom appeared to have no immediate effect on turtle body condition, their diet is likely to have been affected and they were potentially exposed to tumour-promoting compounds produced by the cyanobacteria.[254]

Trichodesmium is a cyanobacteria found in nutrient-poor tropical waters. It appears as slicks on the water's surface and can be distinctly pungent. It was first described by Captain Cook, and though it occurs naturally, blooms in the central Great Barrier Reef are thought to have increased, possibly due to nutrients in catchment run-off, in particular phosphorus, iron and organic material.[255,256] The blooms have been implicated in directly smothering corals and increasing the bioavailability of heavy metals.[257]

Drupella are marine snails that occur naturally in the Indo-Pacific and are known to damage corals in high densities. Outbreaks have been reported in Ningaloo Reef, Japan and the northern Red Sea.[258] To date, no population outbreaks of *Drupella* have been reported on the Great Barrier Reef, although some tourism operators are permitted to implement control measures for this species. Numbers are monitored daily at some locations in the Region through the Eye on the Reef monitoring program.

Physical damage — fishing
Trawling is the fishing activity that causes most of the physical damage to the Region's marine habitats. It is only allowed in 34 per cent of the Marine Park and generally occurs more than once per year in about seven per cent of the Marine Park.[9,259]

The trawl fishery uses trawl nets designed to operate on or near the seabed, mainly on muddy, sandy or silty habitats. Some trawling occurs in areas with patchy algae (including small amounts of *Halimeda*), patchy seagrass and very small amounts of structural habitat elements such as whip, sponge and gorgonian gardens. Trawl gear can cause direct physical impacts on habitats and remove or damage seabed plants and animals.[15,16,260,261,262,263] Other potential physical impacts include altering the vertical relief of seabed features and redistributing sediments. Although damage to more sensitive lagoon floor communities from trawling has occurred in the past,[9] ongoing physical impacts in most regularly trawled areas are likely to be low, as these areas are generally muddy, silty or sandy and likely to be regularly disturbed naturally.[9,195]

Changes in management arrangements, gear improvements, improved understanding and reduced trawl fishing effort have combined to lower the ecological risk in recent years.[195] However, an upper continental slope habitat (90 to 300 metres deep) in the south-east of the Region that includes deepwater eastern king prawn fishing grounds is considered at high risk from trawling.

Other types of commercial and recreational fishing activities may also cause physical damage to marine habitats, such as damage to live coral tissue and coral colonies from line fishing gear. Such physical impacts may have very localised effects on the health of marine habitats and species at popular fishing locations.

The commercial coral collection fishery also causes some physical damage to habitats, however the total harvest in the fishery is very small relative to the amount of coral on the Great Barrier Reef. The potential impacts are very localised.[264] Appropriate management and practices are in place, including an industry Stewardship Action Plan[265]. This has included a voluntary moratorium on coral collecting around the Keppel Islands after reef degradation from flooding and coral bleaching.

Physical damage — other

Diving, snorkelling and boating activities can cause local damage to habitats on the seafloor and the plants and animals that live there. Such habitats include seagrass meadows, coral reefs and the lagoon floor. In this report, anchoring of vessels of any size and grounding of vessels less than 50 metres are included under this potential impact along with diving and snorkelling. Physical damage from fishing and the grounding of ships are considered separately.

The effect of anchoring depends on the size of the vessel, its anchoring equipment and the substrate of the seafloor. For example, anchoring has minimal effect on soft muddy bottoms, but is capable of breaking multiple coral colonies as a result of dropping the anchor or the movement of the anchor and chain across the seafloor. Anchoring can also scar seagrass beds. Management arrangements are in place to minimise anchor damage in areas of highest use, for example moorings and no-anchoring reef protection markers. Areas considered most at risk are fragile fringing reefs around popular inshore island destinations.

Disturbance from the anchoring of ships is a localised chronic impact which expected to become more frequent close to ports.[266] for many of the areas where ships anchor, the biodiversity values are considered to be relatively low and there is only minor concern about any effects. In contrast, the inner anchorage of Gladstone port supports higher biodiversity than other anchorages, and therefore the overall risk to the biodiversity from anchoring is considered to be higher.[266]

The effects of snorkelling and diving are considered to be low and well managed, especially as the majority of Great Barrier Reef tourism operators use a range of measures including briefings and close supervision to minimise diver and snorkeller interactions with coral reefs. First time divers and those taking photographs are the most likely to damage coral.[267] Best environmental practices for diving and snorkelling are available for tourists and recreational users.

Grounding a vessel can damage coral reefs and other fragile habitats. Weather events and operator error and negligence have caused a number of groundings of small vessels in the Region. While most have had negligible consequences, more of these types of incidents have occurred in the last decade because of an increase in severe weather events. The location of all reported vessel groundings in the Region from 1987 to 2012 is presented in Figure 6.25.

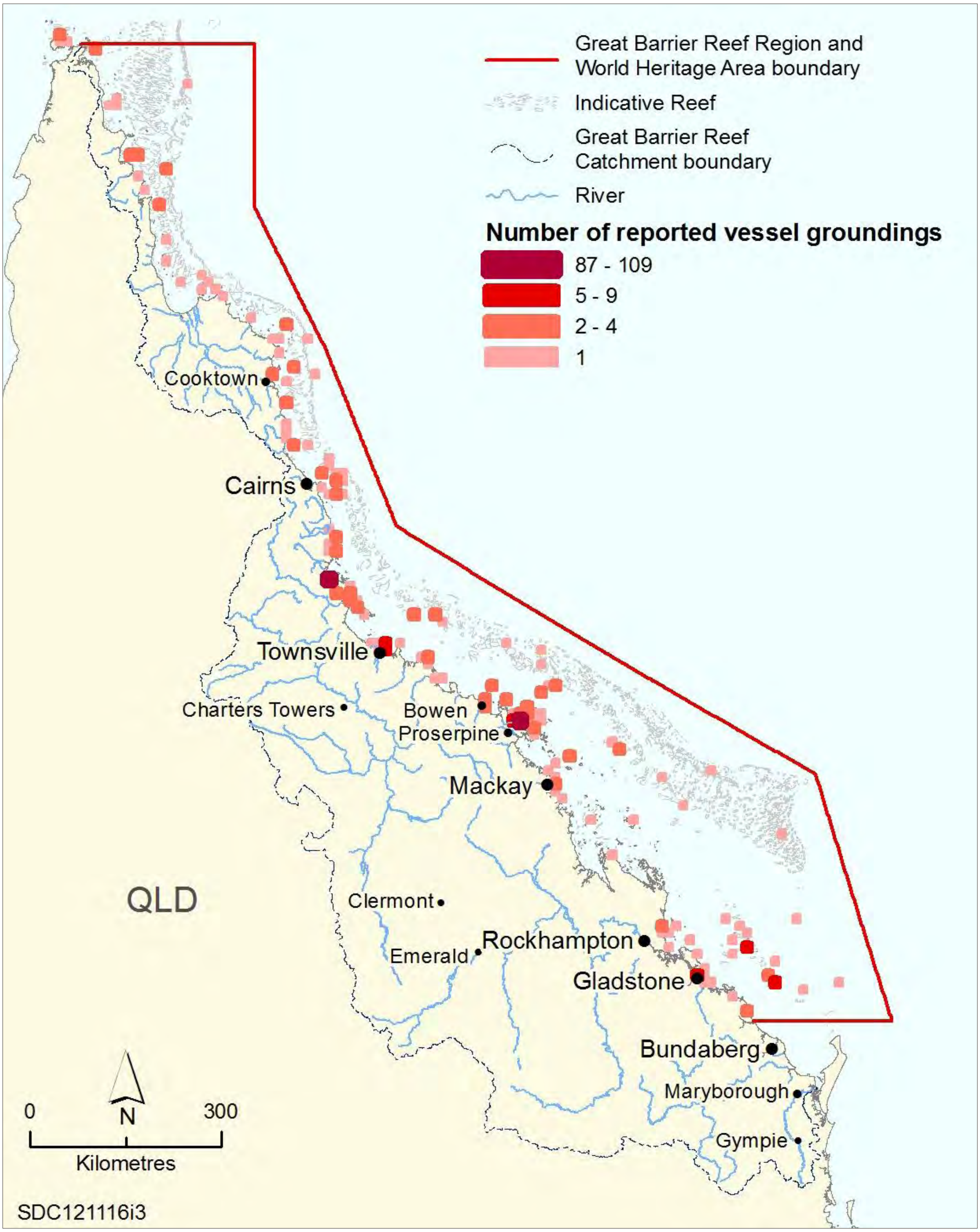


Figure 6.25 Reported vessel groundings in the Region, 1987–2012
The locations with a very high number of groundings over the period are those associated with cyclonic events.

Ship grounding
The nature of the Region's environment, with its thousands of coral reefs and islands, increases the navigational hazards for all ships including cargo, large tourist and recreational vessels. The grounding of a ship can have significant and long-lasting environmental effects on a local area. The grounding of smaller vessels (less than 50 metres in overall length) generally has less effect and is considered in the section on physical damage — other (see above).

Potential impacts from the grounding of a ship include direct physical damage to coral reef or other habitats at the grounding site, leaving visible scars; scraping off and releasing into the local environment toxic substances including anti-fouling paint, copper, zinc, and tributyl tin (also known as TBT, an anti-fouling chemical that targets marine organisms); and cargo and oil spills which can have damaging or lethal effects on marine life.

Despite more than 4000 ship calls to ports adjacent to the Great Barrier Reef each year, there have only been a small number of collisions and groundings.[268] Since 1996, 22 ship groundings and collisions have been recorded in the World Heritage Area.[269]

In April 2010, a Chinese registered coal carrier *Shen Neng I* ran aground on Douglas shoal in the Great Barrier Reef. The vessel was grounded for nine days, severely damaging an estimated 80,000 to 400,000 square metres of reef.[270] It is the largest ship grounding scar on the Great Barrier Reef. At best, it is expected the site of impact will take decades to recover.[270] Anti-fouling chemicals from this and other ship groundings, particularly the *Bunga Terati Satu, Doric Chariot* and *Peacock,* will have affected marine life. These chemicals combine with pulverised reef to damage corals at the grounding sites and surrounding areas where currents transport the paint flakes and pulverised particles.

Spill — large chemical
For the purposes of this report, large chemical spills are those that trigger a national or regional response, are generally more than 10 tonnes, or are likely to cause considerable environmental effects.

Chemicals commonly transported through the Region include, cement, fertilisers, ammonium nitrate, sugar and molasses, liquefied natural gas, coal, sulphuric acid and caustic soda. However, the full breadth of chemicals being transported is not well understood, particularly when it is transported within shipping containers as there is often mislabelling of the container.

Although there has never been a large chemical spill reported in the Region, greater shipping activity and industrial development along the Great Barrier Reef coast is increasing its likelihood. While a large chemical spill would not necessarily be visible, it could have regional and long-lasting effects on Great Barrier Reef values. Apart from the physical smothering of plants and animals, a chemical's toxicity and reactions with water could result in persistent effects on the health, growth, reproduction, development and survival of a range of marine plants and animals for several years.

For example:

- Sulphuric acid would reduce the pH of seawater, affecting calcium deposition in animals with skeletons. It could also coat marine animals such as turtles and cause damage through inhalation.[271]
- Sugar and molasses dissolves and dissipates over large areas. It causes oxygen depletion which can result in mass deaths of fish and other organisms and increased dissolved organic carbon causing microbial changes.[106]
- Liquefied natural gas vaporises after release and can affect air-breathing animals. It is flammable and may also cause thermal shock.[272]

Spill — large oil
A large oil spill is considered to be any spill of oil that has triggered a regional or national response and/or is more than 10 tonnes (Tier 2 and Tier 3 of the National Marine Oil Spill Contingency Plan[273]).

Much of the oil carried in the Region is refined, such as petrol, diesel and heavy fuel oils, rather than crude unrefined oils. Individual tankers carry up to 60,000 tonnes of oil through the inner shipping route. Large bulk carriers operating to Hay Point can carry up to 4000 tonnes of heavy fuel oil.[274] The volumes carried and the potential effects mean a large oil spill is viewed as one of the greatest risks from ships transiting through the Great Barrier Reef.[274]

The largest recorded oil spill in the World Heritage Area occurred in January 2006 when approximately 25 tonnes of heavy fuel oil was spilt from the *Global Peace* while berthing at a coal loading facility in Gladstone Harbour (Table 6.5). While some of the oil was recovered quickly, much deposited on the coastline. There were local effects on coastal species including mangroves, crabs and sediment-dwelling species.[275,276] In December 2002, a spill off Border Island in the Whitsundays resulted in a slick of at least 70 kilometres long in the Region.

Table 6.5 Large oils spills that have affected the values of the Great Barrier Reef

* Although the Torres Strait is outside the Region, many of the Region's values, including large mobile species such as marine turtles and dugongs, were affected including through loss of connectivity to breeding and feeding grounds.

Date	Vessel	Location	Oil amount
March 1970	*Oceanic Grandeur*	Torres Strait*	1100 tonnes
December 2002	*Pacific Quest*	Border Island, Whitsundays	>70 km slick
January 2006	*Global Peace*	Gladstone Harbour	25 tonnes

In 1970, Australia's second largest oil spill occurred in the Torres Strait when the *Oceanic Grandeur* struck an uncharted rock, releasing an estimated 1100 tonnes of oils, including crude oil from the cargo tanks and a lighter diesoline fuel oil. Despite being outside the Region, it is likely the spill affected the Region's values. At the time, the event highlighted Australia's lack of preparedness to respond to a major oil spill and accelerated the development of the National Contingency Plan.

In 2009, two major incidents involving the release of oil occurred in waters adjacent to the Region, one in the Torres Strait only 20 kilometres from the Region's northern boundary, and the other off Moreton Bay near Brisbane (*Pacific Adventurer*), to the south of the Great Barrier Reef.[1] Another major spill involving 12,000 litres of diesel occurred in January 2013 after the grounding of a refuelling barge in the Burnett River just north of Mon Repos, an important turtle nesting beach.

At a global scale, these spills in or adjacent to the Region are relatively small. The top 10 global oil spills recorded range from 140,000 tonnes to 1.6 million tonnes.

Despite increases in shipping traffic, improvements in shipping safety management have resulted in fewer major shipping incidents in the past 10 years.[1] However, a recent survey of coastal pilots indicates there are a high number of near misses that are not reported.[277] These may increase with the growing shipping traffic, combined with factors such as fatigue.[278]

Apart from the physical smothering of plants and animals, oil toxicity and its chemical reactions with water mean a large spill is likely to have persistent effects on the health, growth, reproduction, development and survival of a range of marine plants and animals for several years.[274]

Spill — small chemical or oil

Small chemical and oil spills (defined as less than 10 tonnes) are likely to have had localised effects on environmental and social values. Such spills often happen during refuelling, during port construction and operational activities, while transporting chemicals or oils, and through illegal discharges of bilge waste.[274]

Since 1987, more than 700 reports of spills and discharges have been recorded in the Authority's marine incident database (Figure 6.26). However, most of these reports involve small spills of petroleum products (for example, from bilge pump outs, sinking vessels or vessel groundings, and discharges of hydraulic fluids from construction equipment).[274] Some of these reports are unsubstantiated.

The environmental consequences of small spills will depend on factors such as the type of oil or chemical, the amount spilled, weather conditions and the surrounding habitat. Potential direct effects on the environment include toxicity to marine biota; coating of animals, plants or habitats which can affect respiration and insulation (particularly for seabirds); as well as burns, poisoning and in some cases, mortality.

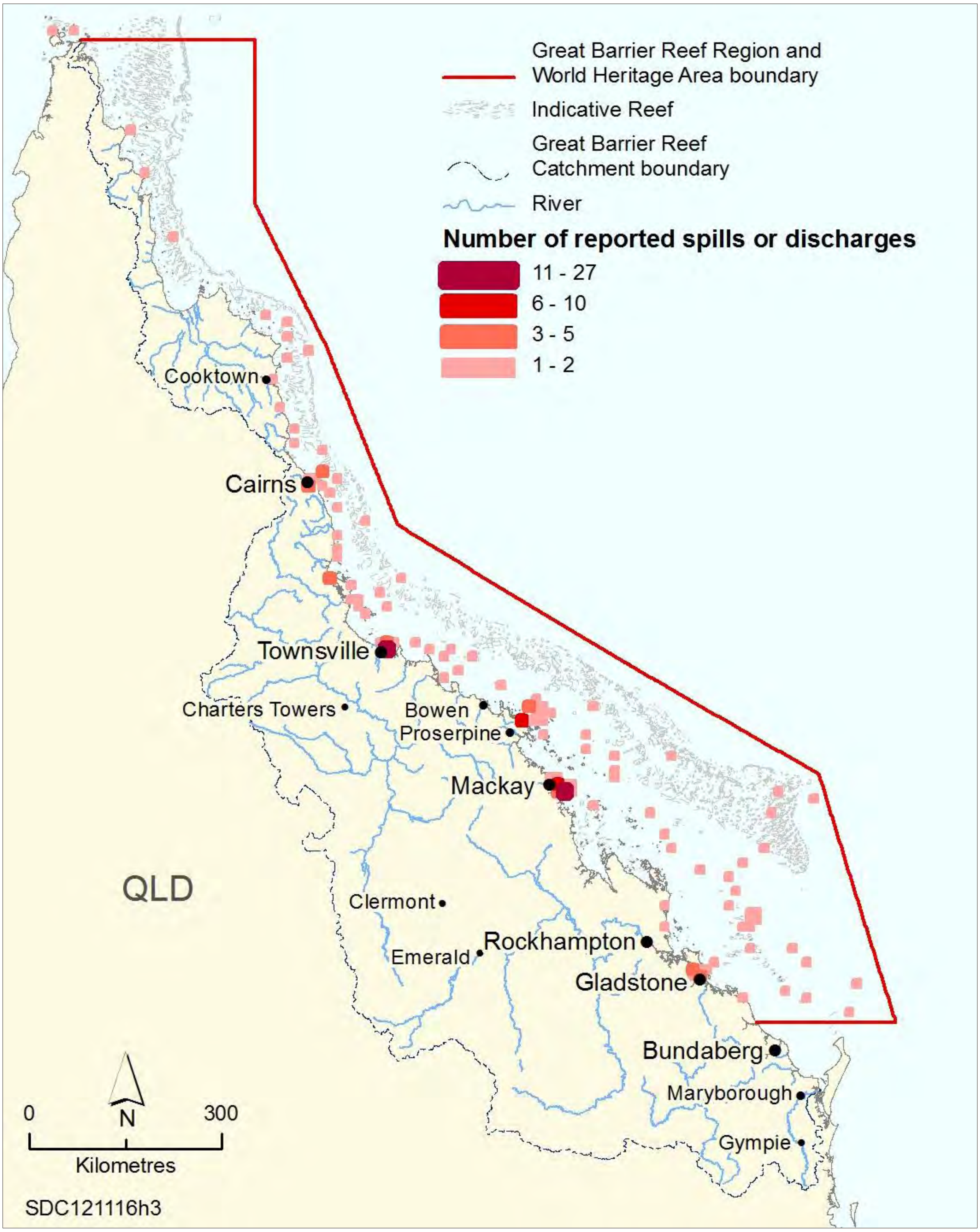


Figure 6.26 Reported spills and discharges in and adjacent to the Region, 1987–2012

Vessel strike on wildlife
Vessel strikes typically affect surface-breathing marine animals such as marine turtles, dugongs, dolphins and whales, often resulting in injury or death. Wildlife may be struck by any moving vessel (for example, jet skis, yachts, dinghies and cargo ships), but the chances and consequences are far greater for high-speed vessels.[279] The likelihood of a strike increases where high-speed vessels overlap with key shallow water habitats (for example seagrass meadows) or movement corridors for vulnerable animals. It also increases in areas adjacent to large regional communities where visits to the Region are more frequent and there are larger volumes of commercial traffic.[280] Dugongs do not appear to swim away from passing vessels, making them at high risk of vessel strike, especially from high speed vessels.[281]

Current published information on vessel strikes on dugongs, whales and dolphins suggests its impact on these species has not increased substantially within the Region and is a relatively infrequent occurrence on these species.[252,282]

Recently, the waters offshore from Gladstone have had an elevated number of marine turtle strandings. In 2011, there were eight times more interactions between marine turtles and vessels compared to 1996 when strandings data began to be recorded.[283]

Go slow areas and transit lanes have been declared in some areas where there is high vessel traffic and large populations of marine turtles or dugongs, such as near Hinchinbrook Island. The increase in boat traffic and the consequent risks to dugongs was of great concern to Traditional Owners prior to adoption of the management arrangements.[284]

Waste discharge from a vessel
The types of waste discharged from vessels into the sea include food waste, litter, grey water (that is, from showers, laundry) and sewage. There are specific requirements under the International Convention for the Prevention of Pollution from Ships, as well as Queensland and Commonwealth legislation (including Great Barrier Reef Marine Park Regulations), regarding how this waste should be treated and/or macerated prior to discharge. There is the potential for animals, such as planktivores and filter feeders, feeding on vessel-generated waste to suffer ill health from an unnatural diet. [285]

Waste discharge from vessels also increases nutrients in the water column, particularly sewage discharge which has high concentrations of nitrogen and phosphorous. Total sewage discharge into the Marine Park only accounts for about six per cent[286] of the nitrogen load, and vessel discharge contributes only a small portion of this.

Wildlife disturbance
Activities such as diving, snorkelling, fish feeding, fishing, reef walking, scenic flights, boating, walking and driving on beaches, and visiting islands can disrupt wildlife on a local scale, particularly in sensitive or heavily visited areas. These activities have the potential to disrupt animal behaviour, reduce their fitness and their ability to feed, breed, nest and migrate.[237,281,287,288,289,290,291,292,293,294,295,296,297,298,299,300]

Attitudes towards interacting with wildlife have changed over the decades. Whereas visitors may have previously ridden on, touched and chased wildlife, they are now much more aware of their activities and the best environmental practices for viewing these animals. At the same time, management arrangements have addressed many interactions (such as approaching whales, visiting important seabird rookeries or approaching critical migratory shorebird roosts).

While there is evidence that the presence of divers can attract or deter marine species, these effects may only be temporary[301]. Feeding to attract marine wildlife can potentially affect some species.[302] Tourism operators must have a permit from the Authority to feed fish as part of their tourist program and must abide by guidelines relating to the activity.

6.4.5 Assessment of impacts on biodiversity

A detailed assessment of the effects the above impacts have had or are currently having on the key biodiversity values identified in Chapter 4 is presented in Table 6.6 and Table 6.7.

The assessment is of past and present effects on indicators, with an indication of future trend. It is recognised that this assessment is generalised and that effects on individual values are not evenly distributed across all the components that make up a value or across the Region. This process is used as the first step to identify the impacts having the most effect on the Region's values. It is these impacts that are the focus of exploring cumulative impacts.

The future risk that these impacts present to the Region's values is assessed in Chapter 10.

Understanding Table 6.6 and Table 6.7

Grading statements

No effect: No interaction; the interaction is insignificant or unknown.	**Very low effect:** Any effects attributable to the impact are minor or localised, with no observable effects on the values.	**Low effect:** The effects of the impact are observable in some locations or to some species, but only to the extent that limited additional intervention would be required to maintain the values.	**High effect:** The effects of the impact are obvious in many locations or for many species to the extent that significant additional intervention would be required to maintain the values.	**Very high effect:** The effects of the impact are widespread to the extent that the values are severely compromised.

Trend

↑	**Increasing:** The intensity and/or spatial extent of the impact is increasing.
↔	**Stable:** The intensity and/or spatial extent of the impact is staying about the same.
↓	**Decreasing:** The intensity and/or spatial extent of the impact is decreasing.

Table 6.6 Past and present effects of impacts on Great Barrier Reef habitats

The assessments presented are based on the information presented in Section 6.4 above. The references cited there also apply to this assessment. * indicates impact is likely to be the result of a variety of activities.

	Impacts	Future trend of the impact	Islands	Beaches and coastline	Mangrove forests	Seagrass meadows	Coral reefs (<30m)	Deeper reefs	Lagoon floor	Shoals	*Halimeda* banks	Open waters	Continental slope
Climate change	Altered ocean currents	↑											
	Cyclone activity	↑	Red	Red	Orange	Red	Dark red	Orange	Orange	Orange	Orange		
	Increased sea temperature	↑	Yellow	Yellow		Orange	Red	Yellow				Orange	
	Ocean acidification	↑					Yellow	Yellow			Yellow	Yellow	
	Rising sea level	↑	Yellow	Yellow									
Catchment run-off	Increased freshwater inflow	↑			Yellow	Orange	Red					Orange	
	Nutrients from catchment run-off	↔		Orange		Red	Dark red		Yellow	Yellow		Red	
	Outbreak of crown-of-thorns starfish	↑					Dark red						
	Pesticides from catchment run-off	↔			Orange	Red	Red					Yellow	
	Sediments from catchment run-off	↔	Yellow	Yellow	Yellow	Red	Dark red	Yellow	Orange	Orange		Orange	
	Urban and industrial discharge	↑	Yellow	Yellow	Yellow	Yellow	Yellow					Orange	
Degradation of coastal ecosystems	Acid sulphate soils	↑	Yellow	Orange	Orange	Yellow	Yellow					Orange	
	Artificial barriers to flow	↑	Yellow	Orange	Yellow	Yellow			Orange				
	Atmospheric pollution	↑											
	Coastal reclamation	↑	Orange	Orange	Orange	Orange	Yellow		Yellow			Orange	
	Light impacts (artificial)	↑											
	Modifying supporting terrestrial habitats	↑	Orange	Red	Red								
Direct use	Dredging	↑	Yellow	Yellow	Yellow	Orange	Yellow		Orange	Orange			
	Dumping and resuspension of dredge material	↑	Orange	Orange	Yellow	Red	Red		Red	Orange		Orange	
	Exotic species and diseases*	↑	Red	Red									
	Extraction — death of discarded species	↔											
	Extraction — fishing spawning aggregations	↔											
	Extraction — herbivores	↔											
	Extraction — lower order predators	↔											
	Extraction — lower trophic orders	↔						Yellow					
	Extraction — top order predators	↔											
	Illegal fishing and poaching	↑							Orange				
	Marine debris*	↑	Yellow	Orange				Yellow	Yellow	Yellow	Yellow	Red	Yellow
	Noise pollution	↑	Orange									Orange	
	Outbreak of disease*	↑					Orange	Yellow					
	Outbreak or bloom of other species*	↑		Yellow		Yellow	Yellow					Yellow	
	Physical damage — fishing	↔				Orange	Yellow		Red	Orange			Yellow
	Physical damage — other	↑				Orange	Orange	Yellow	Orange	Yellow			
	Physical damage — ship grounding	↑	Yellow	Yellow		Yellow	Orange		Yellow	Orange		Yellow	
	Spill — large chemical	↑											
	Spill — large oil	↑	Orange	Orange	Orange	Orange	Yellow					Orange	
	Spill — small chemical or oil	↑	Yellow	Yellow	Yellow	Yellow	Yellow		Yellow	Yellow			
	Vessel strike on wildlife	↑											
	Waste discharge from vessels	↑	Yellow	Yellow			Yellow					Yellow	
	Wildlife disturbance	↑											

Table 6.7 Past and present effects of impacts on Great Barrier Reef species and groups of species

The assessments presented are based on the information presented in Section 6.4 above. The references cited there also apply to this assessment. * indicates impact is likely to be the result of a variety of activities.

	Impacts	Future trend of the impact	Mangroves	Seagrasses	Macroalgae	Benthic microalgae	Corals	Other invertebrates	Plankton and microbes	Bony fish	Sharks and rays	Sea snakes	Marine turtles	Estuarine crocodiles	Seabirds	Shorebirds	Whales	Dolphins	Dugongs
Climate change	Altered ocean currents	↑																	
	Cyclone activity	↑																	
	Increased sea temperature	↑																	
	Ocean acidification	↑																	
	Rising sea level	↑																	
Catchment run-off	Increased freshwater inflow	↑																	
	Nutrients from catchment run-off	↔																	
	Outbreak of crown-of-thorns starfish	↑																	
	Pesticides from catchment run-off	↔																	
	Sediments from catchment run-off	↔																	
	Urban and industrial discharge	↑																	
Degradation of coastal ecosystems	Acid sulphate soils	↑																	
	Artificial barriers to flow	↑																	
	Atmospheric pollution	↑																	
	Coastal reclamation	↑																	
	Light impacts (artificial)	↑																	
	Modifying supporting terrestrial habitats	↑																	
Direct use	Dredging	↑																	
	Dumping and resuspension of dredge material	↑																	
	Exotic species and diseases*	↑																	
	Extraction — death of discarded species	↔																	
	Extraction — fishing spawning aggregations	↔																	
	Extraction — herbivores	↔																	
	Extraction — lower order predators	↔																	
	Extraction — lower trophic orders	↔																	
	Extraction — top order predators	↔																	
	Illegal fishing and poaching	↑																	
	Marine debris*	↑																	
	Noise pollution	↑																	
	Outbreak of disease*	↑																	
	Outbreak or bloom of other species*	↑																	
	Physical damage — fishing	↔																	
	Physical damage — other	↑																	
	Physical damage — ship grounding	↑																	
	Spill — large chemical	↑																	
	Spill — large oil	↑																	
	Spill — small chemical or oil	↑																	
	Vessel strike on wildlife	↑																	
	Waste discharge from a vessel	↑																	
	Wildlife disturbance	↑																	

6.5 Impacts on geomorphological features

A detailed assessment of the effects the identified impacts have had or are currently having on geomorphological features of the Region (as identified in Chapter 4) is presented in Table 6.8.

The assessment is of past and present effects on the values, with an indication of future trend. As with biodiversity above, the assessment is generalised — effects on individual values may not be evenly distributed across all the components that make up a value or across the Region, and there will be spatial variation.

It can be assumed that many of the impacts affecting the condition of biodiversity values (above) may also be affecting the geomorphological features of the Region as the geomorphology and ecology of the Great Barrier Reef are strongly interdependent.[303] However, there is likely to be a lag in the response of geomorphological features to impacts compared to the ecological system. For example, coral species and coral reefs can degrade or die as a result of rises in sea temperature; however, the death of coral may not affect the overall reef structure until much later or until the dead coral begins to erode.[304]

The assessment presented in Table 6.8 demonstrates no high or very high effects on the Region's geomorphological features. Impacts which have had the most effect on geomorphological features are cyclone activity, modifying supporting terrestrial habitats, sediment in catchment run-off, increased freshwater inflow, dredging and dumping of dredge spoil.

- **Cyclones** have produced destructive effects on geomorphological features throughout the Region. Cyclone-induced waves and currents carrying sand and rubble can cause erosion of reefs and reworking of pre-existing sediment deposits.[304,305] Cyclones can also result in large areas of seagrass being ripped up,[305] leading to further instability of sediment in the area.[304] Recent cyclones have also caused the formation of new rubble cays, loss of some sandy cays and erosion of some shorelines by waves. Shoreline and shallow subtidal features are likely to be affected the most, whereas deeper features experience fewer effects.[304] Features such as continental islands and islands with some fringing vegetation and reefs are also likely to be better protected.[304,306] Cyclones are also likely to have rearranged some river deltas, however these are naturally dynamic systems.
- **Artificial barriers to flow** such as weirs and dams; **modifying supporting terrestrial habitats**; **dumping and resuspension of dredge material;** and increased **sediment from catchment run-off** affect the amount of suspended sediment within the Region. Suspended sediment can affect the health of some corals and increase their susceptibility to erosion.[304] It also affects the health of seagrass meadows and can potentially infill submerged palaeochannels.[304] Changes in sediment loads can also affect the shape and size of river deltas.
- Deepwater geomorphological features (90 to 300 metres deep) off the southern Great Barrier Reef may have been affected by **physical damage from fishing activities** (deep sea trawling), however there is limited knowledge about the effects.[304]
- Alterations to channels in river deltas from **dredging** have the potential to remove or rearrange sediment deposits that make up the geomorphological feature.[304]
- **Increased freshwater inflow,** particularly during flood events, has had an effect on islands and shorelines and river deltas within the Region. It also affects the health of coral reefs and seagrass meadows. Extreme weather events in the summer of 2010–11 resulted in increased freshwater inflow. The worst effects were on some inshore reefs close to the mouths of major rivers and on the mainland sides of islands.[305]
- **Coastal reclamation** has affected some shorelines and river deltas by changing the way sediment is eroded, transported and deposited.

Submarine canyons and turbidite deposits occur in deep waters along the continental shelf. Due to the relative inaccessibility, they are presumed to be largely unaffected by the impacts assessed.

Understanding Table 6.8

Grading statements				
No effect: No interaction; the interaction is insignificant or unknown.	**Very low effect:** Any effects attributable to the impact are minor or localised, with no observable effects on the values.	**Low effect:** The effects of the impact are observable in some locations or to some geomorphological features, but only to the extent that limited additional intervention would be required to maintain the values.	**High effect:** The effects of the impact are obvious in many locations or for many geomorphological features to the extent that significant additional intervention would be required to maintain the values.	**Very high effect:** The effects of the impact are widespread to the extent that the values are severely compromised.
Trend				
↑	**Increasing:** The intensity and/or spatial extent of the impact is increasing.			
↔	**Stable:** The intensity and/or spatial extent of the impact is staying about the same.			
↓	**Decreasing:** The intensity and/or spatial extent of the impact is decreasing.			

Table 6.8 Past and present effects of impacts on Great Barrier Reef geomorphological features

* indicates impact is likely to be the result of a variety of activities

	Impacts	Future trend of the impact	Coral reefs	Islands and shorelines	Channels and canyons	River deltas	*Halimeda* banks	Seagrass beds
Climate change	Altered ocean currents	↑						
	Cyclone activity	↑						
	Increased sea temperature	↑						
	Ocean acidification	↑						
	Rising sea level	↑						
Catchment run-off	Increased freshwater inflow	↑						
	Nutrients from catchment run-off	↔						
	Outbreak of crown-of-thorns starfish	↑						
	Pesticides from catchment run-off	↔						
	Sediments from catchment run-off	↔						
	Urban and industrial discharge	↔						
Degradation of coastal ecosystems	Acid sulphate soils	↑						
	Artificial barriers to flow	↑						
	Atmospheric pollution	↑						
	Coastal reclamation	↑						
	Light impacts (artificial)	↑						
	Modifying supporting terrestrial habitats	↑						
Direct use	Dredging	↑						
	Dumping and resuspension of dredge material	↑						
	Exotic species and diseases*	↑						
	Extraction — death of discarded species	↔						
	Extraction — fishing spawning aggregations	↔						
	Extraction — herbivores	↔						
	Extraction — lower order predators	↔						
	Extraction — lower trophic orders	↔						
	Extraction — top order predators	↔						
	Illegal fishing and poaching	↑						
	Marine debris*	↑						
	Noise pollution	↑						
	Outbreak of disease*	↑						
	Outbreak or bloom of other species*	↑						
	Physical damage — fishing	↔						
	Physical damage — other	↑						
	Physical damage — ship grounding	↔						
	Spill — large chemical	↑						
	Spill — large oil	↑						
	Spill — small chemical or oil	↑						
	Vessel strike on wildlife	↑						
	Waste discharge from a vessel	↑						
	Wildlife disturbance	↑						

6.6 Impacts on Indigenous and historic heritage values

6.6.1 Indigenous heritage values

As demonstrated in Chapter 4, the Indigenous heritage values of the Region are interconnected in a cultural landscape. The natural environment is fundamental to Traditional Owner connections to their land and sea country. Therefore, when considering likely impacts on Indigenous heritage values, the first step is to recognise that all impacts identified as affecting natural values in Sections 6.4 and 6.5 are likely to be equally affecting Indigenous heritage values.

Added to this are the effects on the other aspects of Indigenous heritage such as cultural practices, sacred sites, sites of particular significance, stories, songlines, totems, language, technology, tools and archaeology. The following is a series of examples of the ways in which the identified impacts have been and continue to affect these values since European settlement. A structured assessment of the impacts is presented in Table 6.9 below.

Traditional Owners report their ability to catch food has been affected by the **death of discarded species**, resulting in a break with cultural practice, lore and custom, and interference with sites of particular cultural significance. For example, if all the fish are gone from an area, Traditional Owners may not be able to go there anymore. Indigenous communities in Cape York have reported to the Authority's staff large hauls of queenfish being discarded by commercial netters in Princess Charlotte Bay.[307] Indigenous heritage values are also severely affected by the loss of dugong, a cultural keystone species that can be incidentally caught and killed in nets. [308]

Although a legacy activity, past **commercial harvesting of herbivores,** such as marine turtle and dugong, has ongoing effects on Indigenous cultural values and has significantly changed cultural practices. The low population size, in part due to the previous commercial harvests, limits the number of animals available for hunting, as well as changing where animals occur. [308]

Indigenous heritage values can be affected by the **extraction of lower order predators**. For example, a key food source by Injinoo Traditional Owners, the black jewfish, is now found in much lower numbers and in much smaller sizes, altering their ability to maintain their cultural practices and customs. This decline has been attributed to fishing pressure.[284]

The **extraction of lower trophic orders** has affected Indigenous heritage values in some areas. For example, Gooreng Gooreng Traditional Owners from the Gladstone region report a decline in seafoods such as oysters and crabs.[284] As well as being an important food source, the cultural practice tied to collecting these shellfish (usually by women) is being lost as the resource becomes increasingly scarce.[284]

The **illegal take** of culturally significant species including dugong, marine turtles, sea snakes, sharks, rays, crayfish, mullet, oysters, pipi, clamshells, whiting and bream can have direct effects on Indigenous heritage values such as cultural practices, observances, lore, stories, songlines and sites. Taken at the wrong time of year, in the wrong numbers or at a culturally sensitive site reduces the numbers available for use in traditional ways and forces Traditional Owners to change their customs and practice.[284]

Species most affected by **vessel strike on wildlife** are also species culturally significant for many Great Barrier Reef Traditional Owners. Marine turtles, dugongs and whales are totem animals and are part of cultural practice, observances, tradition and stories and songlines. A reduction in these species has directly affected Indigenous heritage values. For example, they are not available as a food source and, therefore, cultural practices such as hunting cannot be undertaken. In turn, observances, lore and customs cannot be continued.

The increasing amount of **marine debris** is affecting cultural keystone species for Traditional Owners. For example, plastics that float in the open ocean affect seabirds[309] — many of which are totem animals and intimately linked with storylines.

Understanding Table 6.9

Grading statements				
No effect: No interaction; the interaction is insignificant or unknown.	**Very low effect:** Any effects attributable to the impact are minor or localised, with no observable effects on the values.	**Low effect:** The effects of the impact are observable in some locations or to some heritage sites or values, but only to the extent that limited additional intervention would be required to maintain the values.	**High effect:** The effects of the impact are obvious in many locations or for many heritage sites or values to the extent that significant additional intervention would be required to maintain the values.	**Very high effect:** The effects of the impact are widespread to the extent that the values are severely compromised.

Trend	
↑	**Increasing:** The intensity and/or spatial extent of the impact is increasing.
↔	**Stable:** The intensity and/or spatial extent of the impact is staying about the same.
↓	**Decreasing:** The intensity and/or spatial extent of the impact is decreasing.

Table 6.9 Past and present effect of impacts on Indigenous and historic heritage values

The assessment of effects on Indigenous heritage takes into account the interconnectedness of nature and culture for Indigenous people. It reflects effects on the Region's natural environment and other aspects of Indigenous heritage such as cultural practices, stories and language. * indicates impact is likely to be the result of a variety of activities.

	Impacts	Future trend of the impact	Cultural practices, observances, customs and lore	Sacred sites, sites of particular significance, places important for cultural tradition	Stories, songlines, totems and languages	Indigenous structures, technology, tools and archaeology	Places of historic significance — historic shipwrecks	Places of historic significance — World War II features and sites	Places of historic significance — lightstations	Places of historic significance — other	Places of scientific significance	Places of social significance — iconic sites
Climate change	Altered ocean currents	↑										
	Cyclone activity	↑										
	Increased sea temperature	↑										
	Ocean acidification	↑										
	Rising sea level	↑										
Catchment run-off	Increased freshwater inflow	↑										
	Nutrients from catchment run-off	↔										
	Outbreak of crown-of-thorns starfish	↑										
	Pesticides from catchment run-off	↔										
	Sediments from catchment run-off	↔										
	Urban and industrial discharge	↔										
Degradation of coastal ecosystems	Acid sulphate soils	↑										
	Artificial barriers to flow	↑										
	Atmospheric pollution	↑										
	Coastal reclamation	↑										
	Light impacts (artificial)	↑										
	Modifying supporting terrestrial habitats	↑										
Direct use	Dredging	↑										
	Dumping and resuspension of dredge material	↑										
	Exotic species and diseases*	↑										
	Extraction — death of discarded species	↔										
	Extraction — fishing spawning aggregations	↔										
	Extraction — herbivores	↔										
	Extraction — lower order predators	↔										
	Extraction — lower trophic orders	↔										
	Extraction — top order predators	↔										
	Illegal fishing and poaching	↑										
	Marine debris*	↑										
	Noise pollution	↑										
	Outbreak of disease*	↑										
	Outbreak or bloom of other species *	↑										
	Physical damage — fishing	↔										
	Physical damage — other	↑										
	Physical damage — ship grounding	↔										
	Spill — large chemical	↑										
	Spill — large oil	↑										
	Spill — small chemical and oil	↑										
	Vessel strike on wildlife	↑										
	Waste discharge from a vessel	↑										
	Wildlife disturbance	↑										

The **modification of supporting terrestrial habitats** since European settlement has changed Traditional Owners' country and diminished cultural and heritage values. For example, timbers that were once abundantly available to make tools are no longer found along many stretches of coastline.[310] Also, in Dharumbal country, coastal pandanus was and still is used for making baskets and matting. The distribution and abundance of the pandanus tree has been greatly reduced since European settlement.[311] Clearing and modifying coastal areas has also reduced the distribution and abundance of the corkwood tree, a well-used and important tree for Wulgurukaba Traditional Owners.[312] A traditional burial site was disturbed in 1998–99 when a dam was built at Francis Creek on the north side of Palm Island; more than forty remains were disturbed during sand removal.[313] Another example is along the shores of Cleveland Bay and Ross River, which have significance as 'Dreaming places' and as important fishing and hunting grounds. Traditional Owners report that traces of the 'big Murri camps' are 'long gone' as a result of modern disturbance to the landscape.[314]

Historically, some **coastal reclamation** has been undertaken without proper engagement or consultation with Traditional Owners, resulting in effects on Indigenous heritage values. Any changes to land and seascapes are changes to Traditional Owners' country and, therefore, diminish culture and heritage values such as story places, songlines and sacred sites. For example, in the Nelly Bay harbour development on Magnetic Island there was an incident that involved digging up of remains.[315] Bindal Traditional Owners have also reported that Ross Creek fish traps have disappeared due to reclamation, meaning it is no longer possible to pass on this traditional practice to future generations.[307] Another example is at Clump Point near Mission Beach — a culturally important story place. Part of the story involves the shape of the bay and headland; changes due to development mean the storyline is broken and the significant cultural site has been affected.[316]

There can be sea burial sites, sacred sites and sites of other cultural significance in the areas where **dredging** is undertaken and, previously, inadequate consultation with Traditional Owners has meant some of these values have been affected.[317] For example, places where access channels are dredged for island resorts or communities are usually also common access points for Traditional Owners, identified and used for thousands of years. In addition, dredging activities can disturb cultural practices and sacred sites. For example, Traditional Owners raised concerns about dredging impacts on local plants and animals in Cleveland Bay.[314] Furthermore, it is reported that any prehistoric archaeological remains in that port area would likely have been destroyed by the prolonged and repeated dredging.[314]

For Traditional Owners, the reefs of the Great Barrier Reef have many stories associated with them. Cultural practices and lore linked with story places are 'broken' or affected if there is a **ship grounding** on those reefs. Particular examples include Piper Reef where the *Peacock* ran aground in 1996[318] and the *Doric Chariot* in 2002[319]. Piper Reef is an important story place for its Traditional Owners and these groundings are likely to have affected the cultural heritage of the site. Sudbury Reef, where the *Bungu Terati Satu* ran aground in 2000,[320] is not only a story place but an important cultural place where young men go for traditional rite of passage[321].

Cyclones change land and seascapes, changing places of significance to Traditional Owners' and affecting Indigenous structures. Subsistence limits on marine resources are affected, potentially resulting in moratoria on Traditional Owner hunting and temporary changes to cultural practices.[322] Cyclones have also had effects on important cultural sites. For example, cyclone Charlie (1988) and cyclone Aivu (1989) destroyed about 50 per cent of the archaeological sites recorded at Upstart Bay in 1987.[323] The recent increases in **freshwater inflow** have affected areas that Traditional Owners use for subsistence. The effects on seagrass meadows and cultural keystone species, such as marine turtles and dugongs, have resulted in Traditional Owners deciding to apply moratoria on hunting while the habitats recover or while the animals are in poor condition.[322,324] That, in turn, means places important for cultural tradition may not be visited, or stories and songlines might not be practiced or passed down to younger generations, because those aspects are directly related to fishing, collecting or hunting activities.

Traditional Owners have observed impacts on Indigenous heritage values from **rising sea levels**. For example, the fish traps in Girringun country in the Cardwell area are being affected.[325] Once culturally significant sites are affected, then stories and songlines are compromised and customary practice has to be changed.

The effect of **pesticides** on the natural environment has a flow-on effect on the cultural values of Traditional Owners. Marine animals and plants affected by pesticides are likely to be linked to a range of Indigenous heritage values.

Cultural practices have been affected by **urban and industrial discharge** including heavy metal contaminants. High levels of heavy metals have been detected in the livers of turtles[326] and dugongs,[126] which could pose health risks to Indigenous people. In the Torres Strait, there is a program designed to encourage Traditional Owners not to eat the liver of dugong or turtle for health reasons. In the Gladstone region, some Traditional Owners consider the health of turtles to be so poor they are not prepared to take animals for cultural reasons.[317]

Traditional Owners report that **physical damage** to reefs, cays and the seabed has affected sacred sites and sites of cultural significance. For example, boats often anchor in bays near Hinchinbrook Island where the Haven fish traps are located. These fish traps are of extremely high cultural significance to Girringun Traditional Owners.[284] In turn, this can have an effect on cultural observances, songlines and storylines.

Traditional Owners have expressed concern about reductions in seagrass due to **physical damage from fishing** such as trawling in shallow water and its effect on their access to marine resources.[284]

6.6.2 Historic heritage values

The historic heritage of the Region includes its lightstations, wrecks, places of significance and iconic sites as described in Chapter 4. A structured assessment of the effects of past and present impacts on this heritage is presented in Table 6.9 above.

Many of the impacts considered are assessed to have not affected the Region's historic heritage. Of those considered to be affecting historic heritage, the effects have been assessed as either: minor or localised with no observable effects on the values; or observable in some locations, but only to the extent that limited additional intervention would be required to maintain the values.

Cyclones have affected historic shipwrecks, World War II features and sites, and lightstations. A recent example is the effect of cyclone Yasi on the wreck of the *SS Yongala* in 2011, including moving some parts and 'sandblasting' its exterior. Throughout historical times, cyclones have damaged historic structures such as resorts.[305]

The connections between the natural environment and the scientific activities historically undertaken in the Region means the heritage value of places of scientific significance is affected to some extent by the impacts affecting the places' natural values.

6.7 Impacts on community benefits of the environment

The benefits that Reef-dependent communities and industries derive from the Region's environment are founded on its biodiversity, geomorphological features, and Indigenous and historic heritage values. The quality and magnitude of community benefits, including its aesthetic value, are therefore affected by impacts that diminish the condition of those values.

The depth and extent of the flow-on effects to community benefits as a result of impacts on biodiversity, geomorphology and heritage values are difficult to assess. However, it is recognised that the economic and employment benefits derived by Reef-dependant industries (such as tourism, commercial fishing and some aspects of recreational use) are at highest risk and stand to be the most affected by a declining ecosystem.

Because everyone's interaction with the Reef is different, effects on community benefits derived from the environment will depend very much on each Reef user's individual perspective.

In broad terms:

- Income and employment benefits are diminished by impacts that affect the productivity and attractiveness of the environment, such as those related to catchment run-off, loss or modification of coastal habitats, climate change, declines in iconic species and a reduction in the aesthetic qualities of the Region. These qualities are essential for Reef-dependent industries like tourism, fishing, recreational use and traditional use of marine resources.
- The benefits derived by people understanding, appreciating, enjoying and admiring the Region's environment are most affected by those impacts that significantly affect key values — in particular coral reef habitats and species, the quality and clarity of the Reef's water, the land and seascapes and iconic species such as dugongs, marine turtles, sharks, whales and dolphins.
- The ability for people to access the Reef's resources is affected by the impacts that diminish those resources, such as those that affect coral reefs as a place to visit and populations of

targeted fish species. In this regard, declines in top predators could affect the commercial and recreational fisheries that target these species, and tourism (particularly dive tourism) for which big sharks and fishes are important natural attractions.[327] A high density of vessels at anchor at a ship anchorage area can interfere with other user's ability to effectively use that area (for example, tourism and commercial, recreational and traditional fisheries).[266]

- People's personal connection with the Reef's environment is diminished by the range of impacts that degrade the quality of its key habitats, iconic locations and iconic species such as those related to catchment run-off, climate change and declines in species of conservation concern. In particular, Traditional Owner connections are affected by any impacts that affect their sea country and their ability to maintain their culture in relation to it.
- The health benefits people derive from the Region are diminished by those impacts that make the Reef a less attractive and fulfilling place to visit, and by those that reduce the quality and availability of its wild-caught food resources.
- The aesthetic values of the Region may be diminished by development activities. For example the building of structures, industrial and port developments, and coastal reclamation could affect the natural scenic values of the coastal areas. Marine debris, along with oil and chemical spills, also affects the aesthetic value of seascapes and islands. Coastal reclamation may affect aesthetic qualities of the landscape and seascape.[328] Increased turbidity diminishes the Region's underwater aesthetic values.[328] Artificial light and noise pollution associated with coastal development and increased shipping activities and anchorage areas[266] may diminish aesthetic attributes such as tranquillity, solitude and remoteness. [328]

The concept of 'shifting baselines' (see Section 7.1) is relevant in considering the extent to which the community benefits derived are affected by changes in the condition of the Region's biodiversity, geomorphological features, and Indigenous and historic heritage values. Over time, many users have adapted their activities and expectations in response to the changing condition of the Reef environment.

6.8 Cumulative impacts

The examination of the effect of impacts on individual values presented in the previous sections identifies the impacts having the most significant effects on key values relevant to matters of national environmental significance in the Region. However, this one-on-one assessment does not take into account cumulative impact — the successive and combined effects of impacts on the environment. In this section, both qualitative models and spatial analysis techniques are applied to investigate the complex interactions between some of the key impacts and values.

6.8.1 Qualitative models

As part of the Sustainable Regional Development Program project to develop a resilience framework to inform decision making in the Great Barrier Reef coastal zone[329], qualitative models were developed for coral reef and seagrass ecosystems, and dugong (a species dependent on seagrass). The models examine the relationships of drivers, activities, impacts and values, and were developed through workshops with experts in coral reef and seagrass biology and ecology

They broadly detail the main variables and effects — excluding minor species groups and weak effects. The models outlined below are only preliminary and will require further refinement and validation before implementation.

A basic feature of qualitative models is the development and analysis of sign-directed graphs, or signed digraphs. These are used to describe the main interacting variables within a system, linking them to their surrounding ecosystem and also to the drivers, activities and impacts of concern. Analysis of the structured lists (for example Table 6.2) and value-impact matrices (for example Table 6.6 to Table 6.9) helps inform assessment of the relative importance of drivers, activities and impacts on values, and how they affect the system. While model links are qualitative — they represent only the 'sign' of the effects (that is, positive, negative or nil) — they, nonetheless, provide a rigorous means to formally assess a system's dynamics and its response to disturbances.

Modelling approach

The use of models for the strategic assessment process is guided by a strategy of model building that ultimately seeks to combine different modelling approaches to better understand, predict and intervene in complex ecological and socio-economic systems.[330,331] The underlying premise is that there are three desired properties of models: *generality*, *realism* and *precision*. A model that attempts to maximise all three properties, however, quickly becomes impractical to apply and difficult to understand. There needs to be a trade-off — a choice to emphasise two properties over a third, leading to three alternative modelling approaches.

Quantitative process models — Models that emphasise precision and realism over generality result in precise predictions for highly specified details of a system's biological and ecological components, processes and relationships. Such models produce precise and testable predictions, and are favoured by managers who ask 'how much do I have to spend on *X* to get this amount of *Y*.' Developing these models, however, typically requires extensive amounts of data. They are tuned to the specific context from which their data were drawn (that is, they lack generality), and thus are not easily transferred to new applications without additional data gathering, tuning of parameters and calibration.

Statistical models — Models that emphasise precision and generality over realism result in precise testable predictions based on correlations among system variables. They are useful for describing general patterns with measured confidence and are more easily exported to new situations, but again, they come with a burden of data acquisition and they provide less understanding of the underlying processes, as correlation is not synonymous with causation.

Qualitative process models — Models that emphasise realism and generality over precision are free from the constraint of extensive and expensive data collection, and while predictions are not precise, they are nonetheless rigorous in their derivation and testable. They are based on the qualitative interpretation of processes and do not require exact specification of functions or parameter values. The process of building a qualitative process model requires answering the general questions of: 'does a variable have a positive or negative effect on another variable?' and 'is a function increasing or decreasing, above or below a threshold?' Predictions are expressed in terms of directional change in a variable (that is, increase, decrease, no change) or as inequalities that highlight key relationships or parameters in the system.

Each approach has its own inherent strengths, and each can provide useful results. Models based on each approach will necessarily be derived from different simplifying assumptions, and each purposefully leaves something out about how the world works. The dilemma is not about which approach is better — each is incomplete but serves the common goals of understanding, prediction and intervention. Rather, the aim is to confront the problem of complexity with an array of alternative models drawn from each approach. Then, if the different models arrive at similar results, even though they are based on different assumptions, a robust concept of the system has been developed that is relatively independent of model details.[331]

While there will always be a need to address management questions with precision, the scale, complexity and pace of change affecting the Great Barrier Reef Region presents significant limitations to the widespread application of quantitative models. However, many — if not most — of the management objectives for the Region can be meaningfully interpreted and approached qualitatively. The challenge is to match the relative scale and complexity of the management problem with the appropriate set of analytical tools and to deliver practical results in a timely manner.

Coral reef ecosystem model

The coral reef model (Figure 6.27) provides a generalised depiction of the processes that enhance or diminish corals, and the role that coral plays in supporting biodiversity. Corals are strongly dependent on successful coral recruitment, compete for space with macroalgae, and provide critical habitat and resources for fishes and invertebrates. Crown-of-thorns starfish can strongly affect corals during outbreaks, and it is hypothesised that such outbreaks are enhanced by nutrients. Drivers, activities and impacts on coral reefs do not stand alone, but are intertwined in a complex web of synergistic or cumulative impacts. The model shows some cause-and-effect relationships are relatively simple, such as an increase in ocean warming increasing the frequency of coral bleaching events, which then leads to a reduction in coral cover. However, an increase in catchment run-off from agriculture leads to increases in four impacts (toxins, nutrients, turbidity and sedimentation) that affect a total of seven ecosystem variables (predatory fish, herbivorous fish, crown-of-thorns starfish, fish and invertebrates, macroalgae, crustose coralline algae and coral recruitment, and coral cover).

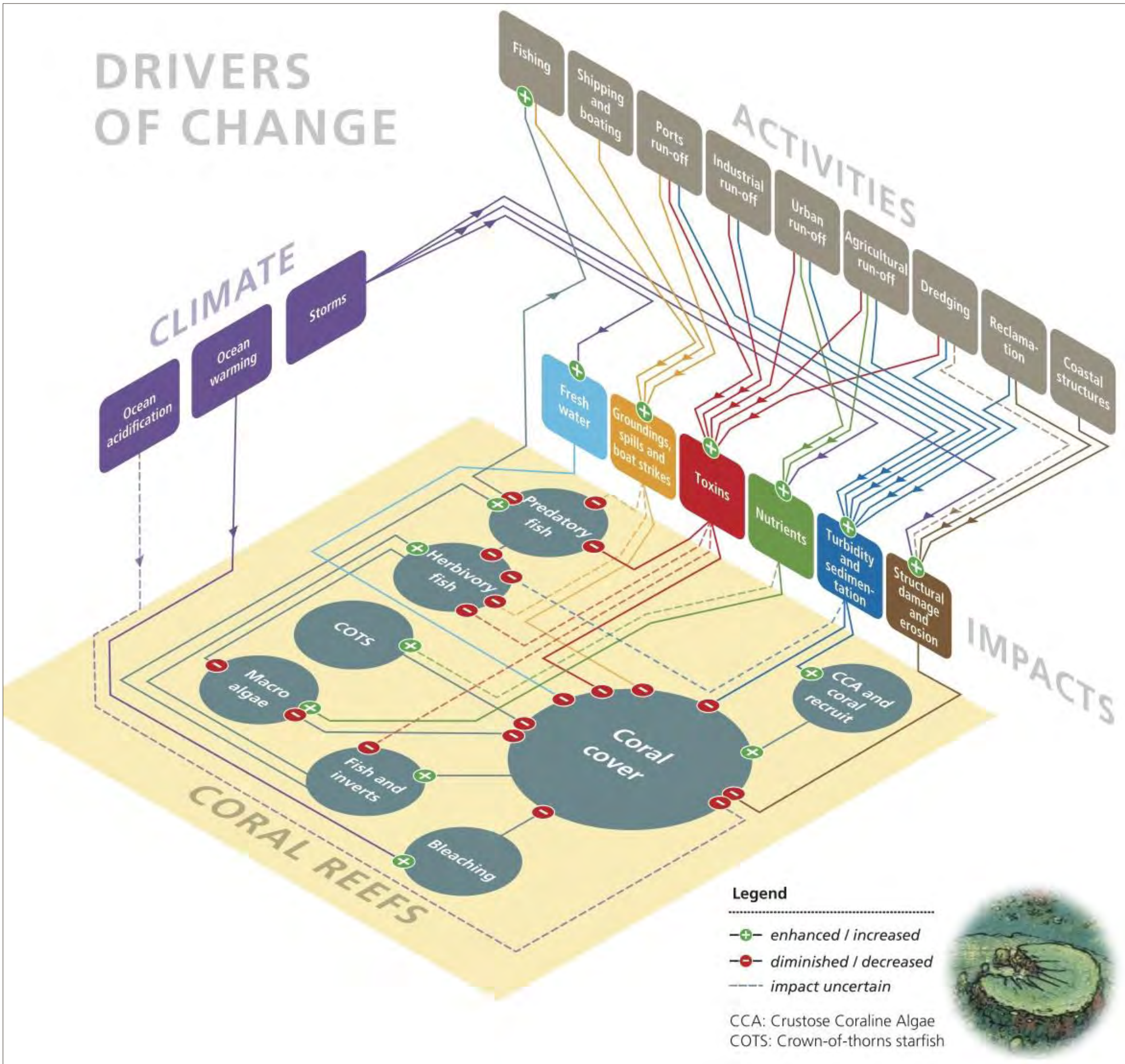


Figure 6.27 Qualitative model of how coral reefs are affected by drivers, activities and impacts

The model illustrates how coral reefs are affected by multiple impacts that result from various direct drivers and activities. It broadly details the main variables and effects, and excludes minor (rare) species groups and weak effects. Links describe direct positive or negative effects of one variable on another. There are a number of links that are uncertain or contentious. These are represented by dashed lines and provide the basis to consider alternative model structures in subsequent analyses (Chapter 11).

Seagrass meadows model and dugongs

The seagrass model (Figure 6.28) represents the dynamics of seagrass meadows. These can be composed of fast growing species of seagrass favoured by frequent disturbances and high grazing pressure (known as ‘r’ species) or slow-growing species favoured by conditions of low disturbance and low levels of grazing (known as ‘K’ species). One of the variables in the model is the ratio of ‘r’ and ‘K’ species, representing the relative dominance of these two types of species. In the model, some variables such as dugong populations or storms can act to shift the relative balance between these two types of seagrass species. Other factors that regulate seagrass include epiphytic algae which grow on the surface of seagrass and can inhibit their growth through shading.

Similar to the model for coral reef ecosystems, the seagrass meadows model shows some cause-and-effect relationships are relatively simple, such as an increase in turbidity and sedimentation suppressing seagrass distribution and abundance, which then leads to a reduction in dugongs. An increase in catchment run-off from agriculture, however, leads to the increase of four impacts (toxins, nutrients, turbidity and sedimentation) that affect a total of five ecosystem variables (scrapers (prawns and fishes), marine turtles, dugongs, epiphytes and seagrass distribution and abundance). There are both positive and negative influences on the relationship between catchment run-off and seagrass distribution and abundance. There are also thresholds for which positive influences can become negative. For example, seagrasses are generally considered nutrient-limited and thrive under conditions of increased nutrients. However, after a certain threshold, they can deteriorate due to light reduction from an increase in epiphytes, macroalgae or phytoplankton.[332]

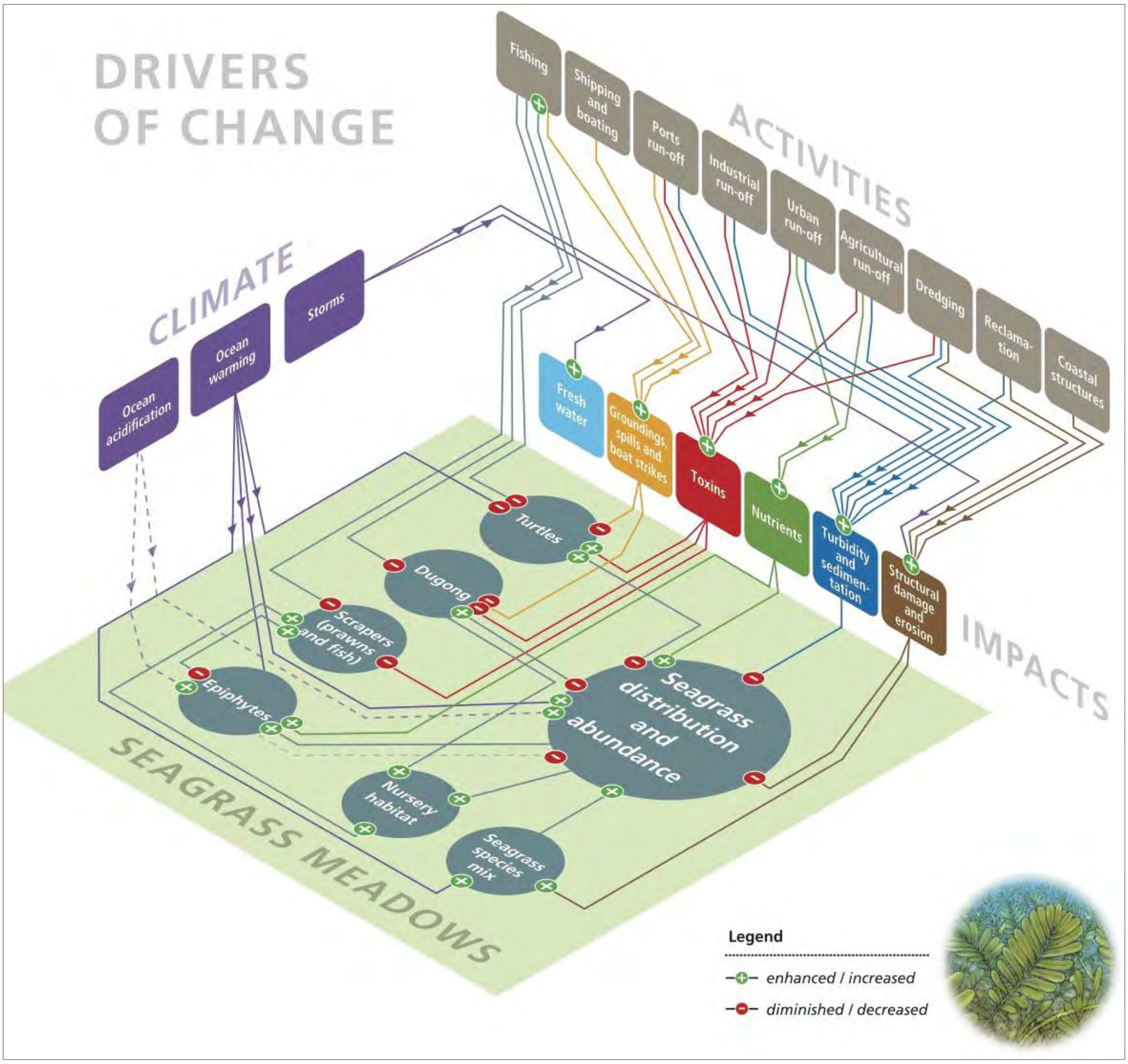


Figure 6.28 Qualitative model of how seagrass meadows are affected by drivers, activities and impacts

The model illustrates how seagrass meadows are affected by multiple impacts that result from various drivers and activities. It broadly details the main variables and effects and excludes minor (rare) species groups and weak effects. Links describe direct positive or negative effects of one variable on another. There were a number of links that were uncertain or contentious. These are represented by dashed lines and provide the basis to consider alternative model structures in subsequent analyses (Chapter 11).

6.8.2 Spatial approaches

Mapping approaches show the spatial distribution of interactions between values and impacts. As an initial step to understanding cumulative impacts across the Region, standard geographic information system analysis, where individual impact gradients are standardised, has been undertaken for both coral reefs and water quality.

The coral reef analysis examines the amount the reefs throughout the Region have been exposed to identified key impacts. The water quality analysis examines the risk that the ecosystem has faced as a result of key water quality impacts, taking into account the likely vulnerability of various ecosystem components.

Coral reefs

As outlined in Chapter 7, the primary drivers of coral decline in the Region have been crown-of-thorns starfish, cyclones and coral bleaching events. Coral bleaching is typically caused by elevated temperatures but can also be caused by freshwater exposure. Figure 6.29 presents the exposure of reefs to each of these key impacts for 2001 to 2011. These individual impacts are then combined and scaled in a similar way for the cumulative exposure map (Figure 6.30).

It is important to note this analysis does not represent all past and current impacts on coral reefs. In particular, many notable impacts to coral reef systems occurred before the decade presented — notably, major crown-of-thorns starfish outbreaks in the 1980s and 1990s, and the 1998 mass coral bleaching event. The 2001–2011 period was chosen based on the availability of remote sensing data and because the decade covers a range of El Nino and La Nina conditions.

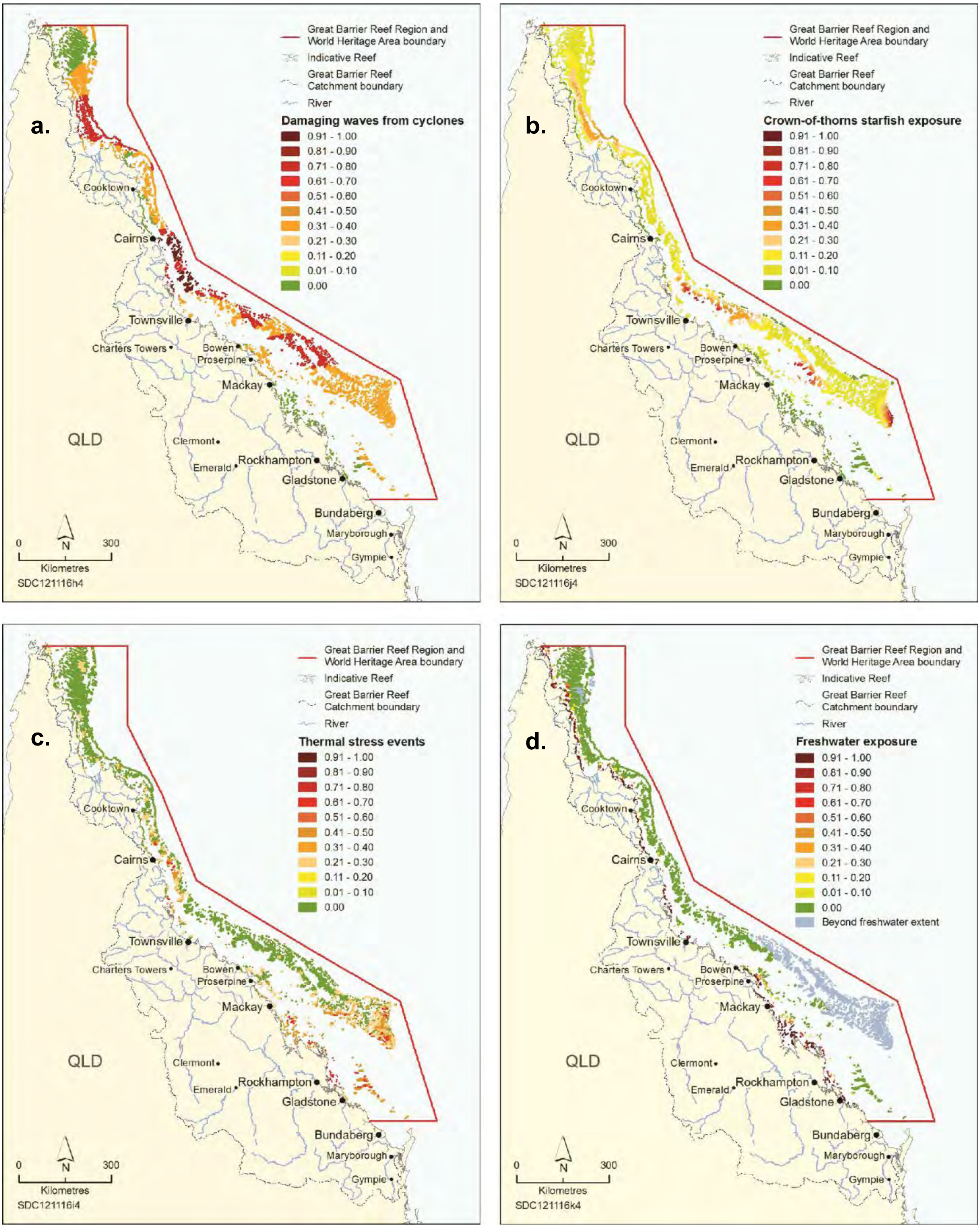


Figure 6.29 Exposure of coral reefs to key impacts, 2001-2011

The key impacts analysed are (a) damaging waves from cyclones, (b) crown-of-thorns starfish outbreaks, (c) thermal stress events and (d) freshwater exposure. Individual impacts are scaled between zero and one, with the most exposed reef areas being scored at one.

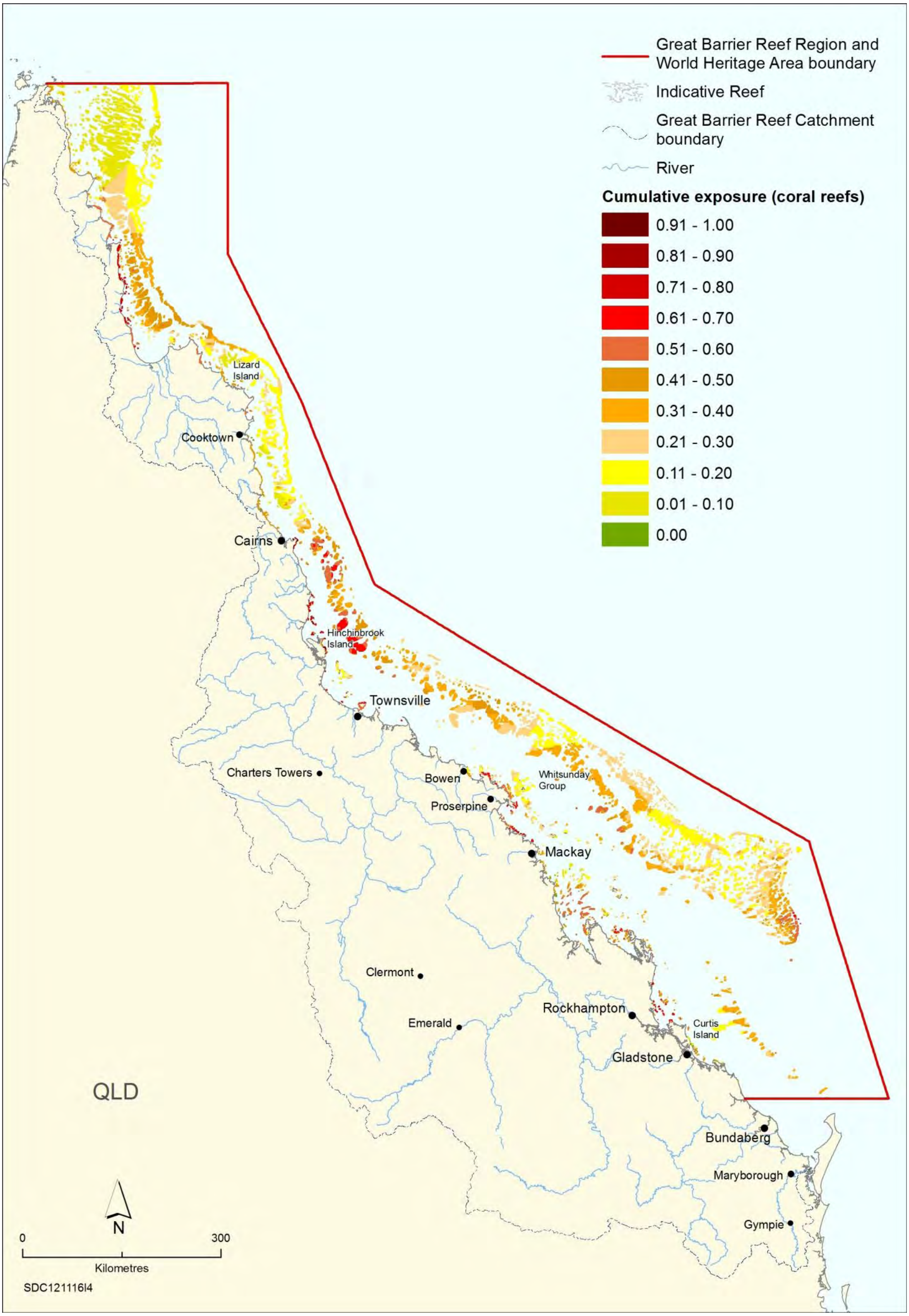


Figure 6.30 Cumulative exposure of coral reefs to key impacts, 2001–2011[333]

The map presents the modelled cumulative exposure of coral reefs to cyclone-induced waves, crown-of-thorns starfish outbreaks, elevated sea surface temperatures and freshwater inflow. The magnitude of the impacts has been normalised between zero and one, where the highest score was 2.40 out of a maximum possible of 4.

Water quality

Freshwater influxes from catchment run-off, and the load of nutrients, sediments, pesticides and other pollutants they carry, affect the marine ecosystems in the Region, particularly inshore Great Barrier Reef habitats and species.[75] Individual habitats and species will be affected by these impacts in different ways, depending on how much it is exposed and how sensitive it is. A relative risk assessment of degraded water quality on Great Barrier Reef ecosystems has been conducted to inform implementation of the Reef Plan and Reef Rescue programs, and has substantially improved understanding of the combined effects of water quality. [334] The outcomes of this risk assessment are reported below.

The exposure of a species or habitat to an impact is typically a function of the intensity of the impact (the concentration or load of a pollutant) and the length of time it is exposed to the impact. For example, a seagrass meadow may be exposed to a high intensity impact for a short period of time, or to lower intensities for longer periods. When quantifying exposure, it is important to determine the threshold concentrations — the concentration which potentially leads to damage or mortality within hours or days — for each habitat or species, as well as determining long-term average concentrations and the duration of exposure.[334] This complicates the description of exposure thresholds given their values may change by one to two orders of magnitude between days, seasons and years.[334] Hence, some key water quality variables, such as suspended sediments, are divided into different thresholds based on ecological responses, periods of exposure and the potential severity of the impact on habitats.[334] Due to limitations in the spatial and temporal availability of data, this assessment defines relative risk as the total area of coral reefs and seagrass meadows in the highest severity classes for several water quality variables.

As outlined in Section 6.4.2, the key impacts in relation to water quality in the Region are nutrients, sediments and pesticides in catchment run-off. Based on these three broad impacts, the key variables examined in the combined impact analysis are:

- Concentrations of **total suspended solids above two milligrams per litre** (Figure 6.31a). This variable correlates strongly with declines in ecosystem condition such as increased growth of macroalgae and declining diversity.[335] Two milligrams per litre is the average annual threshold in the Great Barrier Reef water quality guidelines.[125] The data is extracted from daily remote sensing imagery (at a resolution of one square kilometre) and processed using methods described in Brando *et al.* (2013).[101] The map shows the frequency of valid daily observations where the total suspended solids exceeded two milligrams per litre in the 10 year period from 1 November 2002 to 30 April 2012.
- Concentrations of **total suspended solids above 6.6 milligrams per litre** (Figure 6.31b). This concentration of suspended solids is equivalent to a turbidity of five nephelometric turbidity units.[334] It has been used in the analysis as it has been shown to have various ecosystem effects including coral stress,[336] declines in seagrass cover,[337] fish habitat choice,[338] home range movement[339] and (above 7.5 nephelometric turbidity units) foraging and predator-prey relationships[340,341]. The data is extracted from daily remote sensing imagery (at a resolution of one square kilometre) and processed using methods described in Brando *et al.* (2013). The map shows the frequency of valid daily observations where the total suspended solid concentration exceeded the threshold of 6.6 milligrams per litre (or five nephelometric turbidity units) in the 10 year period form 1 November 2002 to 30 April 2012.
- **Surface exposure to total suspended solids** (Figure 6.31c). An assessment of the frequency and extent of the influence of flood plumes containing differing concentrations of total suspended solids provides an estimation of the extent of surface exposure of habitats during wet season conditions. In the map, surface exposure is modelled using an assessment of plume frequency from satellite imagery and monitored end-of-catchment loads in each wet season (November to May) from 2007 to 2011, as detailed in Devlin *et al*. (2013).[132] The mean of the five annual distributions was selected as a way of factoring in inter-annual variability in river discharge, although it is recognised that this period was characterised by several extreme rainfall events.
- **Chlorophyll** concentrations (Figure 6.31d). Chlorophyll is an indicator of nutrient enrichment in marine waters. Death and Fabricius (2008)[91] identified 0.45 micrograms per litre as an important ecological threshold for macroalgal cover, hard coral species richness and octocoral species richness. This concentration is identified as the annual average threshold for chlorophyll in the Great Barrier Reef water quality guidelines.[125] Significant benefits for the ecological status of reefs in the Region are likely if mean annual chlorophyll concentrations remain below this concentration. The data is extracted from daily remote sensing imagery (one

square kilometre resolution) and processed using methods described in Brando *et al.* (2013). The map shows the frequency of valid daily observations where the chlorophyll concentration exceeded the threshold of 0.45 micrograms per litre in the 10 year period from 1 November 2002 to 30 April 2012.

- **Surface exposure to dissolved inorganic nitrogen** (Figure 6.32e). This variable is a direct indicator of nutrient enrichment. High concentrations of dissolved inorganic nitrogen can reduce coral calcification and increase abundance of macroalgae.[342] There is typically more dissolved inorganic nitrogen in waters adjacent to catchments with intensive agriculture. Surface exposure is modelled annually using plume frequency data from satellite imagery and monitored end-of-catchment loads in each wet season as described in Devlin et al. (2013).[132] The mean of five annual distributions in the period 2007 to 2011 was selected as a way to factor in inter-annual variability in river discharge, although it is recognised that this period was characterised by several extreme rainfall events.
- The **crown-of-thorns starfish initiation zone** (Figure 6.32f). This zone, between Cairns and Lizard Island, has been identified as the area where there is the highest likelihood that a primary outbreak of crown-of-thorns starfish will begin. The four primary outbreaks originating in this zone since 1960 all began two to five years after wet seasons when aggregate discharges early in the season (November to February) from the Burdekin to Daintree Rivers exceeded 10 million megalitres.[343] The area defined to be at highest risk in initiating crown-of-thorns outbreaks is between latitudes 14.5 degrees south and 17 degrees south and is described in Furnas *et al.* (2013). [343]
- **Photosystem II inhibiting (PSII) herbicides** such as diuron, atrazine, simazine, ametryn, hexazinone and tebuthiuron (Figure 6.32g). These chemicals can disrupt photosynthetic activity in marine plants including mangroves, seagrass, coral zooxanthellae and crustose coralline algae. The map is based on an estimate of the relationship between PSII herbicide concentrations and coloured dissolved organic matter (a proxy for salinity) in flood plume conditions in 2010–2011. Risk categories are based on thresholds of diuron for coral and seagrass species: no risk (less than 0.025 micrograms per litre), insignificant (0.025 to 0.1 micrograms per litre), minor (0.1 to 0.5 micrograms per litre), moderate (0.5 to 2.3 micrograms per litre), and major (2.3 to 10 micrograms per litre). This is likely to be an underestimate of the actual risk due to limitations of the method, as outlined in Waterhouse *et al.* (2013).[334]

For most of the maps of the individual variables presented in Figure 6.31 and Figure 6.32, the data is scaled on a five-point scale. The maps of exposure to total suspended solids and dissolved inorganic nutrients are based on 2007–2011 data and represented on a three-point scale. The crown-of-thorns initiation zone is simply mapped.

The combined effect of water quality in the Region has been examined spatially by combining the individual variables and normalising the outcomes on a five-point scale (Figure 6.33).

In preparing the analysis, it has been recognised there remains many issues, complexities, variability, uncertainties and unknowns surrounding the understanding of all elements and the extent and effects of catchment run-off.

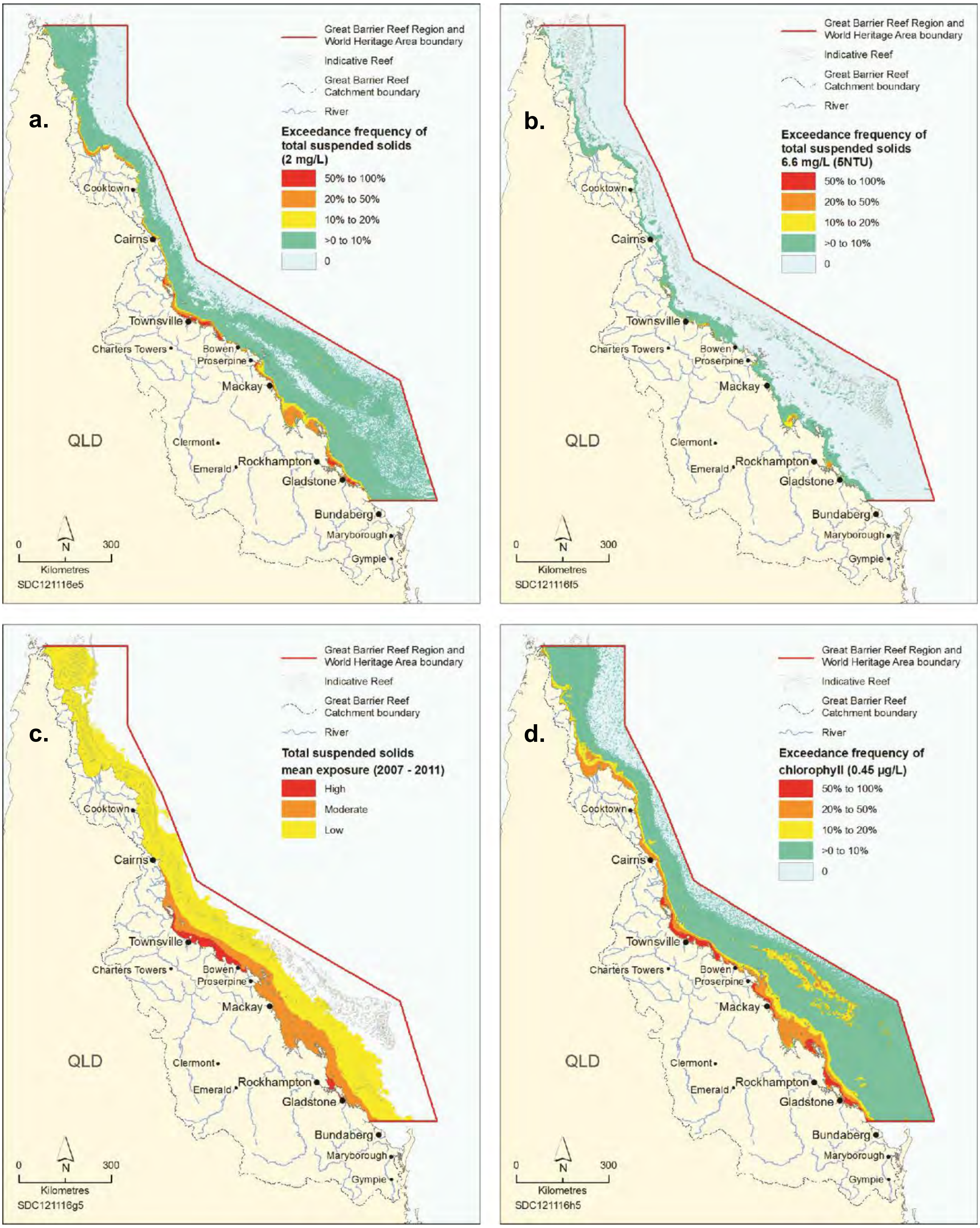


Figure 6.31 Key water quality impacts in the Region (part 1)

(from Waterhouse *et al.* (2013)[334])

Key water quality impacts analysed are:

part 1 — (a) total suspended solids, 2 milligrams per litre exceedance (2002–2012); (b) total suspended solids, 6 milligrams per litre exceedance (2002–2012); (c) total suspended solids exposure (2007–2011); (d) chlorophyll concentrations, 0.45 micrograms per litre exceedance (2002–2012);

part 2 — (e) dissolved inorganic nitrogen exposure (2007–2011); (f) photosystem II inhibiting (PSII) herbicide exposure (2010–2011); and (g) crown-of-thorns starfish initiation zone.

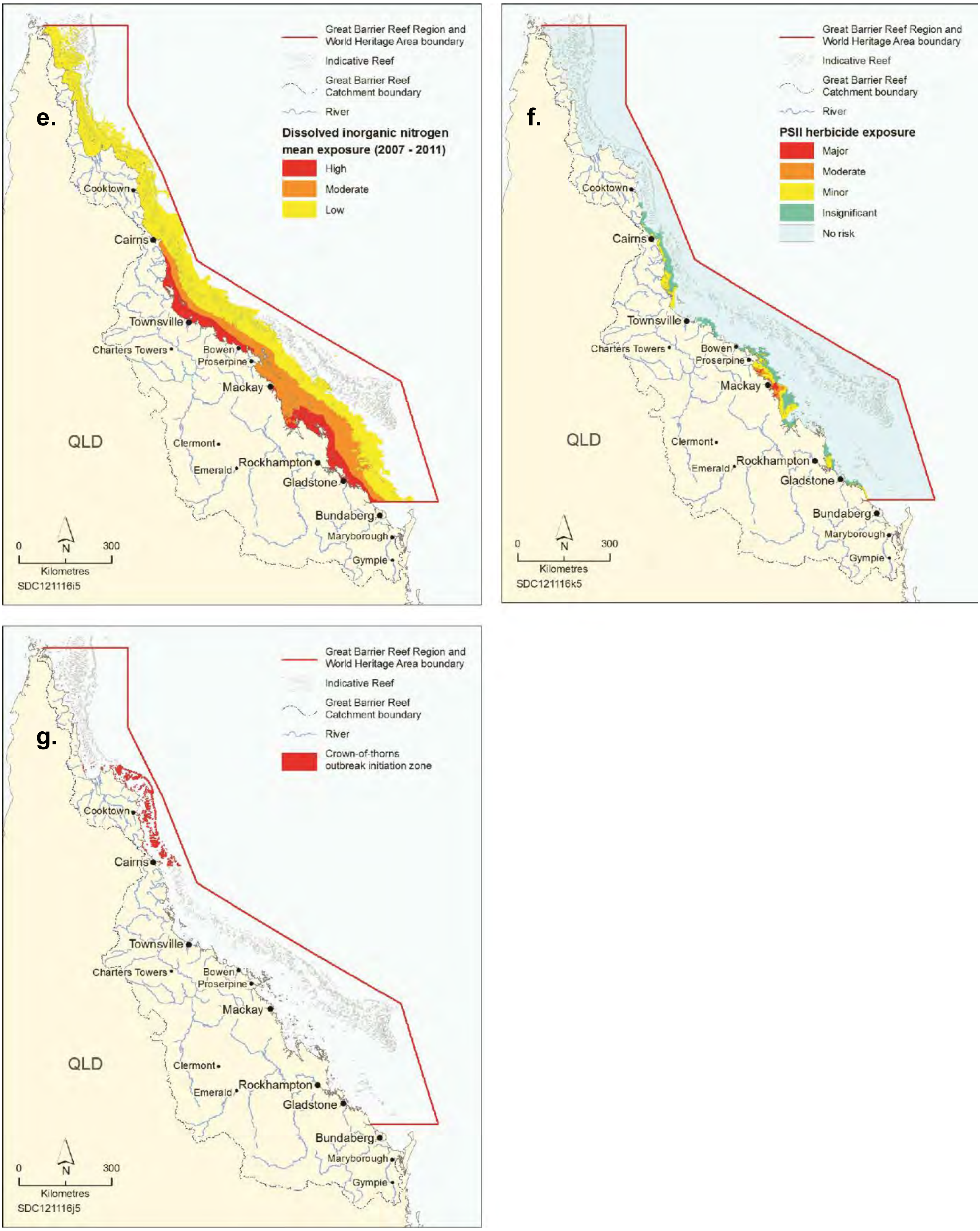


Figure 6.32 Key water quality impacts in the Region (part 2)

(from Waterhouse *et al.* (2013)[334])

Key water quality impacts analysed are:

part 1 — (a) total suspended solids, 2 milligrams per litre exceedance (2002–2012); (b) total suspended solids, 6 milligrams per litre exceedance (2002–2012); (c) total suspended solids exposure (2007–2011); (d) chlorophyll concentrations, 0.45 micrograms per litre exceedance (2002–2012);

part 2 — (e) dissolved inorganic nitrogen exposure (2007–2011); (f) photosystem II inhibiting (PSII) herbicide exposure (2010–2011); and (g) crown-of-thorns starfish initiation zone.

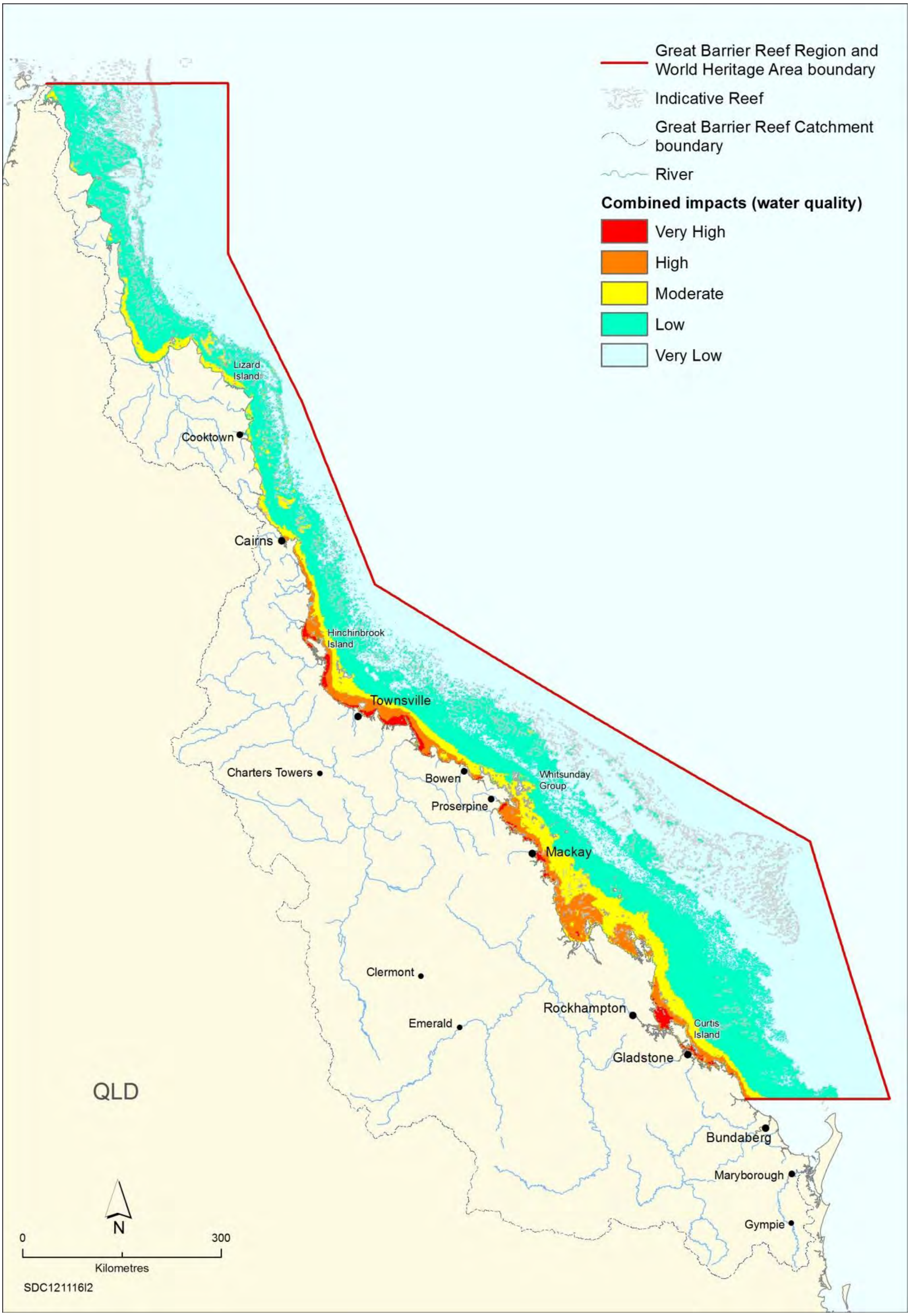


Figure 6.33 Combined key water quality impacts

(from Waterhouse et al. (2013)[334])

Combined assessment of: total suspended sediments (exceedance of 2 milligrams per litre and 6 milligrams per litre thresholds, 2002–2012, and average annual surface exposure, 2007–2011); nutrients (chlorophyll exceedance of 0.45 micrograms per litre thresholds, 2002–2012, and dissolved inorganic nitrogen average annual surface exposure, 2007–2011), PSII herbicide exposure, 2010–2011, and crown-of-thorns starfish initiation zone.

6.8.3 Outcomes of cumulative impact assessments

Cumulative impacts on the Great Barrier Reef

The preliminary qualitative models for coral reefs and seagrass meadows show some cause-and-effect relationships are relatively simple, while others are far more complex involving a large number of network pathways and feedbacks. While it is recognised that the models are preliminary, they demonstrate the ways in which different components are likely to interact and the consequences that changes in the system are likely to have on some of the Region's values.

The spatial analysis of the key impacts on coral reefs and water quality shows the areas of highest exposure to cumulative impacts are inshore, particularly in the southern two-thirds of the Region. The results illustrate the accumulating nature of major pressures on reef and non-reef areas in the Region over the last decade. They provide greater understanding of the scale at which these pressures affect the Region's values.

Over the past 10 years, coral reefs between Cairns and Townsville have experienced the highest cumulative impacts from cyclones, thermal stress, crown-of-thorns starfish outbreaks and increased freshwater inflow. The spatial assessment also shows almost all coral reefs in the Region have been exposed to one or more of these threats over the last decade (see Figure 6.30).

Inshore areas, particularly those south of Cairns, are most at risk of poor water quality. Areas along the coast in the vicinity of Hinchinbrook Island, Townsville and Gladstone showed a very high combined water quality risk, whereas the water quality risk in areas north of Cairns and in offshore areas is distinctly lower (Figure 6.33 above).

Recognising that the inshore waters of the Region are already under significant stress from the decline in water quality driven by increased land-based run-off of suspended solids, nutrients and pesticides[76], the uncertainty regarding the additional effects of sea dumping of dredge material is a key concern, particularly given the potential for large volumes to be dumped.

The frequency and timing of dredge material disposal can also significantly affect for the cumulative impacts on ecosystems. Catchment inputs occur as strong but highly variable pulses during wet seasons, and are ongoing (decadal scale). Dredge inputs involve major pulses during periods of capital dredging, with ongoing maintenance dredging typically occurring in the dry season. Emerging evidence shows turbidity effects of flood plumes may persist for months after major wet seasons.[76,137] If dredging activity results in increased turbidity during otherwise natural clear periods of the year, the combined impacts on ecosystems may be considerably greater than either impact alone. Significant volumes of sea dumping over the next five to 10 years has the potential to add further pressure to already declining inshore ecosystems.

It is important to note the spatial analyses presented in Section 6.8.2 only cover the 10-year period for which accurate and comparable records of these impacts are available. In addition, the analysis does not include many other relevant impacts, all of which combine to affect the natural systems of the Region. Research is currently underway to build a more complete, dynamic understanding of cumulative impacts to guide future management actions to support the resilience of the Reef.

Cumulative impact assessment methods

The analyses provided in this chapter demonstrate that effective cumulative impact assessment requires a suite of tools and approaches to address the challenges of complexity, scale and pace of change. It highlights the need for the systematic application of the tools and approaches to improve understanding of the cause-and-effect relationships of multiple and compounding impacts, and the spatial and temporal scales at which processes and impacts are operating.

It demonstrates the importance of understanding the zones of influence of different activities (the sources of impact) and the need to be particularly vigilant in areas where zones of influence overlap and cumulative impact intensity is highest. Determination of zones of influence requires the use of geographic information systems to spatially identify, map and model activities and impacts and their likelihood of occurring. It also requires 'breaking up' of impacts from point and non-point sources into intensity categories. For example, in Figure 6.34 impact gradients from a point-source discharge from an urban development, and more diffuse impacts such as water quality changes associated with agricultural run-off from catchments, have been divided into high, moderate and low intensities. Their overlapping zones of influence create a mosaic of impact intensities that, combined, have an effect on the values of the area.

Importantly impacts vary in both time and space and with differing levels of severity. For example, major storm and flood events may only occur once every two decades, yet their impact in a flooding year can be severe with a legacy that persists for decades. Hence, the determination of the zone of influence of individual and cumulative impacts requires an understanding of both the spatial and temporal dimensions of the activity or event and its associated effects.

The assessment of impacts in this report also highlights the need for point-source impacts to be assessed at a scale that takes into consideration the influence of other human-related activities and ecological processes operating in the Region.

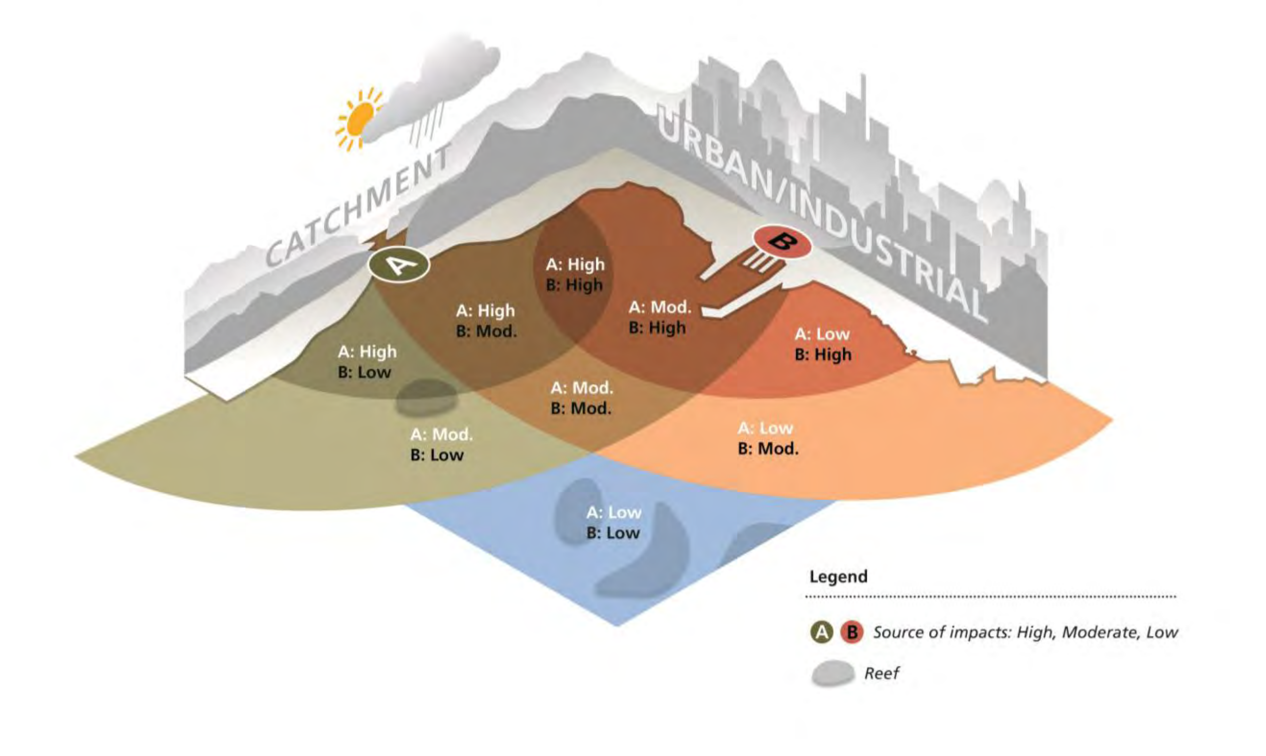


Figure 6.34 Zones of influence of different activities
Zones of influence of different activities (sources) overlap to create a mosaic of impact intensities.

Because quantitative process models need large amounts of data, they have only had limited use in relation to the Region. A staged and complementary approach allows qualitative process models to be used for initial assessments of cumulative impacts, and for them to be employed where there are critical management questions and sufficient data. Knowledge gained from analysis and testing of qualitative models can be used to better focus the application of and inform the construction of quantitative process models.

The spatial modelling examples demonstrate that this approach is feasible. However, a strong understanding of the vulnerability, extent and significance of habitats, as well as their exposure to particular impacts, is required. A basic requirement is systematic habitat classification and mapping. Spatial modelling of cumulative impacts also depends upon an understanding of the extent, linkages and importance of ecosystem processes. These processes act as vectors that redistribute influences or pollutants from a source to a wider zone (for example, currents distribute coral and fish larvae and may also disperse crown-of-thorns starfish larvae and dredge spoil over similar scales and locations). Mapping these influences is crucial to understanding the extent of their impacts.

While significant investment in monitoring and research has increased our understanding of the effects of the pollutants and their interactions, effects on a wide variety of species or habitats are still not fully understood. Each of the numerous inshore species has its own tolerance limit, including at different life stages. Interactions between the organisms and pollutants also add to the complexity. Significant progress has been made, in particular, in identifying thresholds and interactive effects of multiple stressors on seagrass. The Reef Rescue marine monitoring program science providers have developed metrics that include biological indicators of health that have potential for inclusion in revised guidelines.[344]

The water quality spatial analysis has highlighted a paucity of data relating to the toxicity of many contaminants to primary producers — the basis of all food webs — in tropical marine ecosystems, as well as a lack of a comprehensive understanding of biogeochemical cycling.

6.9 Effects on matters of national environmental significance

Based on the assessment of impacts on key values and attributes relevant to matters of national environmental significance, presented above, the following is a summary of the effects on each matter.

6.9.1 World heritage properties

The past and present effects on the outstanding universal value of the Great Barrier Reef World Heritage Area are summarised in Table 6.10. It is structured around the four world heritage criteria relevant to the property and considers those key values and attributes identified in Table 4.8, in Chapter 4.

The impacts assessed have also had some effect on the integrity of the World Heritage Area. While all elements necessary to express its outstanding universal value remain largely intact and the area continues to be an adequate size to ensure complete representation of its features and processes, there have been adverse effects on the property. The legacy impacts of activities in the Region, combined with impacts arising externally, have meant that the condition of some values is in decline.

Table 6.10 Summary of impacts affecting outstanding universal value

Short title of world heritage criteria	Summary of most severe impacts
Major stages of the Earth's evolutionary history	The assessment of impacts on geomorphological features shows the main impacts affecting them are cyclones and increased sediments. Cyclones have the ability to alter and weaken the structure of the geomorphological features, while sediments affect the features that are reliant upon photosynthesis (such as coral reefs and seagrass meadows) and can infill palaeochannels.
Ecological and biological processes	Modifying supporting terrestrial habitats has changed hydrological processes in many parts of the catchment. This has had downstream impacts on ecological and biological processes, reducing connectivity and the health of the World Heritage Area. The strong ongoing links between Aboriginal and Torres Strait Islanders and their land and sea country have been and continue to be affected by those impacts which are diminishing the natural environment of the Region.
Natural beauty and phenomena	Combined effects from cyclones, declining water quality and increasing sea temperature are affecting on the natural beauty and phenomena of the Great Barrier Reef ecosystem. Coastal habitat degradation and highly visible activities, such as coastal development, dredging and shipping, may have also diminished natural scenic values, especially in coastal areas. Transient impacts to the aesthetic experience of a place can include large numbers of tourists, passing ships or turbidity due to weather. Natural phenomena such as nesting marine turtles have been affected by previous commercial harvesting which has increased the species' vulnerability to subsequent impacts. The most severe current impacts affecting nesting marine turtles include death of discarded species and illegal fishing and poaching.
Habitats for conservation of biodiversity	Cyclones, increasing sea temperature, crown-of-thorns starfish outbreaks and increased freshwater inflow are threatening habitats and species. Almost all areas of the Region have been exposed to one or more of these threats over the last decade. The assessment shows the greatest impacts to seagrass and coral habitats arise from the adjacent catchment (specifically increased freshwater inflow, nutrients, pesticides and sediments) and from extreme weather.

6.9.2 Great Barrier Reef Marine Park

The impacts having the greatest effect on the Great Barrier Reef World Heritage Area also apply to the Great Barrier Reef Marine Park. Freshwater influxes from catchment run-off, and the load of nutrients, sediments, pesticides and other pollutants they carry, are affecting the marine ecosystems of the Marine Park. Cumulatively these impacts, along with the other listed severe impacts such as cyclones and those associated with coastal development, mean the southern two-thirds of the Marine Park is experiencing the greatest impacts.[35]

The benefits that Reef-dependent communities, industries and Traditional Owners derive from the Region's environment are based on its natural and heritage values. The quality and magnitude of benefits derived are also diminished as a result of the declining condition of the underlying values. Impacts on coral cover (from crown-of-thorns starfish, cyclones and declining water quality) have meant there are fewer opportunities for people to experience and enjoy healthy coral reefs. Illegal fishing and poaching and death of discarded catch have reduced numbers of targeted fish and iconic fauna (for example, marine turtles and dugong), further affecting catch rates and recreational experiences. Poorer water quality (from impacts related to catchment run-off) has changed underwater visibility, affecting appreciation of coral reefs.

Given the attributes of the biological and geomorphological features of the Marine Park contribute to its aesthetic value, effects on aesthetic value are implicit.[328] Transient impacts to the aesthetic experience of a place can include large numbers of tourists, passing ships or turbidity due to weather. More significant and long-lasting impacts directly affecting tangible attributes of aesthetic values include modifying supporting terrestrial habitats and coastal development.[328]

6.9.3 National heritage places

As the Great Barrier Reef was listed as a national heritage place because of its status as a world heritage property, the summary of impacts affecting outstanding universal value (above) are also relevant to this matter of national environmental significance.

6.9.4 Commonwealth marine area

The assessment summary for the condition and trend of the Great Barrier Reef Marine Park above is also relevant to the Commonwealth marine area.

6.9.5 Listed migratory and listed threatened species

The most severe impacts to listed migratory and threatened species include climate-related impacts (increased sea temperature and cyclone activity), impacts that affect nesting, feeding and breeding habitats such as clearing and modifying supporting terrestrial habitats (which may also increase light and noise impacts) and direct impacts from activities that pose a threat to survival (for example, illegal fishing and poaching, death of discarded species and extraction of top order predators).

A wide range of listed species are unintentionally captured during the Queensland Shark Control Program, including the grey nurse shark, whale shark, marine turtles and humpback whale.[223] Death of discarded species as a result of fishing practices has high effects on listed sharks, marine turtles and dugong. Trawling remains a risk to some listed species including sharks. The commercial inshore net fishery unintentionally catches a number of species which may be injured or killed in the nets (for example, marine turtles, dugongs, inshore dolphins, sharks and sawfish). Even low levels of mortality may compromise the ability of depleted populations to recover. Extraction of top order predators has a very high effect on listed sharks and, through the legacy impacts of commercial harvesting, has had a high effect on crocodiles. While many top predators are not directly targeted by fishing activities in the Great Barrier Reef, some are unintentionally caught and retained, and several sharks are at high risk from fishing.

Recent severe tropical cyclones have damaged wide areas of marine habitat on which dugong and marine turtles rely. In addition, seagrass mortality as a result of floods, especially in early 2011, is thought to be responsible for severe effects on dugong populations.

Pelagic foraging seabirds are also highly vulnerable to changes in ocean currents and sea temperature as many search for food in upwellings, eddies and other sea surface temperature gradients.[28]

Listed shorebirds are affected by artificial barriers to flow and clearing and modification of coastal habitats. Previous broadscale land clearing, principally in the southern two-thirds of the Great Barrier Reef catchment, has indirectly caused major changes to the Region's nearshore environment. This has, in turn, affected the shorebirds that use these habitats. In addition, changes to catchment ecosystems, such as infilling wetlands, and constructing levee banks and drainage, have affected connectivity and the habitats for listed shorebirds.

6.9.6 Wetlands of international importance

The Shoalwater and Corio Bay Area is predominantly within a defence training area. The restricted access provisions applying to the defence area reduce the direct human-related impacts (for example, fishing and coastal reclamation). As a defence training area, some impacts from these activities are likely in the marine component of the area (for example noise, boat and aircraft presence) and there is a risk of marine environmental incidents such as oil spills. Mitigation strategies are in place. Environmental monitoring has shown activities, such as low-flying aircraft, are not posing significant biological threats to the area and the species which rely upon it (for example roosting seabirds).[345] However, the area is not immune to climate-related impacts, with changes in sea temperature and ocean currents likely to affect many species that migrate to the area.[346]

6.10 Key information gaps

There is a tendency to consider the impacts on biodiversity and heritage values as distinct entities, but it is the interaction between drivers, activities and, in particular, their cumulative impacts, that are often of greatest concern. Further, complex and cumulative interactions between biodiversity, ecosystem health, and social, cultural and economic values determine the resilience of the natural and human systems — a concept which is fundamental to the protection of the matters of national environmental significance.

An understanding of impacts relies on knowledge of the value being affected, the activity causing the impact (as well as what is driving it) and how they interact. There is a developing understanding of cause-and-effect relationships for many values and impacts in the Region, but the quantitative nature of these interactions is not well known in most cases. Indirect ecosystem effects of impacts are even less well understood. For instance, it is known that fishing removes a portion of top order predators and that this has the effect of reducing predator populations in fished areas, but little is known about the effect on the rest of the ecosystem. Likewise, the introduction of pesticides has direct effects on plants and animals, however the nature of many of these interactions is not well quantified and indirect impacts are even less understood.

Quantitative understanding of cause-and-effect relationships, both now and under a range of future scenarios, will greatly improve understanding of impacts and their cumulative effects — this currently constitutes a major information gap.

6.10.1 Biodiversity

The impacts of most concern that have been identified for biodiversity are categorised into the broad areas of: climate change, catchment run-off, degradation of coastal ecosystems and direct use. Greater understanding is required for these and other impacts relevant to the Region, particularly:

Climate change

- the likely long-term environmental changes resulting from climate change impacts
- the direct and indirect effects of climate change impacts on the function and behaviour of species and ecosystem processes
- the effect of a changing climate on cyclone activity and ocean currents
- the effects of impacts related to climate change on seabird feeding grounds and nesting areas.

Catchment run-off

- the fate of nutrients, sediments and pesticides entering the Region, including where they go and what impacts they have on an individual catchment basis
- the time lags between changes in agricultural practices and improvements in the Region’s water quality
- the volume and composition of sediment from various sources, including from dumped dredge material and sediment from catchment run-off, compared with natural levels
- the concentration of nutrients in marine sediments, including the rates and relative contribution to the pool of re-mineralised particulate nutrients
- the trigger levels for pollutants that are appropriate for maintaining the health and function of non-Reef ecosystems within the Region

- pollutants from urban and industrial discharge and their relative contribution to pollutant loads in the Region
- the concentrations of heavy metal and implications of legacy mining activities on water quality
- the extent of pollutant delivery to the Region through groundwater
- the exact locations and numbers of crown-of-thorns starfish outbreaks
- a more operationally efficient technique to control crown-of-thorns starfish outbreaks
- the most effective changes to land management practices for reducing the probability and/or severity of future crown-of-thorns starfish outbreaks
- the status of reef health, particularly in areas affected by the current crown-of-thorns starfish outbreak and by tropical cyclone Yasi, to inform management priorities (such as crown-of-thorns starfish control).

Degradation of coastal ecosystems

- changes to natural water movement in the catchment and its effect on the condition of the Region's habitats and species
- identification of catchment sources of bio-available nitrogen and phosphorus constituents in the Region, through improved understanding of nutrient dynamics in riverine, estuarine and marine environments.

Direct use

- the risks to the Region's ecosystems from commercial fisheries (that is, ecological risk assessments, such as that done for the trawl fishery[17])
- for some targeted fish species, stock assessments and harvest strategies are required
- the amounts of retained and discarded catch (including the proportion that dies after being discarded) from the recreational fishing sector
- the amount, species composition and post-release survival rates of discarded catch in commercial fisheries
- information about the status of populations of targeted species where there is limited or no data available, including fishery independent data
- the ecological consequences of localised depletion of populations targeted through fisheries
- development of further technologies to minimise or mitigate fishing impacts
- the impacts resulting from illegal activities in the Region and the ecological benefits of compliance and enforcement
- the effects of illegal fishing on species of conservation concern including dugong, inshore dolphins, marine turtles, sharks and rays
- the fate of dredge material dumped at sea including the full extent of dispersal and the recovery time of any affected benthic communities
- the direct and indirect effects of noise on species within the Region, including from shipping and port development
- the direct and indirect effects of dredging on the surrounding habitats and species
- the risks and key drivers of marine pest introductions, especially the ability of potential marine pests to colonise and affect coral reef environments
- the source, type, quantity and fate of marine debris, including microplastics, within the Region.

6.10.2 Geomorphological features

There is limited information about past and present impacts that have had an effect on geomorphological features. Key information gaps include:

- effects of sediment from catchment run-off and dumping and resuspension of dredge material on geomorphological features such as submerged reefs, palaeochannels and karstic channels
- effects of deep sea trawling on deepwater geomorphological features
- effects of ocean acidification on geomorphic features
- effects of altered ocean currents on geomorphological features such as islands and shorelines.

6.10.3 Indigenous and historic heritage values

The limited knowledge of Indigenous and historic heritage values of the Region means it is difficult to understand the effects of various impacts on those values. Consequently, improving baseline knowledge about the values is an important first step to better management of impacts on those values. Aspects include:

- improved identification of Indigenous and historic heritage values relevant to the Region, including consultation and identification of Indigenous heritage in partnership with relevant Traditional Owners
- a centralised information management system for Indigenous and historic heritage values, including spatial mapping
- improved understanding of the effects of impacts on Indigenous and historic heritage values and potential avenues to avoid, mitigate and offset impacts.

6.10.4 Community benefits of the environment

Because the community benefits derived from the Region's environment are heavily dependent on the quality of that environment, the knowledge gaps described above are also relevant to community benefits. In addition, there is a need to better understand the connection between the state of the environment and the benefits derived from it, including:

- positive and negative impacts of use of the Region on community benefits
- impacts of ports and shipping on community benefits including enjoyment
- positive and negative impacts of urban and industrial development on community benefits
- quantifying impacts on aesthetic values of the Region.

6.10.5 Cumulative impact assessment

Assessment of cumulative impacts is an emerging field with regard to management of the Region and protection of its matters of national environmental significance, including outstanding universal value. As highlighted earlier, there is a need to improve our understanding of:

- the relationships between Great Barrier Reef ecological and human systems and the benefits derived from these systems
- the cause-and-effect relationships of multiple or compounding impacts on values underpinning matters of national environmental significance
- the multiple spatial and temporal scales at which impacts and processes occur and interact with ecological and human systems
- models that account for uncertainty in the range of environmental conditions that will occur over the rest of this century.

The systematic application of tools and approaches outlined in this chapter will greatly assist the Authority to address these information gaps.

The various approaches to cumulative impact assessment adopted as part of this strategic assessment process have also highlighted some significant gaps in the way that information required to inform cumulative impact assessments is collected and applied. Improvements in the following areas would enhance the assessments and further accelerate our understanding of issues highlighted above:

- an accepted set of indicators for the values that underpin matters of national environmental significance that can be used to measure the effects of impacts on the state of ecological and human systems and the benefits derived from these systems
- a comprehensive, dynamic assessment of the key zones of influence within the Region
- establishment of a set of Great Barrier Reef monitoring standards, allowing results to be applied at a range of scales
- integration of monitoring results into management systems to enable impacts from various activities to be jointly considered
- systems to provide improved access (discoverability) to monitoring data (point-source and ambient data) across management agencies and for the public
- improved adaptive management mechanisms and processes, based on greater monitoring and evaluation, to enhance the effectiveness of management actions.

6.10.6 Processes to address information gaps

Scientific knowledge
To guide delivery of the science needed to protect and manage the Great Barrier Reef World Heritage Area, the Authority outlined its scientific information needs in 2001 and 2005. The Outlook Report 2009 provided a fresh basis for identifying the current information gaps and scientific needs for management. These were published after the report and will be updated every five years in line with the Outlook Report cycle.

These identified science information needs guide future research investment. They are intended to open the dialogue between managing agencies and research and monitoring providers. For example, the key research questions used to guide investment in the Great Barrier Reef Node of the Tropical Ecosystems Hub of the National Environment Research Program were formulated with reference to the Authority's published needs.

Targeted and effective research and monitoring programs for addressing management needs require strong partnerships between research providers and the relevant management agencies. Governance structures and engagement activities are required to align monitoring and research activities with management needs. Effective governance structures create implicit information networks that can provide managers with regular updates about emerging issues, as well as trends and changes detected though monitoring activities that can be incorporated into management decisions and actions.

Research providers include:

- research institutions where research and monitoring is carried out by scientists and technicians highly trained in the relevant fields. Major institutions include the Australian Institute of Marine Sciences, James Cook University, the University of Queensland, the University of Central Queensland, the University of the Sunshine Coast, CSIRO, and government agencies such as the Authority and Queensland Government departments
- Reef-based industries where monitoring may be conducted by individuals with varying levels of training. It may be a voluntary contribution to management, undertaken to meet a permit condition or a compulsory reporting obligation
- members of the community, typically on a voluntary basis, and by people associated with a recognised 'citizen science' monitoring program
- Traditional Owners, through Traditional Use of Marine Resources Agreements and through natural resource management initiatives.

As part of its management activities, the Authority is working in partnership with CSIRO to establish a social and economic long-term monitoring program for the Great Barrier Reef.

Investment in Great Barrier Reef science is delivered through a range of programs and government initiatives, as well as through co-investment from the private sector. Apart from the ongoing funding of the Australian Institute of Marine Science, none of the major monitoring programs for the Great Barrier Reef currently have secure ongoing funding. Most rely, at least partly, on time-limited funding programs such as the National Environment Research Program and the Australian Government Caring for our Country Reef Rescue initiative for their continuation. In parallel with the strategic assessment, an integrated monitoring framework is being developed to provide the basis for reviewing monitoring priorities and activities and coordinating monitoring efforts and outputs. The framework will contain recommendations for long-term funding and governance mechanisms for monitoring (see Chapter 13).

Scientific programs are becoming increasingly spatial in focus and output, generating a variety of spatial datasets about the Region's values, its use and impacts. As a consequence, the process of gathering, synthesising, interpreting and delivering these datasets is becoming increasingly important. Continued collaboration between the Authority and its partners will help to identify and address gaps in spatial data and opportunities to share data and make it more 'discoverable' by others.

The Authority helps facilitate the delivery of the science needed to protect and manage the World Heritage Area through:

- articulating problems
- framing specific questions
- assisting in project design
- providing letters of support for grant applications
- advising on the most useful form and timing of delivery

- synthesising spatial datasets and delivering outputs to science partners and the community
- helping interpret science for government and the public
- facilitating policy and operational outcomes from science.

Community knowledge

The Authority aims to have better outcomes for management through partnerships with Traditional Owners, industry and the community — building and sharing knowledge to support biodiversity and heritage conservation at local and regional scales.

Indigenous people are the primary source of information on the value of their heritage and how it is best conserved. The Authority is conscious of the need for Indigenous people to control intellectual property and other information relating to their heritage.

Traditional ecological knowledge is held by the many Traditional Owner clan groups with links to Great Barrier Reef sea country and is gradually being transferred to managers, especially through the establishment of Traditional Use of Marine Resources Agreements along the length of the Great Barrier Reef.

Strong relationships with stakeholders, such as tourism operators and commercial fishers, and their associations help the Authority understand use of the Region and allow information about the Reef, its condition and matters of interest to be relayed to the Authority. A range of voluntary programs formalise and streamline the provision of such information, in particular the Eye on the Reef program. The Authority also works with the community to gather knowledge and understanding of the importance and extent of values and processes.

The Authority's Reef Guardian and High Standard Tourism programs encourage participants to share their knowledge and experiences about stewardship activities which benefit the Reef.

The Authority receives a range of invaluable information from members of its Reef Advisory Committees and Local Marine Advisory Committees and during its day-to-day interactions with community members.

6.11 Summary of outcomes

- **The Great Barrier Reef Region is a large and complex natural system** which is being affected by a wide range of past and present impacts, including direct, indirect, consequential and cumulative impacts. A broad list of impacts has been consolidated into 40 separate impacts, grouped into four categories: climate change; catchment run-off; degradation of coastal ecosystems; and direct use.
- **The impacts affect many of the values** relevant to the matters of national environmental significance in the Region. Attributes of the outstanding universal value have been affected, including those relating to biodiversity, geomorphological feature, ecosystem processes, natural beauty and man's interaction with the natural environment. The impacts assessed have also had some effect on the integrity of the World Heritage Area.
- **Twenty-five impacts are assessed as having high or very high effects** on the Region's values. The most severe past and present impacts include climate change impacts (cyclones, sea temperature increase); catchment run-off impacts (freshwater inflow, nutrients, crown-of-thorns starfish outbreaks, pesticides and sediments); modifying supporting terrestrial habitats; and several impacts of direct use (death of discarded species, dredging, dumping and resuspension of dredge material, and illegal fishing and poaching).
- **Impacts are compounding, focused inshore** in the southern two-thirds of the Region**.** The impacts affecting the Great Barrier Reef do not act in isolation. Many of those of most concern are land-based in origin, arising from activities undertaken in the southern two-thirds of the catchment. Combined with inshore activities, it means the zone of most intensive impact is the inshore area in the southern two-thirds of the Region. This corresponds with the declining state of values found in central and southern inshore areas. Cumulative impacts are particularly challenging to quantify, assess and manage. These impacts are beginning to be better understood through descriptive qualitative models and spatial mapping tools.
- **Some of the Region's values have been particularly affected** by the impacts assessed, with many rated as experiencing a number of high and very high effects. The combined effects of increased nutrients, more sediments and extreme weather events have seriously affected key

habitats such as coral reefs and seagrass meadows. Species of conservation concern continue to be at risk, including dugongs, inshore dolphins, sawfish and some sharks, primarily due to degradation of inshore and estuarine habitats, loss of connectivity, legacy impacts and some past and present fishing activities (both legal and illegal).

- **Indigenous heritage values have been severely affected,** and these effects are intensified by the closeness of Traditional Owners' relationship to the environment. Their intimate association with their sea country is made up of tangible and intangible values, stretching over tens of thousands of years. Traditional Owners and their ancestors have witnessed profound effects relevant to all aspects of their culture and heritage, both in the past and now. For example, there have been significant and widespread effects on cultural practices, customs and lore, sacred sites, sites of particular significance, songlines, totems, languages and burial sites from a wide range of impacts. Traditional Owners emphasise that, for them, these changes in country have impacted on their culture.
- **The vast majority of impacts are assessed as increasing into the future**, driven mainly by climate change, economic growth and population growth. Some, related to direct use of the Region, are assessed as likely to be stable (such as extraction — death of discarded species, extraction — top order predators and physical damage — fishing). Improvements in shipping management mean that despite projected increases in shipping traffic a stable trend is also likely for impacts from ship groundings. The success of recent initiatives to improve the quality of catchment run-off entering the Region means related impacts are likely to stabilise in the future.
- **The future impacts of climate change are predicted to be very serious.** As greenhouse gas concentrations continue to rise at unprecedented rates, effects on the Great Barrier Reef become more severe. The concentration of carbon dioxide has increased from a pre-Industrial Revolution concentration of 280 parts per million to 396 parts per million in March 2013. Already coral bleaching as a result of elevated sea temperature has been a major cause of coral decline. If carbon dioxide levels are allowed to reach 450 parts per million, scientists predict reefs will be in rapid and terminal decline worldwide from multiple impacts including mass bleaching and ocean acidification.
- **Recent extreme weather has had significant effects.** There has been a cluster of floods, temperature extremes and cyclones over the last decade which has significantly affected the Region's values.
- **High concentrations of nutrients, sediments and pesticides continue to have long-lasting effects.** Targeted investment in halting and reversing the decline in water quality is producing results. However, there is likely to be a significant lag time before measurable water quality improvements are achieved in the marine environment, with sediments and nutrients projected to continue affecting biodiversity for many years. With continued pesticide use in the catchment, it is almost certain that pesticides will continue to be a component of catchment run-off.
- **Crown-of-thorns starfish are a major and more frequent impact on coral reefs.** Rather than experiencing outbreaks in a natural cycle of about every 50 to 80 years, the Reef has been affected by three in the past 50 years and the beginning of a further outbreak has been detected. Crown-of-thorns starfish have been a major cause of coral loss in recent decades. There is evidence of a link between outbreaks and increased nutrient concentrations and possibly loss of predators in fished areas.
- **The effects of dredge disposal can be widespread.** The operation of ports and further port development will require capital and maintenance dredging, potentially involving much larger volumes. Recent research indicates re-suspended dredge material may move over much greater distances from disposal sites than previously assumed. While the full extent of any effects on the Region's values is not well understood, uncertainty regarding the additional effects of sea dumping is a key concern, particularly given the potential for large volumes of proposed dredge material to be dumped and resuspended in areas of the Region already in poor condition.
- **Growth in the catchment is intensifying impacts**. Queensland's strong economic growth at rates faster than the Australian and OECD averages is substantially the result of activities in the Great Barrier Reef catchment. This economic growth and its accompanying population growth are, in turn, driving changes in activities that affect the Region, as well as the terrestrial habitats and processes that support it.

- **The effects of legacy impacts continue**. It is important to recognise that the Region is not a pristine natural system. The conditions and trends evident today are a product of the past 200 years. Past activities in and adjacent to the Region continue to significantly influence components of the environment and reduce its ability to bounce back from current impacts. Legacy impacts are assessed as also significantly affecting many Indigenous values in the Region; for example the past commercial harvesting of dugongs and green turtles continues to have a widespread effect on cultural practices, places important for cultural tradition, and stories.
- **Past and some current impacts from fishing are affecting values.** Over the past two decades, significant progress has been made in addressing the environmental impacts from fishing. A number of high risks remain and continue to affect the Region's values.
- **Marine debris is a global problem affecting the Region's values.** Around the world, marine debris, particularly plastic, is an increasing problem as it accumulates in the ocean and on beaches. As a result of ingestion and entanglement, it is affecting a range of the Reef's wildlife.
- **The majority of popular destinations are inshore in the south of the Region.** Some of the most nationally and internationally recognised tourism destinations are nearshore islands along the southern two-thirds of the Region — the area experiencing the most intensive cumulative impacts. Such tourism destinations are highly dependent on a healthy Reef ecosystem. If not addressed, continuing declines in biodiversity and water quality are expected to reduce the attractiveness of these destinations and their viability as tourist destinations. Given the proximity of these areas to major population centres, declines in the natural environment also significantly affect recreational use of the Region. Combined, there are significant flow-on impacts on the economies and employment opportunities of adjacent Great Barrier Reef catchment communities.

The overall effect that each of the identified impacts has had on the Region's biodiversity, geomorphology and Indigenous and historic heritage values is summarised in Table 6.11, based on the number of values affected and the severity of the effect.

Table 6.11 Summary of the past and present effects of impacts on the Region's values

Effect on values	Impacts affecting the Region's values			
	Biodiversity	**Geomorphological features**	**Indigenous heritage**	**Historic heritage**
Very low	• Extraction — lower trophic orders • Light impacts (artificial) • Ocean acidification • Outbreak of disease • Outbreak or bloom of other species • Rising sea level • Urban and industrial discharge • Vessel strike on wildlife • Waste discharge from a vessel • Wildlife disturbance	• Acid sulphate soils • Coastal reclamation • Ocean acidification • Pesticides from catchment run-off • Physical damage — fishing • Physical damage — other • Ship grounding	• Exotic species and diseases • Increased sea temperature • Light impacts (artificial) • Spill — large oil • Spill — small chemical and oil • Waste discharge from a vessel	• Atmospheric pollution • Coastal reclamation • Extraction — herbivores • Extraction — lower order predators • Extraction — lower trophic orders • Extraction — top order predators • Modifying supporting terrestrial habitats • Outbreak of disease • Outbreak or bloom of other species • Ship grounding • Waste discharge from a vessel
Low	• Acid sulphate soils • Coastal reclamation • Dredging • Noise pollution • Physical damage — other • Ship grounding • Spill — large oil • Spill — small chemical and oil	• Artificial barriers to flow • Cyclone activity • Dredging • Dumping and resuspension of dredge material • Increased freshwater flow • Increased sea temperature • Modifying supporting terrestrial habitats • Nutrients from catchment run-off • Outbreak of crown-of-thorns starfish • Sediments from catchment run-off	• Acid sulphate soils • Altered ocean currents • Artificial barriers to flow • Dumping of dredge material • Extraction — fishing spawning aggregations • Extraction — top order predators • Increased freshwater inflow • Marine debris • Noise pollution • Nutrients from catchment run-off • Outbreak of crown-of-thorns starfish • Outbreak of disease • Pesticides from catchment run-off • Sediments from catchment run-off • Urban and industrial discharge • Wildlife disturbance	• Cyclone activity • Dumping and resuspension of dredge material • Exotic species and diseases • Illegal fishing and poaching • Increased freshwater flow • Marine debris • Noise pollution • Nutrients from catchment run-off • Outbreak of crown-of-thorns starfish • Pesticides from catchment run-off • Physical damage to benthos • Sediments from catchment run-off • Ship grounding • Spill — large oil • Spill — small chemical and oil • Urban and industrial discharge • Wildlife disturbance
High	• Artificial barriers to flow • Exotic species and diseases • Extraction — fishing spawning aggregations • Extraction — herbivores • Extraction — lower order predators • Extraction — top order predators • Increased freshwater inflow • Marine debris • Physical damage — fishing		• Coastal reclamation • Cyclone activity • Extraction — death of discarded species • Modifying supporting terrestrial habitats • Physical damage — fishing • Physical damage — other • Rising sea level • Vessel strike on wildlife	

Effect on values	Impacts affecting the Region's values			
	Biodiversity	Geomorphological features	Indigenous heritage	Historic heritage
Very high	• Cyclone activity • Dumping and resuspension of dredge material • Extraction — death of discarded species • Illegal fishing and poaching • Increased sea temperature • Modifying supporting terrestrial habitats • Nutrients from catchment run-off • Outbreak of crown-of-thorns starfish • Pesticides from catchment run-off • Sediments from catchment run-off		• Dredging • Extraction — herbivores • Extraction — lower order predators • Extraction — lower trophic orders • Illegal fishing and poaching • Ship grounding	

Effect on value	Very low	Low	High	Very high

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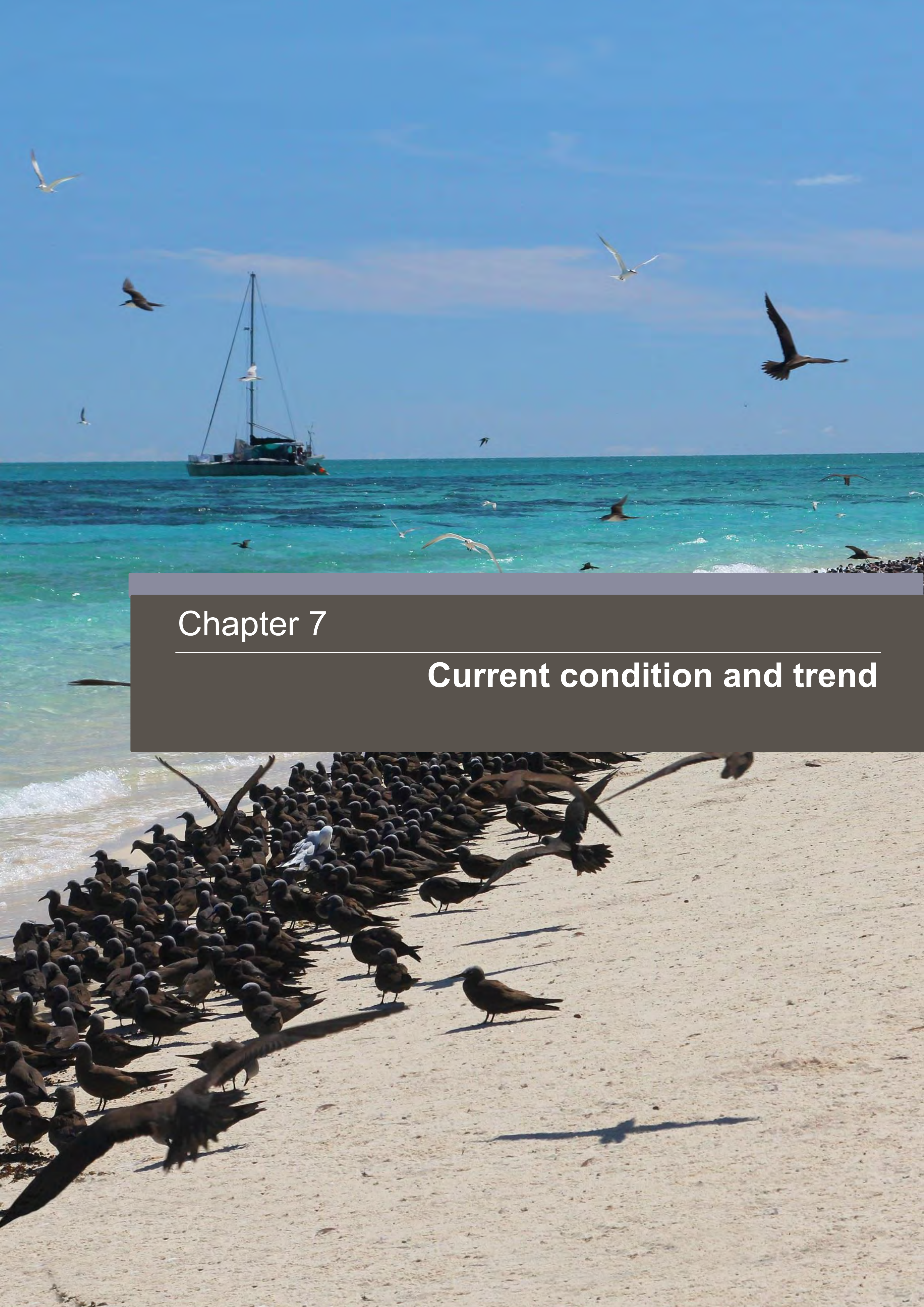
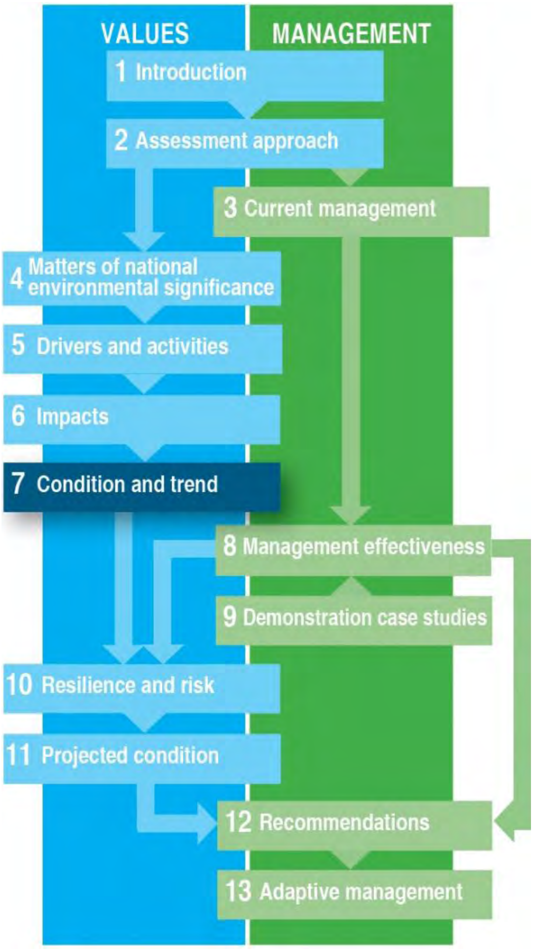


Chapter 7

Current condition and trend



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Cover page image: Seabirds on Michaelmas Cay, with anchored yacht.

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

2.2 Condition and trend of matters of national environmental significance

a) describe the current condition and trend of key indicators of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area

b) for world heritage values, benchmark the current condition of key indicators of outstanding universal value against the retrospective Statement of Outstanding Universal Value which describes the state of the Great Barrier Reef World Heritage Area at the time of listing in 1981

c) identify key information gaps and processes to address critical information needs.

7 Current condition and trend

This chapter contains an assessment of the current condition and trend of the key indicators of matters of national environmental significance in the Great Barrier Reef Region (the Region). Each key indicator identified in Chapter 4 is assessed against a standard set of grading statements in four categories: biodiversity, geomorphological features, Indigenous and historic heritage values, and community benefits derived from the environment (Sections 7.1 to 7.4). The current condition of the key indicators of environmental processes relevant to the matters of national environmental significance is also assessed against a standard set of grading statements (Section 7.5).

A summary of the condition and trend of each matter of national environmental significance, including the Reef's outstanding universal value, is presented in Section 7.6 and the chapter concludes with a summary of key information gaps concerning the Region's values.

7.1 Biodiversity

Outcomes of an assessment of the condition and recent trend of key biodiversity values and attributes (see Chapter 4) are presented below:

- Table 7.1 — Great Barrier Reef habitats (11 elements)
- Table 7.2 — terrestrial habitats that support the Great Barrier Reef (nine elements)
- Table 7.3 — species (17 elements).

A discussion of the key findings about the condition and trend of some biodiversity indicators follows the tables.

While Indigenous heritage values are considered separately in the Section 7.3, it is recognised that the interconnection between the Great Barrier Reef's natural environment and its Indigenous heritage means the condition of biodiversity values is intrinsically linked to the condition of Indigenous heritage values. Similarly, the community benefits derived from the environment (Section 7.4) are linked to the condition of the Reef's biodiversity. Likewise, the aesthetic values encompassed under criterion (vii) of the World Heritage Convention for attributes which 'contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance' are closely linked to the condition of biodiversity within the property.

Shifting baselines: How much has the Reef changed?

When we look at the Great Barrier Reef, we tend to compare it with our previous experiences — we have a 'baseline' of what we think the Reef is like naturally and, therefore, how much it has changed. However, such a baseline can move with time as gradual changes accumulate, often without being noticed. Older generations may remember when there were more and bigger fish, but younger generations may consider the current abundance as normal or healthy. This is particularly an issue in marine environments where humans, as terrestrial beings, have only recently developed the technology to undertake surveys and research, although we have been exploiting the oceans for much, much longer. In fact, research has been largely conducted in marine systems that are already degraded to some extent, and there is little understanding of how these systems operated in the absence of human activity.[1] A lack of marine ecosystem knowledge and understanding, combined with our preconceptions of what comprises a pristine ecosystem[2], has resulted in a 'shifting baseline' syndrome, where chronic, imperceptible decline has influenced our collective awareness of what the system used to be.

On the Great Barrier Reef, most scientific research and monitoring began in the 1970s and 1980s. Only a few years before proclamation of the *Great Barrier Reef Marine Park Act 1975* and the 1981 world heritage listing, two of the Reef's principal research institutions were established — James Cook University in 1978 and the Australian Institute of Marine Science in 1972. But there is increasing evidence of profound changes in the Reef well before this time, some stretching back over the past 200 years (Figure 7.1). The lack of rigorous scientific data before the 1980s presents a significant challenge for assessing the true condition and long-term trend of the ecosystem, including the risk of using a shifted baseline to make the assessment. For example, the first systematic surveys of subtidal reefs in the late 1960s began after a severe outbreak of crown-of-thorns starfish had impacted coral populations along much of the Great Barrier Reef.[1] Our understanding of the significance of recent declines in coral reefs[3,4] depends critically on the context of those declines — if they follow significant undocumented declines prior to the commencement of monitoring, then we have an even greater cause for concern.

Evidence for shifted baselines in the Great Barrier Reef has come from older people who remember how conditions were different[5] or from observations recorded in images, journals and ship's logs. Historical photographs of inshore coral reefs have been especially powerful in illustrating long-term changes in these habitats (Figure 7.1).[6] Comparison of historical photographs showing abundant and diverse corals with more recent ones suggests, in many cases, there has been a long-term decline in condition in many areas. There are some scientific challenges in interpreting these photographs,[7] but importantly, it is now simply not possible to find healthy reef communities at many sites that had such communities historically. This strongly suggests the changes represent long-term degradation.

Traditional Owners and many older people in the broader community consider that fish stocks and other marine resources have declined from the very considerable early bounty that was available on the Reef. This conclusion is supported by fish surveys on inshore reefs. The results of these surveys suggest coral trout stocks on these reefs in general were markedly depleted by as early as 1984 before widespread monitoring began.[8]

Recent research provides rigorous evidence of major changes in inshore reefs before extensive monitoring was developed in the 1980s. This supports the realisation that our current knowledge of the condition of inshore reefs is actually a shifted baseline. The coral community composition on an inshore island (Pelorus Island in the Palm Islands, north of Townsville) had remained largely stable for many hundreds of years, until the mid-1900s when there were major, unprecedented changes, either to different coral types or to communities no longer dominated by corals.[9] These changes coincided with major development of the coastal zone and catchments in the area. Importantly, the results suggest that what we think of as the 'natural' community on these reefs may well be a result of much more turbid, disturbed water conditions, all occurring before the research and monitoring of recent decades.

A shifting baseline is also an issue for understanding trends in environmental conditions on the Reef, such as water quality. Again, there is very little data prior to the 1980s. One of the few pieces of evidence comes from the Low Isles expedition of 1928 when measurements of water turbidity were taken. These suggest the water on the inshore reefs near Port Douglas was relatively clear compared to current conditions. However, water clarity is notoriously variable in time and space, and there is insufficient replication of measurements since 1928 to know if those conditions were typical. Major changes in the activities that cause increased sediments and nutrients in Reef waters suggest the current monitoring is set in the context of a dramatically changed baseline.

This emerging picture of how much the Reef may have changed presents a significant challenge for management of the Great Barrier Reef Region, since it makes it difficult to benchmark progress. It is clear that key aspects of the ecosystem, especially in the inshore southern areas, were already significantly degraded at the time of world heritage listing in 1981. This means we may need to aim for improvements to 1981 conditions, rather than just maintaining or restoring conditions present at the time of listing.

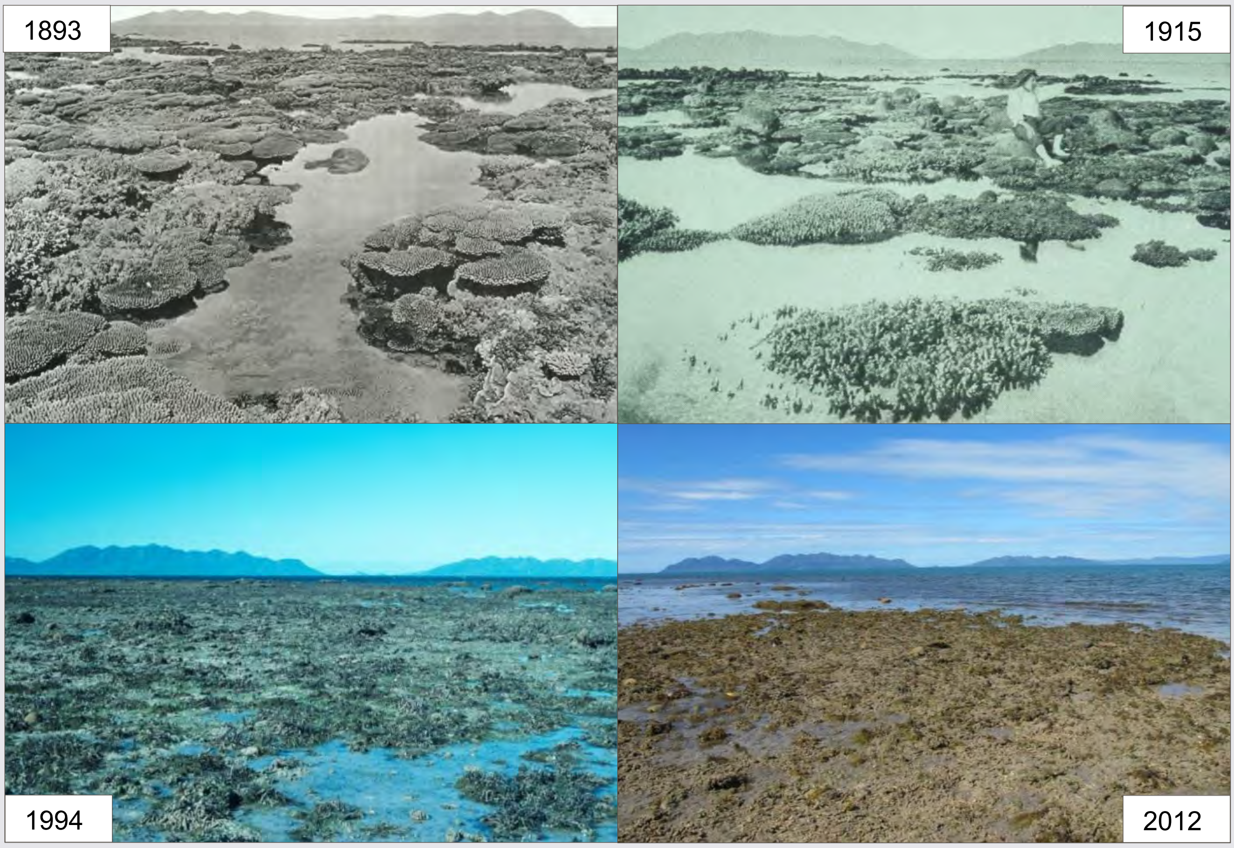

Figure 7.1 Shifting baselines on inshore coral reefs, Stone Island, offshore Bowen

Comparisons of historical photographs provide an illustration of the changes in inshore coral reefs over the last century. This series of photographs can be accurately compared using the skyline in the background. The changes largely took place before monitoring programs commenced. Although the condition of the reef has been fairly stable for the past 20 years or so, it cannot be assumed to be in a natural or healthy condition — in fact, the reef has degraded and its current, stable condition is a shifted baseline. *(2012 photograph courtesy of the University of Queensland*)

Table 7.1 Current condition and trend of biodiversity values — Great Barrier Reef habitats

Understanding the table

Very good (green)	Good (yellow-green)	Poor (orange)	Very poor (red)
Very good: All major habitats are essentially structurally and functionally intact and able to support all dependent species.	**Good:** There is some habitat loss, degradation or alteration in some small areas, leading to minimal degradation but no persistent, substantial effects on populations of dependent species.	**Poor:** Habitat loss, degradation or alteration has occurred in a number of areas leading to persistent substantial effects on populations of some dependent species.	**Very poor:** There is widespread habitat loss, degradation or alteration leading to persistent, substantial effects on many populations of dependent species.

Area (See Chapter 2, Figure 2.3)		**Trend**		**Confidence in condition and trend**	
N.I.	Northern inshore	↑	Improving	●	Adequate high-quality evidence and high level of consensus
N.O.	Northern offshore	↔	Stable	◐	Limited evidence or limited consensus
S.I.	Southern inshore	↓	Deteriorating	○	Very limited evidence, assessment based on anecdotal information
S.O.	Southern offshore	—	No clear trend		

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: Information on condition and trend of habitats is highly variable with some well known (e.g. shallow coral reefs) and others poorly known, particularly habitats in remote areas or deep waters (e.g. *Halimeda* banks). The habitats of the northern third of the Great Barrier Reef are believed to remain in very good condition and are able to support dependent species. Southern habitats, especially those inshore, have deteriorated, particularly seagrass meadows and coral reefs.	N.I.	↔			
	N.O.	↔			
	S.I.			↓	
	S.O.		↔		

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Islands: There are about 1050 islands within the World Heritage Area, including continental islands, coral cays and mangrove islands. There is limited monitoring of the condition of most islands. Most are likely to be in good condition, but there is increasing pressure from recreational use, coastal development and climate change. References:[10,11,12,13,14,15]	N.I.		↔			◐	◐
	N.O.		↔			◐	◐
	S.I.		↓			◐	◐
	S.O.		↔			◐	◐
Beaches and coastlines: Beaches and coastlines are important habitats for migratory shorebirds, seabirds and marine turtles. In the remote north, they remain relatively undisturbed, except for marine debris. Structures near urban centres and ports have extensively modified some coastline habitats and affected coastal processes. Artificial barriers to freshwater flow have disrupted sediment supply to beaches, and increased fine sediments have resulted in mangrove forests replacing beaches. References:[16,17, 18, 19]	N.I.	↔				◐	◐
	S.I.		↓			◐	◐
Mangrove forests: The Region includes an estimated 2070 square kilometres of mangrove habitat. Mangrove forests are a dynamic habitat, with some localised declines and some expansions. The overall condition of mangrove forests is relatively stable and abundance is being maintained. References:[17,20,21,22,23,24 ,20,25]	N.I.	↔				◐	◐
	S.I.		↔			●	●
Seagrass meadows: Intertidal seagrass meadows are in poor condition with serious declines reported over the past four years, especially those in the paths of cyclones and those exposed to flooding. Little is known about the abundance and condition of subtidal and deepwater seagrass meadows. The limited information available suggests these habitats can be affected by severe cyclones. Fewer impacts mean northern area meadows are likely to be in very good condition. References:[26,27,28,29,30,31,32,33,34]	N.I.	↔				◐	◐
	N.O.	↔				○	○
	S.I.				↓	◐	◐
	S.O.			—		○	○
Coral reefs (<30m): Since 1986, average hard coral cover on reefs of the Great Barrier Reef ecosystem is estimated to have declined from 28 to 13.8 per cent and the rate of decline is increasing. The two major causes of loss are cyclones and outbreaks of crown-of-thorns starfish; others include catchment run-off and coral bleaching. The decline is most severe on southern inshore reefs. References:[4,35,36,37,9,38,39,40,41,42,43,44]	N.I.		↔			◐	●
	N.O.		↔			◐	●
	S.I.				↓	●	●
	S.O.			↓		●	●

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Deeper reefs (>30 m): There is no long-term data on the condition of mesophotic and deeper cold water reefs, but for most there is no indication of recent physical damage. The one exception is Myrmidon Reef for which there is information from the 1980s and after cyclone Yasi in 2011. This showed substantial damage to this deepwater reef. Recent studies indicate these reefs have a higher coral diversity than previously thought. References: [45,46,47,48]	N.O.	↔				◐	◐
	S.O.		↔			◐	◐
Lagoon floor: The lagoon floor generally consists of soft sand and mud and supports a wide range of species. While a large-scale study of the Region's lagoon floor has provided a comprehensive and extensive snapshot of the habitat, there is no long-term monitoring. Although the habitat is likely to be in good condition overall, there are some known impacts of trawling in some areas. Recent extreme weather is likely to have damaged lagoon floor habitats, but no assessments have been made. References: [49,50,51,52]	N.I.		↔			◐	○
	N.O.		↔			◐	○
	S.I.		↔			◐	○
	S.O.		↔			◐	○
Shoals: Shoals include continental rock, Pleistocene reef edges and submerged coral reefs. They are diverse and variable and provide habitat and structure in an otherwise flat seafloor. They remain in good condition throughout the Region with no evidence that they are significantly threatened. References: [53,54,55,56,57]	N.I.		↔			◐	◐
	N.O.		↔			◐	◐
	S.I.		↔			◐	◐
	S.O.		↔			◐	◐
***Halimeda* banks:** Large areas of the far northern Great Barrier Reef are dominated by *Halimeda*, a calcareous green algae. The habitat is poorly studied, but is likely to be in very good condition given its isolation from land-based impacts and its level of protection from trawling. Its rate of calcification is likely to be affected by changes in ocean chemistry. References: [49,51,52,58,59,60]	N.O.	↔				◐	◐
Continental slope: The continental slope makes up about 15 per cent of the Region. The habitat is little studied. Much of the habitat remains undisturbed and is therefore likely to be in very good condition. A deepwater trawl fishery operating in the south-east of the Region probably has some physical impacts on the continental slope. References: [45,49,61,62]	N.O.	↔				○	○
	S.O.		↔			○	○
Open waters: Many species depend on open waters. Inshore areas of open water are being degraded, particularly in the southern two-thirds of the Region. There is emerging evidence that an increase in nutrients causes a shift in phytoplankton populations, providing favourable conditions for the development of crown-of-thorns starfish larvae. Offshore and northern areas are considered to be in better condition. References: [63,35,64,65,66,67,68]	N.I.		↔			●	◐
	N.O.		↔			●	◐
	S.I.			↓		●	●
	S.O.		↔			●	●

Table 7.2 Current condition and trend of biodiversity values — terrestrial habitats that support the Great Barrier Reef

This assessment examines the current condition and trend of relevant terrestrial habitats catchments adjacent to the Great Barrier Reef Region. Four broad areas have been examined: northern coastal, northern inland, southern coastal and southern inland.

Understanding the table

Very good: All major habitats are essentially structurally and functionally intact and able to support all dependent species.	**Good:** There is some habitat loss, degradation or alteration in some small areas, leading to minimal degradation but no persistent, substantial effects on populations of dependent species.	**Poor:** Habitat loss, degradation or alteration has occurred in a number of areas leading to persistent substantial effects on populations of some dependent species.	**Very poor:** There is widespread habitat loss, degradation or alteration leading to persistent, substantial effects on many populations of dependent species.

Area (See Chapter 2, Figure 2.3)		**Trend**		**Confidence in condition and trend**	
N.C.	Northern coastal	↑	Improving	●	Adequate high-quality evidence and high level of consensus
N.In.	Northern inland	↔	Stable	◐	Limited evidence or limited consensus
S.C.	Southern coastal	↓	Deteriorating	○	Very limited evidence, assessment based on anecdotal information
S.In.	Southern inland	—	No clear trend		

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: Terrestrial habitats that support the Reef are generally in very good condition in the northern catchment. However, these habitats have been substantially modified in southern areas (south of about Port Douglas), especially saltmarshes, wetlands, woodlands and forests. The functioning of connecting waterbodies has deteriorated, reducing connectivity to the marine environment.	N.C.	↔			
	N.In.	↔			
	S.C.			↓	
	S.In.			↓	

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Saltmarshes: Saltmarshes occur along the length of the Great Barrier Reef coast. They have been significantly modified by coastal development, affecting more than 30 per cent of the habitat in the catchment. The impact is highest in areas with grazing and cropping, urban growth or large communities. References: [66,67,17]	N.C.	↔				◐	◐
	S.C.			↓		◐	◐
Freshwater wetlands: Freshwater wetlands across the catchment are relatively intact, but many are functioning poorly due to a range of factors, including loss of connectivity, sediment and nutrient overload, changes to groundwater and weed infestations. Losses of wetlands are often underestimated, especially for infrequently inundated wetlands on highly developed coastal floodplains. In some coastal floodplain basins, up to 80 per cent of freshwater wetlands have been lost. The rate of wetland loss has slowed in recent years. References: [17]	N.C.		↔			◐	◐
	N.In.		↔			◐	◐
	S.C.			↓		◐	◐
	S.In.			↓		◐	◐

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Forested floodplain: Since European settlement, the area of forested floodplain has been reduced by nearly 50 per cent and much of its remaining extent is subject to grazing. There is 12,700 square kilometres of forested floodplain remaining within the Great Barrier Reef catchment. The habitat is affected by clearing and land modification, changes to overland and groundwater flows, weed and pest invasion, water extraction and reduced connectivity. References: [17]	N.C.	—				◐	○
	N.In.	—				◐	○
	S.C.			↓		◐	●
	S.In.			↓		◐	●
Heath and shrublands: Heath and shrublands occur within coastal environments. Approximately 94 per cent of the heath and shrublands in the catchment remains intact, with about 78 per cent afforded protection in national parks, conservation areas and state forests. References: [17]	N.C.	↔				◐	●
	N.In.	↔				◐	●
	S.C.	↔				◐	●
	S.In.	↔				◐	●
Grass and sedgelands: Grass and sedgeland habitats occur throughout the catchment. The greatest loss of grasslands has been in the Fitzroy and Burdekin regions where more than 60 and 40 per cent (respectively) of the habitat has been lost. Coastal grasslands have been extensively modified for agricultural production or urban settlements. References: [17]	N.C.	↔				◐	●
	N.In.	↔				◐	●
	S.C.				—	◐	○
	S.In.				—	◐	○
Woodlands: The condition of woodlands varies throughout the catchment. There have been significant losses in the Burdekin and Fitzroy regions and an average loss of 39 per cent throughout the catchment. Woodlands are now relatively well protected from broadscale clearing as a result of legislative changes, however there remains extensive grazing pressure in this habitat. References: [17]	N.C.		↔			◐	◐
	N.In.		↔			◐	◐
	S.C.			↔		◐	◐
	S.In.				↔	◐	◐
Forests: The condition of forests varies throughout the catchment. There have been losses in all areas, averaging 39 per cent. Forests are now relatively well protected from broadscale clearing. It is estimated that the loss of woody vegetation is due mainly to clearing for agriculture and, to a much lesser extent, urban development. References: [17]	N.C.	↔				◐	●
	N.In.		↔			◐	●
	S.C.				↔	◐	●
	S.In.			↔		◐	●
Rainforests: There have been losses in rainforest habitats throughout the catchment, in particular the Wet Tropics, Fitzroy and Burnett–Mary regions. The loss of rainforest has averaged 38 per cent across the catchment. References: [17]	N.C.	↔				◐	◐
	N.In.		↔			◐	◐
	S.C.		↔			◐	◐
	S.In.		↔			◐	◐
Connecting waterbodies: Aquatic connections between freshwater and marine environments are still functioning well in northern areas. In contrast, aquatic connectivity has been substantially altered in the south. In southern coastal areas, changes to hydrological flows and the construction of bunds, weirs and other structures have altered the functioning of the waterbodies and decreased connectivity, except in flood events. In the southern upper catchment, the construction of dams is a major barrier. Groundwater connectivity has also been affected. References: [17]	N.C.	↔				◐	◐
	N.In.	↔				◐	◐
	S.C.			↓		◐	◐
	S.In.				↓	◐	◐

Table 7.3 Current condition and trend of biodiversity values – species

Understanding the table

Very good	Good	Poor	Very poor
Very good: Only a few, if any, species populations have deteriorated as a result of human activities or declining environmental conditions.	**Good:** Populations of some species (but no species groups) have deteriorated significantly as a result of human activities or declining environmental conditions.	**Poor:** Populations of many species or some species groups have deteriorated significantly as a result of human activities or declining environmental conditions.	**Very poor:** Populations of a large number of species have deteriorated significantly.

Area (See Chapter 2, Figure 2.3)

- **N.I.** Northern inshore
- **N.O.** Northern offshore
- **S.I.** Southern inshore
- **S.O.** Southern offshore

Trend

- ↑ Improving
- ↔ Stable
- ↓ Deteriorating
- — No clear trend

Confidence in condition and trend

- ● Adequate high-quality evidence and high level of consensus
- ◐ Limited evidence or limited consensus
- ○ Very limited evidence, assessment based on anecdotal information

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: There is only condition and trend information for a limited number of species and species groups; hence the assessment of some components is highly uncertain. Of those for which there is information, there have been significant declines in many, especially in the inshore southern two-thirds of the Region, and some iconic and cultural keystone species such as dugongs and some marine turtles. Serious declines have been recorded in most hard corals and seagrasses, some fishes and sharks, plus some seabird and shorebird populations. There are four examples of species showing good recovery after past serious declines: humpback whales, estuarine crocodiles, loggerhead turtles and green turtles (southern stock). However, even these species have not recovered to their original numbers.	N.I.		↔		
	N.O.		↔		
	S.I.			↓	
	S.O.		↔		

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Mangroves: The Region's mangrove forests are very diverse with at least 39 mangrove species and hybrids recorded. The highest diversity is in the far north. In contrast to international trends, the diversity and abundance of mangrove species along the Great Barrier Reef coast are being maintained. References: [69,70,71,22,23]	N.I.	↔				◐	◐
	S.I.		↔			◐	◐
Seagrasses: The Great Barrier Reef is maintaining seagrass diversity; however, there have been recent severe declines in abundance and changes in community composition in southern inshore areas. These are mainly due to cyclones and flood events, in addition to the longer term impacts of catchment run-off. Little is known about the condition of offshore seagrass species. References: [27,29,72, 30, 31]	N.I.	↔				◐	◐
	N.O.	↔				○	○
	S.I.				↓	◐	◐
	S.O.			—		○	○

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Macroalgae: The biodiversity of macroalgae is being maintained. There is little information about its condition, but it is assumed to be good to very good. Interactions between coral and macroalgae are affected by changes in ocean chemistry and the presence of herbivores. Shifts in the coral-algae balance may influence future coral reef recovery. References: [73,74,75,76,77,78,79,80]	N.I.	↔				○	○
	N.O.	↔				○	○
	S.I.		↔			◐	◐
	S.O.	↔				○	○
Benthic microalgae: Benthic microalgae are little studied. It is assumed that they remain undisturbed and in very good condition for much of the Region. References: [81,82]	N.I.	↔				○	○
	N.O.	↔				○	○
	S.I.		↔			○	○
	S.O.	↔				○	○
Corals: Coral diversity and abundance has substantially decreased on inshore reefs south of Cooktown. Hard coral cover has also declined in southern offshore areas, principally due to cyclone impacts. Coral in the far north of the Region is in better condition, largely due to better water quality and fewer extreme weather events. Little is known about the recently discovered cold water corals in very deep parts of the Region (more than 1000 metres). References: [4,35,36,38,39,40,41,42,44,83,84,85,86,87,88]	N.I.		↔			●	●
	N.O.		↔			●	●
	S.I.				↓	●	●
	S.O.			↓		●	●
Other invertebrates: There are thousands of species of invertebrates in the Region. Some, such as prawns, crabs and sea cucumbers, are important in fisheries. Currently there are no invertebrate species assessed as overfished in stock status reports. Little is known about the status of most non-commercial species. An outbreak of crown-of-thorns starfish is a serious emerging concern for the health of Great Barrier Reef coral reefs. It can be assumed the changing environment in southern inshore areas has affected dependent invertebrates. References: [49,89,90]	N.I.	↔				○	○
	N.O.	↔				○	○
	S.I.		↓			○	○
	S.O.	↔				○	○
Plankton and microbes: Little is known about the status of plankton and microbes. Changes in water temperature and quality are likely to be altering plankton communities which, in turn, will be affecting higher trophic levels. References: [91,92]	N.I.	↔				○	○
	N.O.	↔				○	○
	S.I.		↔			○	○
	S.O.	↔				○	○
Bony fish: There are about 1600 species of bony fish in the Region. Very little is known about the status of most species. While long-term monitoring of coral reef fish populations does not indicate declines in the species monitored, understanding of fishing activities suggests targeted species are under significantly more pressure in the southern two-thirds of the Region. These are likely to be exacerbated by severe weather events, reduced habitat and declining water quality. There is little evidence of declines in northern populations. References: [90,93,94,95,96,97,98,99,100,101,102,103,104,105,106,107,108,109,110,111]	N.I.	↔				◐	◐
	N.O.	↔				◐	◐
	S.I.		↔			◐	◐
	S.O.		↔			◐	◐

	Area	Condition and trend: Very good	Condition and trend: Good	Condition and trend: Poor	Condition and trend: Very poor	Confidence: Condition	Confidence: Trend
Sharks and rays: There are 134 species of sharks and rays recorded, including some listed threatened and migratory species. Overall, populations of sharks and rays are considered to be in good condition. However, there are significant concerns about a small number of species, including one (the speartooth shark) which may now be extinct in the Region. Their life histories and habitat preferences make them vulnerable to impacts. Inshore and estuarine species are the most affected by cumulative human-induced impacts. References: [112,113,114,115,116,117,118,119,120,121,49,117,122]	N.I.			↓		◐	○
	N.O.		↓			◐	○
	S.I.			↓		◐	○
	S.O.		↓			◐	○
Sea snakes: There are 14 species of sea snakes with permanent breeding populations in the Region. Abundance estimates are only available for a few species or for small areas, and there is little information about population trends. Some species are taken as incidental bycatch in the trawl fishery, but the effects on the populations are poorly understood. References: [49,123,124,125,126]	N.I.		↓			◐	○
	N.O.		↓			◐	○
	S.I.		↓			◐	○
	S.O.		↓			◐	○
Marine turtles: Each of the six species of marine turtle has a different population status and trend. Although the nesting populations of some species are thought to be increasing, for example loggerhead and green turtle (southern stock), other nesting stocks are declining, for example green turtle (northern stock) and hawksbill. Little is known about the foraging components of most populations, but there are concerns for some species particularly due to pressures outside the Region. Declines in seagrass meadows after recent floods and cyclones have placed additional stress on southern green turtle stocks. References: [127,128,129,130,131,132,133,134,135,136,137,138,139]	N.I.			↓		●	●
	N.O.			↓		●	●
	S.I.		↔			●	●
	S.O.		↔			●	●
Estuarine crocodiles: Estuarine crocodiles occur in most coastal waters in the Region. They are also regularly reported at mid-shelf and some offshore islands. The species is steadily recovering from previous population declines. References: [140,141,142,143,144]	N.I.		↑			◐	◐
	N.O.		↑			◐	◐
	S.I.		↑			◐	◐
	S.O.		↑			◐	◐
Seabirds: Between 1.4 and 1.7 million seabirds from at least 20 species breed annually on islands and cays in the Region. Declines of up to 70 per cent in nesting seabird populations have been recorded. Although all seabirds are vulnerable to impacts of climate change, it is the offshore and pelagic foraging seabirds that are most at risk. Some catastrophic nesting failure has already been recorded in the south. References: [12,145,146,147,148,149,150,151,152,153,154,155,156,157,158,159,160,161]	N.I.		↔			●	◐
	N.O.			↓		●	◐
	S.I.		↔			●	◐
	S.O.			↓		●	◐
Shorebirds: There are no population estimates for the Region's shorebirds. Australia-wide declines of between 70 and 80 per cent have been recorded in the past 24 years. Internationally significant numbers of shorebirds occur at a number of sites within the Region. Changes to the coastline from population growth directly affect the habitats used by shorebirds. References: [162,163,164]	N.I.			↓		◐	◐
	S.I.			↓		◐	◐

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Whales: It is estimated that 15 species of whale visit the Region and there is no definitive information on the condition of most of these. This assessment is based on knowledge of the humpback whale population, which is recovering strongly after being decimated by whaling. An estimated population of 10,000 in 2007 grew to 14,500 in 2010 and 17,000 in 2012. References:[165,166,167,168,169]	N.I.		↑			◐	◑
	S.I.		↑			◐	◑
Dolphins: The number of dolphin species in the Region is estimated to be 17; there is limited information about most populations. Two listed inshore species, the Australian snubfin and Indo-Pacific humpback, are considered most at risk and are likely to be in decline. References:[170,171,172,173,174,175,176,177,178,179,180,181,182,183,184,185,186,187,188,189]	N.I.		↔			◐	○
	N.O.		↔			◐	○
	S.I.			↓		◐	◑
	S.O.		↔			◐	○
Dugongs: The northern population of dugong remains healthy with a stable population trend. A substantial decline in dugongs occurred in waters south of Cooktown since the 1960s, but the population was thought to have stabilised in 2009. However, a series of extreme weather events from 2009 to 2011 led to impacts on seagrass meadows and a further recent decline in dugong numbers. References:[190,191,192,193,193,194,195,196,197,198,199,200,201,202,203,204,205,72]	N.I.		↔			●	●
	S.I.				↓	●	●

7.1.1 Summary of overall condition of biodiversity

The Great Barrier Reef remains one of the world's most unique and biologically diverse ecosystems. At the scale of the Great Barrier Reef Region, most of its habitats and species are assessed to be in good to very good condition, although for many, a lack of accurate information means the assessment is principally based on limited evidence and anecdotal information.

On a regional scale, the habitats and species north of around the Port Douglas–Cooktown area are generally in better condition than those further south. Also, habitats further offshore and in deeper water are typically subject to fewer stresses and are therefore presumed to be healthier, including the lagoon floor, shoals, *Halimeda* banks, deeper reefs and the continental slope.

However, unsustainable practices — some dating back more than a century — combined with the last 10 years of extreme weather have affected the ecosystem and reduced its ability to recover from disturbance.[4] This is especially true for inshore areas adjacent to the more developed part of the catchment. For some species, such as dugongs and inshore dolphins, and some habitats, such as coral reefs and seagrass meadows, their condition in this area is assessed as poor or very poor and declining.

The Authority's vulnerability assessments of the elements that make up the Great Barrier Reef's biodiversity[206] identified nine species or groups of species that are highly vulnerable. This included dugong, marine turtles, inshore dolphins (Indo-Pacific humpback and Australian snubfin), sharks and rays including sawfish, sea snakes, seabirds (offshore and pelagic foraging), king and blue threadfin salmon, and snapper. Many of these at-risk species are listed migratory or threated species. Many are also cultural keystone species for Great Barrier Reef Traditional Owners.

Vulnerability assessments also identified overwhelming evidence that a range of threats is continuing to affect inshore habitats along the developed coast and the species that use these habitats.[206] The key ecosystem-level impacts affecting habitats and species and reducing the Great Barrier Reef's resilience are climate change, poor water quality including the effects of catchment run-off, loss of coastal habitats from coastal development, illegal fishing and poaching and some remaining impacts from lawful fishing.[43] Legacy impacts, some dating back 150 years, include early catchment clearing, historic levels of commercial fishing and unsustainable commercial harvesting of species such as humpback whales, sea cucumber, dugongs and green turtles.[206] These impacts are detailed in Chapter 6.

There are few examples of recovering populations. Those that are recovering are species that declined as a result of human-related impacts which are now eliminated or reduced, for example commercial whaling for humpback whales and incidental capture of marine turtles in trawl nets. These populations have yet to recover to their original size and, as they tend to be long-lived species, full recovery is likely to take decades.

7.1.2 Coral reefs

There are more than 400 species of hard coral and at least 150 species of soft corals, sea fans and sea pens in the Region. Coral reefs are the cornerstone of the Great Barrier Reef ecosystem and their evolutionary history, species diversity, habitat values and natural beauty are major contributors to the Reef's outstanding universal value.

Research indicates coral abundance has significantly declined over the past 40 to 50 years through a combination of successive cyclones, crown-of-thorn starfish outbreaks and mass bleaching events[3], combined with insufficient time for recovery between these disturbances. Since 1986, estimated average hard coral cover on the Great Barrier Reef has declined from 28 to 13.8 per cent (Figure 7.2).[4] The rate of decline has increased substantially in recent years, averaging approximately 1.45 per cent per year since 2006. Two-thirds of the loss has occurred since 1998.[4]

At a Reef-wide scale, the two biggest direct causes of coral cover loss are cyclones[4,43,44] and crown-of-thorns starfish outbreaks[35].[4] Importantly, such large long-term declines imply corals in some areas are failing to recover fully after disturbances[207] or their recovery is being interrupted by subsequent disturbances. Catchment run-off is likely to have been a major contributor to such loss of resilience, particularly in inshore areas. At stakeholder meetings during the strategic assessment, participants also raised concerns about the effects on coral reefs of ports and disposal of dredge material.

There is strong evidence of a link between poor water quality and crown-of-thorns starfish outbreaks, through increased nutrients.[35,208] In addition, there is some evidence of a link between these outbreaks and fishing pressures: reefs in fished Habitat Protection Zones (dark blue zones) have almost four times the number of outbreaks as reefs in no-take Marine National Park Zones (green zones)[209], resulting in reduced coral cover.[8]

The decline in coral cover has been most severe on reefs south of latitude 20 degrees, particularly since 2006. Since that time, coral cover has reduced from about 35 per cent to eight per cent. Over a shorter timeframe and with less available data to assess trends, data from the Authority's marine monitoring program of inshore reefs adjacent to the developed central and southern areas of the catchment, indicates that on average cover has declined by 34 per cent since 2005. [210,211]

In addition, there is evidence that since European settlement, but prior to most modern monitoring efforts, inshore reefs were particularly affected (see Figure 7.1). Research on Pelorus Island employed sophisticated coral core dating techniques of the reef substrate to understand the historical composition of coral assemblages.[9] Results suggest coral communities in the past were remarkably stable and bounced back after disturbance. They were dominated by *Acropora* corals, now thought to be characteristic of clearer water. However, between 1920 and 1955, these assemblages collapsed and were replaced either by corals typical of more turbid, muddy waters or by communities with little live coral. Importantly, these changes indicate a reduced capacity for the system to absorb disturbance and bounce back to its previous state.[212] This loss of resilience and degradation coincided with prolonged increases in sediment and nutrient loads in the inshore Great Barrier Reef, due to coastal and catchment development.[9]

Many of the inshore reefs of the southern two-thirds of the Region are similar in condition to those around Pelorus Island, and there is evidence that some of these have undergone similar shifts,[6] suggesting widespread degradation in the condition of these reefs.

It is important to note that the 'very poor' grade for the current condition of southern inshore coral reefs and corals in Tables 7.1 and 7.3 above is based on different criteria to the *Reef Water Quality Protection Plan* report cards and the Reef Rescue marine monitoring program report for 2012 and derives a different outcome. The assessment criteria used in this report are the same for all habitats and species, and are consistent with those used in the Authority's assessment of condition in its Outlook Reports. It is significant that, despite the different criteria and the difference in grade, neither assessment is suggesting the status of inshore southern coral is 'good' or 'very good'.

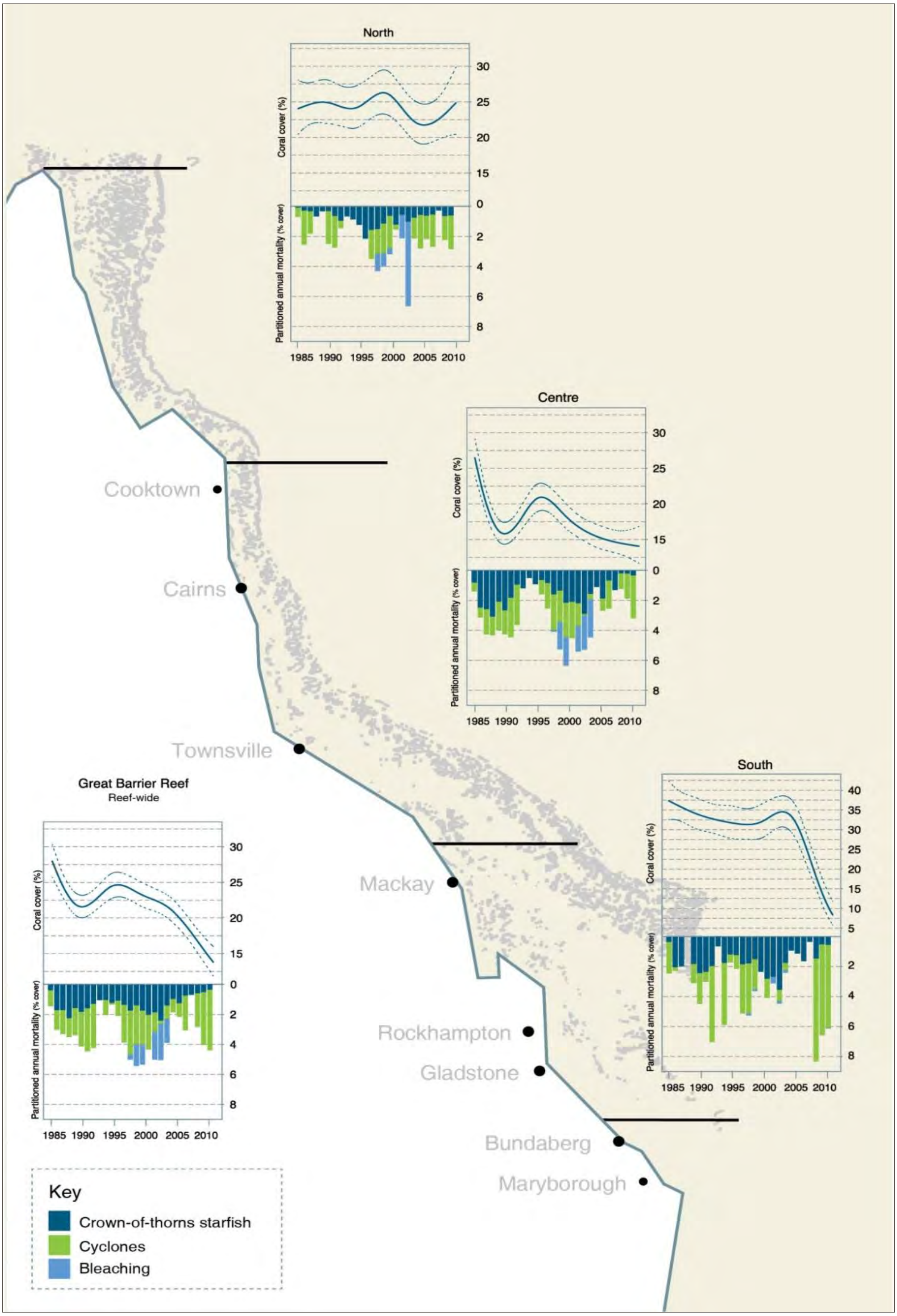

Figure 7.2 Hard coral cover in the Great Barrier Reef, 1986–2012[4]

Modelling of data from the Australian Institute of Marine Science's long-term monitoring program shows hard coral cover in the Great Barrier Reef has declined significantly since monitoring began in 1986. Declines have been most severe in the central and southern two-thirds of the Region. Crown-of-thorns starfish and cyclones have been responsible for most of the mortality. The solid line represents modelled coral cover, while the dashed lines either side represent the associated standard errors. The inverted bar graphs indicate the relative contributions to annual coral mortality.

In contrast, inshore reefs adjacent to less developed, northern catchments do not appear to have undergone the same loss of resilience and degradation.[213] Coral cover in the far north has not shown similar declines over the past three decades and is in better condition than in the rest of the Region. This is largely due to better water quality and fewer extreme weather events.[4] The overall health of reefs in this area means they are likely to have greater resilience and are therefore better able to recover from impacts — for example, the bleaching event in 2002 which was the cause of the dip in coral cover shown in (see Figure 7.2).

7.1.3 Seagrass meadows

Seagrass meadows are an important component of the Great Barrier Reef ecosystem. They can be found on sandy or muddy bottoms from intertidal areas to depths of 60 metres or more, on reef platforms in individual reef lagoons, and the Great Barrier Reef lagoon.[34] Seagrass meadows are the main food source for dugongs and green turtles — both species of conservation concern. They are also habitat builders and act as nurseries for juvenile prawns, fishes, crabs and tropical lobsters, while also providing high rates of carbon sequestration.

Up until the past five years, seagrass meadows appeared to have been relatively stable for about 20 years.[26] Fluctuations were mainly due to natural cycles, although influenced by catchment run-off. The meadows were also likely to show prompt recovery from declines. However, current evidence from 30 monitored intertidal meadows along the Region's coast suggests seagrass abundance and reproductive effort in and adjacent to large areas in the southern two-thirds of the Region have recently declined (Figure 7.3).[214] Ongoing monitoring shows: 67 per cent of monitoring sites have reduced seagrass abundance; 50 per cent of sites exhibit shrinking meadow area; many sites have limited or no seed production; indications of light limitation at 63 per cent of sites; nutrient enrichment at 33 per cent of sites; and 90 per cent of sites with either high or elevated nitrogen.[34] Little is known about the abundance and condition of subtidal and deepwater seagrass meadows. The limited information available suggests declines in the abundance of these meadows and that these habitats can be affected by severe cyclones.

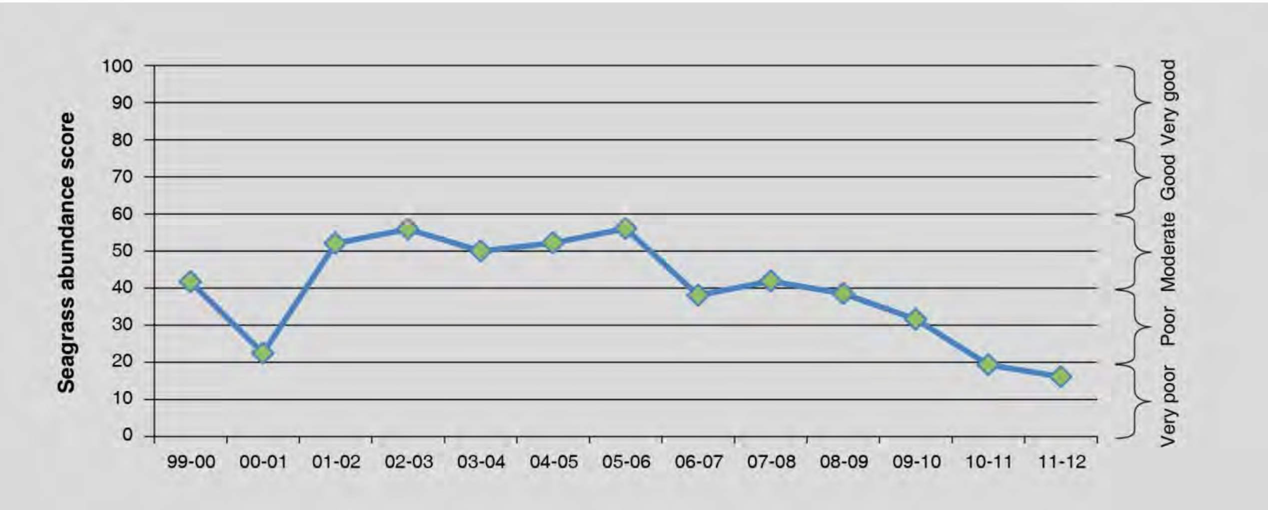

Figure 7.3 Average abundance of intertidal seagrass meadows, 1999–2012[27]

Significant declines in the abundance of intertidal seagrass meadows have been recorded in the southern two-thirds of the Region since about 2009 and are linked to the effects of tropical cyclones, catchment run-off and cloud cover. Intertidal meadows are composed of estuarine, coastal and reefal habitat types. The overall health of seagrass is a combination of abundance, reproductive effort, nutrient status and light availability.

Significant losses of seagrass meadows occurred in 2010–11 in the path of tropical cyclone Yasi.[27] There were also broader scale losses in meadows exposed to flooding. These severe events followed a number of years of decline due to other cyclonic events and major freshwater inflow (see Figure 6.2), as well as declining water quality and extended periods of cloud cover which limits growth periods. Examples of declines include Mourilyan Harbour where seagrass meadows had been consistently present for the past 15 years but have now been lost,[28] as well as substantial reductions in the meadows adjacent to Cairns,[29] Townsville[30] and Gladstone[31].

The decline in seagrass meadows has had profound effects on species which depend on this habitat.[215,216] The extreme weather events of 2011 led to unprecedented losses of dugongs and green turtles within the Region. About twice as many marine turtles were found stranded on Queensland beaches in that year compared to previous years; the number of strandings remained high in 2012 (Figure 7.4). A detailed analysis of the effects on dugong populations is provided in the dugong demonstration case study presented in Section 9.3.

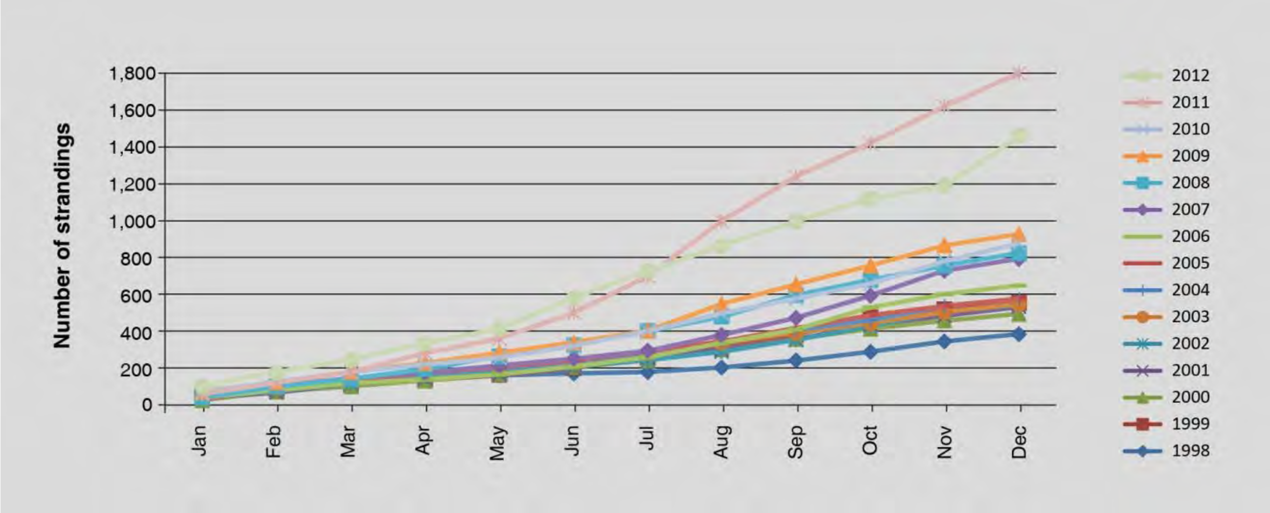

Figure 7.4 Cumulative monthly marine turtle strandings for the Queensland east coast, 1998–2012[217]

Marine turtle strandings in 2011 were about double previous years. Higher than normal strandings were also recorded in 2012. The data only includes cases confirmed in the field by a trained person and later verified by an expert.

7.1.4 Marine turtles

All marine turtle species in the Region are matters of national environmental significance, being listed as both migratory and threatened species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). They are also one of the attributes for listing the Great Barrier Reef as a World Heritage Area. They form a key part of the Marine Park's biodiversity and are listed as a protected species under the Great Barrier Reef Marine Park Regulations 1983. Marine turtle species are also listed under the *Nature Conservation Act 1992* (Qld) and identified as priority species in the Queensland Government's *Back on Track Actions for Biodiversity* plans.[218]

Within the Great Barrier Reef, there are 38 islands which are important nesting sites for marine turtles (Figure 4.10 in Chapter 4). Of these, Raine Island is highly significant as it supports the world's largest aggregation of nesting green turtles. Other important islands include Milman Island, Wild Duck Island, Peak Island and the cays of the Capricorn Bunker Group.[127,128,129,131] On a global scale, these islands are important for the survival of four species of marine turtle: loggerhead, green, hawksbill and flatback turtles.

Marine turtles, as a group, are exposed to many impacts including climate change, declining water quality from catchment run-off, habitat loss from coastal development, some direct and indirect impacts from commercial and recreational fishing and poaching (illegal hunting), boat strike, disease, feral animals eating eggs and destroying nests, and ingestion of marine debris. There is traditional hunting of green turtles and, based on the best available information, this is considered sustainable. Not all impacts occur on all species or in all parts of the Region. In addition, some impacts occur outside the Region and in the waters and on the beaches of other countries.

Some 1800 marine turtles were reported stranded on the east Queensland coast in 2011 (see Figure 7.4).[217] Most were from the southern Great Barrier Reef green turtle stock and were associated with declines in seagrass meadows. Fortunately, the population is expected to withstand this increased mortality as it mainly affected small immature animals, rather than productive mature females, and numbers were increasing at the time.[128,135]

Different life histories, habitat preferences and susceptibility to impacts mean the condition and current trend of each of the Region's marine turtle species varies significantly (Table 7.4).

Table 7.4 Summary of condition and trend for marine turtle species in the Region	
Species	**Summary of condition and trend**
Green — northern Great Barrier Reef stock	This is the largest remaining green turtle stock in the world. There was an upward trend in the annual nesting population from 1976 to 1996, followed by a downward trend since that time, largely attributed to selective harvesting of adult females throughout their range. There are concerns about juvenile recruitment into the stock.[128]
Green — southern Great Barrier Reef stock	The nesting component of the stock has been increasing at 3.8 per cent per year for the past four decades. There are no indicators of population-level impacts on the nesting beaches used by this stock or its foraging component.[128]
Hawksbill	The primary index nesting site at Milman Island indicates the Torres Strait–northern Great Barrier Reef stock is in decline at about three per cent per year. There is no trend data for the foraging component of the population.[129]
Loggerhead	The nesting population is currently recovering after declining by more than 80 per cent between 1970 and the early 2000s. There are concerns for juvenile recruitment into the foraging population from pressures outside the Region.[127]
Flatback	The nesting component of the eastern Queensland stock is currently stable. There is virtually no data on the foraging population.[131]
Leatherback	A very small number of leatherbacks are known to have nested in the Region but no nesting has been recorded since 1996. The Region's population is considered to be part of the south-west Pacific genetic stock which is in decline.[132]
Olive Ridley	No nesting occurs in the Region and there is virtually no data on foraging animals.[130]

7.1.5 Inshore dolphins

Two of the Region's dolphin species are considered to be at risk: the Australian snubfin dolphin and the Indo-Pacific humpback dolphin.[176,219] They are listed as migratory species under the EPBC Act and are two of the many species of global conservation significance included in the Statement of Outstanding Universal Value of the Great Barrier Reef World Heritage Area — making them matters of national environmental significance.

The Australian snubfin and Indo-Pacific humpback dolphins occupy similar inshore habitats and have small (less than 350 square kilometres) discrete home ranges along the coast, with little overlap.[220] Each localised population is estimated to have fewer than 100 individuals, meaning there is a very high reliance on mature females within each population.[176,220] These factors make the species particularly susceptible to any human-induced mortality, potentially resulting in localised extinction.

There are currently no overall population estimates for the Australian snubfin or Indo-Pacific humpback dolphins in the Region,[170] however there are local population estimates for Australian snubfin dolphin aggregations in Cleveland-Halifax Bays[176] and in Keppel Bay-Fitzroy River[220] of about 70 dolphins each. An aggregation has also been recorded at Princess Charlotte Bay-Bathurst Bay on Cape York Peninsula,[221] but no population census has been undertaken. All three areas have either an extensive port expansion program planned (Cleveland Bay) or proposals for new port developments (Fitzroy River delta and Bathurst Bay).

There have been population estimates for Indo-Pacific humpback dolphins in Cleveland Bay (50 or less)[176]; the Capricorn coast (about 64); Keppel Bay (about 107); and Port Curtis (about 85)[222]. Populations are known to inhabit the Great Sandy Strait[172] and Moreton Bay[173] south of the Region.

The apparent declining trend in populations of these species throughout the Region is of great concern. For populations to remain stable, modelling suggests that the Australian snubfin population in Cleveland–Halifax Bays and Keppel Bay–Fitzroy River can sustain a human-induced death rate of only one animal every four years or one animal every year respectively.[176,220] The human-induced deaths of two snubfin dolphins in Halifax Bay in 2011 means the long-term viability of this population is at risk.

There are similar concerns for Indo-Pacific humpback dolphins in Keppel Bay and Port Curtis where eight died of unknown causes in 2011.[217] Although there is very limited mortality of inshore dolphins in gillnets (including nets associated with the Queensland Shark Control Program), the nets are recognised as a serious threat to these species due to the extremely low levels of human-induced mortality that the populations can withstand.[220,176] In the 20-year period from 1991 to 2010, the Queensland Marine Wildlife Stranding and Mortality Database (StrandNet) reported 35 Australian snubfin and Indo-Pacific humpback dolphins drowned in nets from the Queensland Shark Control Program and from the commercial net fishery.[223] Indirect impacts such as the degradation of inshore habitats and declining water quality are likely to be also affecting inshore dolphins.[186,220,224] The carrying capacity of the home range is directly related to the quality and productivity of its habitat.[225,226] Recognising that known populations of inshore dolphins within the Region are considered to be isolated,[176,220] their survival appears to be closely related to the quality and quantity of their habitat.[220]

Other direct impacts on dolphins include disease and ingestion of or entanglement in marine debris.[183]

7.1.6 Dugongs

The Region is home to a globally significant population of dugongs — a listed migratory species under the EPBC Act and one of the key attributes for listing the Great Barrier Reef as a World Heritage Area. Dugongs are also of great cultural, spiritual and social importance, especially to the Reef's Traditional Owners.

A dugong surfaces for air

The Great Barrier Reef provides essential habitat and population connectivity between Queensland's two most significant locations for dugong, Torres Strait and Hervey Bay.[227] In northern areas of the Reef, populations are in good condition and the trend over several decades of monitoring is stable. However, dugong populations south of Cooktown have been mostly declining for decades with an estimated population of only 600 animals between the Daintree River and the southern limit of the Region in 2011,[190,228] compared with an estimate of 2059 from the previous survey in 2005. This is the lowest number recorded in this area since surveys began in 1986, and is considered a response to several years of above average rainfall and the broadscale impacts of cyclone Yasi in February 2011. The decline is likely to be explained mostly by animals moving out of the survey area to seagrass meadows elsewhere, rather than by mortality.

The population status of dugong and the factors that have contributed to this decline are discussed in detail in the dugong demonstration case study (see Section 9.3).

Improving outcomes for inshore dolphins

In recent years, a number of management arrangements have been introduced to better protect the Australian snubfin dolphin and the Indo-Pacific humpback dolphin. Declaration of Dugong Protection Areas in the late 1990s and rezoning of the Great Barrier Reef Marine Park in 2004 mean that 132,500 square kilometres of the inshore waters of eastern Queensland are now closed to large-mesh gill netting. However, core habitats for Australian snubfin and Indo-Pacific humpback dolphins are only partially protected by these arrangements (Figure 7.5).[170,220,229] For example, the majority of the Fitzroy River Australian snubfin dolphin population live in a General Use zone[220] which allows for a wide range of uses such as fishing, aquaculture, shipping and boating.

In 2006, the Queensland Government recommended two devices to reduce interactions between commercial fishers and dolphins: passive acoustic monitoring to enable fishers to detect the presence of dolphins and avoid interaction; and acoustic alarms to deter dolphins from approaching fishing gear. A recent study found these devices may not be as effective as first thought. The dolphins were only vocal about one-third of the time, reducing their chance of detection by fishers, and the likelihood of the dolphins leaving the area did not change significantly when the acoustic alarms were active.[229]

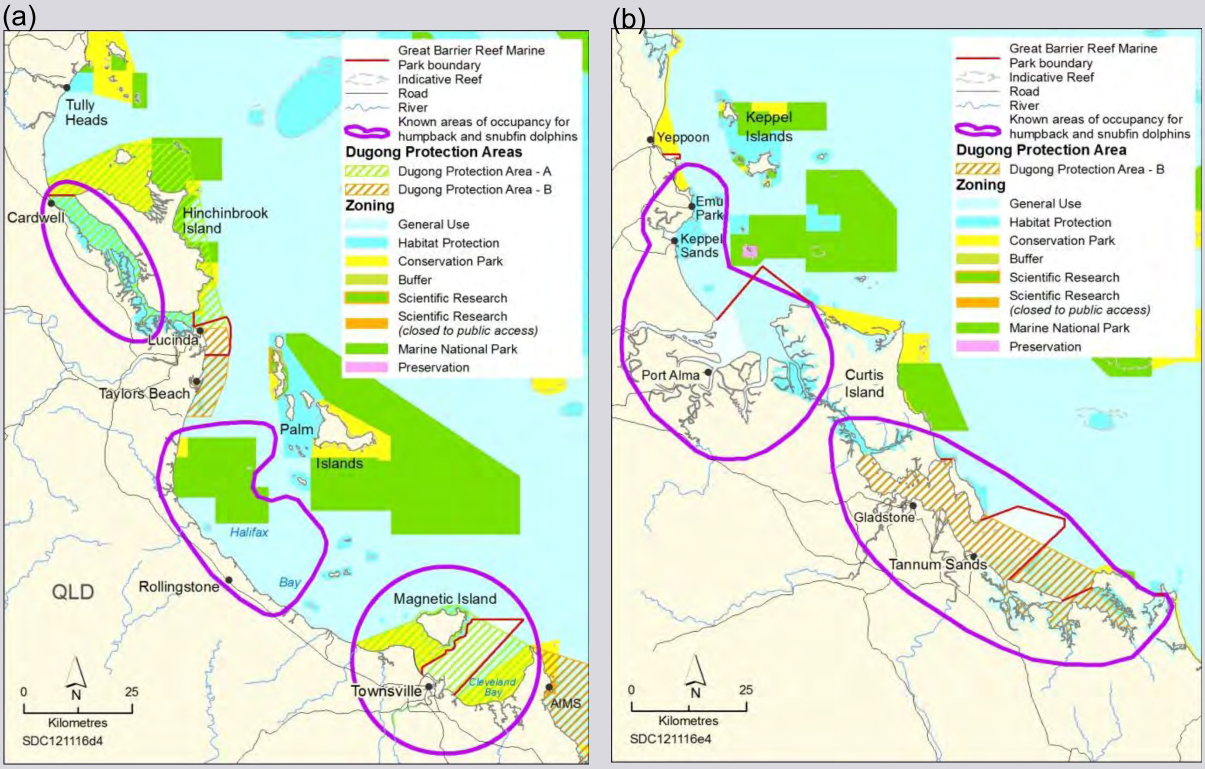

Figure 7.5 Overlap of protected areas and inshore dolphin populations

(a) Hinchinbrook Channel, Halifax and Cleveland Bay, and (b) Keppel Bay and Port Curtis region
Areas known to be occupied by Indo-Pacific humpback and Australian snubfin dolphins are outlined in purple.

Increasing coastal development is predicted to magnify pressure on inshore dolphins. For example, if approved, proposed developments within the Fitzroy River estuary would directly modify between 14 to 25 per cent of the known Australian snubfin dolphin habitat in that area.[220]

The most critical components likely to contribute to an improvement in the condition and trend of these inshore dolphins are preventing further habitat degradation, enhancing water quality and reducing all impacts causing mortality in the species. Improved management of the species also requires improved knowledge of their abundance and distribution, including a population estimate for the entire World Heritage Area.

7.1.7 Seabirds

The Great Barrier Reef Region supports more than 10 per cent of Australia's breeding seabird population,[146] not counting short-tailed shearwaters which nest in huge numbers in southern Australia. There are significant nesting sites on islands throughout the Region for a range of seabirds. Each year, between 1.4 and 1.7 million seabirds from at least 20 species breed on islands and cays in the Region.[146] This represents more than 25 per cent of Australia's tropical seabirds, more than 50 per cent of offshore foraging black noddies and approximately 25 per cent of wedge-tailed shearwaters, brown and masked boobies and red-tailed tropic birds.[146] The number of non-breeding birds (birds which use the ecosystem for feeding but breed elsewhere) is estimated to be about 425,000, giving a total seabird population that may exceed two million.

Seabirds are relevant to a number of matters of national environmental significance (see Chapter 4). Six of the Region's breeding and non-breeding seabirds are listed threatened species and 23 are listed migratory species under the EPBC Act. In addition, the number of breeding seabird species is included in the Statement of Outstanding Universal Value for the Great Barrier Reef World Heritage Area.

In this time of a changing climate, there is growing concern about seabird species with foraging strategies and prey species that are strongly influenced by climatic conditions, particularly the offshore and pelagic foraging seabirds. In the southern part of the Region, there have already been incidences of serious nesting failure of wedge-tailed shearwaters. These failures are closely correlated with reduced availability of their pelagic prey as a result of the El Niño Southern Oscillation cycles and higher than average increases in sea surface temperature,[155] as well as the interaction between the two.

Fourteen seabird species regularly breed at Raine Island in the Region's north.[12] Significant declines have been reported in the total number of seabirds breeding on the island. The estimated average annual breeding population for 1994–2003 was 70 per cent lower than for 1979–1993. There is no evidence the birds have moved to other breeding sites in the Great Barrier Reef,[149] however the monitoring design has limited power to determine seasonal peaks in breeding which may contribute to variation in annual breeding survey results.[159] Declines were evident in 13 of the 16 species surveyed including the common noddy, brown booby and lesser frigatebird — the most common species in the area.[149] Between December 1995 and December 2000, a population decline of more than 40 per cent was reported for wedge-tailed shearwaters in the Capricorn cays.[150]

7.1.8 Targeted bony fish species

Only a small proportion of the Great Barrier Reef's bony fish species are targeted by fishers. There are concerns for some of these species. The vulnerability of two species of threadfin salmon has been assessed as high.[230] The vulnerability of grey mackerel has been assessed as medium.[231] The stock of snapper has been assessed as overfished.[90] There is evidence of localised depletions of coral trout species, with biomass in the no-take (green) zones being typically two to four times greater than in the fished (blue) zones.[232] The 2012 Queensland Fisheries Stock Status[233] summary reported that coral trout has moved from being considered 'sustainably fished' to 'uncertain' due to depressed catch rates, as well as triggered performance measures.

As with most species of conservation concern, the fundamental biology of some of these fishes, such as being long-lived and late maturing, makes them vulnerable to depletion. In addition, fishing activity, including illegal fishing in no-take zones, has contributed to declines of some targeted fish species. The importance of no-take zones is illustrated in recent research on larval fish connectivity between reefs, which demonstrated that fish productivity in this zone is contributing to the biomass of fish both within the zone and on reefs in surrounding areas.[93]

7.1.9 Sharks and rays

There are 134 known shark and rays species that inhabit the Region. Seven shark species and three species of ray are listed as either migratory or threatened species and are therefore matters of national environmental significance (see Chapter 4). On an ecosystem level, they are also important values relevant to the World Heritage Area, national heritage place and Marine Park matters of national environmental significance.

Some sharks and rays have more conservative life history traits than other fish, including a slow growth rate, low reproduction rate and late maturation, whereas others are fast growing, have high reproductive output and mature early. Some species display high levels of specificity in their habitat and prey,[112,113,114,115] making them susceptible to overfishing and slow to recover if overfished. Sharks and rays are captured (both as targeted and non-targeted catch) in a number of fisheries (commercial and recreational) within the Region. However, accurate identification of some species taken is still lacking, along with broad confidence in the validity of catch, release and survivorship data.[234] In addition, Queensland's Shark Control Program targets some sharks considered dangerous to bathers; however, the program also unintentionally catches a range of other non-dangerous shark species and many species of ray.[223] There is evidence of a decline in shark numbers and sizes caught under the program.[235] This decline could be a reflection of reduced population numbers rather than improved control methods.

Of the listed species, there have been significant range contractions and population declines for the largetooth (previously called the freshwater), green and dwarf sawfish. More concerning is the possibility that the speartooth shark, listed as critically endangered under the EPBC Act, has now become extinct on the east coast of Australia. The last verified specimen was recorded in 1983 from the Bizant River, which flows into Princess Charlotte Bay.[121] Whale sharks, shortfin makos, longfin makos and porbeagle sharks are pelagic species which are rarely seen within the Region, and there is limited information on their status and trends. Similarly, the white shark and grey nurse shark are temperate species which are also rarely sighted.

Of the remaining species, there is concern for the grey reef shark and whitetip reef shark,[122] and some other sharks such as the coastal Australian blacktip shark, hammerhead sharks and some sharks and rays that interact with the trawl fishery. [112,117,119,122,236,237,238,239] Shark-like batoids (for example, sawfishes, guitarfish and shovelnose rays) may be particularly vulnerable to nets set in inshore waters due to their body shape and preference for inshore habitats.[240]

7.2 Geomorphological features

Geomorphology refers to landforms and the processes that shape them. The interplay of all the coastal and marine geomorphic elements of the Region is a major component of the outstanding universal value of the World Heritage Area. The major geomorphological features of the Region are described in Chapter 4.

The current condition and trend of key geomorphological features is presented in Table 7.5.

Table 7.5 Current condition and trend of geomorphological features

Understanding the table

Very good	Good	Poor	Very poor
Very good: All major geomorphological features are structurally intact and there is no evidence of human impacts.	**Good:** There is minimal degradation or alteration to geomorphological features in some areas, but no substantial effects at a Reef-wide scale.	**Poor:** Degradation or alteration has occurred in a number of areas affecting the nature and integrity of the geomorphological feature.	**Very poor:** There is widespread degradation or alteration in geomorphological features at a Reef-wide scale.

Area (See Chapter 1, Figure 1.1)	Trend	Confidence in condition and trend
GBR Great Barrier Reef Region	↑ Improving	● Adequate high-quality evidence and high level of consensus
	↔ Stable	◐ Limited evidence or limited consensus
	↓ Deteriorating	○ Very limited evidence, assessment based on anecdotal information
	— No clear trend	

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: Recent advances in mapping technology have provided unprecedented high resolution imagery of the underwater landscapes and geological features of the Great Barrier Reef. There has been no significant change to the geomorphology since the end of the last sea level rise 6500 years ago. Geomorphological features close to the populated coast are likely to have been impacted relatively more due to increased human activity and development in this area. The effects of future climate change impacts on geological features are unknown but are likely to be negative.	GBR		↓		

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Coral reefs: Coral reefs are geomorphological features dependent upon the health of reef-building corals and the environmental conditions that promote their growth. Since 1986, average hard coral cover of the Great Barrier Reef ecosystem is estimated to have declined from 28 to 13.8 per cent, and the rate of decline is increasing. Without coral, the reef features become prone to erosion. Some corals are also showing signs of decreased calcification rates which has implications on the future of the structures. There is no long-term data on the condition of deeper submerged reefs but, for most, there is no indication of recent physical damage. References:[4,35,36,37,9,38,39,40,41,42,43,44,45,46,47,48,64,241]	GBR		↓			◐	◐
Islands and shorelines: There are about 1050 islands within the World Heritage Area, including continental islands, coral cays and mangrove islands. There is limited monitoring of the condition of most islands. Cyclones and coastal development have impacted the geomorphology of some islands and shorelines. Artificial barriers to flow have disrupted sediment supply to beaches, while increased fine sediments have resulted in mangrove forests replacing beaches. References:[16,17, 18, 19,10,11,12,13,14,15,241]	GBR		↓			◐	◐

		Condition and trend				Confidence	
	Area	Very good	Good	Poor	Very poor	Condition	Trend
Channels and canyons: Although little is known about submarine canyons, karstic channels and blue holes, their depth and distance from shore mean they are likely to be in very good condition and stable into the future. Palaeochannels can be found closer to the coastline and are therefore more at risk of human impacts such as sediment from catchment run-off. The impacts of climate change on these features are unknown. References: [241]	GBR	↔				○	○
River deltas: River deltas within and adjacent to the Region range in condition. They are in relatively good condition in areas north of Port Douglas where there has been relatively limited catchment development. In the central and southern areas, it is likely the geomorphology of river deltas has been affected by coastal development and changed sediment loads from catchment development and artificial barriers to flow. These effects can be positive or negative on the feature. References: [241]	GBR		↓			○	○
***Halimeda* banks:** Large areas of the far northern Great Barrier Reef are dominated by *Halimeda*, calcareous green algae. It is likely these banks are in very good condition given their isolation from land-based impacts and level of protection from trawling. References: [58,59,60,241]	GBR	↔				○	○
Seagrass meadows: Intertidal seagrass meadows are in poor condition with serious declines reported over the past four years, especially those in the paths of cyclones and those exposed to flooding. Little is known about the implications of this loss on geomorphological processes performed by seagrass such as sediment trapping. The abundance and condition of subtidal and deepwater seagrass meadows are also poorly known. Fewer impacts mean northern area meadows are likely to be in very good condition and effectively stabilising and trapping sediment. References: [26,27,28,29,30,31,32,33,241]	GBR			↓		○	○

7.3 Indigenous and historic heritage values

The Region's Indigenous and historic heritage values relevant to matters of national environmental significance are outlined in Chapter 4. Outcomes of an assessment of the condition and recent trend of key values are presented below.

They are grouped into:

- Table 7.6 — Indigenous heritage values (four elements)
- Table 7.7 — historic heritage values (six elements).

A discussion of the key findings about the condition and trend of some Indigenous and historic heritage values is presented after the tables.

This report considers Indigenous heritage values as a whole and recognises the interconnectedness of all elements, including the natural values described in Sections 7.1 and 7.2 above.

Table 7.6 Current condition and trend of heritage values — Indigenous

Understanding the table

Very good	Good	Poor	Very poor
Very good: Places with heritage values have been systematically and comprehensively identified and included in relevant inventories or reserves. Heritage places are in very good condition with identified values retaining a high degree of integrity.	**Good:** Places with heritage values have been systematically identified and included in relevant inventories or reserves. Heritage places are in good condition with identified values generally retaining their integrity.	**Poor:** Places with heritage values have not been systematically identified. Heritage places are in poor condition and/or their values lack integrity.	**Very poor:** Places with heritage values have not been identified. Heritage places are in degraded condition and their values lack integrity.

Area (See Chapter 1, Figure 1.1)	Trend	Confidence in condition and trend
GBR Great Barrier Reef Region	↑ Improving	● Adequate high-quality evidence and high level of consensus
	↔ Stable	◐ Limited evidence or limited consensus
	↓ Deteriorating	○ Very limited evidence, assessment based on anecdotal information
	— No clear trend	

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: Traditional Owners with connections to the Great Barrier Reef Region maintain their cultural practices and customs. Places of Indigenous heritage values have not been systematically identified and many have deteriorated, especially around development areas and on islands. Some species of cultural significance are under pressure. Story, language and songlines are being affected by activities in the Region.	GBR			↓	

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Cultural practices, observances, customs and lore: Traditional Owners with connections to the Great Barrier Reef Region maintain their cultural practices and customs. There is evidence of inter-generational transfer throughout the Reef.	GBR		↔			◐	◐
Sacred sites, sites of particular significance, places important for cultural tradition: There are many places, especially in coastal systems and on islands, where there is pressure on sacred sites and other sites of cultural significance. This is particularly around areas of high development and those exposed to severe weather events. Other sites are intact and in good condition and are being well managed by Traditional Owners.	GBR			↓		◐	◐

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Stories, songlines, totems and languages: Story, language, songlines and totems are being affected by activities such as shipping, anchoring and dredging. These have a particularly significant impact as they may transgress these traditional systems. Some species of cultural significance, such as whales, dugongs, turtles, rays, sharks and dolphins, and other coastal resources, are under pressure, especially in areas south of Cooktown.	GBR			↓		◐	◐
Indigenous structures, technology, tools and archaeology: Indigenous structures (for example fish traps), tools, technologies and archaeology have not been systematically identified. They are under pressure from coastal development and vehicle use. Some specific sites, such as the Hinchinbrook fish traps, are managed by Traditional Owners. The significance of some sites, such as the rock quarry on South Molle Island, is recognised on the National Heritage List.	GBR			↓		◐	◐

Table 7.7 Current condition and trend of heritage values — historic heritage

Understanding the table

Very good	Good	Poor	Very poor
Very good: Places with heritage values have been systematically and comprehensively identified and included in relevant inventories or reserves. Heritage places are in very good condition with identified values retaining a high degree of integrity.	**Good:** Places with heritage values have been systematically identified and included in relevant inventories or reserves. Heritage places are in good condition with identified values generally retaining their integrity.	**Poor:** Places with heritage values have not been systematically identified. Heritage places are in poor condition and/or their values lack integrity.	**Very poor:** Places with heritage values have not been identified. Heritage places are in degraded condition and their values lack integrity.

Area (See Chapter 1, Figure 1.1)

GBR Great Barrier Reef Region

Trends

- ↑ Improving
- ↔ Stable
- ↓ Deteriorating
- — No clear trend

Confidence in condition and trend

- ● Adequate high-quality evidence and high level of consensus
- ◐ Limited evidence or limited consensus
- ○ Very limited evidence, assessment based on anecdotal information

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: There is good understanding and recording of some aspects of historic heritage, for example historic shipwrecks and lightstations. Heritage values are being maintained or restored at some lightstations. Most places of historic significance are poorly recorded and their condition is not well understood.	GBR		↓		

		Condition and trend				Confidence	
	Area	Very good	Good	Poor	Very poor	Condition	Trend
Places of historic significance — historic shipwrecks: There is a comprehensive understanding of the historic shipwrecks of the Region (i.e. those greater than 75 years). Known wrecks have been systematically recorded as part of the Australian National Shipwrecks Database, with some 470 historic shipwrecks recorded within the Region. Reference: [242]	GBR		↔			◐	○
Places of historic significance — World War II features and sites: The features and sites of significance in relation to World War II include shipwrecks, aircraft wrecks, unexploded ordnances and features on islands. Generally, they have been identified but little is known of their condition.	GBR		—			◐	○
Places of historic significance — lightstations: The locations and values of lightstations, including the lighthouses and ancillary structures, are well known. Heritage values are being maintained or restored at lightstations where there is a permanent presence, such as on Low Isles and Lady Elliot Island. However, some other sites are deteriorating.	GBR		↓			◐	◐
Places of historic significance — other: Other places of historic significance include Endeavour Reef, sites of turtle and dugong factories, and Mrs Watson's cottage on Lizard Island. Most are poorly recorded and their condition is not well understood. Some historic photos have been collected.	GBR		—			○	○
Places of scientific significance (research stations, expedition sites): The Great Barrier Reef has long been an important site for scientific endeavours, from the Yonge expedition in 1928–29 to modern research stations, for example Heron, Orpheus and Lizard islands. The location of significant research is generally well recorded in scientific publications. Some sites near research stations are maintained.	GBR		↔			◐	◐
Places of social significance — iconic sites: The iconic sites of the Great Barrier Reef include Raine Island, Cod Hole, Michaelmas Cay and reef, Green Island and reef, Whitehaven Beach and Hill Inlet. They are well recognised and many are comprehensively managed. As with the overall condition of the Great Barrier Reef, the condition of some iconic sites has declined.	GBR		↓			◐	◐

7.3.1 Traditional Owner connections

Traditional Owner connections integrate nature, heritage and culture, and Indigenous heritage is made up of tangible and intangible elements. Landscapes, seascapes, sites and areas of their country are particularly important to Aboriginal and Torres Strait Islander peoples, intertwined with the more intangible elements such as cultural practices, observances, customs, lore, stories, songlines, totems and languages (see Chapter 4). There are a variety of cultural sites within the sea country of the Great Barrier Reef, including sacred sites, ceremonial sites, burial grounds, rock art sites, middens, fish traps, cultural landscapes and story places. These significant places provide a strong connection to traditional clan areas and form part of Australia's rich heritage.

For Traditional Owners, nature and culture combine to make a living heritage. They are increasingly re-asserting their role in managing their country through active engagement in on-country management and in policy and planning programs.

> *"…we've had a long long long association with the Reef. It is one of the seven wonders of the world but we also have a common culture and obligation to it."* [243]

7.3.2 Cultural keystone species

As with most cultures, the environment is central to Indigenous heritage values and includes some plants and animals of particular significance. These plants and animals are referred to as 'cultural keystone species' and they play a fundamental role in Traditional Owner culture, including through diet, materials, medicine, totems and stories.[244] In the Region, populations of many of these cultural keystone species have been significantly reduced — examples include dugongs, green turtles, some sharks and some bony fish (see Section 7.1 above). This in turn affects the Region's Indigenous heritage values. For example, the declines in fish, turtle and dugong numbers in the inshore coastal zone have affected the traditional practice of building platforms out into the sea to hunt and fish for these species.

When Traditional Owner Marie Shipton was asked about seeing marine turtle nesting along her beaches she replied *"…no we don't anymore… we used to have a lot of turtle and dugong but it's very few now, but we don't know where they're gone.."* [245]

Through their own practices and partnerships with managing agencies, Traditional Owners are working to look after these keystone species. One example is the Traditional Use of Marine Resources Agreements between Traditional Owner groups, the Great Barrier Reef Marine Park Authority (the Authority) and the Queensland Government.

Saltwater people managing 'Gungu' (green turtles) in their sea country

Ecological monitoring and information exchange between Traditional Owners, scientists and Marine Park managers have helped conserve 'Gungu' (green turtles) in Gudjada sea country around Bowen. The on-ground conservation project undertook a preliminary investigation of the incidence and prevalence of fibropapilloma disease in green turtles in Edgecombe Bay, as well as tagging and monitoring of the green turtle population in Gudjada sea country. The project was a partnership between the Gudjuda Reference Group, Girringun Aboriginal Corporation, the Authority, the Queensland Government, WWF-Australia and James Cook University scientists. It provided the opportunity for Traditional Owners to share their cultural lore, custom and Traditional ecological knowledge. It also enabled scientists to share western science and wildlife monitoring techniques with Indigenous communities, building Traditional Owner capacity in monitoring and management of their sea country.

7.3.3 Identifying Indigenous heritage values

One aspect of the statements used to grade the condition of heritage values is the degree to which those values have been recorded and identified. Based on this aspect, many of the Indigenous heritage values of the Great Barrier Reef Region are graded as being in poor condition. There is no systematic and comprehensive inventory of the Region's tangible or intangible Indigenous heritage values. While Traditional Owners have a good understanding of their own country and its values, this has rarely been integrated into the broader information systems of managing agencies. The Authority's website *Story Place* is a reference database that shares information and knowledge about traditional connections to sea.[246]

Girringun Traditional Owners record their important cultural heritage sites

As part of the implementation plan for their Traditional Use of Marine Resources Agreement, Girringun Traditional Owners have conducted comprehensive cultural heritage surveys to inform management planning. This involves documenting previously unrecorded cultural heritage sites, providing recommendations on their management and protection, and providing baseline information about the natural and cultural landscape so that, for example, damage from cyclones Yasi and Larry may be assessed. Participation of Girringun rangers was fundamental to the activity. It was an opportunity to provide training in cultural and heritage management and to further empower the Traditional Owners of the area.

7.3.4 Historic heritage values

Historic heritage values illustrate the way in which the many cultures of Australian people have modified, shaped and created the cultural environment of the Region. They are assessed as being generally in good condition in the Region, although some historic lightstations and some of the Region's iconic sites are likely to be deteriorating.

While some specific aspects of the Reef's historic heritage have been well documented (for example shipwrecks and lightstations), knowledge of many historic places or events is limited (for example World War II features and sites). Even for values that are relatively well recorded, understanding about their full extent in the Region continues to improve as technology improves and visitation to the Region increases. For example, new shipwrecks continue to be found and recent investigations indicate there may be between 160 and 200 aircraft wrecks from World War II within the outer boundaries of the Region.

7.4 Community benefits of the environment

The condition and trend of the Region's community benefits are determined in large part by the quality of the environment (its biodiversity, geomorphological feature and Indigenous and historic heritage values) from which the benefits are derived. Outcomes of an assessment of the condition and recent trend of community benefits are presented in Table 7.8.

A discussion of the key findings follows the table.

Table 7.8 Current condition and trend of community benefits of the environment

Understanding the table

Very good: There is a significant contribution to the wellbeing of local communities and the nation. The Region contributes strongly to regional and national economies, and is highly valued, well understood, and enjoyed by catchment residents, the nation and the world community.	**Good:** There is a valuable contribution to the wellbeing of local communities and the nation. The Region contributes to regional and national economies, and is valued, understood and enjoyed by catchment residents, the nation and the world community.	**Poor:** There is a small contribution to wellbeing of local communities and the nation. The Region makes a minor contribution to regional and national economies and many do not understand or enjoy its values.	**Very poor:** There is little or no contribution to the wellbeing of local communities or the nation. The Region contributes very little to regional and national economies and most do not understand or enjoy its values.

Area (See Chapter 1, Figure 1.1)	**Trend**	**Confidence in condition and trend**
GBR Great Barrier Reef Region	↑ Improving	● Adequate high-quality evidence and high level of consensus
	↔ Stable	◐ Limited evidence or limited consensus
	↓ Deteriorating	○ Very limited evidence, assessment based on anecdotal information
	— No clear trend	

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: The Region's environment provides a range of benefits to catchment communities and the nation. Many catchment residents understand and appreciate the Reef and have a strong personal attachment to it. Much of the natural beauty of the Reef remains, but underwater aesthetic values have declined in some areas. Reef-dependent industries contribute strongly to the Australian economy. In recent years, some community benefits have been adversely affected by the direct and indirect effects of extreme weather.	GBR		↔		

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Income: Much of the economy derived from the Great Barrier Reef is based upon use of its biological resources. The economic contribution generated by tourism, recreation, commercial fishing and scientific research in the Reef catchment and the World Heritage Area in 2012 was about $5.7 billion. This has been relatively stable over the past five years. References: [247,248]	GBR		↔			●	●
Employment: Tourism, recreation and commercial fishing based on the Great Barrier Reef environment generated almost 69,000 full-time equivalent jobs throughout Australia in 2012, compared to 54,000 in 2007. Scientific research conducted on the Reef generated more than 900 jobs. References: [248]	GBR		↔			●	●
Understanding and appreciation: The Authority, the tourism industry and Reef HQ Aquarium provide information on the Reef, its key issues and actions that can be taken. Students at 293 Reef Guardian schools are receiving key messages about the Reef's protection and actions they can take. Many new residents within the Region may have little knowledge of the Reef and its management. References: [247]	GBR		↔			◐	◐
Enjoyment: Opportunities to experience clear oceans, healthy coral reefs and healthy fish are important to Reef visitors. Visitors generally report that they are satisfied or very satisfied with their visit to the Great Barrier Reef. References: [247,249]	GBR	↔				◐	◐
Access to Reef resources: Millions of people visit the Region each year. It provides a wide range of recreational opportunities such as boating, snorkelling, diving, fishing and nature appreciation. There are also opportunities for commercial fishing, marine tourism and education. In some key locations, management arrangements partition use to allow for a range of activities. References: [247,250,251]	GBR		↔			◐	◐

	Area	Condition and trend: Very good	Condition and trend: Good	Condition and trend: Poor	Condition and trend: Very poor	Confidence: Condition	Confidence: Trend
Personal connection: More than 80 per cent of Reef catchment residents have visited the Great Barrier Reef at least once in their lives, and almost 10 per cent visit the Reef more than 10 times a year. Some residents report that they chose where they live so as to be close to the Reef. Many report a close attachment to particular sites in the Region. Traditional Owners continue to maintain connection to their sea country, for example through stories and songlines, sites of cultural significance and important saltwater ceremonies. Many people who are employed in the Region show a strong personal attachment to its environment. References: [247]	GBR	↔				◐	◐
Health benefits: Catchment residents often report that they derive health benefits from the Great Barrier Reef environment and its resources. Examples include being able to 'unwind' and 'get away from it all', the release of stress, improved fitness through outdoor activities, and improved diet through access to wild-caught seafood. References: [247]	GBR	↔				○	○
Aesthetics: The natural beauty of most of the Region remains intact, especially for offshore coral reefs and aerial vistas, as well as for neighbouring islands (many of which are national parks). The significant loss of coral cover, especially in southern inshore areas, has reduced underwater aesthetic value. References: [252]	GBR		↓			◐	◐

7.4.1 Economic benefit

The Great Barrier Reef provides long-term economic benefits and employment to Queensland coastal communities and the nation. These benefits are based upon use of its biological resources. This includes marine tourism and recreation, which are nature-based and heavily reliant on a healthy and diverse ecosystem, and commercial fishing, which is almost totally dependent on natural ecological systems for productivity and sustainable profit. Exploration and the recovery of minerals or petroleum are banned in the Marine Park.

The Australia-wide economic contribution generated by tourism, recreation, commercial fishing and scientific research in the Reef catchment and the World Heritage Area in 2012 was $5.7 billion.[248] This supported the equivalent of about 69,000 full-time jobs. These estimates are based on both the direct and indirect contributions of the activities considered and are driven by just over $7 billion of expenditure in the catchment (Table 7.9).[248]

Tourism in the catchment and the World Heritage Area represents more than 90 per cent of the direct expenditure of Reef-related activities (Table 7.9).[248] This then flows through the economy, with tourism accounting for 91 per cent and 93 per cent of the value-added and employment contributions to Australia respectively. Although the Reef provides an impetus for travel to the broader catchment, not all visitors to the catchment visit the Great Barrier Reef. Analysis of more Reef-specific information indicates direct Reef-related expenditure in 2012 was about $480 million, which contributed almost $389 million (value-added) to Australia's economy and generated employment equivalent to more than 4800 full-time jobs. This is based on 1.9 million direct visits to the Marine Park annually and excludes the 2.3 million passengers who transfer through the Marine Park to adjacent islands.[248]

Importantly, the Reef is considered a major driver or incentive for international travellers to visit Australia.

Recreation, which covers household recreational activity by those who live in the catchment area, contributed just over 2700 full-time equivalent jobs. Recreational activity covers trip-related expenditure for fishing, boating, sailing and visiting islands, as well as household expenditure on recreational equipment.

Commercial fishing contributed $160.3 million and provided the equivalent of 975 full-time jobs in 2012.

Table 7.9 Economic contributions of Reef-related activities to Australia, 2012 [248]

The economic contribution of tourism, recreation, commercial fishing and scientific research in the Great Barrier Reef catchment and the World Heritage Area are provided. Direct expenditure is the total amount of money (in millions of dollars) spent within each industry. Value-added figures are estimates of the profit (in millions of dollars) that each industry generated during 2012. Full-time equivalent is the equivalent of one employee working full-time.

	Direct expenditure ($m)	Value-added ($m)	Employment (full-time equivalent)
Tourism	6,410.6	5,175.6	64,338
Recreation	332.4	243.9	2,785
Commercial fishing	192.5	160.3	975
Scientific research	106.1	98.0	881
Total	**7,041.5**	**5,677.8**	**68,979**

7.4.2 Visitation

There are now more than 1.8 million tourism visitor days spent on the Great Barrier Reef each year (see Figure 5.14 in Chapter 5). The number of tourists visiting the Reef fell between 2006 and 2011 after a peak of almost two million visitor days in 2005, however there was evidence of growth in 2012. The recent declines can largely be attributed to international financial instability, the strong Australian dollar, extreme weather events, particularly in 2011, and growing competition from alternative international tourism destinations.

In addition to the tourists directly visiting locations within the Marine Park, there are an estimated 2.3 million transfers of visitors, residents and workers to and from islands within the Region.

In the stakeholder workshops held as part of the strategic assessment process (see Appendix 5), participants highlighted favourite Great Barrier Reef places including islands, coral reefs, beaches, estuaries, bays and inlets. There is a spectrum of such locations throughout the Region, supporting recreational activities such as boating, snorkelling, diving, fishing, wildlife watching, nature appreciation, relaxing, walking, camping and generally spending time with family and friends, as well as for commercial fishing, marine tourism and education.

It is estimated there are more than 14 million recreational visits to the Marine Park by Great Barrier Reef catchment residents every year, plus visits by non-paying and independent travellers from outside the catchment.[253] In 2011 and 2012, 87 per cent of coastal residents visited a beach; 73 per cent visited a second beach; 30 per cent visited an island; and 42 per cent went either fishing, boating or sailing in the Great Barrier Reef.[250] Across the Reef catchment, nine per cent of people own a boat. Rates of ownership are higher in coastal areas, with almost 17 per cent of Whitsundays residents owning a boat (see Section 5.4.5).[254]

Results of a 2012 survey show 75 per cent of tourists to coastal parts of the Great Barrier Reef catchment went to a mainland beach, 60 per cent visited an island and 50 per cent went to an offshore reef. Their activities included snorkelling or diving (50 per cent); sailing (25 per cent); private boating (20 per cent); and fishing (20 per cent). These visitors highly valued the opportunities to experience clear oceans, healthy coral reefs and healthy reef fish, and were mostly highly satisfied with these aspects of their visit.[255]

7.4.3 Understanding and appreciation

There are many opportunities for coastal residents and visitors to learn about and help protect the Great Barrier Reef.

A key component of many tourism operations in the Region is presenting and interpreting the Reef environment to their visitors. This is especially the case for the more than 60 per cent of visitors who travel with certified high standard tourism operations,[256] as high standards of presentation and interpretation are key commitments in the certification process.

The Authority's Reef HQ Aquarium, located in Townsville, also provides people of all ages and physical abilities the chance to see and gain an appreciation for a living coral reef ecosystem, what makes it special and why it needs to be protected. More than 3.4 million local, national and international visitors have visited the facility since it opened in 1987, and visitation continues to increase. In 2012, 94 per cent of respondents to Reef HQ Aquarium's visitor survey believed they had gained an improved understanding of the issues relating to the Great Barrier Reef, while 89 per cent believed they had a better understanding of how they can help protect and conserve the ecosystem.[257] The facility's reef videoconferencing program has also showcased the living reef to more than 680 locations nationally and internationally, directly engaging more than 52,000 people.

Through the Authority's Reef Guardian stewardship program, local stakeholders are encouraged to take hands-on actions to care for the Reef. Participants are encouraged to go beyond what is required by law in their day-to-day activities and become active stewards for the Reef. This includes sharing information about their actions. There are now 293 Reef Guardian schools involving about 114,900 students working on Reef-related projects. The program was expanded in 2007 to include local councils, and in the past two years pilot programs were introduced for farmers, graziers and commercial fishers.

Participants in the Authority's Eye on the Reef program contribute substantially to understanding trends in Reef condition, contributing more than 10,000 surveys from about 500 reefs throughout the Region.

The extent to which people care about the Great Barrier Reef is evident in responses to a 2012 survey where visitors indicated they were more sensitive to changes in the Reef environment — such as oil spills, ship groundings, waste spills from ports, water clarity and rubbish — than to increases in local prices. When asked if they would be willing to pay to help 'fix' various threats to the Reef, visitors indicated they would be prepared to pay $10 (median response) for each visit to improve water quality. They were also willing to pay $5 (median response) to protect top predators or reduce the risk of shipping accidents.[255]

7.4.4 Personal connections

The Great Barrier Reef is a key part of the identity of adjacent coastal communities. It is a major 'point of difference' for these communities and something to be proud of. Traditional Owners are strongly linked to their sea country through their living culture and traditions, including their stories and songlines, sites of cultural significance and important saltwater ceremonies.

Most residents within adjacent coastal communities have visited the Reef environment and many maintain a close connection, with 10 per cent going to the Reef more than 10 times in a year.[258] Some residents choose to live at their current locations so they can enjoy the benefits of being close to the Great Barrier Reef.[259]

Reef-dependent commercial fishers and tourism operators identify very strongly with their occupations and the places where they live and work. This is highlighted by the fact that few, if any, who were directly affected by cyclone Yasi or the central Queensland floods in 2011 changed their jobs or moved elsewhere after the extreme weather events. This was despite economic imperatives to find alternative income or maintain their wage.[260]

7.4.5 Knowledge about community benefits

It is widely recognised that communities of the Great Barrier Reef catchment and beyond derive a range of significant benefits from the Region's environment. Supporting evidence specific to the Region is patchy, however studies from elsewhere show parks and protected areas contribute to the health and wellbeing of communities. They are places of adventure and challenge, exercise, peace and quiet, recreation, gathering and relaxation, and offer a range of recreational activities to bring families and friends together.[261]

It is anticipated that the Great Barrier Reef's role in supporting and sustaining local communities will be better understood in the future when a social and economic long-term monitoring program, designed by CSIRO and James Cook University researchers, is implemented.

The ecosystem services that the Region provides to communities, for example the role of wetlands, mangroves and seagrass in trapping sediments and therefore maintaining clear water on the Reef, are poorly understood.

7.5 Environmental processes

The key environmental processes relevant to matters of national environmental significance are outlined in Chapter 4. Outcomes of an assessment of the condition and recent trend of these environmental processes are presented in Table 7.10.

It is important to note that while there is a good understanding of the variables that contribute to some of the key physical and chemical processes — such as sedimentation, sea temperature, nutrient cycling and freshwater inflow — there is a poor understanding and almost no monitoring of many others, especially ecological processes.

Table 7.10 Current condition and trend of environmental processes

Understanding the table

Very good: There are no significant changes in process as a result of human activities.	**Good:** There are some significant changes in processes as a result of human activities in some areas, but these are not to the extent that they are significantly affecting ecosystem functions.	**Poor:** There are substantial changes in processes as a result of human activities, and these are significantly affecting ecosystem functions in some areas.	**Very poor:** There are substantial changes in processes across a wide area as a result of human activities, and ecosystem functions are seriously affected in much of the area.

Area (See Chapter 2, Figure 2.3)		**Trends**		**Confidence in condition and trend**	
N.I.	Northern inshore	↑	Improving	●	Adequate high-quality evidence and high level of consensus
N.O.	Northern offshore	↔	Stable	◐	Limited evidence or limited consensus
S.I.	Southern inshore	↓	Deteriorating	○	Very limited evidence, assessment based on anecdotal information
S.O.	Southern offshore	—	No clear trend		

	Area	Very good	Good	Poor	Very poor
Overview: A recent cluster of severe weather events (cyclones and floods), especially in the southern area, has adversely affected the Region's physical processes. Sea temperature and sea level are rising throughout the Region. The acidity of the ocean continues to slowly increase. The processes of sedimentation, including resuspension, and nutrient cycling continue to be affected in inshore areas on the developed coast. Ecological processes remain largely intact in northern areas and any changes are not significantly affecting the ecosystems. Primary production, symbiosis, reef-building and connectivity are in poor condition in the southern inshore area and are deteriorating.	N.I.		↔		
	N.O.		↔		
	S.I.			↓	
	S.O.		↔		

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Waves, currents and tides: Ocean currents vary naturally. There is increasing evidence of intensified flow and accelerated warming in the East Australian Current adjacent to the Region's southern coast. This current is transporting greater volumes of warmer water southward, carrying larvae and juveniles with it. There is little information about the Hiri Current travelling north along the coast in northern Great Barrier Reef waters. Severe cyclone activity over the past four years has caused large waves which have damaged benthic habitats. There have been no significant changes to tides within the Region. References: [262,263,264]	N.I.	—				○	○
	N.O.	—				○	○
	S.I.		—			◐	○
	S.O.		—			◐	○
Cyclones: Between 2008 and 2012, there was a cluster of category three and above cyclones that affected the Great Barrier Reef. Impacts have been most severe in the southern half of the Region, causing significant damage to benthic habitats. Cyclones are forecast to become more intense. References: [139,153,265,266,267,268,269,270,271,272,273]	N.I.		↔			●	●
	N.O.		↔			●	●
	S.I.			↓		●	●
	S.O.			↓		●	●
Wind: There is emerging evidence of increases in wind strength Australia-wide, but little information specific to the Region. Changes in the wind patterns may have consequences for inshore ocean turbidity through the resuspension of sediments, for island formation and for the distribution of planktonic larvae. References: [274]	N.I.		↓			○	○
	N.O.		↓			○	○
	S.I.		↓			○	○
	S.O.		↓			○	○
Sedimentation: Exposure of the Great Barrier Reef to terrestrial sediments and resuspended marine sediments has increased, especially in southern inshore areas. Significant investment in land-based management measures has resulted a six per cent reduction in the sediment load delivered to the Great Barrier Reef since 2009. Dumping of dredge material also affects sedimentation processes with resuspension plumes likely to travel considerably further than previously thought. There may also be more resuspension in shallow water due to increases in wind in the Region. References: [275,276,277]	N.I.	↔				●	●
	N.O.	—				●	●
	S.I.			↔		●	●
	S.O.		↔			●	●
Sea level: The fastest rates of sea level rise in Australian waters are being recorded in northern areas, with sea level in the Region continuing to rise by about 3.1 mm per year. Even modest rises in sea level may have substantial consequences when combined with natural variability arising from the El Nino Southern Oscillation and the Pacific Decadal Oscillation, for example to turtle nesting success. References: [273,278,279,280,281]	N.I.		↓			●	●
	N.O.		↓			●	●
	S.I.		↓			●	●
	S.O.		↓			●	●

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Sea temperature: Average sea surface temperature has risen substantially over the last century, with 15 of the 20 warmest years occurring in the past two decades. This has caused some coral bleaching plus observable effects on growth rates of corals and overall coral cover. Increasing sea temperature provides additional energy to the formation of tropical cyclones. References: [273,282,283,284]	N.I.			↓		●	●
	N.O.			↓		●	●
	S.I.			↓		●	●
	S.O.			↓		●	●
Light: Increased sedimentation may be altering light levels in inshore areas of the southern two-thirds of the Region. On a local scale there is increasing light pollution from coastal facilities, potentially affecting any turtle nesting and the behaviour of hatchlings in the vicinity. References: [285]	N.I.	↔				◐	◐
	N.O.	↔				◐	◐
	S.I.			↓		◐	◐
	S.O.		↔			◐	◐
Nutrient cycling: Most inshore areas of the southern two-thirds of the Region are exposed to nutrients which continue to enter the Great Barrier Reef at greatly enhanced levels. Recent significant investment in land management practices has reduced the nutrient load entering the Region from the adjacent catchment. For example, since 2009 improvements in farming practices has resulted in a seven per cent reduction in the load of total nitrogen delivered to the Great Barrier Reef.. References: [286,287,288]	N.I.		↔			●	●
	N.O.		↔			●	●
	S.I.			↔		●	●
	S.O.		↔			●	●
Ocean acidity: A decline of 0.1 units in the pH of Great Barrier Reef waters has already been recorded and further significant declines are expected. Rates of decline are greater in southern areas of the Region. The most immediate effects may be on crustose coralline algae, a species vital to reef building. References: [64,289,290,291]	N.I.		↓			◐	●
	N.O.		↓			◐	●
	S.I.		↓			◐	●
	S.O.		↓			◐	●
Freshwater inflow and salinity: After a period of significantly lower than average freshwater flow, significant volumes of freshwater have entered the Region in the past five years, including record flows for some rivers. This freshwater has reached beyond the coastal zone and has had direct effects on marine species as well as delivering increased loads of sediments, nutrients and pesticides. The salinity of Great Barrier Reef waters is generally stable. References: [292]	N.I.		↓			●	●
	N.O.	↔				●	●
	S.I.			↓		●	●
	S.O.	↔				●	●
Microbial processes: Many marine microbes are sensitive to changes in temperature, pH, nutrients, salinity and oxygen and respond rapidly to changing environmental conditions. There is little specific information available for the Great Barrier Reef, but it is assumed the condition of microbial processes is a reflection of other ecosystem processes. In recent decades, there has been a global increase in reports of disease in marine organisms, linked to increasing temperatures and thermal stress. References: [92,293,294,295,296,297]	N.I.	↔				○	○
	N.O.	↔				○	○
	S.I.		↔			○	○
	S.O.	↔				○	○

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Particle feeding: Based on knowledge of some particle-feeding species, the process is assumed to be healthy and stable. Some species of prawns are targeted by the trawl fishery. Turbidity increases the rate of particle feeding undertaken by corals. References: [49,298,299,300,301]	N.I.		↔			○	○
	N.O.		↔			○	○
	S.I.		↔			○	○
	S.O.		↔			○	○
Primary production — pelagic: The presence of elevated chlorophyll *a,* together with intense and extensive phytoplankton blooms following the discharge of nutrient-rich flood waters, suggests pelagic primary production in the southern inshore area is likely to be significantly impacted by elevated nutrient loads. This in turn affects zooplankton populations, such as crown-of-thorns starfish larvae. References: [63,302,303,304]	N.I.		↔			◐	◐
	N.O.		↔			◐	◐
	S.I.			↓		◐	◐
	S.O.		↔			◐	◐
Primary production — benthic: The overall condition of benthic primary production in the Region remains generally good. However, certain primary producers, such as coral and seagrasses, are in decline and have been for many decades, resulting in a loss of primary production and a deterioration of habitat, especially in southern areas. There is evidence of increased primary production by macroalgae, indicating a phase shift from coral to macroalgae domination at some reefs. References: [305,306,307]	N.I.		↔			◐	◐
	N.O.		↔			◐	◐
	S.I.			↔		◐	◐
	S.O.			↔		◐	◐
Herbivory: Populations of herbivorous fish are generally healthy and not under pressure; however, the largest herbivore species, the dugong, has declined significantly in the southern inshore area. The herbivorous green turtle population has increased in the south, however there are indications that the northern stock is in decline. References: [80,308,309,310,311,312,313,314]	N.I.		↔			◐	◐
	N.O.		↔			◐	◐
	S.I.			↓		●	◐
	S.O.		↔			●	◐
Predation: While little is known about trends in the ecological process of predation, the condition of the ecosystem's top predators can provide an indication of its condition. There are 115 species of top predators identified within the Region (for example, sharks, mackerel and coral trout). While several species are declining, threatened or over exploited, the majority are either caught in sustainable numbers or not harvested. References: [315,119,120,236,316]	N.I.		↔			○	○
	N.O.		↔			○	○
	S.I.		↔			○	○
	S.O.		↔			○	○

	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence: Condition	Trend
Symbiosis: There is a massive number and wide range of symbiotic relationships in the Region including those that are mutually beneficial (mutualism); beneficial to one organism without affecting the other (commensalism); and beneficial to one organism to the detriment of another (parasitism). Very little is known about most, however based on the overall condition of the ecosystem, it is likely they are in good condition. The most significant symbiosis is between coral and algae, providing coral with more than 90 per cent of its energy. The decline in coral cover will have had a significant effect on this symbiosis which is also known to break down during thermal stress (coral bleaching). Areas affected by poor water quality may also experience higher parasite numbers. References: [317,318,319,320,321,322,323,324,325,326,327,328,329,330]	N.I.		↔			○	○
	N.O.		↔			○	○
	S.I.			↓		○	○
	S.O.			↓		○	○
Competition: There is little information about the multitude of competitive interactions in the Great Barrier Reef ecosystem, but it is likely the majority are in good condition. Coral reefs are highly competitive ecosystems; particularly significant is the competitive balance between coral and algae. A phase shift from coral to macroalgae domination has been recorded at some reefs. References: [331,332,333,334,305,73,78]	N.I.		↔			○	○
	N.O.		↔			○	○
	S.I.			↓		◐	◐
	S.O.		↔			○	○
Connectivity: Connectivity within the ecosystem has not been comprehensively studied, but marine species and habitats are thought to remain well connected. However, it is likely fragmentation in seabed habitats has reduced connectivity over the lagoon floor. There is reduced aquatic connectivity between marine and freshwater habitats which is affecting dependent species. Continued connectivity between no-take zones and other marine areas is improving overall species abundance. There remains very good connectivity with other areas visited by migratory species, for example the Torres Strait, Coral Sea and Antarctica. References: [48,93,335,336,337,338,339]	N.I.	↔				○	○
	N.O.	↔				○	○
	S.I.			↓		○	○
	S.O.		↔			○	○
Recruitment: Recruitment is likely to be in good condition for most of the Region. The apparent lack of recovery of many severely degraded, southern inshore reefs is likely to be partly due to poor recruitment and low juvenile survival. There is also likely to have been poor recruitment in southern inshore seagrass meadows. There is deteriorating recruitment offshore for seabirds and some important green turtle nesting sites. References: [72,289,340,341,342]	N.I.		↔			●	●
	N.O.		↔			●	●
	S.I.			↓		●	●
	S.O.		↔			●	●
Reef building: Reef building is primarily driven by the formation of calcium carbonate skeletons. How fast a reef is built is the net effect of recruitment, calcification and erosion. Reef building is likely to be in good condition for much of the Region, but has been affected by cyclones and reduced coral cover, especially in the southern area. Increasing sea temperatures and ocean acidification are likely to be reducing calcification rates. References: [64,343,344,345,346,347,348]	N.I.		↓			◐	◐
	N.O.		↓			◐	◐
	S.I.			↓		◐	◐
	S.O.			↓		◐	◐

7.6 Condition and trend of matters of national environmental significance

7.6.1 World heritage properties

The current condition and trend of the outstanding universal value of the Great Barrier Reef World Heritage Area is benchmarked against the retrospective Statement of Outstanding Universal Value as a way of describing changes in the property's condition since inscription (Table 7.11).

Excerpts from the statement relating to each of the four relevant world heritage criteria have been assessed (Table 7.11 (a) to (d)). The grading statements are based on those used by the International Union for Conservation of Nature to assess natural world heritage sites. The title of each grade has been adapted to align with those used in other parts of the strategic assessment. Each assessment is a 'grade of best fit' for the whole property and all matters relating to the excerpt. An overall trend in condition is provided, comparing current condition with the likely condition at the time of inscription. Confidence in the assessment is also indicated.

Like most of the attributes relevant to the matters of national environmental significance, outstanding universal value is distributed across the whole of the Region rather than being found at discrete locations. It is therefore assessed across the entire Region.

An assessment of the property's integrity is presented in Table 7.12. This benchmarking is based on Section II.E of the *Operational Guidelines for the Implementation of the World Heritage Convention*[349] which sets out the requirements for integrity, namely: the extent to which the property includes all elements necessary to express its outstanding universal value; that it is of adequate size to ensure the complete representation of the features and processes which convey the property's significance; and protection from the adverse effects of development and/or neglect.

These two assessments show the outstanding universal value of the World Heritage Area remains largely intact. Many elements that make up the outstanding universal value remain in good condition. The Region remains a globally outstanding example of an ecosystem that has evolved over the millennia, and almost all geomorphological processes remain in good condition. Examples of all stages of reef development remain, although the overall health of reefs, especially in the southern two-thirds of the Region, has declined significantly. While the condition of some elements such as humpback whales has improved, others have experienced serious declines since 1981. These include inshore coral reefs in southern areas, southern dugong populations, some species of marine turtle, and offshore and pelagic foraging seabirds. The natural beauty of most of the Region remains intact, however its underwater aesthetic value has declined in southern inshore areas. This, in turn, affects the image and the human experiences of the Reef (for example, Indigenous culture, tourism and recreation). The property continues to meet the requirements for integrity, meaning its natural attributes are whole and intact.

It is important to note that, while most of the excerpts assessed are rated as currently being in very good or good condition, the trend for about two-thirds of these is assessed as deteriorating.

Table 7.11 Benchmarking the outstanding universal value of the Great Barrier Reef World Heritage Area

The assessments presented in this table are based on the same information used to assess current condition and trend in Sections 7.1 to 7.5. The references listed there also apply to this assessment.

Understanding the table

Very good	Good	Poor	Very poor
Very good: All elements necessary to maintain the outstanding universal value are essentially intact, and their overall condition is stable or improving. Available evidence indicates only minor, if any, disturbance to this element of outstanding universal value.	**Good:** Some loss or alteration of the elements necessary to maintain the outstanding universal value has occurred, but their overall condition is not causing persistent or substantial effects on this element of outstanding universal value.	**Poor:** Loss or alteration of many elements necessary to maintain outstanding universal value has occurred, which is leading to a significant reduction in this element of the outstanding universal value.	**Very poor:** Loss or alteration of most elements necessary to maintain the outstanding universal value has occurred, causing a major loss of the outstanding universal value.

Area (See Chapter 1, Figure 1.1)	**Trends**	**Confidence in condition and trend**
GBR Great Barrier Reef Region	↑ Improving	● Adequate high-quality evidence and high level of consensus
	↔ Stable	◐ Limited evidence or limited consensus
	↓ Deteriorating	○ Very limited evidence, assessment based on anecdotal information
	— No clear trend	

a) **Natural beauty and phenomena (previously criterion (iii) now criterion (vii)):** contains unique, rare or superlative natural phenomena, formations or features or areas of exceptional natural beauty, such as superlative examples of the most important ecosystems to man.

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: The significant loss of coral cover, especially in areas south of about Cooktown, has reduced underwater aesthetic value, as has increasing turbidity in inshore areas. The natural beauty of large areas remains intact, especially for offshore coral reefs in the far north and aerial vistas, as well as for neighbouring islands (many of which are national parks). While many of the natural phenomena remain intact, others are likely to have deteriorated, for example some turtle nesting locations and coral spawning.	GBR		↓		

Excerpt from statement	Comment	Area	Condition and trend				Confidence
			Very good	Good	Poor	Very poor	
Superlative natural beauty above and below the water	The natural beauty of most of the Region remains intact, especially for offshore coral reefs and aerial vistas, as well as for neighbouring islands. The significant loss of coral cover has reduced underwater aesthetic value.	GBR		↓			●
Some of the most spectacular scenery on Earth	Both above and below the water, the area's scenery remains spectacular. There have been some declines in the aesthetics of inshore reefs in the southern two-thirds.	GBR		↓			●
One of a few living structures visible from space	The Reef remains visible from space and technological advances make these images more accessible.	GBR	↔				●
A complex string of reefal structures along Australia's north-east coast	Reefal structures remain intact. Recent estimates vastly increase the extent of coral with the identification of more deepwater reefs.	GBR	↔				●
Unparalleled aerial panorama of seascapes comprising diverse shapes and sizes	Aerial vistas remain spectacular, with scenic flights a popular tourism activity.	GBR	↔				●
Whitsunday Islands provide a magnificent vista of green vegetated islands and white sandy beaches spread over azure waters	The majority of the Whitsunday Islands are protected and managed as national parks. There have been some changes to island scenery, such as on resort islands.	GBR		↔			●
Vast mangrove forests in Hinchinbrook Channel, or the rugged vegetated mountains and lush rainforest gullies	All of Hinchinbrook Island is protected and managed as a national park. Patches of mangrove forests and rainforest were affected by cyclone Yasi.	GBR	↔				●
On many of the cays there are spectacular and globally important breeding colonies of seabirds and marine turtles	There have been serious declines in some populations of seabirds and some marine turtle species.	GBR			↓		●
Raine Island is the world's largest green turtle breeding area	Long-term data indicates that, since the mid-1970s, green turtle nesting on Raine Island has increased and then plateaued over the past two decades. It is thought to have declined recently.	GBR			↔		●

Excerpt from statement	Comment	Area	Condition and trend				Confidence
			Very good	Good	Poor	Very poor	
Beneath the ocean surface, there is an abundance and diversity of shapes, sizes and colours... Spectacular coral assemblages of hard and soft corals	Since 1986, average hard coral cover is estimated to have declined from 28 to 13.8 per cent, principally in the southern two-thirds of the Region. This is mainly due to storm damage (48 per cent), crown-of-thorns starfish (42 per cent), and bleaching (10 per cent).	GBR			↓		●
Thousands of species of reef fish provide a myriad of brilliant colours, shapes and sizes	There are about 1500 species of bony fish. Long-term monitoring of about 200 species of coral reef fish has not detected declines in the species monitored. A small number of targeted species are under significant pressure.	GBR	↔				●
The internationally renowned Cod Hole is one of many significant tourist attractions	There is anecdotal evidence of severe declines in the number and condition of potato cod at Cod Hole.	GBR			↓		◐
Superlative natural phenomena include the annual coral spawning, migrating whales, nesting turtles, and significant spawning aggregations of many fish species	The number of migrating humpback whales is increasing. Nesting numbers have declined for at least two of the six species of marine turtle. Protection for fish spawning aggregations has improved, but most sites are unknown.	GBR		—			●

b) Major stages of the Earth's evolutionary history (previously criterion (i) now criterion (viii)): outstanding examples representing the major stages of the Earth's evolutionary history

	Area	Condition and trend			
		Very good	Good	Poor	Very poor
Overview: The Region remains a globally outstanding example of an ecosystem that has evolved over millennia, and almost all geomorphological evolutionary processes remain intact. Examples of all stages of reef development remain, although the overall health of reefs, especially in the southern two-thirds, has declined significantly.	GBR	↔			

Excerpt from statement	Comment	Area	Condition and trend				Confidence
			Very good	Good	Poor	Very poor	
Globally outstanding example of an ecosystem that has evolved over millennia	The Reef remains an outstanding example of evolutionary history. Recent research has identified deepwater reefs that extend for hundreds of kilometres along the outer shelf at between 40 and 70 metres depth.	GBR	↔				◐
Area has been exposed and flooded by at least four glacial and interglacial cycles, and over the past 18,000 years reefs have grown on the continental shelf	The deepwater reefs are providing valuable records of past coral reef responses to climate and sea level change.	GBR	↔				●
Today, the Great Barrier Reef forms the world's largest coral reef ecosystem... Including examples of all stages of reef development	The Great Barrier Reef remains the world's largest coral reef ecosystem and, while its condition has deteriorated, it remains one of the most world's most healthy reef systems, including examples of all stages of reef development.	GBR		↓			●
Processes of geological and geomorphological evolution are well represented, linking continental islands, coral cays and reefs	Geomorphological features and processes are well represented. Most remain in most good condition but some processes are declining, especially in the inshore southern two-thirds.	GBR		↓			◐
The varied seascapes and landscapes that occur today have been moulded by changing climates and sea levels, and the erosive power of wind and water, over long time periods	The impacts of modern climate change are beginning to have effects on seascapes, for example through reduced reef building.	GBR		↓			◐
One-third of the Great Barrier Reef lies beyond the seaward edge of the shallower reefs (and) comprises continental slope and deep oceanic waters and abyssal plains	Evidence of cold water coral communities have been found on deepwater knolls along the edge of the Great Barrier Reef at depths of more than 1000 metres, but these deep areas are hardly known.	GBR	—				◐

c) **Ecological and biological processes (previously criterion (ii) now criterion (ix)):** outstanding examples representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: Many ecosystem processes remain in good condition, however some, such as recruitment and reef building, are declining. Any processes associated with species groups that are in decline (for example, corals and seagrasses) have likely also declined. In the inshore southern two-thirds, there are particular concerns about some processes such as connectivity, nutrient cycling and sedimentation, principally associated with land-based activities in the catchment. Traditional Owners maintain their cultural practices and customs, however Indigenous heritage values are under pressure especially in the southern two-thirds of the Region.	GBR		↓		

Excerpt from statement	Comment	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence
Significant diversity of reef and island morphologies reflects ongoing geomorphic, oceanographic and environmental processes	There remains a diverse range of reef and island morphologies. Most geomorphic, oceanographic and environmental processes remain in good condition but some are declining, especially in the inshore southern two-thirds.	GBR		↓			●
Complex cross-shelf, longshore and vertical connectivity is influenced by dynamic oceanic currents	Most marine species and habitats are thought to remain well connected. There is increasing evidence of intensified flow and accelerated warming in the East Australian Current.	GBR		—			◐
Ongoing ecological processes such as upwellings, larval dispersal and migration	Ecological processes remain in good condition in northern areas. Some processes are in poor condition inshore in the southern two-thirds of the Region and are deteriorating.	GBR		↓			◐
Ongoing erosion and accretion of coral reefs, sand banks and coral cays combine with similar processes along the coast and around continental islands	Reef building is likely to be in good condition for much of the Region, especially in the north, but has been affected by cyclones and reduced coral cover, especially in the southern two-thirds of the Region.	GBR		↓			◐
Extensive beds of Halimeda algae represent active calcification and accretion over thousands of years	*Halimeda* beds are poorly studied, but are likely to be in very good condition given their isolation from land-based impacts and level of protection from trawling.	GBR	↔				◐

Excerpt from statement	Comment	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence
Biologically the unique diversity of the Great Barrier Reef reflects the maturity of an ecosystem that has evolved over millennia; evidence exists for the evolution of hard corals and other fauna	The diversity of species remains high, but some species are in poor condition, especially inshore in the southern two-thirds of the Region.	GBR		↓			●
Vegetation on the cays and continental islands exemplifies the important role of birds....in seed dispersal and plant colonisation	Many islands are national parks or protected within the Marine Park. There are introduced plants on most islands.	GBR		↓			◐
Human interaction with the natural environment is illustrated by strong ongoing links between Aboriginal and Torres Strait Islanders and their sea country, and includes numerous shell deposits (middens) and fish traps, plus the application of story places and marine totems	Traditional Owners with connections to the Great Barrier Reef maintain their cultural practices and customs. Indigenous heritage is under pressure especially in the southern two-thirds of the Region.	GBR			↓		◐

d) Habitats for conservation of biodiversity (previously criterion (iv) now criterion (x)): habitats where populations of rare or endangered species of plants and animals still survive

	Area	Condition and trend: Very good	Good	Poor	Very poor
Overview: There are significant concerns about some key habitats, particularly seagrass meadows and coral reefs, and some species such as dugongs, some marine turtles and some dolphins. These concerns are not as great in far northern areas, which remain relatively intact. Populations of humpback whales, estuarine crocodiles, loggerhead turtles and green turtles (southern stock) are recovering from historical declines. There have been no records of species extinction, though there is concern that speartooth shark has not been recorded in or near the Region since 1982.	GBR			↓	

Excerpt from statement	Comment	Area	Condition and trend: Very good	Good	Poor	Very poor	Confidence
One of the richest and most complex natural ecosystems on Earth, and one of the most significant for biodiversity conservation	The Great Barrier Reef remains a complex ecosystem, rich in biodiversity. Some key habitats are under pressure, especially in southern inshore areas.	GBR		↓			◐
Tens of thousands of marine and terrestrial species, many of which are of global conservation significance	Some populations (dugong, sharks, seabirds and marine turtles) are known to have declined. Others such as humpback whales, loggerhead turtles and estuarine crocodiles are increasing.	GBR		↓			●
The world's most complex expanse of coral reefs... Contain some 400 species of corals in 60 genera	There remain more than 400 species of hard coral and at least 150 species of soft corals, sea fans and sea pens, living in a complex reef system. There has been a serious decline in hard coral cover in the southern two-thirds of the Region.	GBR		↓			●
Large ecologically important interreefal areas. The shallower marine areas support half the world's diversity of mangroves	The Region's mangrove forests remain very diverse with at least 39 mangrove species and hybrids recorded.	GBR		↔			●
Large ecologically important interreefal areas. The shallower marine areas support … many seagrass species	Seagrass diversity remains; however, there have been recent severe declines in abundance and community composition in the inshore southern two-thirds of the Region.	GBR			↓		●
Waters also provide major feeding grounds for one of the world's largest populations of the threatened dugong	The dugong population in northern areas remains robust. The population in the southern two-thirds of the Region was very low at the time of listing and remains so. Declines in the condition of seagrass meadows have had profound effects on dugongs in recent years.	GBR			↓		●
At least 30 species of whales and dolphins occur here	Little is known about the populations of most whale species. Two inshore dolphin species are known to be at risk.	GBR		—			◐
A significant area for humpback whale calving	The humpback whale population is recovering strongly after being decimated by whaling. The calving habitats are well protected.	GBR	↑				●

Excerpt from statement	Comment	Area	Condition and trend				Confidence
			Very good	Good	Poor	Very poor	
Six of the world's seven species of marine turtle occur in the Great Barrier Reef. As well as the world's largest green turtle breeding site at Raine Island, the Great Barrier Reef also includes many regionally important marine turtle rookeries	Of the habitats that support marine turtles, the condition of seagrass meadows and coral reefs have declined significantly. While nesting habitats are generally in good condition, sea level rise, increasing air temperature and extreme weather events are affecting their condition.	GBR		↓			●
Some 242 species of birds have been recorded in the Great Barrier Reef. Twenty-two seabird species breed on cays and some continental islands, and some of these breeding sites are globally significant	While the nesting habitats for seabirds remain in generally good condition, declines of up to 70 per cent in some nesting populations have been recorded. There is evidence this may relate to reduced availability of pelagic prey.	GBR			↓		●
The continental islands support thousands of plant species, while the coral cays also have their own distinct flora and fauna	Plant diversity is generally well protected, with about one-third of the islands contained within national parks.	GBR		↓			●

Table 7.12 Benchmarking the integrity of the Great Barrier Reef World Heritage Area

Based on the extent to which the property meets the criteria set out in the *World Heritage Convention Operational Guidelines*.[349]

	Area	Condition and trend			
		Very good	Good	Poor	Very poor
Overview: The Great Barrier Reef is the world's third largest World Heritage Area and encompasses all but the most northerly part of the Great Barrier Reef ecosystem. Except for small exclusions, it is all within a marine protected area, and is therefore afforded a high level of direct protection and management. External pressures such as climate change, catchment run-off and coastal development are affecting its overall integrity.	GBR		↓		

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Includes all elements necessary to express its outstanding universal value: The Great Barrier Reef meets all four natural criteria. While some ecosystems, habitats and populations are under pressure, the elements remain largely intact, particularly in the northern third of the Region.	GBR	↓				◐	◐

	Area	Condition and trend				Confidence	
		Very good	Good	Poor	Very poor	Condition	Trend
Is of adequate size to ensure the complete representation of the features and processes which convey the property's significance: The Great Barrier Reef Region is vast, covering 14 degrees of latitude and extending 80 to 250 kilometres from the coast. Except for some small exclusions and about 600 of the 1050 islands, almost all of the World Heritage Area is within marine or national parks, and is therefore afforded a high level of protection and management. While it is of adequate size to ensure complete representation of features and processes, increasing pressures from outside the Region are affecting them.	GBR	↔				◐	◐
Is protected from the adverse effects of development and/or neglect: While activities within the property are comprehensively managed and use is generally sustainable, the remoteness of some of the property poses challenges for managing agencies. This, and previous assessments, have demonstrated that the most significant impacts on the property's values arise from external pressures such as climate change, catchment run-off and coastal development. In the southern two-thirds of the Region, where there are greater levels of development, the condition and trend of some values are in decline.	GBR			↓		◐	◐

7.6.2 Great Barrier Reef Marine Park

Habitats in the northern third of the Great Barrier Reef are believed to remain in very good condition and are able to support dependent species. Southern habitats, especially those inshore, have deteriorated, particularly seagrass meadows and coral reefs. Terrestrial habitats that support the Reef are generally in very good condition in the northern catchment. However, these habitats have been substantially modified in the southern two-thirds of the catchment, especially saltmarshes, wetlands, woodlands and forests. The functioning of waterbodies connecting the catchment to the Region has deteriorated.

Of those species and species groups for which there is information, there have been significant declines in many, especially those in the inshore southern two-thirds of the Region, and some iconic and cultural keystone species such as dugongs and some marine turtles. Serious declines have been recorded in most hard corals and seagrasses, some fishes and sharks, plus some seabird and shorebird populations. There are four examples of species showing good recovery after past serious declines: humpback whales, estuarine crocodiles, loggerhead turtles and green turtles (southern stock).

There has been no significant change to geomorphological features since the end of the last sea level rise 6500 years ago. Those close to the developed coast are likely to have been relatively more affected more due to increased human activity and coastal development. The effects of climate change impacts on geomorphological features are unknown but are likely to be negative.

Traditional Owners with connections to the Great Barrier Reef Marine Park maintain their cultural practices and customs. Places of Indigenous heritage values have not been systematically identified and many have deteriorated, especially around development areas and on islands. Stories, languages and songlines are being affected by activities in the Region. Most places of historic significance are poorly recorded and their condition is not well understood. Heritage values are being maintained or restored at some lightstations.

The Marine Park's environment provides a range of benefits to catchment communities and the nation. It is a source of national pride for many Australians. Many catchment residents understand and appreciate the Reef and have a strong personal attachment to it. Reef-dependent industries contribute strongly to the Australian economy. In recent years, some community benefits have been adversely impacted by the direct and indirect effects of extreme weather.

7.6.3 National heritage places

As the Great Barrier Reef was listed as a national heritage place because of its status as a world heritage property, the summary of condition of its outstanding universal value (Section 7.6.1 above) is also relevant to this matter of national environmental significance. In addition, five of the criteria for national heritage places were identified at the time of listing as being relevant to the Great Barrier Reef. Table 7.13 presents a summary of condition and trend for each.

Table 7.13 Current condition and trend of the Great Barrier Reef national heritage place

The Great Barrier Reef was listed as a national heritage place because it is a world heritage property. Five of the listing criteria for national heritage places have been identified as relevant to the Great Barrier Reef.

Relevant national heritage place criteria	Summary of current condition and trend
(a) the place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history	The place retains its importance in the course and pattern of Australia's natural and cultural history.
(b) the place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history	The Region has many uncommon, rare and endangered aspects of Australia's natural and cultural history (for example, marine turtles, seabird, shorebirds, shell middens and fish traps). There are few examples of recovering populations of endangered species. The Region supports globally significant populations of dugongs (an iconic and cultural keystone species). There have been significant declines in dugongs and some marine turtles. While Traditional Owner connections remain strong, places of Indigenous heritage value have not been systematically identified and many have deteriorated, especially near developed areas and on islands.
(c) the place has outstanding heritage value to the nation because of the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history	The Great Barrier Reef is renowned for its potential to yield information that will contribute to an understanding of Australia's natural or cultural history. Natural history is well studied, and the place has vast potential to yield cultural history information.
(d) the place has outstanding heritage value to the nation because of the place's importance in demonstrating the principal characteristics of: i. a class of Australia's natural or cultural places; or ii. a class of Australia's natural or cultural environments	Some of the natural and cultural places and environments are currently in poor condition and declining (for example, seagrass meadows, coral reefs, and some Indigenous heritage values). Natural and cultural places and environments that are more remote, for example north of about Port Douglas and further offshore (such as outer barrier reefs), are in good to very good condition.
(e) the place has outstanding heritage value to the nation because of the place's importance in exhibiting particular aesthetic characteristics valued by a community or cultural group.	A recent review of the aesthetic value of the Great Barrier Reef found it had a significant profile in the minds of international visitors and Australians as an iconic, international attraction. It was closely associated with the range of natural environments and experiences it offers.[252] A general decline in the condition (and trend) of a number of habitats, species, processes and values in the southern two-thirds of the Region (for example, coral cover, Indigenous heritage values and charismatic fauna such as dugong and turtles) means it is likely that this criterion has been affected.

7.6.4 Commonwealth marine area

The assessment summary for the Great Barrier Reef Marine Park above is also relevant to the Commonwealth marine area.

7.6.5 Listed migratory and listed threatened species

Listed migratory and listed threatened species are assessed as being in generally poor condition, with the exception of humpback whales, estuarine crocodiles and green turtles (southern stock). Threatened inshore and estuarine species or migratory species that rely on habitats in these areas (for example, seabirds and shorebirds) are the most affected by cumulative impacts, both within and beyond the Region. A summary of condition and trend for each group of listed migratory or threatened species is provided below.

Each of the six species of **marine turtle** (listed migratory and threatened) has different population status and current trends. Although the nesting populations of some species are thought to be increasing, for example loggerhead and green turtle (southern stock), other nesting stocks are declining, for example green turtle (northern stock) and hawksbill. Little is known about the foraging components of most populations, but there are concerns for some species particularly due to pressures outside the Region. Declines in seagrass meadows following the 2011 floods and cyclones have placed additional stress on southern green turtle stocks.

Estuarine crocodiles (listed migratory) are in good condition throughout the Region and populations are increasing.

Little is known about the population dynamics of some listed **whale** species. The blue, fin, sei, Antarctic minke whale, Bryde's whale, killer whale and sperm whales are believed to be seasonal migrants to the Region and are rarely sighted. The humpback whale population is in good condition and population numbers are recovering.

Australian snubfin and Indo-Pacific humpback dolphins (listed migratory) are considered to be at risk and in decline in the southern inshore two-thirds of the Region due to a number of factors, including habitat loss from declining water quality, climate change and coastal development (for example, all three of the known snubfin dolphin aggregations are in the vicinity of either a planned port expansion or a proposal for a new development).

The northern population of **dugong** (listed migratory) remains healthy with a stable population trend. There has been a substantial decline in dugongs in waters south of Cooktown since the 1960s, but the population was thought to have stabilised in 2009. However, a series of extreme weather events from 2009 to 2011 affected seagrass meadows and therefore dugong numbers. Populations in the southern inshore area are now assessed as being in very poor condition.

There are significant concerns about a small number of **sharks** which are listed migratory or threated species, including the speartooth shark which may now be extinct in the Region. The life histories and inshore habitat preferences of many listed shark and ray species make them vulnerable to impacts.

Twenty-four species of **seabirds** are listed as either migratory or threatened. There are also 30 species of listed migratory **shorebirds**. Monitoring of listed seabirds and shorebirds that breed in the Region is currently insufficient to reliably determine condition and trend. Although all seabirds are vulnerable to impacts of climate change, it is the offshore and pelagic foraging seabirds which are most at risk. Some catastrophic nesting failure has already been recorded in wedge-tailed shearwaters in the south. Australia-wide declines in shorebirds of between 70 and 80 per of cent have been recorded in the past 24 years.

7.6.6 Wetlands of international importance

The Shoalwater and Corio Bay wetland encompasses coastal and subcoastal ecosystems which are relatively undisturbed and in very good condition.[350] This can be attributed mainly to its restricted access as a defence training area. Military use of the site is strictly controlled, managed and monitored and has not caused any known changes to the ecological character of the site. This relies in part upon the fact that almost all training activities and associated infrastructure are outside the boundaries of the site. The Defence Department has pest animal management programs for the site and a regional oil spill response plan is in place.[351]

A high level of habitat diversity is present, varying from open sandy and rocky shorelines, estuarine embayments and inlets, to a number of remarkable groundwater-dependent freshwater wetlands. These wetlands support a broad range of natural values, including threatened wetland flora and fauna species, and a significant diversity and abundance of waterbirds. The area was thought to provide a refuge for dugong and turtle after the extreme weather events of 2011, as much of its seagrass habitat was in good condition. It continues to be valued for its Indigenous heritage, with Traditional Owners continuing to access the area with the support of the Australian Defence Force.

7.7 Key information gaps

The following is a summary of the key information gaps in relation to the condition and trend of values underpinning matters of national environmental significance.

7.7.1 Biodiversity — habitats and species

Monitoring programs and research have provided a good understanding of status and trends of many habitats and species underpinning matters of national environmental significance but there are still gaps for some important elements.

- A small percentage of **islands** are monitored annually for pest species but information is lacking on the status and trends of island habitats, including about 700 islands in the World Heritage Area that are not part of the protected area estate (many of which have important values such as seabird rookeries).
- While the spatial extent of **mangrove forests** is relatively well mapped, trends for species composition remain a gap.
- Many intertidal and limited subtidal **seagrass meadows** are monitored for health and species composition; but the majority of subtidal and deeper meadows are not monitored.
- **Macroalgae** on reefs are monitored as part of coral reef monitoring, but elsewhere in the Region very little is known about this group.
- Emergent mid-shelf and offshore **coral reefs** are well studied and monitored except in the far northern area. Trends in inshore fringing reefs are not as well known and knowledge of their status is a key gap. **Deeper reefs** (including coral dominated shoals) and their corals are only beginning to be discovered and are not as well understood. These deepwater reefs may play an important role in the future resilience of the Great Barrier Reef.
- **Lagoon floor** habitats (including *Halimeda* banks and non-coral dominated shoals) have been mapped as a one-off project but there is no information on trends.
- Knowledge of **continental slope** habitats and species remains a gap. Recent surveys are providing insights into what is there, however there is little information on habitat and species and no trend information. Information on the upper continental slope in the south-east of the Region is required to improve future ecological risk assessments.[239]
- **Invertebrates**, both marine and terrestrial (other than corals and some commercially important species like prawns), are not well understood.
- Information on **phytoplankton** populations comes mostly from chlorophyll analysis of water samples and remote sensing as well as through ad hoc bloom observations. There is very little knowledge of phytoplankton species diversity and condition and trend, while zooplankton are very poorly understood.
- Although knowledge of **microbes** is improving through studies of diseases of coral and other species, understanding of this area remains relatively poor.
- **Bony fish** are included in surveys of coral reefs, but outside of this habitat there is little information except through fishery catch data. More information on targeted fish stocks and bycatch, particularly species identified as being ‘at risk’, is required to improve fisheries management.
- Recent studies have improved knowledge on movement and behaviour for some **shark and ray** species, but generally there is a poor understanding of their distribution, status and trends. A clear understanding is needed of the biology, ecology, species status and harvest of the lesser known bycatch species (for example, the shark-like batoids).

- Most information on **sea snakes** comes from studying bycatch from the trawl fishery. Sea snake populations and trends are poorly understood.
- Trends in **marine turtle** populations are modelled and inferred from long-term nesting and foraging ground data from a limited number of sites. However, there is a general lack of long-term data for any species in the far north, and further information on juvenile recruitment and foraging animals in inshore waters and benthic habitats of the Region is required. As migratory species, a better understanding of impacts on populations outside the Region is required. Little is known about olive ridley turtles or foraging flatback turtles.
- Monitoring of **seabirds** that breed in the Region is currently insufficient to reliably determine condition and trend. There is a lack of biological and ecological information on seabirds to help inform a robust management response.
- There are no population estimates for **shorebirds** in the Region
- There is improving information on inshore **dolphins** but there remains very poor information on population trends and dynamics, as well as key habitats and dietary requirements for these species.
- Ongoing five-yearly aerial surveys of **dugongs** continue to be required, coupled with a better understanding of movement patterns and diving behaviour to inform the scales at which dugongs should be managed.
- The **spatial distributions** of most species and habitats are poorly collated, synthesised and mapped. Intertidal habitats are relatively well mapped and a few studies have employed existing field datasets to predictively model distribution and condition of other biodiversity values.

7.7.2 Geomorphological features

An initial study on the important features and processes that make up the geomorphological aspects of the World Heritage Area identifies that further work is required on these attributes, including:

- a more detailed assessment of impacts where sensitivity and/or risk is identified as medium to high
- identification of geological features and processes that are susceptible to cumulative impacts.

7.7.3 Indigenous and historic heritage values

There is very little information available on Indigenous or historic heritage. Many places of significance are not well documented and only some are listed on a heritage register (under the EPBC Act). It is important to also recognise that both Indigenous and historic heritage values will continue to evolve to represent the flow of history and changing community perceptions.

Indigenous heritage
Indigenous heritage is a unique, irreplaceable part of Australia's national cultural heritage which requires improved recognition, protection and understanding. With regard to the Indigenous heritage of the Region, the Authority recognises:

- existing information is limited and not well collated to provide a **baseline of knowledge**
- there is no appropriate **consultation process** with Traditional Owners to re-establish the permissions relating to access and use of information (for example intellectual property)
- there is no cultural heritage **information management** system.

The Authority also recognises gaps in its knowledge of the following specific aspects of Indigenous heritage values and their appropriate management:

- **places of significance** for Traditional Owners, including sacred sites, spiritual sites, burial sites, songlines and ceremonial sites — some of which may not be at all obvious
- **tangible places of importance** for Indigenous people, including middens, fish traps, scarred trees, camp sites and rock art sites
- **archaeological sites or Indigenous places** recognised as being of national significance (for example, the axe quarry on South Molle Island and the 'contact' rock art of Flinders Island)
- intangible **story places and songlines** and their connections to biodiversity values and ecological processes

- **places or totems** and the reasons they are of contemporary value to Indigenous people
- Indigenous **place names and language** relevant to the Region. Some have been recorded (for example, Bandjin Reefs or Woopaburra place names) but many more need to be before this knowledge is lost.

Historic heritage
Specific aspects of the Region's historic heritage have been documented, for example the locations of historic lighthouses and some 470 historic shipwrecks are recorded. There is also information about the heritage values of many islands. However, there remain gaps in knowledge about many historic places or events. Knowledge gaps of particular significance include:

- the location and condition of **European exploration sites,** such as places visited by early French explorers; many of the places located by Captain Cook in his voyage of discovery; and those relevant to Captain Bligh's voyage after the wreck of the *Pandora*
- key **World War II sites**, including training areas, vessel and aircraft wrecks, structures, and sites for testing and dumping of ordnance and chemicals.
- places that trace the history of **extractive industries,** from the early days of guano mining, through to dugong and turtle factories, the mining of limestone and granite, oil exploratory leases, and the evolution of fishing and collecting.

7.7.4 Community benefits of the environment

Some aspects of social, cultural and economic benefits, such as employment and income, have been assessed intermittently, but there has been little systematic monitoring of community benefits derived from the Great Barrier Reef environment. For example, there is very little quantitative information on recreational activity, including where recreational users go and what they do, or about the benefits derived from the environment by Indigenous communities. The following aspects are pivotal to a better understanding about the ways people use and derive benefit from the Region's environment:

- **peoples' activities** in the Region, including:
  - where they go
  - what they do
  - how they access these locations
  - their levels of satisfaction, enjoyment, understanding and appreciation
  - their motivations for visiting
- **economic contributions** of Reef-dependent and non-Reef dependent activities undertaken in the Region and its catchment; plus Reef-dependent industries outside of the catchment
- **stakeholder and community perceptions** of matters such as crowdedness, threats to the Reef, incompatible use, pollution, biophysical changes and aesthetic qualities
- **personal attachment** (including cultural, spiritual and traditional ties) to the Reef by Traditional Owners, stakeholders and visitors
- the extent of **knowledge** that different groups of people have about the Great Barrier Reef and the factors that affect its condition
- the uptake of **new and emerging technologies** and how these influence use, appreciation, enjoyment and understanding of the Region
- different types and components of **media and social networks**, including the different types of Region-related information that is gathered and communicated
- number, types and scale of **health benefits** derived from the Great Barrier Reef and from living adjacent to the Reef
- the range and importance of **ecosystem services** provided by the Great Barrier Reef
- social and cultural limits around **acceptable use** of the Reef
- the **aesthetic and superlative natural phenomena** that make up the world heritage property. While an initial study was completed in early 2013, further work is required to understand the management implications of aesthetic values, including experiential attributes.

7.7.5 Environmental processes

Knowledge of physical and chemical processes is improving but ecological processes are still very poorly understood. It is these processes that connect the elements of the ecosystem into a whole, and understanding this interconnectivity remains an important gap.

- A quantitative understanding of the **interconnectedness** of the ecosystem is largely lacking. There is a critical need and increased emphasis on developing qualitative, quantitative and spatial models to inform system-level understanding and management.
- There is very little information available on **microbial processes** apart from some disease-causing species.
- There is some information on pelagic **primary production,** particularly through remote sensing, while benthic primary production is inferred through surveys of primary producers. There is no system-level understanding of primary production.
- There is moderate information on herbivore and predator populations, but quantitative information about the processes of **herbivory** and **predation** is poor.
- **Symbiotic relationships** are well known for many organisms, including corals, but there is little information available on the spatial distribution of key organisms and the condition of the relationships, except through coral bleaching studies.
- There is reasonable information on the ecosystem components that contribute to **reef building**, but the interplay between accretion and erosion is not well monitored.
- There is some information on **competition**, for instance between coral and algae on reefs, however this needs to be better understood in the face of climate change. Information on other forms of competition is generally lacking.
- There is some knowledge of fish and coral larval **connectivity** as well as the way some fish populations use different habitats through their life cycle (for example, mangroves or rivers to coral reefs). There is a critical need for an ongoing effort to better understand connectivity.

7.7.6 Processes to address information gaps

The information gaps identified above will be addressed using the same approaches outlined in Chapter 6, Section 6.11, including both scientific and community knowledge.

7.8 Summary of outcomes

- Most **habitats and species** are in good to very good condition overall. However, past and current impacts, including water quality, crown-of-thorns starfish outbreaks, increased sea temperature and recent extreme weather, have resulted in serious declines in the inshore biodiversity values of the southern two-thirds of the Region.
- For **inshore areas south of about Port Douglas**, the condition of species such as dugongs and inshore dolphins and habitats such as coral reefs and seagrass meadows is assessed as being poor to very poor. Other species assessed as being in poor condition include marine turtles, sharks and rays including sawfish, sea snakes, seabirds, shorebirds, blue and threadfin salmon and snapper — many of which are listed migratory or listed threatened species.
- **Terrestrial habitats** that support the Great Barrier Reef ecosystem are generally in very good condition north of Port Douglas. Further south, in the bulk of the Region’s catchment, all habitats that support the Great Barrier Reef have been substantially modified. This has affected connectivity and the capacity for these habitats to support marine habitats and species.
- **Geomorphological features** of the Region are interconnected with its ecological systems. They are largely unchanged over many millennia and in good or very good condition. Some features are likely to have been affected in the southern two-thirds of the Region.
- **Indigenous heritage** values including sites, cultural keystone species, structures and stories, are being affected by coastal development, climate change and extreme weather, as well as activities taking place within the Region. These values are assessed as being in poor condition overall.

- Some **historic heritage** values such as shipwrecks and structures have been comprehensively identified and recorded. They are assessed as being in good condition, though many will deteriorate with the passage of time.
- **Community benefits** are dependent on the condition of biophysical values of the Great Barrier Reef. Economic contributions have been relatively stable at $5.7 billion (2012) and employment at 69,000. Impacts such as extreme weather have affected some values, for example access to reef resources and enjoyment, but community benefits are generally assessed as being in good to very good condition.
- The **natural beauty** of most of the Region remains intact, especially for offshore coral reefs and aerial vistas, as well as for neighbouring islands. The significant loss of coral cover, especially in inshore areas in the southern two-thirds of the Region, has reduced underwater aesthetic value.
- Information is lacking for many **environmental processes**, particularly ecological processes. They are critical to the functioning of the Great Barrier Reef. The assessment found individual environmental processes were in good or very good condition in the northern third of the Region, and in good or poor condition further south.
- For the Great Barrier Reef World Heritage Area, three of the four relevant criteria of **outstanding universal value** plus integrity are assessed as being in good to very good condition when benchmarked against their condition in 1981. The attributes that make up the habitats for conservation of biodiversity (previously criterion (iv) now criterion (x)) are assessed as being in poor condition overall. Of particular concern is that more than half of the attributes for all criteria show a deteriorating trend since inscription of the area.

A summary of the current condition of all key values is presented in Table 7.14.

Table 7.14 Current condition of key values

The table is a summary of the assessment of condition presented above. Where the condition of a value is different for different areas of the Region, the poorest grade is shown.

Condition	Key values			
	Biodiversity	**Geomorphological features**	**Indigenous and historic heritage values**	**Community benefits**
Very good	• Macroalgae • Benthic microalgae • Heath and shrublands • *Halimeda* banks • Other invertebrates • Plankton and microbes	• Channels and canyons • *Halimeda* banks		• Enjoyment • Personal connection • Health benefits
Good	• Islands • Beaches and coastlines • Mangrove forests and mangroves • Deeper reefs (>30 m) • Lagoon floor • Shoals • Continental slope • Forested floodplain • Rainforests • Bony fish • Sea snakes • Estuarine crocodiles • Open waters • Saltmarshes • Whales • Dolphins	• Coral reefs • Islands and shorelines • River deltas	• Indigenous cultural practices, observances, customs and lore • Places of historic significance — historic shipwrecks • Places of historic significance —World War II features and sites • Places of historic significance — lightstations • Places of historic significance — other • Places of scientific significance • Places of social significance — iconic sites	• Income • Employment • Understanding and appreciation • Access to Reef resources • Aesthetics
Poor	• Coral reefs (<30 m) and corals • Seagrass meadows and seagrasses • Freshwater wetlands • Grass and sedgelands • Woodlands • Connecting waterbodies • Sharks and rays • Marine turtles • Seabirds • Shorebirds • Dugongs	• Seagrass meadows	• Indigenous sacred sites, sites of particular significance, places important for cultural tradition • Indigenous stories, songlines, totems and languages • Indigenous structures, technology, tools and archaeology	
Very poor				

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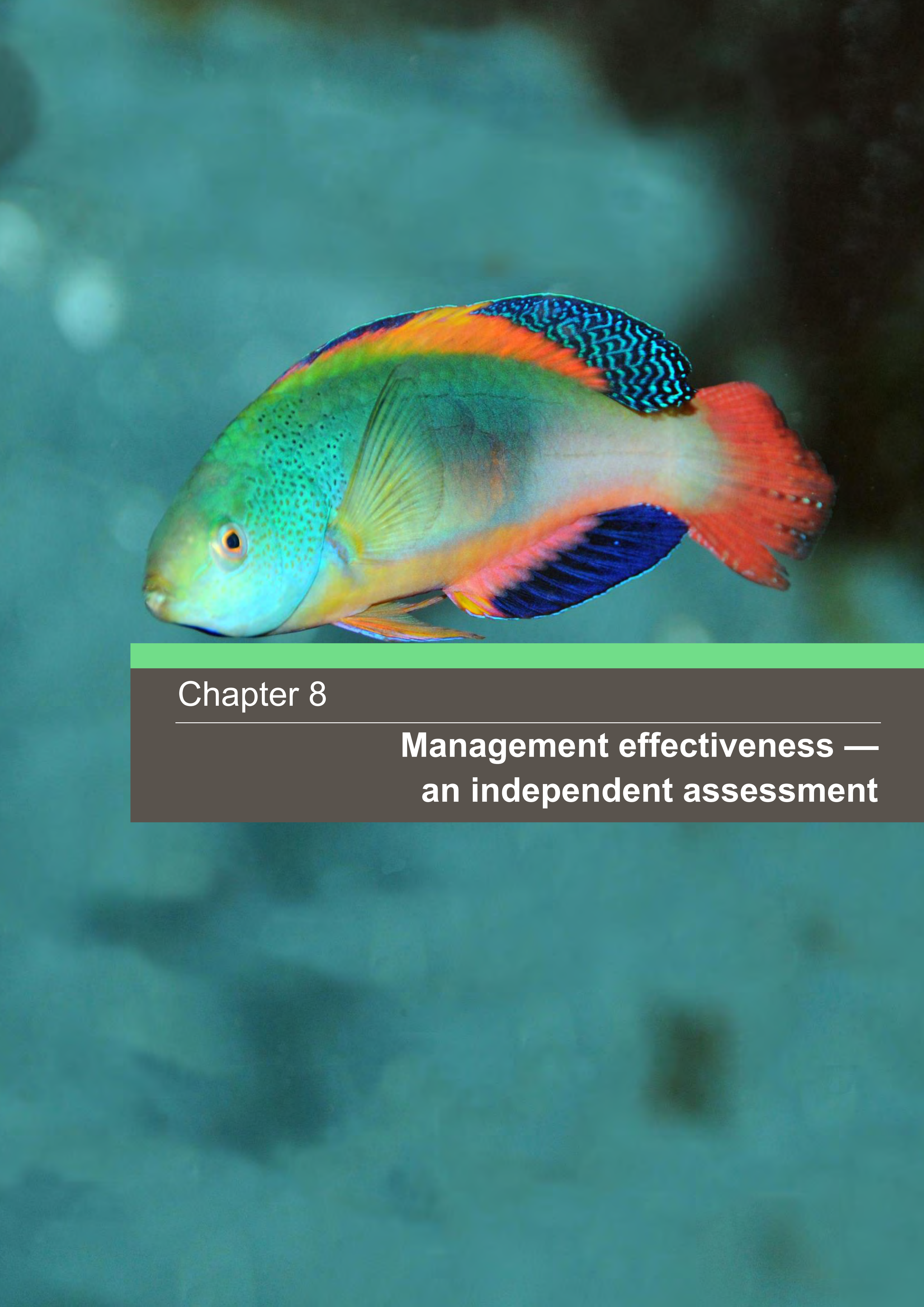
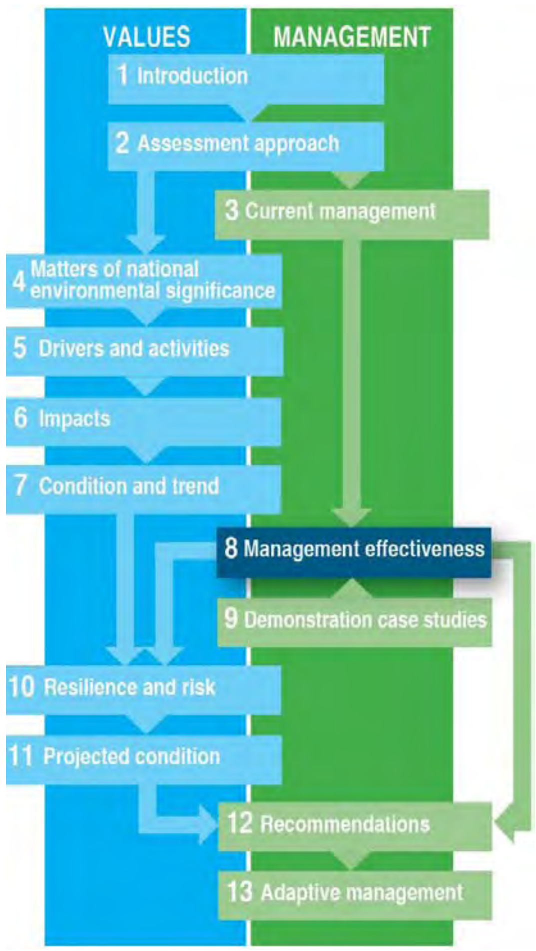


Chapter 8

Management effectiveness — an independent assessment



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Cover page image: Scotts fairy wrasse (*Cirrhilabrus scottorum*).

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

4.1 Current Program

4.1.1 Describe and assess the effectiveness of the Program to:

- *a. identify the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, and determine their current condition and trend, including spatial and non-spatial approaches*
- *b. identify and analyse direct, indirect, consequential and cumulative impacts, including the methods used to determine these types of impacts*
- *c. consider environmental, social, cultural and economic issues*
- *d. avoid, mitigate, offset and adaptively manage impacts*
- *e. address uncertainty and risk*
- *f. provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be unacceptable*
- *g. halt and reverse any declines and enhance the condition of the relevant matters of national environmental significance, including mechanisms to deliver a 'net benefit' to the condition of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area*
- *h. adapt to reasonable climate change scenarios*
- *i. integrate with related local, Queensland and Australian government programs to protect and manage the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area*
- *j. meet Australia's international responsibilities in relation to the environment and protection of world heritage*
- *k. monitor, evaluate and report on the:*
  - *i. condition and trends of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area*
  - *ii. impacts of activities, including the setting of targets to benchmark management performance.*

Note: In this report ‘current Program’ is referred to as ‘current management arrangements’.

8 Management effectiveness — an independent assessment

8.1 Background

The current management arrangements of the Great Barrier Reef Authority (the Authority) are described in Chapter 3.

This chapter provides a summary of key findings from the independent assessment of management effectiveness undertaken by Professor Marc Hockings (UniQuest Pty Ltd), Dr Andrea Leverington (UniQuest Pty Ltd) and Brian Gilligan. It describes:

- assessment method
- the effectiveness of the Authority’s management arrangements to:
  - protect values relevant to the matters of national environmental significance (biodiversity, Indigenous and historic heritage values and community benefits)
  - address external impacts (climate change, water quality and coastal development)
  - manage direct use
  - meet the criteria set out in item 4.1.1 of the terms of reference for the strategic assessment (Appendix 2)
  - protect each of the matters of national environmental significance.

The terms of reference for the independent review are contained in Appendix 4 and its full report is available on the Authority's website at www.gbrmpa.gov.au. In this chapter, direct excerpts from the independent assessment report are shown in italics. The independent assessment report was prepared in early 2013, based on information available at that time. Notes about significant changes to management since then have been provided.

Outcomes from the independent assessment inform recommendations for management improvements (Chapter 12) and the Program Report.

8.2 Assessment method

Management effectiveness evaluation is defined as the assessment of how well protected areas are being managed — primarily the extent to which they are protecting values and achieving goals and objectives.

The independent assessment used the International Union for Conservation of Nature (IUCN) World Commission on Protected Areas framework for evaluating management effectiveness[1] which has been widely applied around the world to assess management effectiveness in a range of circumstances. The framework (Figure 8.1) focuses on six management elements and the links between them. Within the framework, effective management:

- begins with understanding the **context** of the protected area, including its values, the threats it faces and opportunities available, its stakeholders, and the management and political environment
- progresses through **planning**: establishing vision, goals, objectives and strategies to conserve values and reduce threats
- allocates **inputs** (resources) of staff, money and equipment to work towards the objectives
- implements management actions according to accepted **processes**
- eventually produces **outputs** (goods and services) which should usually be outlined in management plans and work plans
- results in impacts or **outcomes**, hopefully achieving defined goals and objectives.

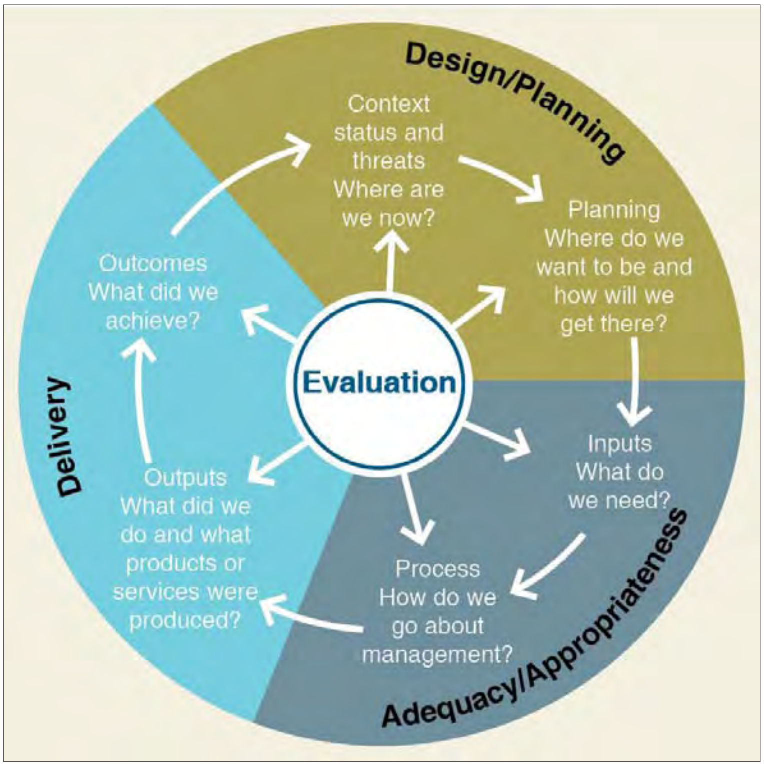


Figure 8.1 Framework for assessing management effectiveness of protected areas[1]

The assessment system was adapted from that used in the *Great Barrier Reef Outlook Report 2009*[2]. The key difference is that this evaluation focused on the management activities within the Authority's jurisdiction and any joint management arrangements with the Queensland Government (for example, joint permitting arrangements and the Field Management Program), whereas the assessment conducted for the Outlook Report 2009 considered all relevant management activities across the Australian and Queensland governments.

In accordance with items 4 and 8 of the terms of reference for the independent assessment, it also:

- took more explicit account of matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area; direct, indirect, consequential and cumulative impacts; and condition and trend of the values underpinning matters of national environmental significance
- considered whether the Authority's management arrangements provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be unacceptable
- considered jurisdictional consistency of management arrangements to achieve outcomes
- assessed the effectiveness of the range of management tools (as set out in Table 8.1) used to protect and manage the values.

Table 8.1 Management tools considered in assessing management effectiveness

Management tool	Purpose
Great Barrier Reef Marine Park Act and Regulations	The *Great Barrier Reef Marine Park Act 1975* and Regulations govern the protection and management of the Great Barrier Reef Marine Park. They provide for the Zoning Plan and plans of management and govern permitting decisions.
Zoning Plan	Provides control of use (predominantly extractive activities) and, to a lesser extent, access within the Great Barrier Reef Marine Park. Establishes the need for permits for some uses in the Marine Park, such as tourism, infrastructure and research. There are complementary arrangements in adjacent areas under Queensland jurisdiction.
Plans of management	Set out specific arrangements for areas, species, ecological communities or activities (for example, Cairns Area and Whitsundays Plans of Management). They complement zoning and permitting arrangements. Some components are legally binding.
Permits	Facilitate opportunities for use of the Great Barrier Reef. Permits are issued mainly for marine tourism, research, harvest fisheries, dredging, dumping and infrastructure (for example, jetties and marinas) and include detailed environmental impact assessments. Matched in adjacent areas of Queensland jurisdiction, generally providing a joint permit. Fisheries licences are issued and managed by the Queensland Government.
Fees and charges	Three main fees and charges apply in the Marine Park: • The cost of assessing an application for a permit for commercial activities is partly recovered through payment of a permit application assessment fee. • The environmental management charge applies to some commercial activities operating under a permit issued by the Authority. The revenue is applied to Marine Park management. • Bonds (usually as a bank guarantee) may be held by the Authority to cover the risks associated with a proposed activity.
Traditional Owner agreements	Formal Traditional Use of Marine Resources Agreements describe how Traditional Owner groups work with Australian and Queensland governments to manage traditional use activities in sea country. Indigenous Land Use Agreements are between one or more native title groups and other people or parties about the use and management of land and waters.
Compliance	Activities that encourage adherence with legal requirements, both through education and enforcement. Includes formal (for example, the Field Management Program jointly undertaken with the Queensland Government) and informal (for example, the Eyes and Ears Incident Reporting program) activities.
Site infrastructure	On-ground infrastructure installed to better protect the values of individual sites (for example, reef protection markers, public moorings and signs). Implemented and maintained by the Authority and Queensland Parks and Wildlife Service through the Field Management Program.

Management tool	Purpose
Policy	Specific arrangements that guide decision makers and the public. Types of policy documents include: strategies, policies, site management arrangements, position statements and guidelines.
Partnerships	Formal arrangements, often executed through a memorandum of understanding or an agreement, to enable a partnership approach to management of the Marine Park (for example, intergovernmental agreement with the Queensland Government, Reef Advisory Committees, Local Marine Advisory Committees, memorandum of understanding with a government authority and partnership with Ecotourism Australia).
Stewardship and best practice	Voluntary arrangements with stakeholders that provide the opportunity for contributions to protection and management (for example, Reef Guardian programs, Pro-vision Reef Stewardship Action Plan, best environmental practices).
Education and community awareness	Programs to inform and motivate members of the community about the Great Barrier Reef and its protection and management, including ways they can contribute (for example, Reef HQ Aquarium, the Authority's website, information sheets, zoning maps).
Research and monitoring	Undertaken, commissioned or partnered by the Authority to better inform decisions on protection and management of the Great Barrier Reef (for example, reef health and impact surveys, Eye on the Reef monitoring and climate change research programs).

8.2.1 Impacts and values assessed

While all of the management topics assessed in the Outlook Report 2009 are considered in this assessment, additional topics were included to address the requirements of a strategic assessment conducted under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The following 15 management topics were assessed:

Values

- biodiversity protection
- heritage (both Indigenous and historic)
- community benefits

External impacts on values

- climate change and extreme weather
- water quality protection (catchment run-off)
- coastal development (protection of coastal ecosystems)

Direct uses

- tourism (marine-based)
- fishing – commercial
- fishing – recreational
- recreation (non-extractive)
- port activities
- shipping
- defence activities
- research activities.

The scale of the management topics range from localised issues that affect only a small proportion of the total area (for example defence activities) to others which have implications across all or most of the Region (for example, climate change and extreme weather, recreation, commercial fishing). The management topics were not weighted or graded to account for differences in scale and complexity.

Each management topic was assessed independent of the others to ensure the grades were based on that value, impact or use alone. Consequently, the grades given need to be interpreted in relation to the scale and complexity of the management topic (Table 8.2).

Table 8.2 A comparison of the scale and complexity of management topics assessed				
Management topic	**Scale**	**Complexity**		
		Social	**Bio-physical**	**Jurisdictional**
Values				
Biodiversity protection	*Region-wide*	*minor*	*major*	*moderate*
Indigenous heritage	*Region-wide but variable in intensity*	*major*	*moderate*	*moderate*
Historic heritage	*Region-wide*	*moderate*	*minor*	*moderate*
Community benefits	*Region-wide*	*major*	*moderate*	*minor*
External impacts on values				
Climate change and extreme weather	*Region-wide*	*major*	*major*	*major*
Water quality protection	*Great Barrier Reef catchment and mainly inshore waters*	*major*	*major*	*major*
Coastal development	*Coastal areas and mainly inshore waters*	*major*	*major*	*major*
Direct uses				
Tourism	*Region-wide but variable in intensity*	*major*	*moderate*	*moderate*
Fishing – commercial	*Region-wide but variable in intensity*	*moderate*	*major*	*moderate*
Fishing – recreational	*Region-wide but variable in intensity*	*moderate*	*major*	*moderate*
Recreation	*Region-wide but variable in intensity*	*major*	*moderate*	*moderate*
Port activities	*Concentrated around ports*	*moderate*	*major*	*major*
Shipping	*Concentrated around shipping areas*	*moderate*	*moderate*	*moderate*
Defence activities	*Limited in area and duration*	*minor*	*minor*	*minor*
Research activities	*Region-wide but limited in intensity*	*minor*	*moderate*	*minor*

8.2.2 Calculation of grades

Assessment criteria were developed for each of the six management elements of the evaluation framework, with a total of 45 criteria across the elements (Table 8.3) Criteria varied slightly from the Outlook Report 2009 — they were refined to take account of lessons from that assessment and other subsequent assessments. Additional indicators were incorporated to align with the requirements of the strategic assessment's terms of reference. In addition, some criteria were deleted as they were considered not relevant to the strategic assessment or had proved difficult to reliably assess during the Outlook Report process.

Each management topic was assessed against all 45 criteria to determine a grade of management effectiveness. The independent assessors provided a justification for the rating and documented the main evidence they considered in reaching their judgement. These individual ratings were added and then scaled to produce an overall rating for each management element of the framework. A four-point rating scale commonly used in management effectiveness evaluation systems, and adopted in the Outlook Report 2009, was used in this assessment.

Table 8.3 Assessment criteria to assess effectiveness of management
A total of 45 criteria guided the calculation of the grades for management effectiveness.

Criteria Number	Criteria Description
Context	
CO1	The values that underpin matters of national environmental significance in the Great Barrier Reef (including outstanding universal value of the Great Barrier Reef World Heritage Area) relevant to…..are understood by managers.
CO2	Direct and indirect impacts associated with…..are understood by managers.
CO3	Consequential and cumulative impacts associated with…..are understood by managers.
CO4	The current condition and trend of matters of national environmental significance (spatial and non-spatial) relevant to…..are known by managers.
CO5	The stakeholders relevant to…..are well known by managers.
Planning	
PL1	There is a planning system in place that effectively addresses…..
PL2	The planning system for…..addresses the major pressures and drivers impacting on the Great Barrier Reef's values.
PL3	Actions for implementation regarding…..are clearly identified within the plan.
PL4	Clear, measurable and appropriate objectives for management of…..have been documented.
PL5	The main stakeholders and/or the local community are effectively engaged in planning to address…..
PL6	Sufficient policy currently exists to effectively address…..
PL7	There is consistency across jurisdictions when planning for…..
PL8	Plans provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be acceptable.
Inputs	
IN1	Current financial resources are adequate and prioritised to meet management objectives to address…..
IN2	Current human resources within the managing organisations are adequate to meet specific management objectives to address…..
IN3	The right skill sets and expertise are currently available to the managing organisations to address…..
IN4	The necessary biophysical information is currently available to address…..
IN5	The necessary socio-economic information is currently available to address…..
IN6	The necessary traditional (Indigenous) knowledge is currently available to address…..
IN7	There are additional sources of non-government input (e.g. volunteers) contributing to address…..
Processes	
PR1	The main stakeholders and/or industry(ies) are effectively engaged in the ongoing management of…..
PR2	The local community is effectively engaged in the ongoing management of…..
PR3	There is a sound governance system in place to address…..

Criteria Number	Criteria Description
PR4	There is effective performance monitoring to gauge progress towards the objective(s)
PR5	Appropriate training is available to the managing agencies to address…..
PR6	Management of…..is consistently implemented across the relevant jurisdictions.
PR7	There are effective processes applied to resolve differing views/ conflicts regarding…..
PR8	Direct and indirect impacts of activities associated with…..are appropriately considered.
PR9	Consequential and cumulative impacts of activities associated with…..are appropriately considered.
PR10	The best available biophysical research and/or monitoring information is applied appropriately to make relevant management decisions regarding…..
PR11	The best available socio-economic research and/or monitoring information is applied appropriately to make relevant management decisions regarding…..
PR12	The best available traditional (Indigenous) knowledge is applied appropriately to make relevant management decisions regarding…..
PR13	Relevant standards are identified and being met regarding…..
PR14	Targets have been established to benchmark management performance.
Outputs	
OP1	To date, the actual management program (or activities) have progressed in accordance with the planned work program for…..
OP2	Implementation of management documents and/or programs relevant to…..have progressed in accordance with timeframes specified in those documents.
OP3	The results (in OP1 above) have achieved their stated management objectives.
OP4	To date, products or services have been produced in accordance with the stated management objectives for…..
Outcomes	
OC1	The relevant managing agencies are to date effectively addressing…..and moving towards the attainment of the desired outcomes.
OC2	The outputs relating to…..are on track to ensure the values of the Great Barrier Reef are protected (refer CO1).
OC3	The outputs (refer OP1 and 3) for…..are reducing the major risks and the threats to the Great Barrier Reef.
OC4	Use of the Great Barrier Reef relating to…..is demonstrably environmentally sustainable.
OC5	Use of the Great Barrier Reef relating to…..is demonstrably economically sustainable.
OC6	Use of the Great Barrier Reef relating to…..has demonstrably enhanced community understanding and/or enjoyment.
OC7	The relevant managing agencies have developed effective partnerships with local communities and/or stakeholders to address…..

The rating scale was:

- ineffective — zero to 20 per cent of optimal condition
- partially effective — 21 to 50 per cent of optimal condition
- mostly effective — 51 to 80 per cent of optimal condition
- effective — 81 to 100 per cent of optimal condition.

For the outcomes element, two grades were assigned — one for outcomes related to biodiversity, the other for all outcomes, taking into account biodiversity outcomes and those relating to social, economic and management objectives.

8.2.3 Traditional Owner and stakeholder input

Members of Local Marine Advisory Committees, Reef Advisory Committees and participants in the regional strategic assessment workshops were asked to provide their views on the strengths and weaknesses of the identified management tools (see Table 8.1). The assessment allowed respondents to choose the management topics they wished to address (they could respond to as many or as few as they wished). They were asked to indicate strengths and weaknesses in the Authority's management of the topic and to rate the effectiveness the management tools employed on a four-point scale (very effective, mostly effective, partially effective, not effective). They could also indicate if they had no opinion or believed the tool was not applicable to the topic. Respondents were only asked to assess tools the Authority had indicated were applicable to management of a particular issue (for example, permits are not relevant to recreational fishing). Participants were able to provide this information electronically using a web-based survey.

Ninety-five respondents provided 222 assessments of the management topics. The majority of respondents (69 per cent) are members of Local Marine Advisory Committees, while 16 per cent are members of Reef Advisory Committees. A third of the respondents attended one of the strategic assessment workshops. A small number of respondents are Traditional Owners. The average length of time that respondents had been involved in the Great Barrier Reef was 18.5 years but the length of experience was highly variable ranging from none to 60 years. Only three respondents lived outside Queensland, while a further 11 lived in Queensland outside the Great Barrier Reef catchment.

The method for undertaking the assessment of management effectiveness was presented at the Local Marine Advisory Committee chairs' workshop in Townsville in October 2012, and at three stakeholder workshops coordinated by the Authority in Townsville, Cairns and Rockhampton in December 2012. The independent reviewers presented the preliminary assessment of management effectiveness and the assessment results concerning the management tools at the stakeholder workshops. Participants were provided an opportunity to discuss outcomes for particular topics.

Feedback from stakeholders has been included in a summary statement for each of the management topics. Full results are available on the Authority's website at www.gbrmpa.gov.au.

8.3 Protecting values

This section provides a summary of the effectiveness of the Authority's current management arrangements to protect the values of the Region. Direct excerpts from the report are in italics, whereas non-italicised text has been added by the Authority for contextual purposes. A grading table is provided for each management topic (see Table 8.4 to Table 8.7).

8.3.1 Biodiversity protection

The Authority is the lead agency for managing biodiversity protection in the Region and uses a number of regulatory and non-regulatory tools.

Protection of the biodiversity of the Great Barrier Reef Region is the primary objective for much of the management action undertaken in the Great Barrier Reef and its catchment and forms part of the primary objective under the Great Barrier Reef Marine Park Act 1975 (the Act)*. Management of biodiversity is undertaken using an array of tools, principally the Zoning Plan, but also management plans, permits, policy documents, site management, stewardship, education and best practices. A number of Queensland and Commonwealth agencies also have responsibility for protection of biodiversity in the Region. This potentially complex management regime has been simplified through intergovernmental coordination and cooperation.*

Table 8.4 Management effectiveness scores for biodiversity protection

	Biodiversity protection	Effective	Mostly effective	Partially effective	Ineffective
	Context				
	Planning				
	Inputs				
	Processes				
	Outputs				
Outcomes	Overall				
	Biodiversity				

Evidence has shown a declining trend in coral cover over time,[3] with an estimated 50 per cent decline in coral cover on the Great Barrier Reef over the past 27 years,[4] which is cause for considerable concern. This highlights the importance of considering cumulative and consequential impacts which are currently less well understood by managers, although these issues are now receiving greater attention in assessments and other considerations of the Authority.

Threat abatement plans, recovery plans and wildlife conservation plans under the EPBC Act, as well as specific on-the-water actions by the Authority (for example, reef protection markers and special management areas), are in place to address individual biodiversity issues for a small number of species and habitats that occur within the Region. Some of those plans, such as the recovery plan for marine turtles, have not been updated in many years. With regard to iconic and threatened species, such as dugong and some marine turtles, these plans and actions have had some effect in stabilising populations. Status and trend assessments prepared by the Authority indicate that more species are continuing to decline than have stabilised or are increasing resulting in the partially effective biodiversity outcomes. However, status and trend are uncertain for many groups because of lack of data.

The information base for biodiversity protection continues to improve through scientific research and the compilation and assessment of information by Authority staff (such as vulnerability assessments and assessment of status of habitats and species). Gaps in knowledge — for example status and trend for some specific plant and animal groups, habitats and ecosystems — are well recognised. Traditional Owners are increasingly involved in biodiversity management, though their knowledge and understanding is often not available or accessible for decision making.

Planning for biodiversity protection has been significantly improved since the Outlook Report 2009 through preparation of the draft Biodiversity Conservation Strategy 2012 and the Informing the outlook for the Great Barrier Reef Coastal Ecosystems technical report. However, targets in the draft Biodiversity Conservation Strategy tend to be process and output-focused and should be complemented by additional outcome-focused targets. On a Reef-wide scale, the Zoning Plan and the complementary plans for the adjacent Great Barrier Reef Coast Marine Park have made the most significant contribution to biodiversity protection

These have provided a robust framework and are already demonstrating positive results.[5] However, the zoning provisions only address biodiversity protection from direct extractive uses, particularly fishing. Major threats to biodiversity, such as climate change, coastal development (with the exception of Commonwealth managed Islands) and catchment run-off are not addressed by either the zoning provisions or individual biodiversity protection measures, although programs such as the Reef Plan which are designed to improve water quality will have a positive impact on biodiversity. Many of the actions to address biodiversity are long term and will take time to manifest an improvement in biodiversity outcomes.

Major risks and threats to biodiversity protection are well documented, and risk assessments and management procedures are in place for the major threats. Vulnerability assessments are being prepared for key species and habitats. These provide comprehensive documentation of risks to biodiversity values and mitigation measures within the Region. However, there remains little capacity to track the Authority's resource allocations that specifically target biodiversity objectives or to assess which outputs and outcomes result from management actions. Secure long-term funding for monitoring will be needed to provide data on changes to biodiversity outcomes over time.

Key stakeholders in biodiversity protection have been identified and are generally well known to managers especially through Reef Advisory Committees, Local Marine Advisory Committees and other consultative mechanisms.

Effectiveness of management tools as assessed by stakeholders
Surveyed stakeholders considered the Zoning Plan to be the most effective of the Authority's management tools used to manage biodiversity conservation in the Marine Park. Zoning, the Great Barrier Reef Marine Park Act and Regulations, education and community awareness, plans of management, and stewardship and best practice were considered to be effective or mostly effective by more than 50 per cent of the respondents. Permits and compliance were seen as the weakest tools in biodiversity protection.

Zoning, along with education and community awareness, were singled out as management strengths. Problems raised by jurisdictional limitations on the Authority to manage activities in the coastal zone and commercial fisheries were commonly cited as weaknesses. Recommendations for improvement included increased field presence and compliance action with greater penalties for breaches.

Workshop participants acknowledged that the Authority undertook an extensive biodiversity protection program; however, they expressed concern that the work being undertaken was not sufficient to protect the values of the reef.

8.3.2 Indigenous and historic heritage values

Table 8.5 Management effectiveness scores for Indigenous heritage values

Indigenous heritage		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

Indigenous heritage values
The Authority has a lead role in the protection of Indigenous heritage in the Region.

Aboriginal and Torres Strait Islander peoples are the Traditional Owners of the Great Barrier Reef Region. There are more than 70 Aboriginal and Torres Strait Islander Traditional Owner clan groups that maintain heritage values for their land and sea country. These values may be cultural, spiritual, economic, social or physical, and demonstrate continuing connections with the Reef and its natural resources.

Traditional Owners have recognised inherent rights and interests over their sea country in which the Authority has a management responsibility. Key management measures for Indigenous heritage include partnerships, education and community awareness, stewardship and best practise, legislation and Traditional Use of Marine Resources Agreements and Indigenous Land Use Agreements.

The Authority acknowledges the Convention on Biological Diversity that states in Article 10[6] Sustainable Use of Components of Biological Diversity that each contracting party shall, as far as possible and as appropriate (among other things):

> *"Protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements".*

The Authority's knowledge of Indigenous values is improving with the Reef Rescue Land and Sea Country Indigenous Partnerships Program[7] and the development of Traditional Use of Marine Resource Agreements. However, direct and indirect impacts, cumulative impacts associated with *traditional use of marine resources, and the less tangible Indigenous heritage such as traditional knowledge and maintenance of cultural practice are not widely available and therefore not well understood nor considered across the Authority. The importance of the Reef in Indigenous economies is also not well understood and not incorporated fully into management.*

Planning for Indigenous heritage was considered in the Authority's Great Barrier Reef Marine Park Heritage Strategy (Heritage Strategy).[8] *Actions are included in this document, although there are no targets or timeframes associated with the actions. The Reef Rescue Land and Sea Country Indigenous Partnerships Program articulates a set of objectives and targets to ensure "the continued use, support and reinvigoration of traditional ecological knowledge to underpin biodiversity conservation". This program will be evaluated at its completion, however to date there has been 100 per cent completion against milestones. The Authority's Strategic Plan*[9] *also includes specific objectives concerning working with Aboriginal and Torres Strait Islanders to take into account traditional affiliations, culture, heritage values and rights of management in the Marine Park.*

The Australian Government, under the Caring for our Country initiative, committed $10 million over five years towards the Reef Rescue Land and Sea Country Indigenous Partnerships Program in 2008. This funding expires in June 2013. (Note: An extension of the Reef Rescue programs was announced after preparation of the independent assessment report).

Identifying Traditional Owners who can speak for country can be difficult. The Authority has established an Indigenous Reef Advisory Committee to bring together expertise and experience in Indigenous partnership initiatives and sea country management from within the Great Barrier Reef and other parts of Australia to provide issues-based advice that informs the operations of the Authority. One of the benefits of the Traditional Use of Marine Resources Agreement program is the relationship between sea country and a Traditional Owner group that is identified and agreed upon as part of the Traditional Use of Marine Resources Agreement development process.

Sea Country Plans, such as the Kuku Yalanji example (near Mossman), have been developed by Traditional Owners for their own country. This plan identifies values, planning needs and management outcomes and is funded by the Authority and the Department of Sustainability, Environment, Water, Population and Communities through a small grants program. The Authority's environment impact management assessment processes need to consider these plans to ensure permitted activities are consistent with community plans. The Field Management Program also includes planning, development, engagement of Traditional Owners, training, mentoring, resourcing, monitoring, compliance, planning and reporting.

The Authority's framework for Traditional Use of Marine Resources Agreements complements existing community-based measures developed by some Traditional Owner groups to manage their use of some of these resources and recognises entitlements enshrined in the Native Title Act 1993. These agreements promote the sustainable use of threatened species such as dugong and turtle, and iconic species such as barramundi cod and giant clams within the Marine Park. There are currently five Traditional Use of Marine Resources Agreements and one Indigenous Land Use Agreement covering more than 20 per cent of the Great Barrier Reef, engaging 14 Traditional Owner clan groups (jointly signed by the Authority and Queensland Government). (Note: An additional Traditional Use of Marine Resources Agreement was accredited after preparation of the independent assessment report.)

While progress has been made by the Authority in engaging with key Indigenous stakeholders in the Great Barrier Reef, further work is needed to develop a mutually agreed and culturally appropriate process for joint planning. An Indigenous cultural heritage strategy would enable a shared vision to be developed with Traditional Owner groups with actions and timeframes for implementation. The strategy should include protocols for managing culturally sensitive information within the Authority and externally.

Effectiveness of management tools as assessed by stakeholders

Traditional Use of Marine Resources Agreements were the only management tool considered to be effective or mostly effective by more than 50 per cent of respondents. Policy and permits, as well as the Great Barrier Reef Marine Park Act and Regulations, were seen as ineffective in addressing Indigenous heritage issues.

Respondents generally recognised an improving engagement of the Authority with Traditional Owners, with a better policy and program platform as well as positive results from the development of Traditional Use of Marine Resources Agreements. At the same time, respondents — especially those who are Traditional Owners — recognise there is more to be done, particularly in relation to better informing and involving Traditional Owners in planning and management.

Traditional Owners who participated in the stakeholder workshops expressed wide-ranging views on this topic, including the desire for the development of stronger partnerships and greater involvement in decision making and management. The need for education and communication with the wider community was also discussed. The need for acknowledgement of native title rights in the management of the Region was also raised.

Table 8.6 Management effectiveness scores for historic heritage values

Historic heritage		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

Historic heritage values

The Authority has a regulatory role in the protection of historic heritage aspects of the environment (however, it has no jurisdiction over Queensland island heritage). The Authority works with other agencies to protect these values.

For the purposes of this report, historic heritage encompasses historic shipwrecks, World War II features and sites, lighthouses and associated structures, historic landscapes, and historic places and structures that embody a specific cultural, historic or scientific value. Natural heritage is considered under biodiversity protection.

There is generally a reasonable understanding by the Authority of the Region's values relevant to historic issues. However, while the Authority has a good understanding of the impacts on natural heritage, the consequential and cumulative impacts associated with historic heritage are less well understood. Information on condition and trend has improved through the 2010–2011 audit of Commonwealth islands' historic heritage. However, little is known about the condition and trend of shipwrecks, World War II sites, or heritage places such as Endeavour Reef.

The Great Barrier Reef Marine Park Act and Regulations provide the legislative power for the protection of historic heritage values and consideration of potential impacts to heritage through the permitting process. There are also strong drivers for heritage management under the Commonwealth and world heritage obligations. These obligations also drive consistency of implementation of historic heritage management across jurisdictions.

The Authority's Heritage Strategy,[8] *endorsed in 2005, provides guidance for protection of the Marine Park's heritage values through a range of planning instruments and policies. Historic shipwrecks are protected through specific legislation and entry controls. The* Heritage *Strategy identifies actions but does not set a timetable for implementation or indicate relative priorities. Risks and threats have been more explicitly addressed in new periodic reporting processes for world heritage sites. The Authority's Heritage Strategy requires updating to effectively address major pressures and drivers impacting on historic heritage.*

An assessment of the Heritage Strategy showed reasonable progress was being made, with 65 per cent of the actions completed or good or satisfactory progress having been made towards completion. Thirty-five per cent of actions had not commenced or been considered. Only one heritage management plan is currently in place, although two others are underway. Policy documents to address issues associated with historic heritage require updating and implementation.

Resourcing of the management of historic heritage is poor, with less than one full-time equivalent position dedicated to working in this area. The frameworks for engagement with stakeholders, industry and the community is good, but limited due to staff resources, with expert advice and consultation provided through the Reef Advisory Committees, the Australian Heritage Council, the tourism industry, Local Marine Advisory Committees, the World Heritage Committee and the Queensland Museum.

The Authority is currently developing a heritage register that will capture all values relevant to historic heritage. The register will assist managers and the community in knowing the location of and an understanding of heritage values.

Effectiveness of management tools as assessed by stakeholders

Insufficient responses were received to evaluate the effectiveness of management tools for historic heritage. Workshop participants raised the issue of confusing federal and state jurisdictions as a barrier to effective management.

8.3.3 Community benefits

The Authority has a regulatory role in the protection of the environment including the social and economic aspects of the environment. The Authority, together with other agencies, works to adopt an integrated approach to the management of the social, economic and environmental aspects of the Region.

Community benefits of the Reef encompass socio-economic aspects such as employment and income, in addition to less tangible attributes such as understanding, appreciation, enjoyment, personal connection, health benefits and access to the Reef. Many of these attributes are values based.

Table 8.7 Management effectiveness scores for community benefits

Community benefits		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

Management by the Authority is undertaken using a range of measures, including stewardship and best practice, legislation, zoning plans, permits and site infrastructure. While information and understanding of the value of the Reef from an economic perspective is assessed and monitored, an understanding of the broader community benefits that the Region supports is not well understood nor quantified. This has been recognised and the Authority, as part of the strategic assessment, is beginning to seek community views about threats, values and pressures in relation to community benefits as part of the strategic assessment.

There is likely to be increasing conflict between economic benefits of the Reef — associated with port and coastal development — and the personal, recreational and value based benefits. The consequential and cumulative impacts on community benefits (from these developments) *have not been well documented or assessed thoroughly.*

Many of the pressures associated with community benefits, such as population change, coastal development, economic growth and climate change, are outside the Authority's direct jurisdiction. However, the Authority's Recreation Management Strategy[10] *made some progress towards recognising the enjoyment and personal attachment to the Reef. Social, cultural and heritage values are considered when assessing permits applications, but this application is limited by the Authority's knowledge of these aspects in specific locations.*

In particular, the Reef Guardian program, Reef HQ Aquarium, and the Recreation Management Strategy have objectives for management associated with community benefits. The Field Management Program, jointly managed with the Queensland Government, also has a strong commitment to ensuring public access to the Reef and islands.

Many of the community benefit issues are considered under programs and policies developed for other purposes such as access to resources, conservation and multiple use. Currently there are no guidelines or benchmarks for social or economic impact assessments for the World Heritage Area. An overarching strategy that outlines the objectives for community benefits, while showing the linkages across the programs, would clarify the Authority's roles and responsibilities. It would also provide an improved framework to assess the management effectiveness with greater accuracy.

Stakeholder engagement through the Reef Advisory Committees, Local Marine Advisory Committees and stakeholders brought together for the strategic assessment enable managers to gain a better understanding of community values and issues of concern. Volunteer programs, such as components of the marine monitoring program (for example, Seagrass Watch) and Eye on the Reef, also provide avenues for community involvement in protecting the Great Barrier Reef.

Effectiveness of management tools by stakeholders
The Zoning Plan, the Great Barrier Reef Marine Park Act and Regulations were seen as most effective tools used by the Authority in promoting community benefits, primarily by making the Marine Park accessible to the community. The permits system, stewardship programs such as Reef Guardians, and research and monitoring were seen as very or mostly effective by more than half of the respondents.

Community partnership programs such as Reef Guardians and educational materials were viewed as strengths of the Authority's management. A lack of adequate resources for management was identified as a weakness.

Stakeholders at the workshops commented that the Authority did not prioritise managing community benefits and that with growing coastal populations there was potential for greater conflict between user groups, which was not being addressed.

8.4 Assessing external impacts

This section provides a summary of the effectiveness of the Authority's current management arrangements to address external impacts. Direct excerpts from the report are in italics, whereas non-italicised text has been added by the Authority for contextual purposes. A grading table is provided for each management topic (see Table 8.8 to Table 8.10).

8.4.1 Climate change and extreme weather

Table 8.8 Management effectiveness scores for climate change and extreme weather

Climate change and extreme weather		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

The Authority has had a lead role in facilitating awareness of the impacts from climate change and extreme weather and in building resilience in the Marine Park. It has an advisory role to other agencies in relation to mitigation and adaptation to climate change and extreme weather in the Region.

The Authority has limited jurisdictional responsibility for addressing climate change in the broad sense. However, the Authority contributes significantly to the development of international best practice for managing responses to climate change and extreme weather issues as they relate to the Reef's marine ecosystems. This is chiefly done through research and monitoring, partnerships with research institutions, government agencies and stakeholder groups and education, community awareness and stakeholder engagement programs.

The Great Barrier Reef *Climate Change Adaptation Strategy and Action Plan 2012–2017* (the *Action Plan*)[11] *acknowledges the important role the Authority plays in informing national and international climate policy and providing knowledge to support effective management of inshore areas. However, the direct management role of the Authority is statutorily limited, requiring a focus on ecosystem-based adaptation to increase the resilience of the Reef by reducing impacts from other sources such as land-based sediments and nutrients. Assessing the effectiveness of the Authority in this role is challenging, as so much depends on the actions of others.*

The Authority's planning initiatives are focused on enhancing the capacity of ecological, socio-economic and management systems to adapt to change in ecological and social variables. Dedicated staff positions have been established and specialist expertise exists within the Authority to coordinate efforts in this area, as well to facilitate national, regional and international collaboration which is necessary to address the complex issues involved. Climate change considerations have now been incorporated into many business areas across the Authority, rather than being confined to one work unit.

Work completed from 2007 to 2012 under the Great Barrier Reef *Climate Change Action Plan* 2007–2012[12] *has included raising awareness of the implications of climate change for the Great Barrier Reef* *and the ecosystem services it provides. Effort has also been focused on building interest in adaptation planning as a way to reduce future risks from climate change and minimise its impact on the environment. This has included work with reef-dependent industries such as tourism and fishing, as well as communities, and considers planning and adaptation actions at all levels from individuals and businesses through to managers and government.*[13]

Vulnerability assessments[14,15] *for specific functions and activities that have the potential to impact on the Region's values continue to provide good contextual information for management of climate change implications. The assessment for the Outlook Report 2009 noted that managers and key community stakeholders recognised that while climate change drivers and influences are largely global in nature, regional and local activities give rise to specific vulnerabilities that require action.*

Climate change plans and strategies were in place in 2009 and the focus has now moved to implementing the Action Plan. This plan aims to translate objectives into specific policies and measurable actions for on-ground management by the Authority to increase the resilience of the Reef ecosystem. Specific threats such as increasing sea temperatures, ocean acidification, increased storm events and associated changes to freshwater inputs, currents and connectivity have been identified as matters to be addressed by adaptation initiatives that seek to minimise the impacts of these events.

A number of the Authority's management initiatives contribute to offsetting the impacts of climate change by reducing risks from other stressors. The Authority's climate change work provides adaptation resources to help minimise the vulnerability of coastal communities and Reef-dependent industries while also increasing their capacity to collaborate in building ecosystem resilience to climate change. From a review of the supporting evidence, implementation and evaluation of the Action Plan appears to be on schedule.

While direct and indirect impacts of activities related to climate change and extreme weather are understood by managers — and risk-based approaches have been applied in adaptation work — they are not yet appropriately considered in all aspects of Reef management. The amendment of policy documents and procedures, along with the development of practical guidelines for relevant permit-holders and applicants, has been identified as priorities for attention.

Work continues on identifying the gaps in available biophysical information. The Authority recognises the particular need to clarify socio-economic factors such as the resource dependency[16] *of different stakeholder groups on various marine and coastal natural resources that are likely to be altered under a changing climate. Some of these information gaps are now being addressed. Evaluation of resilience indicators and completion of a reef resilience atlas were identified in 2009 as particularly important to address cumulative impacts, both biophysical and socio-economic.*

By 2012, the Authority's climate change work was instrumental in improving understanding and consideration of consequential and cumulative impacts, but this remains a challenge. Critical elements of current condition and trend cannot be confidently determined and monitored by managers. Efforts continue, including work with Traditional Owners, to apply available traditional knowledge to consider climate change implications, particularly through Traditional Use Marine Resources Agreements.

Community engagement relating to climate change and extreme weather continues through the Authority's initiatives such as Eye on the Reef and the Reef Guardian program which includes schools, councils, fishers and farmers. Work under the Action Plan contributed to substantially strengthened partnerships with key sectors of the commercial fishing industry and the marine tourism industry. A Reef Health *incident response* system *was developed in 2011,*[17] *in consultation with stakeholders, and includes response plans for:*

- *coral bleaching*
- *cyclone*
- *coral disease*
- *crown-of-thorns starfish (in preparation).*

Case studies of actions that can enhance the Reef's resilience to climate change and extreme weather are being documented by the Authority.

Despite significant progress in building the ecological resilience of the Reef, and the social and economic resilience of Reef industries, the work of the Authority cannot make the Reef and its industries invulnerable to the impacts of extreme weather. A series of extreme weather events such as cyclones, floods and heatwaves between 2002 and 2011 caused significant impacts to corals, seagrasses, dugongs and green turtles, as well as the tourism and fishing industries. This decade of extreme weather provided an indication of what is to come if the planet's climate continues to change at the current rate. The future success of the Authority's work in adapting to climate change and extreme weather is dependent on successful global efforts to mitigate climate change.

The planned and systematic approach being applied gives confidence that the Authority is achieving all that might be reasonably expected to reduce the threats posed to matters of national environmental significance from climate change and extreme weather in the Great Barrier Reef Region. However, in spite of good systems and processes, the long-term trend for Great Barrier Reef ecosystems is still poor, and the extent to which specific initiatives can effectively address particular problems will only become clear over time. This situation highlights the importance of robust performance monitoring and adaptive management by the Authority.

Effectiveness of management tools as assessed by stakeholders

Research and monitoring was considered to be the most effective of the management tools used by the Authority to manage climate change and extreme weather in the Great Barrier Reef Region. The Great Barrier Reef Marine Park Act and Regulations were considered to be only partially effective, while education and community awareness was mostly effective. Surprisingly, given the effort the Authority has expended in these areas, stewardship and best practice and partnerships were not regarded as particularly effective by a majority of respondents in this survey. However, feedback from evaluation processes conducted in relation to projects with partners in the fishing industry provides positive evidence that the Authority's partnership and stewardship approach is valued and has been effective in progressing climate change and extreme weather related activities and management. This suggests there may be a need to promote awareness about the success of these partnerships. Workshop participants recognised the work that the Authority was undertaking, but felt the Authority lacked jurisdictional responsibility in this area.

8.4.2 Water quality protection (catchment run-off)

Table 8.9 Management effectiveness scores for water quality protection (catchment run-off)

	Water quality protection	Effective	Mostly effective	Partially effective	Ineffective
	Context	■			
	Planning		■		
	Inputs		■		
	Processes		■		
	Outputs		■		
Outcomes	Overall			■	
Outcomes	Biodiversity			■	

The Authority has a lead role for the management activities that impact water quality within the Marine Park, as well as an advisory or partnership role with other agencies in relation to activities that occur outside the Region that may impact on the water quality in the Marine Park.

The Authority's management of water quality is through legislation and permits for point source discharges into the Marine Park, as well as undertaking the marine monitoring functions of the Reef Water Quality Protection Plan *(Reef Plan)*[18]*. However, the most significant contribution to water quality decline in the Great Barrier Reef is from activities outside the Marine Park associated with agricultural practices. This limits the Authority's capacity to take direct action with respect to water quality decline. The non-point source discharges, such as run-off from agriculture, is managed through partnerships with the Queensland Government, the Department of Sustainability, Environment, Water, Population and Communities, land holders and industry groups, and through education and community awareness, stewardship and best practice.*

The assessment for management effectiveness undertaken for the Outlook Report 2009 concluded there was slow progress being made towards the attainment of the desired outcomes and to reducing the risks and threats to the Reef's values. The Outlook Report 2009 recognised the positive work that was being done through the Reef Plan, but highlighted the little evidence of change through a lack of monitoring, and the lack of delivering with the planning framework.

The values that underpin the matters relevant to water quality are well understood by the Authority. While many of the direct and indirect impacts of poor water quality are well known, knowledge is not as comprehensive concerning the consequential and cumulative impacts of water quality. Current condition and trend are known for specific species such as corals and seagrass; however, despite early evidence of a reduction in loads of pollutants, there is still little documented evidence concerning improvements in water quality in the Region.

Since the Outlook Report 2009, a review of Reef Plan has provided better focus and direction for managers including the Authority, including targets for water quality and land management improvement. The revised Reef Plan reduces the list of actions from 65 to 11 to provide a more strategic and adaptive plan. It is focused on outcomes and takes into account new policy documents and regulatory frameworks. Measureable targets, improved accountability, and coordinated monitoring, evaluation and reporting underpin it. Targets are focused on short and medium-term outcomes for water quality and land management. In addition, Water *Quality* Guidelines for the Great Barrier Reef Marine Park[19] *and the development of a Coastal Ecosystems Assessment Framework*[20] *by the Authority set limits for water entering the Marine Park and provide a framework for assessment of ecosystem services within the basins located in the catchment with a focus on improving the health and resilience of the Reef. In terms of assessing performance, a Reef Plan monitoring, evaluation and reporting strategy has been developed and the first Reef Plan report card has been published.* (Note: since preparation of the independent report, a second and third Reef Plan report card have been published.)

The Authority engages with key stakeholders and has expanded the Reef Guardians Program (which commenced with schools and local councils), to include farmers, graziers and fishers. However, as the management of water quality leaving the Great Barrier Reef catchment is significantly within the Queensland Government's jurisdiction, the Authority can only work with the community and stakeholders to encourage best practice land management.

The Authority has its greatest direct influence on water quality through the Great Barrier Reef Marine Park Act and Regulations (section 66(2)e of the Act) under which it is illegal to discharge waste into the Marine Park except for some permissible actions. Permitting the discharge of wastewater into the Reef is assessed on a case by case basis, against guideline trigger levels. (Note: trigger levels in the Regulations are for aquaculture only.)

The Authority has allocated significant resources into understanding the water quality issues from a biophysical aspect, though information is still limited with respect to the socio-economic impact of loss of ecosystem services from poor water quality. The Authority monitors the long-term health of key marine ecosystems and the condition of water quality in the inshore lagoon. The Australian Government has committed more than $200 million to the improvement of water quality in the Reef, including water quality grants, Reef Partnerships, Land and Sea Country Indigenous Partnerships, research and development, and monitoring and reporting (including the publication of an annual Great Barrier Reef water quality report card). (Note: the Queensland Government spent $175 million between 2009 and 2013 and has committed to an additional $35 million per year through to 2020 under Reef Plan).

Effectiveness of management tools as assessed by stakeholders

Education and community awareness, followed by research and monitoring, were considered to be the most effective of the management tools used to manage water quality in the Great Barrier Reef Marine Park. Compliance and the Great Barrier Reef Marine Park Act and Regulations were seen as the weakest tools in managing water quality.

Reef Plan and the Reef Guardian programs are regarded by many respondents as strengths of management. Water quality is seen as an area where effective partnerships are crucial for effective management. A lack of jurisdictional responsibilities, the sheer scale of the issue, and lack of corresponding resources and political will are seen as the major weaknesses and impediments. A number of respondents called for greater attention to compliance with existing Regulations, stiffer penalties for breaches and an extension of the Authority's powers to control activities outside the Marine Park that impact on Great Barrier Reef values.

These findings were supported at the workshops where discussions focused on management issues outside the Authority's jurisdiction, and where participants supported the positive changes achieved by stewardship programs.

8.4.3 Coastal development (protection of coastal ecosystems)

Table 8.10 Management effectiveness scores for coastal development (protection of coastal ecosystems)

	Coastal development (protection of coastal ecosystems)	Effective	Mostly effective	Partially effective	Ineffective
	Context				
	Planning				
	Inputs				
	Processes				
	Outputs				
Outcomes	Overall				
	Biodiversity				

The Authority has an advisory role in the management of coastal development and the protection of coastal ecosystems.

Fourteen broad categories of coastal ecosystems are important to the functioning of the Great Barrier Reef Region: coral reefs, lagoon floors, islands, open water, seagrasses, coastline, estuaries, freshwater wetlands, forested floodplains, heath and shrublands, grass and sedgelands, woodlands, forests and rainforests. These ecosystems provide important links between land, freshwater and marine environments, as well as feeding and breeding grounds for many terrestrial, wetland and marine species. Changes to, or loss of these coastal ecosystems, can lead to a variety of adverse environmental, social and cultural impacts, with serious implications for matters of national environmental significance and for industries and communities dependent on the Great Barrier Reef Region.

Critical habitats in the Great Barrier Reef catchment provide for marine ecosystem functions directly through ecosystem connectivity. They also support healthy marine ecosystems by preventing excess sediments, nutrients and pollutants from being transported to the Reef lagoon. Reef coastal ecosystems support a variety of ecosystem functions, such as nursery areas for marine species, floodwater buffers and sediment and nutrient sinks.

As a result of the Outlook Report 2009, the Authority has developed a comprehensive document, Informing the outlook for the Great Barrier Reef Coastal Ecosystems[21] *which assessed the pressures affecting coastal ecosystems that have the potential to influence the Reef's health and resilience. This document provides an effective context for management as it describes the functioning, as well as the threats, pressures, risks and trends of the Reef's coastal ecosystems.*

The Authority's regulatory role in managing coastal ecosystems is restricted to addressing the impacts of coastal development works such as jetties, marinas and dredging which occur below mean low water (within the Marine Park) *or on Authority-managed Commonwealth islands. The Authority has an advisory role to the Department of Sustainability, Environment, Water, Population and Communities on the EPBC Act referrals, for actions likely to have a significant impact on the Great Barrier Reef World Heritage Area and a joint assessment role for activities impacting on matters within the Marine Park. Such actions may be located within or outside the Region. The Authority also works in partnership with Queensland and local governments to provide technical advice and facilitate improved understanding of the values of the World Heritage Area and the critical role coastal ecosystems play in the functioning of the Reef. Additionally, the Authority's stewardship programs, including its Reef Guardians program, focus on working with industry sectors and the broader community to improve understanding of the connectivity between coastal and marine ecosystems and to facilitate improved management practices.*

The Queensland Government has jurisdiction over most development and management in the coastal zone (above the mean low water mark). The former Queensland Coastal Protection State Planning Policy has been replaced with the new draft Coastal Protection State Planning Regulatory Provision. This potentially has significant implications for the Great Barrier Reef Region because it removes many of the specific requirements placed on local government and potential developers to undertake best practice and to minimise environmental harm.

It is evident the Authority has a reasonable understanding of the direct and indirect impacts associated with coastal ecosystems, though there has been little quantification of these impacts. The consequential and cumulative impacts require better understanding and monitoring. Urgent action (by the Authority) *is also needed to improve the health of coastal ecosystems to boost the health and resilience of the Reef. Vulnerability assessments for each of the at-risk coastal ecosystems have also been undertaken.*

Targets and performance measures for coastal ecosystems included in the Authority's draft Biodiversity Conservation Strategy,[22] *lack outcome specific targets. Reef Plan, which focuses on non-point source water quality, also contains a number of performance measures relating to coastal ecosystems. The Authority's stakeholder engagement remains effective.*

The Authority's stakeholder engagement on coastal ecosystem management is increasing. The Australian Government's Reef Rescue grants to improve land management practices laid the groundwork for building relationships with farmers. Partnerships continue to grow through the Authority's Reef Guardian Farmers stewardship program. Coastal ecosystems management is also the focus of coastal Reef Guardian Councils and Schools, and is regularly discussed at Local Marine Advisory Committees and Reef Advisory Committees.

The work done in the Authority's draft Biodiversity Conservation Strategy and Informing the outlook for Great Barrier Reef coastal ecosystems suggests the long-term condition and trend for coastal ecosystems is very poor if joint management action is not taken soon to halt and reverse the decline in inshore and coastal ecosystems, particularly south of Port Douglas.

Given the number of agencies involved in managing coastal ecosystems, an integrated framework for planning, assessment and approvals is needed to ensure the values of the Great Barrier Reef Region are maintained and where possible improved.

Effectiveness of management tools as assessed by stakeholders
Most respondents rated the Authority's management tools for coastal ecosystems as either not effective, or only partially effective. The only tools to be rated as effective or very effective by more than 40 per cent of the respondents were research and monitoring along with education and community awareness.

The work of the Authority's Reef Guardians program with local farmers and other partnership programs were regarded as a strength by respondents, while a lack of influence (by the Authority*) on coastal planning and development decisions (and by some, a perceived political will to control development) are regarded as the most significant weaknesses. Respondents see a need to extend the Authority's jurisdictional control over activities that impact on the values of the Marine Park, to improve compliance action (especially in relation to permit conditions and compliance action by state authorities), and an increased focus on partnerships between the Authority, local government and local industry.*

Stakeholder comments at workshops reflected the survey results, consistently raising concerns over the Authority's limited influence over the management of coastal ecosystems and the consequential impacts on Reef health and resilience.

8.5 Managing direct use

This section provides a summary of the effectiveness of the Authority's current management arrangements for each of the direct use categories. Direct excerpts from the report are in italics, whereas non-italicised text has been added by the Authority for contextual purposes. A grading table is provided for each management topic (see Table 8.11 to Table 8.18).

8.5.1 Tourism

Table 8.11 Management effectiveness scores for tourism

Tourism		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

The Authority is the lead agency for management of marine tourism in the Region.

Management of tourism in the Great Barrier Reef employs a mix of management tools, with emphasis on plans of management for intensively used areas and partnerships with accredited tour operators, as well as permits — often with specific conditions.

Tourism within the Reef is recognised by managers as one of the most significant uses of the Region and the presentation of its values. Tourism is acknowledged to be a major driver for economic growth and employment for coastal Queensland. Tourism, commercial fishing, recreation and scientific research contribute $5.7 billion per annum — of this, $5.2 billion is attributed to tourism.[23]

The Outlook Report 2009 recognised high levels of visitor satisfaction and significant economic benefits to local communities but noted that longer-term environmental performance would depend on clearer understanding of the implications of latent capacity in the permit system and improved documentation of the levels of specific activities undertaken in each location over time. This has been partially improved with the implementation of the Authority's environmental management charge online system and the development of the Reef Management System (a permitting system).

With the launch of the Great Barrier Reef as a National Landscape in March 2012, the Authority sought to reinforce the mutual understanding between tourism operators and managers on values underpinning matters of national environmental significance in the Great Barrier Reef for tourism. The Authority chaired the regional Steering Committee for the Great Barrier Reef National Landscape which has members from Tourism Queensland, Queensland Parks and Wildlife Service, key tourism industry representatives, and the conservation sector.

Plans of management covering less than 10 per cent of the total Great Barrier Reef area are in place for the areas that receive more than 80 per cent of tourist visits but enhanced planning capability within the Authority and a schedule of regular reviews would improve consistency. The Outlook Report 2009 assessment noted some tourism activities occur over a wide area and that the planning system did not include an overarching strategy to guide tourism activities. An overarching strategy, although under development, is still outstanding and an expansion of site planning has not occurred to areas where growth is increasing such as the southern Great Barrier Reef. If site planning is not pre-emptive, protection of the Region's values in these expanding areas will not be as effective.

Policies covering many aspects of tourism are now outdated and work is still needed to address shortcomings identified in 2009. Implementation of the Action Plan, marine tourism contingency planning and development of a co-ordination framework to assist with consistency across jurisdictions are priorities in working towards an overarching strategy for managing tourism in the Region.

Sound governance, industry partnerships and management processes are in place to address tourism issues; the Authority is widely recognised as a world leader in this area. Joint permitting and assessment processes support consistency in the approach across jurisdictions. Most tourists are carried by a small number of highly accredited tour operators. The Authority's permit conditions seek to limit cumulative impacts. The potential problems arising from significant latent capacity within the permit system have been recognised and, at least, partially addressed through the Authority's plans of management, capping permits and a booking system for sensitive sites. While the permitting system manages tourism well, a tourism permit can be more than 16 pages long and contain more than 50 conditions. Whether these permits are effective at informing and educating tourism operators about what they can and can't do — while delivering required outcomes for the environment, social, cultural and heritage values — requires evaluation. A key issue is the complexity of the current management arrangements for tourism. Knowing where you can go and what you can do relies on knowledge of *zoning plans, plans of management, complex permissions and best practices. Simplification and alignment of current arrangements through regular ongoing reviews is required.*

Since 2012, environmental management charge records can be recorded online … improving efficiencies for the operators and the government agencies involved. Permit bookings are displayed on the Authority's website, providing a new level of public transparency.

The tourism industry has experienced difficulty in retaining and attracting experienced staff due to industry downturns and competition from the mining sector. This, alongside a reduction in educational opportunities (the reef discovery training program is no longer operational) has generally led to a decline in the delivery of education on Word Heritage Area values and the Authority's obligations regarding presentation of these values. However, within the Authority there continues to be high levels of skills related to marine tourism management and impact assessment. Expert advice also continues to be sought through the Tourism and Recreation Reef Advisory Committee and also the Indigenous Reef Advisory Committee. Representatives from the tourism industry are also members of Local Marine Advisory Committees.

The Authority endeavours to build on best available biophysical and monitoring research information to make relevant management decisions, including reef health monitoring information provided by tourism operators through the Eye on the Reef program. This program collects information through various methods including the Sightings Network, the Eyes and Ears Incident Reporting Network, Tourism Weekly Monitoring, Rapid Monitoring and Reef Health and Impact Survey sub-programs. Eye on the Reef has been enhanced and now integrates data and reporting across programs, while having a user-friendly data portal and the provision for online training.

Effectiveness of management tools as assessed by stakeholders

The Zoning Plan, followed by plans of management, was seen as the Authority's most effective tools in managing tourism. All tools, with the exception of site infrastructure (for example, reef protection markers, public moorings and signage), were seen as very effective by some respondents. More than half of the respondents understood compliance to be only partially effective.

Good industry relationships and strong partnerships with groups such as the Association of Marine Park Tourism Operators, together with the zoning and permit systems and plans of management, are seen as strengths. Nevertheless, respondents identified a need to improve standards in some Reef tourism operations with more experienced and trained interpretive staff. They saw the Authority could play a role in improving standards through the permit and compliance monitoring systems. More regular reviews of plans of management and making permits for commercial tourism operators easier to understand were suggested improvements.

Other areas for improvement identified include:

- *more effective engagement at the management level with tourism operators*
- *reduced bureaucracy and enhanced flexibility in permit processing*
- *more human resources allocated to speed up permit processing*
- *streamlining processes for reviewing and amending plans of management*
- *more compliance activity and 'sticks' to deal with the poor performing operators who are 'damaging the brand'*
- *innovative policy development rather than continuing rounds of 'document to exhaustion'.*

The desirability of the Authority in taking a proactive leadership role in defining the iconic tourism experience, rather than simply responding to proposals by tour operators, was also raised, as was the need for site infrastructure to follow destination development planning rather than being reactive. Workshop participants raised the inflexibility of plans of management to respond to changes in the tourism industry.

8.5.2 Fishing – commercial

Table 8.12 Management effectiveness scores for fishing – commercial

Fishing – commercial		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

The Authority has a regulatory role in the management of commercial fishing through its Zoning Plan, Regulations and permits for a limited number of Queensland managed commercial and developmental fisheries. The Authority has an advisory role to other agencies in relation to the management of commercial fishing in the Region.

Fishing is the principal extractive use of the Great Barrier Reef. Commercial fishing targets a range of species including fish, sharks, crabs, lobsters and prawns. Viable commercial fishing industries depend on a healthy ecosystem. The total revenue from commercial fishing in the World Heritage Area in 2010–11 was estimated at $192 million.[23]

Management of fishing and its dependent aquatic environment is shared between the Australian and Queensland governments. While the Authority has a direct role in ensuring that fishing is ecologically sustainable in the Marine Park it has an advisory role on the management of commercial fisheries, and works with other agencies to improve fisheries management.

The Authority's primary management tools with respect to commercial fishing are the Zoning Plan, associated Regulations, stewardship (Reef Guardian Fishers) and permits for a small number of harvest fisheries and developmental fisheries. Special management areas are in place to regulate fishing practices in areas important to dugongs. These tools complement the Queensland legislation that licences commercial fishing. Compliance, undertaken by the joint Australian and Queensland governments' Field Management Program, also plays a significant role in managing the impacts of commercial fishing.

As identified in the Outlook Report 2009, the Authority has a good understanding of commercial catch information. Cumulative impacts associated with commercial fishing are reasonably well known. The Authority's recent Ecological *risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef found the overall ecological risks from trawling are relatively low, but there are some high ecological risks for deep water skates, several rays, and sea-snakes.*[24] *A reduction in trawl fishing effort of more than 40 per cent between 2005 and 2009, driven by prevailing economic conditions rather than management intervention, has significantly reduced the ecological risk from trawling. However, higher effort levels are still allowable under existing management arrangements. Further reductions in trawl bycatch and other efforts to reduce risks for species of conservation concern are important for the sustainability of the fishery.*

Stewardship among commercial fishers is promoted through the Authority's Reef Guardian Fishers program which currently involves nine fishing operations and up to 50 fishing vessels. These commercial fishers demonstrate leadership in their sector by going well beyond Regulations to maximise the ecological sustainability of their operations. A significant example of stewardship by commercial fishers is the self-imposed moratorium on commercial coral collection in a large part of the Keppel Islands following flooding impacts.

The Authority has completed vulnerability assessments for threadfin salmon and grey mackerel. These assessments show the minimum legal size for both species are smaller than reported sizes at first maturity, exposing these species to fishing pressure before fish can breed. …The Authority is also actively involved with a range of fishery related projects, such as assessment of coral trout stocks. However, the status and trend of many other fish stocks are unknown. Protection of dugongs from netting in the Townsville region has improved through rule changes for commercial fishing within part of the Bowling Green Bay Species Conservation (Dugong Protection) Special Management Area in 2011. However, illegal fishing is considered one of the greatest risks to the environmental sustainability of commercial fishing.

Commercial fisheries arrangements in the Reef are accredited against national sustainability guidelines. The Authority is involved in this role in an informal advisory capacity only. Engagement with stakeholders is critical for the Authority to positively influence the management of fishing. The Authority partners with the Queensland Government, the fishing industry and other stakeholders such as the CSIRO and James Cook University to better understand the impacts of fishing on the Reef and to help ensure use of the Reef is ecologically sustainable. The Authority has also worked with commercial fishers to develop a Reef Guardian Fishers stewardship program to recognise and promote sustainable fishing practices. The sector is also represented on most Reef Advisory Committees and Local Marine Advisory Committees.*

The Authority's Field Management Program resources are focused on compliance, partnerships and engagement, with further work undertaken through the Climate Change Adaptation Strategy and Action Plan. However, funding for the Field Management Program has been static since 2008 and declining in real terms. Funding has not kept pace with an increase in the protected area.

Effectiveness of management tools as assessed by stakeholders
Zoning was considered to be the most effective of the Authority's management tools used to manage commercial fishing in the Great Barrier Reef Marine Park although the compliance effort and political will to enforce restrictions is seen as weak. Getting the balance right between the interests of commercial and recreational fishers is seen as an area requiring attention by some respondents. Vessel monitoring systems are regarded as effective but need to be extended. Research and monitoring, along with the Great Barrier Reef Marine Park Act and Regulations, were considered to be very or mostly effective by more than 50 per cent of the survey respondents. The Authority's partnerships, compliance, plans, permits and policy were seen as ineffective or only partially effective by more than 60 per cent of respondents.

8.5.3 Fishing — recreational

The Authority has a limited regulatory role in relation to recreational fishing and collecting (primarily through the Zoning Plan and Regulations). The Authority has an advisory role to the Queensland Government in relation to the management of recreational fishing in the Region.

Table 8.13 Management effectiveness scores for fishing — recreational

Recreational fishing		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

Recreational fishing is one of the most significant recreational activities undertaken on the Reef. The main target species are coral trout and other cod, emperor, tropical snapper, barramundi, bream, mackerel, whiting, crabs, lobster and bait fish. Recreational fishers report that they release nearly half of all fish caught[25] but the survival of released fish is highly variable and dependent on a number of factors including the experience of the fisher.

Management of the ecological sustainability of recreational fishing by the Authority is primarily through the Zoning Plan and Regulations, through public appreciation areas that limit spearfishing (and some commercial fishing activities), in addition to education and awareness programs. As is the case with commercial fishing, compliance plays a role in the management of recreational fishing. Recreational fishing is predominately managed by the Queensland Department of Agriculture, Fisheries and Forestry through size, take and possession limits; however, there is no total allowable catch for this fishery. Fishing gear constraints and limitations of the take of certain species contained in the Zoning Plan and the Great Barrier Reef Marine Park Regulations also contribute to the management of recreational fishing and collecting.

The Authority's Recreation Management Strategy[10] identified the key threats to the Reef from recreational fishing but did not consider this activity in detail. Ecosystem effects and cumulative impacts of fishing are poorly understood, but are likely to be concentrated in inshore areas close to major population centres. Local depletion, particularly of some inshore species, is of concern in some areas.[5] Economic data estimated that more than $57 million per annum was spent on recreational fishing, with more than 3.4 million fishing trips undertaken in 2012.[23]

While anchor damage in the Whitsundays led to the establishment of no-anchoring areas, the Recreation Management Strategy identified that recreational fishing practices are unlikely to result in significant direct or indirect impacts on the habitats of the Region. However, an increase in the coastal population and the fly-in-fly out community could lead to a decline in the Region's values if not spatially monitored and managed.

The Authority has no specific policy document on recreational fishing, and there are no explicit objectives, actions or targets articulated for recreational fishing. Responsible reef practices[26] are detailed on the Authority's website, providing best practice guidance for a number of activities associated with recreational fishing, such as boating, anchoring and mooring. Consequential or cumulative impacts are less well understood by the Authority and will require long-term trend and habitat monitoring to give confidence that potential impacts can be effectively addressed. Compliance and wider Field Management Program financial resources, associated with the surveillance of recreational fishing, appears inadequate and on the decline. For the Reef to be environmentally sustainable, illegal fishing needs to be identified and ceased. The current Field Management Program is operating at capacities set in the 1990s when Reef usage and pressures were lower, and prior to the seven-fold expansion of the area of highly protected zones and the emergence of climate change.

Stakeholder engagement is good with respect to user groups, with representatives on the Local Marine Advisory Committees. However, many individuals do not belong to groups or clubs. The Recreation Management Strategy identifies that engagement and collaboration with recreational users, Traditional Owners and the community more broadly are likely to play a key role in further reducing risks associated with recreational fishing. As identified in the Outlook Report 2009, effective collaboration in management efforts and getting a better indication of the total recreational fishing effort are particularly challenging in the diffuse recreational fishing sector.

Effectiveness of management tools as assessed by stakeholders

The Zoning Plan was the only tool considered to be very or mostly effective in managing recreational fishing by more than 50 per cent of respondents. The Zoning Plan, associated educational maps and materials, and a broad ecosystem-based approach to management were seen as strengths of the Authority's management of recreational fishing.

Policy, along with stewardship and best practice, were seen as being the least effective. A lack of capacity to manage recreational fishing effort or take and a lack of rangers in the field were regarded as weaknesses. A lack of effective compliance of the Zoning Plan, the Great Barrier Reef Marine Park Act and Regulations was also highlighted by many respondents. Some respondents proposed additional Marine National Park Zones (green zones), especially along the coastline, to improve fish recruitment and the sustainability of recreational fishing.

Workshop participants consistently raised the need for more baseline information about recreational fishing, a greater compliance presence and the cross-jurisdictional issues with state fisheries management. The introduction of a recreational fishing licence to improve user compliance and raise additional revenue for management of the Marine Park was also proposed. Improved information based on better research and monitoring was seen as necessary to improve management and the understanding of users.

8.5.4 Recreation

The Authority has a regulatory role (predominantly through the Zoning Plan) and a strong partnership role to manage recreation within the Region.

The Authority manages recreation through a variety of management tools including legislation, the Zoning Plan, plans of management, site management, partnerships, education and community awareness. Permits are not required for low impact activities, including recreational activities; however, permits may be required for group activities where the impact is likely to be significant. Specific policies for interactions with whales and dolphins and on seabird breeding islands are also in place. However, the diffuse nature of recreation and lack of permit control mean that plans of management and site planning arrangements do not provide certainty regarding where uses may occur and where impacts are likely to be acceptable.

The Authority considers tourism as those travelling or carried by a commercial tourism operation, while recreation includes locals recreating and a portion of traditional tourists under international definitions (for example, free and independent tourists).

Table 8.14 Management effectiveness scores for recreation

Recreation		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

The assessment of management effectiveness for recreation undertaken for the Outlook Report 2009 concluded that despite the lack of an overarching planning framework and targeted management objectives, quality recreation products and services have been provided, and that good governance and management processes are in place to address recreation issues. In response, the Authority prepared a Recreation Management Strategy. The strategy is designed to provide an overarching framework for the management of recreation in a coordinated manner and to inform the public of the management approach. The strategy also identifies which management tools are in place for each recreation activity. The values that attract large numbers of visitors are well documented, and threats and risks to those values are clearly articulated in the strategy. The risk analysis determined there were no threats that posed a very high or high risk to the values. Cumulative impacts are recognised as an issue in the strategy, but are not specifically addressed. The condition and trend of recreation is referenced, but the strategy does not address the impacts of recreation on condition and trend as a whole.

The implementation of the Recreation Management Strategy is identified in the Authority's Strategic Plan, and resources are allocated in line with the objectives. Funding is concentrated mainly on describing what and where activities are undertaken and on stewardship and education programs, and less on site planning, site infrastructure and recreation-specific policy document development.

Stakeholder engagement remains strong with the Tourism and Recreation Reef Advisory Committee consulted regularly as part of recreation planning. Recreation representatives are also included in the 12 Local Marine Advisory Committees, many of which have produced regional brochures specifically for recreational users. Authority staff in the Cairns, Mackay and Rockhampton regional offices interact with recreational users particularly through Community Access Points. However, the diversity and informality inherent in the sector presents an ongoing challenge to engage with the majority of recreational users and to document their values and activities spatially.

Coordination between relevant agencies (the Authority, Queensland Parks and Wildlife Service, Queensland Boating and Fisheries Patrol, Maritime Safety Queensland, Australian Water Police) to enforce Marine Park Acts, Regulations, Zoning Plans and plans of management is high. In addition, some products and services such as maps and brochures are jointly prepared and presented.

The Recreation Management Strategy provides excellent data concerning the risk-based approach adopted by the Authority, while identifying the major risks and threats associated with recreation and avenues to reduce those risks. However, time frames and targets to meet the objectives will assist in assessing the performance on the strategy in achieving the desired outcomes.

Effectiveness of management tools as assessed by stakeholders
All of the Authority's management tools, except compliance and policy, were seen as very or mostly effective by more than 40 per cent of respondents, with the Zoning Plan and the Great Barrier Reef Marine Park Act and Regulations being seen as the most effective tools overall. The Zoning Plan, Reef Guardian programs and educational programs are seen as strengths in recreation management, while a lack of compliance enforcement and availability of field staff are the main identified weaknesses.

Workshop participants raised the need for better understanding of the changing recreational sector, in particular the growing number of new recreational users as a result of the mining boom. Suggested future management actions included more reef protection markers and moorings, as well as increased education.

8.5.5 Port activities

Table 8.15 Management effectiveness scores for ports
Including dredging and dredge material disposal.

Ports		Effective	Mostly effective	Partially effective	Ineffective
Context			■		
Planning				■	
Inputs				■	
Processes			■		
Outputs				■	
Outcomes	Overall			■	
Outcomes	Biodiversity			■	

The Authority has an advisory role in the management of ports, due to most ports being located outside of the Marine Park (within port exclusion areas) (see Table 5.2, Chapter 5).

The planning and development responsibilities for ports lie with the Queensland Government and the Department of Sustainability, Environment, Water, Population and Communities. [Note: The role of the Department is generally confined to the assessment of referred actions that will or are likely to have a significant impact on matters of national environmental significance.] The department has no broader planning, development *The role of the Authority is therefore restricted to the consequential impacts from ports. However, actions may affect matters of environmental significance and trigger a referral requirement under the EPBC Act, requiring assessment from the Department of Sustainability, Environment, Water, Population and Communities and potentially the Authority if it affects the Marine Park or World Heritage Area. Outside the Marine Park, the Authority's role is advisory. This means that while the impact of the port development may be assessed, the Authority has limited responsibilities over the planning of port locations and port activities that occur within the exclusion areas. For example, dredging often occurs outside the Marine Park or within the excluded area. Dredging and disposal may also occur within the Marine Park, but in these instances the Authority has some accountability and will assess the activity under its permit process.*

The increase in the number of proposals for new and expanded ports along the Great Barrier Reef coast is of particular concern. There is also an increase in requests for dredging to extend outside of port exclusion areas and into the Marine Park — for example dredged entrance channels to allow for larger draft ships to access ports such as Townsville and Hay Point. The Authority has identified risks from the proposed port developments to the inshore area of the Region, which have the potential to cause significant negative impacts on species and habitats critical to the healthy functioning of the Reef's ecosystem.

While dredging associated with ports usually occurs within port limits, dredge material disposal often occurs within the Marine Park. There is generally a good understanding by staff of the Authority of the direct and indirect impacts of dredging on the values of the Reef and policies for the disposal of dredge material and environmental impact management require direct and indirect impacts to be considered. However, this is often considered on an application-by-application basis and the consequential and cumulative impacts of dredging and spoil disposal are less well understood. The Authority has little knowledge about the condition and trend of many of the ecosystems and species at risk from port development.

The Authority has a role to play in the implementation of offsets associated with some port approvals under the EPBC Act (for example, Curtis Island and Abbot Point). This is a new role for the Authority; it *is currently developing guidelines and procedures for managing the funds, while ensuring the offsets meet the intended effects and expenditure is not duplicated with other offsets (for example, those required under Queensland Government approvals).*

There is no overarching strategy for port development in Queensland although a consultation paper was recently released, and there are multiple port expansions and new port development proposals. This has a significant impact on the Authority's ability to protect the Region's values, as each port proposal is assessed individually on its merits. Where there are activities within the Authority's jurisdiction, this case-by-case approach results in increased workloads and does not enable issues, such as cumulative impacts, to be addressed at a strategic level. The complex jurisdictional environment within which ports operate — combined with the lack of Authority policy documents for ports — continues to negatively impact on the Authority's capacity to avoid, mitigate, offset and adaptively manage the impacts from ports on the Region's values. Greater certainty and coordinated planning and approval processes are required between the Commonwealth and Queensland jurisdictions to inform where and how ports can operate within and adjacent to the Region.

Where the Authority has jurisdiction over impacts of port development (for example, dredge material disposal within the Marine Park), objectives, actions for implementation, guidelines and standards have been developed. Guidelines for hydrodynamic numerical modelling for dredging projects[27] provide guidance and standards for all new applications. The draft Biodiversity Conservation Strategy is committed to "reducing threats to protected and at risk habitats, species and groups of species" are also in draft form. The environmental management charge currently does not extend to dredge material disposal. Given the charge is a contribution towards management of the Marine Park, extension of this charge to high risk activities such as ports and dredging should be considered.

Resourcing for assessing and managing the impacts of port proposals or developments has increased but is not sufficient to keep pace. While staff have been committed to developing policy positions, assessments have also increased. Stakeholder engagement by the Authority is sound, with regular meetings held for key stakeholders such as Local Marine Advisory Committees and Reef Advisory Committees, as well as regular meetings with the Queensland Ports Association. Community input is limited to occasions when a proposal triggers the environmental impact assessment process under the EPBC Act or the Great Barrier Reef Marine Park Act because it may have impacts on matters of national environmental significance or the proposal occurs within the Marine Park. Documentation associated with environmental impact assessment processes are made available for public comment.

There is little evidence of outcomes to support ports being environmentally sustainable. However, ports are seen to be economically sustainable and local communities are reliant on ports for goods and services, as well as employment. This is balanced against the loss of amenity and 'enjoyment' and potential economic losses of other industries (for example fishing) near port developments and potentially further afield given the potential for dredge material to resuspend and disperse further than the dredge disposal areas.

Effectiveness of management tools as assessed by stakeholders

None of the management tools available to the Authority were seen to be particularly effective in managing ports. Permits (including impact assessment), the Great Barrier Reef *Zoning Plan 2003* (the Zoning Plan), *research and monitoring, and the Great Barrier Reef Marine Park Act and Regulations were considered to be the most effective of the management tools. Policy was seen as the weakest tool in managing ports with more than 90 per cent of respondents rating it as ineffective or only partially effective. Two contrasting views of the Authority's involvement in planning and management of ports were evident in the responses. One reflected a view that the Authority does not fully understand port development and their environmental management systems and is "driven by a culture that regards port activity as inherently harmful". The other view sees ports as a major threat to the Reef but that the Authority lacks the jurisdictional authority, capacity or willingness to address the impacts posed by port development and management.*

The engagement of the Authority with port authorities was seen positively, although there was generally little strength in management identified by respondents. Jurisdictional limitations and a corresponding lack of influence of port development and management decisions, weak compliance enforcement, a lack of understanding by the Authority of the ports industry and a lack of consistent messages from the Authority concerning port development were identified as weaknesses.

A number of respondents saw an extension of the jurisdictional reach of the Authority to have a greater say over port development as a potential solution, while a number called for more explicit policy from the Authority on port planning and management.

Extensive discussions about ports occurred at the stakeholder workshops. The main management issues raised were: the need to improve assessment processes, overlapping state and federal responsibilities, concerns about dredge disposal, improved governance arrangements for ports, and the Authority's lack of influence over decision making and management.

8.5.6 Shipping

Table 8.16 Management effectiveness scores for shipping

Shipping		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

The Authority has a limited regulatory role and a strong partnership role with other agencies to manage shipping within the Region. There are stringent management requirements for commercial shipping in the waters of the Great Barrier Reef which was designated a Particularly Sensitive Sea Area by the International Maritime Organisation in 1990.Shipping in the Great Barrier Reef is managed by several government agencies including the Australian Maritime Safety Authority, Maritime Safety Queensland, and the Authority.

The main management tools used by the Authority to manage shipping include legislation and the Zoning Plan. Shipping traffic is confined to designated shipping areas in the Great Barrier Reef Region, defined in the Zoning Plan 2003, unless a specific permit is issued. Permits, compliance, policy documents and education are used to a lesser extent.

The assessment of management effectiveness undertaken for the Outlook Report 2009 concluded there were relatively few incidents threatening the Reef's values relative to the large number of shipping movements in and through the area, and that invasive species were the highest risk with respect to shipping.

Statistics show there is a general upward trend in the number of pollution and vessel incidents reported.[28] (Note: While there is an upward trend in reported vessel incidents, the number of shipping incidents (i.e. for vessels greater than 50 metres in length) has fallen since the introduction of the Reef vessel tracking service.[29] *The most concerning issues with regards to shipping are the threat of oil, chemical and cargo releases, groundings and the introduction of invasive marine species. In addition, a greater range of hazardous substances (such as chemicals and liquefied natural gas) is now being shipped through the Reef.*

Since the release of the Outlook Report 2009 and in response to mining industry growth, there has been a significant increase in development proposals to expand all of Queensland's major trading ports. There are also several new port development proposals. Mining industry growth will result in the construction of new shipping berths, infrastructure development, dredging and a rise in shipping traffic through Reef waters. The extent to which this increase in ports and shipping activities will emerge as a threat to the health of the Reef will undoubtedly depend on how well these activities are managed by all stakeholders, industry and regulators.

Potential direct and indirect environmental impacts associated with shipping activities are understood by the Authority, although the cumulative impacts are less well known. A reasonable planning and legislative framework for managing shipping is in place. However, there are exceptions for threats posed by bio-fouling, ballast water discharges, containerised chemicals, noise, turbidity and light, antifouling biocide leaching, physical impacts from vessel groundings, response and rehabilitation of environment following grounding events, and increasing anchorage concerns (where the Authority has fewer measures in place).

The Great Barrier Reef Marine Park is one of the world's most regulated shipping areas. However, experience from the Shen Neng 1 grounding in 2010[30] *highlighted significant gaps in the Authority's ability to take action and rehabilitate following this incident. Agencies that manage shipping, including the Authority, need to address a major gap in the capacity to respond to non-oil spills with rapid clean up (for example, access to emergency funds sufficient to clean up in a timely and cost-effective manner).*

There is concern (from the independent assessors) *about resourcing levels given the increase in shipping movements. With the decline in funding for the Field Management Program, there is significant risk for appropriate preparedness and response times to a shipping incident.*

There is good stakeholder engagement with regular discussions about shipping issues at Local Marine Advisory Committee and Reef Advisory Committee meetings, with representatives from the shipping sector members on some of the committees. Regular meetings are held with the Queensland Ports Association. The Australian Maritime Safety Authority, the Authority and Maritime Safety Queensland work closely together to protect the marine environment from adverse consequences of shipping operations and provide for the safety of life of ship crews, passengers and other users of the Reef.

The Authority is working with other agencies to assess the effectiveness of current shipping safety measures to inform any additional measures needed to protect the value of the Reef. The Authority's plans for oil pollution response are well documented and managed. However, there continues to be an absence of clear measurable objectives and targets with respect to shipping, while progress on addressing other contaminants and marine pests remains slow.

Effectiveness of management tools as assessed by stakeholders

The Zoning Plan and compliance were seen as very or mostly effective by more than 50 per cent of respondents. The Great Barrier Reef Marine Park Act and Regulations, along with education and community awareness, were seen as least effective with 60 per cent of respondents regarding them as ineffective or only partially effective.

Collaboration with other authorities and arrangements for compulsory pilotage and designated shipping lanes are regarded as strengths of the Authority in management of shipping, while the capacity to address likely increases in shipping and potential impacts from marine pests were cited as weaknesses.

Workshop participants consistently raised management issues which are outside the Authority's jurisdiction, such as the need for improved pilotage, bilge and ballast water management, marine debris and other impacts from 'parked' ships, exclusion of other users in high shipping areas, and management response to groundings.

8.5.7 Defence activities

The Authority has a limited regulatory role in the management of defence activities within the Region. Defence activities and movements by the navy, air force and army occur throughout the Region. Three defence training areas are within the Great Barrier Reef: Shoalwater Bay, Cowley Beach and Halifax Bay. The Shoalwater Bay, Tully, High Range and Mt Stuart training areas also include significant catchment areas which drain into the Reef.

Table 8.17 Management effectiveness scores for defence activities

Defence activities		Effective	Mostly effective	Partially effective	Ineffective
Context					
Planning					
Inputs					
Processes					
Outputs					
Outcomes	Overall				
	Biodiversity				

The Defence Department is responsible for the conduct of training activities by the defence forces, including visiting overseas defence force members. This responsibility includes the management of the environmental impacts of those activities, subject to the application of zoning plans. The management of defence operations within the Great Barrier Reef Region therefore relies substantially on the environmental management standards of the Defence Department and the strength of the partnership agreement between this body and the Authority.[31] *The assessment for the Outlook Report 2009 concluded the limited area of operations and the high level of performance by the Defence Department in managing the environmental impacts means that defence activities pose minimal threats to Great Barrier Reef values.*

The Department of Defence has an environmental management strategy that includes objectives to implement best practice environmental management in its operations. In addition, a strategic environmental assessment for defence activities in the Great Barrier Reef World Heritage Area (the

Strategic Environmental Assessment)[32] *was developed by the Defence Department and the Authority, covering defence activities in the Great Barrier Reef World Heritage Area. This document clearly outlines the values of the Great Barrier Reef and adjacent areas, including matters of national environmental significance and the potential risks to these values. The assessment was developed in 2006 and is currently being updated.*

As noted in the Outlook Report 2009, defence activities are allowed under the Zoning Plan. Strategic documents, policies and regular meetings facilitate implementation of the management agreement and ensure a consistent approach with other management agencies. Specific defence resources are devoted to environmental management, while staff exchanges, secondments, patrols and systematic application of the Defence Heritage Toolkit help boost the department's expertise to manage defence activities and their potential impacts on Reef values.

Adequate biophysical information within defence training areas continues to be available for the Authority's management decisions. Navy hydrographic surveys improve knowledge of benthic habitats, ocean and weather conditions relevant to management. Surveys and studies about a range of ecological communities and species are undertaken. Local communities continue to be engaged in planning for specific exercises and routinely through Defence Environmental Advisory Committees.

Training exercises are thoroughly planned and include good performance monitoring, debriefs and post exercise monitoring. The identification of clear performance indicators, particularly those related to addressing cumulative impact issues, remains a challenge. The other challenge relates to the high level of reliance by the Authority on planning, assessment and performance monitoring work undertaken by the Defence Department. While Authority staff have an appropriate mix of skills to fulfil their statutory responsibilities for defence activities, the liaison and monitoring work is undertaken as a relatively low priority by a small number of Authority staff in competition with other core business. The skills required to assess defence activities are limited to a few core staff. An increase in training and sharing of corporate knowledge is essential to ensure this activity is effectively managed into the future.

A systematic approach generally ensures that statutory and planning timeframes are routinely met and results are reported by the Defence Department in a timely manner. The knowledge base for confident management of defence activities in the Great Barrier Reef, both within the Authority and in the wider community, continues to increase as a result of consultative meetings and reports documenting efforts to minimise environmental impacts, along with a lack of evidence of death or injury to species such as dugong and marine turtles.

Effectiveness of management tool as assessed by stakeholders

Insufficient responses were received to assess the effectiveness of management tools for defence activities.

8.5.8 Research activities

The Authority has a lead role in relation to the management of research activities (that is, access to the Marine Park to undertake research) within the Region. The Great Barrier Reef is known internationally as a premier site in which to conduct scientific studies. The majority of research occurs at the four major research stations at Lizard Island, Orpheus Island, One Tree Island and Heron Island. Diffuse research is conducted at other locations.

The Authority manages the impacts of research activities on Reef values, including extractive and observational research use, through a mix of management tools. As provided for in the Great Barrier Reef Marine Park Act and Regulations, permits for specific research projects and accreditation of partner research institutions are the principal means of managing the potential impacts from this activity. These mechanisms cross reference to the Zoning Plan and plans of management for specific geographic areas, as well as to specific policy documents on managing research and provisions for compliance and enforcement of permit conditions.

Table 8.18 Management effectiveness scores for research activities

Research activities		Effective	Mostly effective	Partially effective	Ineffective
Context		X			
Planning			X		
Inputs			X		
Processes			X		
Outputs			X		
Outcomes	Overall	X			
	Biodiversity	X			

The Authority's Scientific information needs for the management of the Great Barrier Reef Marine Park report[33] identifies key information needed to better inform management of the area. This document, along with partnership agreements with key research institutions, provides the basis for research alignments which should deliver valuable outcomes for improved management. The Authority is updating this document as a key input to the development of an integrated monitoring framework for the World Heritage Area.

The assessment of management effectiveness undertaken for the Outlook Report 2009 concluded that management of research in the Reef was moving towards desired outcomes, reducing risks and threats to Reef values. While research activities were generally considered to be environmentally sustainable, it was recognised there was a need to more effectively manage research through the implementation of a relational database designed to capture and manage permitted use. To date, this system (now renamed the Reef Management System) is still under development and unable to inform intended and actual research take through queries and reports. This limits the ability to manage cumulative use. This has been identified as an area requiring improvement and will be particularly valuable for the scientific research zones that surround research stations where research is heavily concentrated.

Further opportunity to improve the management of cumulative impacts has been identified through the development and implementation of environmental management plans for high use scientific research zones. In 2009, the development of these plans was judged to be slow, with only one plan completed and another two in draft form. While little progress has been made since then, other management arrangements are in place to assist with the effective management of these zones. For example, permit conditions require consultation and negotiation between researchers and research station staff regarding the location and timing of permitted research activities. Researchers are also required to submit reports detailing their collection throughout the permit duration.

Historically, research has been focused on biophysical systems but there has been more recent interest in socio-economic drivers. While more biophysical information is available upon which to address management of scientific research, there is limited traditional knowledge and socio-economic information is only slowly becoming available. Research proposals with the potential to impact Indigenous values are referred to the relevant Indigenous liaison staff for guidance. However, Traditional Owner participation in research within their sea country, and dissemination of research results to them, is limited (in contrast to their high level of interest in this area). Direct risks and threats to Reef values from specific research activities are recognised but potential cumulative impacts on the Region's values are unclear and warrant more focused attention. Ironically, the Reef's reputation as *one of the best managed reef systems in the world is likely to make it a preferred site for more research which could significantly add to the pressure on research sites.*

The Authority has very successful and effective relationships with the research community in relation to how scientific research is managed in the Great Barrier Reef. This is shown through the accreditation process and strong partnerships with research institutions. Co-accreditation arrangements are in place to ensure consistency between jurisdictions, while permits require stakeholder and local community engagement as necessary. Management staff have appropriate research skills and expertise to effectively manage research activities; however, resources available for the management of research activities are limited. Consequently there is limited capacity to contribute to the formulation of Regulations and policies associated with research or to develop environmental management plans for scientific research zones. The 2004 Policy on Managing Scientific Research in the Great Barrier Reef Marine Park[34] *needs to be reviewed and updated to reflect this focus on cumulative impacts. In addition, the limited impact and collection limits in the Regulations need to be revised to ensure the take limits are ecologically sustainable (for example, a researcher could collect five tiger sharks from one location under the current accreditation scheme).*

Uncertainties resulting from the limited understanding of potential cumulative impacts and limited attention to compliance with permit conditions make it impossible to state categorically that outcomes for management of research activities are being met and objectives are as clear and measurable as they need to be.

Research activities on the Reef are well regarded internationally and there are robust management processes and governance arrangements in place to manage research on the Reef. In general, research is not seen to have a large and detrimental impact on the Reef ecosystem. However, confidence that research is environmentally sustainable is reduced by the limited knowledge of cumulative impacts of collection undertaken for research. It will be important for an updated policy, coupled with information needs documentation, to set clear targets to guide the management of research of the next 25 years. Particular attention should be paid to addressing potential cumulative impacts in intensively researched areas.

Effectiveness of management tools as assessed by stakeholders

The Zoning Plan, partnerships, and education and community awareness were seen as the Authority's most effective management tools for scientific research. Compliance, policy, stewardship and permits were seen as ineffective or only partially effective.

The existing partnerships with research institutions are identified as a major strength. However, the limited research capability within the Authority itself is noted as a weakness and is attributed to the lack of long-term secure funding to support strategic research. The possibility of establishing a specialist board to guide research was raised by some respondents. The limited amount of compliance monitoring, especially on the cumulative impacts of research, is identified as a weakness, along with the need for better housekeeping and management of research sites.

8.6 Effectiveness of specific measures to address impacts

This section contains an assessment of the effectiveness of the Authority's current management arrangements to address impacts. It is structured around the relevant criteria in item 4.1.1 of the terms of reference for the strategic assessment (Appendix 2) which were also part of the assessment criteria for the independent review. The relevant criteria are:

a. [not applicable]
b. identify and analyse direct, indirect, consequential and cumulative impacts, including the methods used to determine these types of impacts
c. consider environmental, social, cultural and economic issues
d. avoid, mitigate, offset and adaptively manage impacts
e. address uncertainty and risk
f. provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be unacceptable
g. halt and reverse any declines and enhance the condition of the relevant matters of national environmental significance, including mechanisms to deliver a 'net benefit' to the condition of

the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area

h. adapt to reasonable climate change scenarios

i. integrate with related local, Queensland and Australian government programs to protect and manage the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area

j. meet Australia's international responsibilities in relation to the environment and protection of world heritage

k. monitor, evaluate and report on the:
   - i. [not applicable]
   - ii. impacts of activities, including the setting of targets, to benchmark management performance.

The grades were calculated by averaging the scores for each criterion across all management topics. A summary of the individual scores is provided in Appendix 1 to the full report of the independent assessment, available on the Authority's website. In order to understand the relative influence of impacts on values, a contextual understanding of the condition and trend of values is needed. The assessment considered the Authority's understanding of the current condition and trend of matters of national environmental significance (items (a) and (k)(i) above) for each management topic. This is discussed in Section 8.8. The summary below was reviewed and endorsed by the independent assessors.

8.6.1 Understanding impacts and considering issues

The independent assessment found the Authority has generally a good understanding of direct and indirect impacts associated with impacts of highest concern. Impacts are better understood where the Authority has greater jurisdictional responsibility, for example tourism, defence activities, and research activities. An understanding of the direct and indirect impacts of water quality, dredging and coastal development on the Region's values is improving within the Authority. An understanding of, and plans and processes to address cumulative use and impacts on outstanding universal value, was assessed as lacking across the Authority's entire management scheme.

The assessment outcomes in relation to understanding impacts are summarised in Table 8.19.

Table 8.19 Effectiveness of the Authority's management arrangements to understand impacts

Indicator	Grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
4.1.1(b) identify and analyse direct, indirect, consequential and cumulative impacts on relevant matters of national environmental significance, including the methods used to determine these types of impacts					
Direct and indirect impacts are understood by managers					Strengths: • Zoning Plan (for extractive activities) • Plans of management (for tourism and recreation) • Reef Plan • Policy documents (for example *Biodiversity Conservation Strategy*) • Research and monitoring (for example Outlook Report) Weaknesses: • Permits (case-by-case assessments and limited understanding of cumulative use) • Policy documents (for example, limits on acceptable use, cumulative impact assessment policy) • Research and monitoring (of cumulative impacts)
Consequential and cumulative impacts are understood by managers					

The Great Barrier Reef Marine Park Regulations explicitly require consideration of environmental, social, cultural and heritage values as part of every permit assessment for activities which occur within Great Barrier Reef Marine Park. However, the effectiveness of these permits assessments relies on the Authority's knowledge of these aspects in specific locations. The independent assessment found limitations in the Authority's understanding of Indigenous heritage, historic heritage and community benefits. It identified that further work is needed to maintain relationships with Traditional Owners, support co-management and develop a mutually agreed and culturally appropriate process for the integration of Indigenous knowledge into management. For a number of historic heritage matters, the assessors found there is insufficient understanding of their location, condition and trend and suggested that a database with spatial capacity would improve consideration of the potential impacts from proposed activities on heritage values in the Region. The consideration of community benefits were found to vary according to the understanding and perspective of the community. The independent assessors noted there is likely to be increasing conflict between economic benefits associated with port and coastal development and the aesthetic and recreational benefits. Currently, the Authority has no guidelines or benchmarks for assessing or managing community benefits derived from the Region or policies to guide the assessment of cumulative impacts.

Stakeholder engagement and application of biophysical information were identified as the strongest aspects of management across all management topics. Respondents (from stakeholder surveys) saw a need to extend the Authority's jurisdictional control over activities that impact on the values of the Marine Park, to improve compliance action and to increase the focus on partnerships between the Authority, local government and local industry. The assessment outcomes in relation to considering issues are summarised in Table 8.20.

Table 8.20 Effectiveness of the Authority's management arrangements to consider issues

Indicator	Grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
4.1.1(c) consider environmental, social, cultural and economic issues in its decision-making processes					
Engagement with stakeholders and local community		■			Strengths: • Act and Regulations (Regulations 88Q and 88R) • Partnerships (for example, Reef Advisory Committees, Local Marine Advisory Committees) Weaknesses: • Policy documents (for example, lack of integrated strategies and processes to address Indigenous heritage, lack of minimum requirements for public consultation) • Research and monitoring (traditional and social information)
Availability of information to enable consideration of issues:					
Biophysical		■			
Indigenous			■		
Social			■		
Local community and stakeholders effectively engaged in ongoing management		■			

8.6.2 Managing impacts

Assessors found that where the Authority has a high level of control over activities, its effectiveness at avoiding, mitigating and adaptively managing impacts was effective or mostly effective (for example, tourism, research activities, defence activities, recreation). Where the Authority has 'diffuse' or limited jurisdictional responsibility, its ability to avoid, mitigate and adaptively manage impacts was found to be only partially effective. The partially effective grade was found to be pronounced in areas of planning, process and outcomes and for activities occurring outside the Marine Park (for example, port activities, coastal development) and those occurring in the Marine Park, but not under the Authority's direct jurisdictional control (for example, commercial and recreational fishing).

An assessment of the effectiveness of the Authority's management in the south of the Great Barrier Reef around the Keppel Islands found a number of examples of planning that support the protection of the Keppel Bay area. This includes zoning plans, specific threat abatement plans with no-anchorage areas, declared fish habitat, and Reef Plan. However, it was identified that further work is required to develop a plan of management in this area to address increased use (Table 8.21).

On a Reef-wide scale, assessors found the Authority's Zoning Plan and the complementary plans for the adjacent Great Barrier Reef Coast Marine Park have made the most significant contribution to biodiversity protection. The Representative Areas Program (1999–2004)[35] involved a systematic planning and consultative program to develop new zoning for the Marine Park. The outcomes resulted in the protection of at least 20 per cent of every bioregion, leading to the protection of 'representative' examples of all different habitat types, reducing risks to the Marine Park. This process also maximised the benefits and minimised the negative impacts of the rezoning on the existing users of the Marine Park, addressing uncertainty for extractive uses in particular. The Zoning Plan has been in operation since 1 July 2004. However, the zoning provisions only address biodiversity protection from direct extractive uses, particularly fishing, and do not address uncertainty for a range of other activities (for example, where some development can and cannot occur).

Across the Authority's entire management scheme an understanding of, and plans and processes to address cumulative use and impacts on *outstanding universal value* was assessed as lacking".

The assessors noted that recent changes by the Queensland Government to the state's coastal planning provisions potentially has significant implications for the Great Barrier Reef Region because it removes many of the specific requirements placed on local government and potential developers to undertake best practice and to minimise environmental harm. These changes potentially reduce the capacity of management agencies, like the Authority, to impose requirements to avoid, minimise or mitigate impacts from coastal development activities on the Reef, its ecosystems and species.

In addition, the complex jurisdictional environment within which ports operate, combined with the lack of Authority policy documents for ports, was found to reduce the capacity to effectively avoid, mitigate, offset and adaptively manage the impacts from port activities on the Region's values. Given the positive results of Reef Plan, the independent assessors suggested an extension of this arrangement may be needed for other activities.

The assessment outcomes in relation to managing impacts are summarised in Table 8.21.

Table 8.21 Effectiveness of the Authority's management arrangements to manage impacts

Indicator	Grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
4.1.1(d) avoid, mitigate, offset and adaptively manage impacts from activities					
Direct and indirect impacts are appropriately considered					Strengths: • *Climate Change Adaptation Strategy and Action Plan* (both 2007–2012 and 2012–2017) • Permits (for example, for tourism and research activities) • Partnerships (defence activities, High Standard Tourism program) Weaknesses: • Plans of management (for example, consistency across jurisdictions and need for development of new plans in growth areas) • Policy documents (for example, cumulative impact management, net environmental benefits and offsets policies)
Consequential and cumulative impacts are appropriately considered					
Management is effectively addressing impacts and moving toward attainment of desired outcomes (NOTE: an ineffective rating was given to climate change)					
Use of the Great Barrier Reef is demonstrably environmentally sustainable (NOTE: Ineffective rating given with regard to climate change)					

8.6.3 Providing certainty

One of the key desired outcomes of the strategic assessment process is to guide management of the Great Barrier Reef by providing greater certainty on where sustainable uses can occur, the type of activities that will be allowed and the conditions under which activities may proceed. The assessors found that, in accordance with the Act, the Authority continues to place primary emphasis on the long-term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region. The Authority allows ecologically sustainable use, so far as this is consistent with the Region's protection and conservation.

The independent assessment found zoning provides a high level of certainty for extractive activities. However, zoning does not provide explicit guidance on where many activities not directly regulated by the Zoning Plan can be carried out. The assessors considered that greater certainty and coordinated planning and approval processes are required by Commonwealth and Queensland jurisdictions to inform where and how ports can operate within and adjacent to the Region. In addition, they considered the diffuse nature of recreation and lack of permit control mean plans of management and site planning arrangements do not currently provide a high level of certainty regarding where uses may occur and where impacts are likely to be acceptable.

The Authority's plans of management were assessed as effective tools to manage activities in specific areas. The current plans are predominantly designed to address tourism and recreation in areas that were, and continue to be, high use areas. The assessors noted these plans have not been updated for some time and do not account for the full range of direct uses. In addition, emerging high use areas (for example, offshore Townsville and Rockhampton) have no plans of management in place to address uncertainty and increasing multiple uses.

The assessment outcomes in relation to providing certainty are summarised in Table 8.22.

Table 8.22 Effectiveness of the Authority's management arrangements to provide certainty

Indicator	Grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
4.1.1(e) address uncertainty and risk					
There is a planning system in place that effectively addresses the management topic					Strengths: • Zoning Plan • Plans of management (for tourism and recreation) • Policy documents (for example, environmental impact management policy) Weaknesses: • Plans of management (require updating and new plans needed in growth areas) • Policy documents (for example, limits on acceptable use, cumulative impact assessment policy)
The outputs are reducing the major risks and the threats to the Great Barrier Reef (NOTE: An ineffective rating was given to climate change)					
4.1.1(f) provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be unacceptable					
Plans provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be acceptable.					Strengths: • Zoning Plan • Plans of management Weaknesses: • Plans of management (require updating and new plans needed in growth areas) • Policy documents (for example, limits on acceptable use)

The level of certainty provided to activities in the Region through the current management arrangements varies according to the activity. The levels of certainty provided for the major activities are summarised in Table 8.23 and detailed in Figure 8.2 to Figure 8.10. There is a high degree of certainty for many activities in many areas, including tourism, fishing, research activities, shipping, recreation and defence activities. Using tourism as an example, certainty is provided through a range of management tools, including the Zoning Plan, plans of management and permits (Figure 8.2).

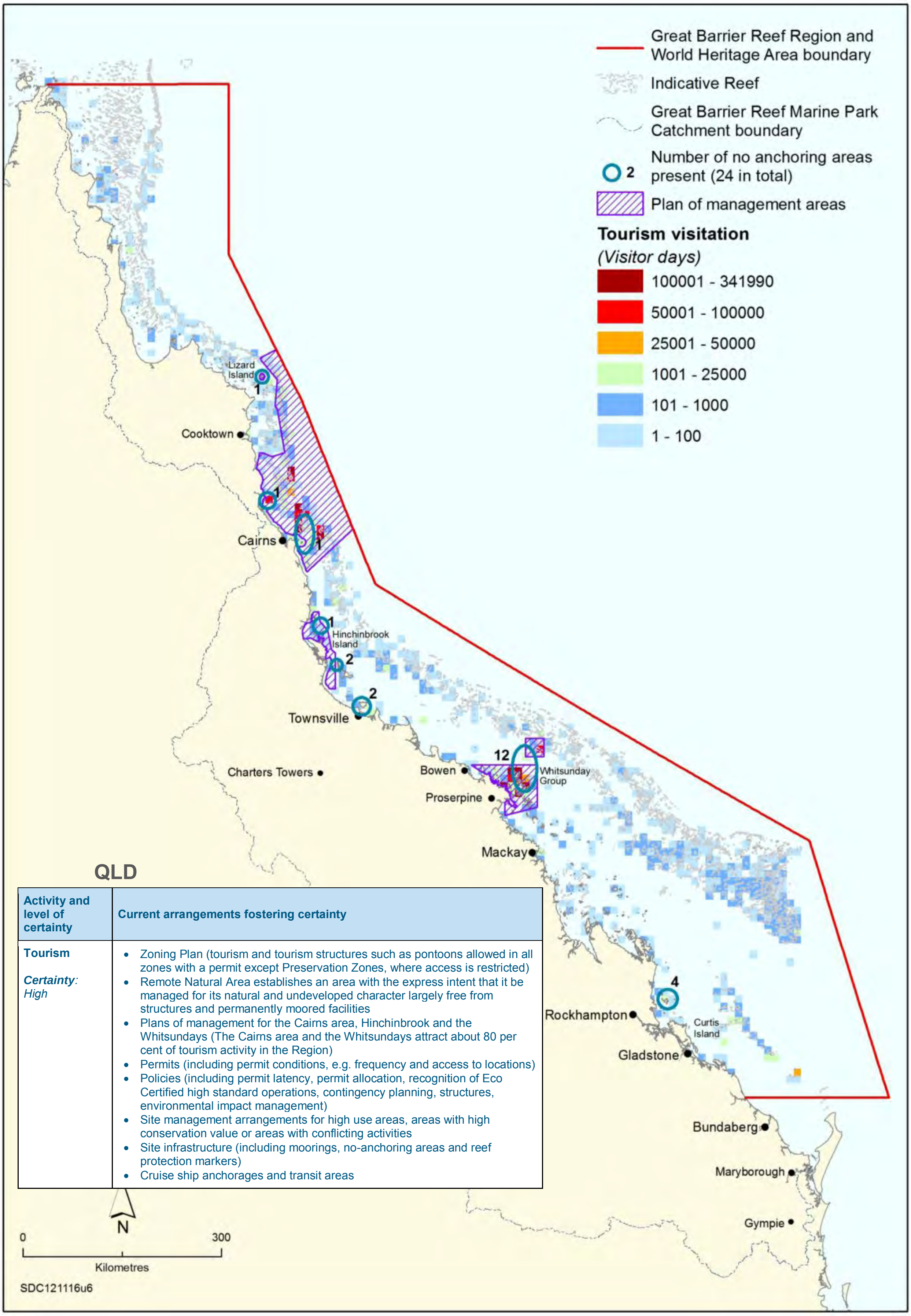
Table 8.23 Summary of management certainty provided for activities that occur in the Region

Activity	Level of certainty
Traditional use	Medium
Tourism	High
Fishing and collecting	High
Recreation	Medium
Ports	Low
Shipping	High
Defence activities	High
Research activities	High

For shipping, a Designated Shipping Area (defined in the Zoning Plan), compulsory pilotage areas and designated ship anchorages (adjacent to some ports) provide spatial certainty for shipping activities in the Region. Additional management tools, including permits for barging of bulk fuel, sea dumping permits and the Vessel Traffic Service (managed by the Australian Maritime Safety Authority), set requirements for ship operations and reporting.

The Authority's current management arrangements for the operation of ports provide a low level of certainty (Figure 8.10), principally because many are located outside its jurisdiction. The Marine Park boundary provides a degree of certainty — 10 port areas are outside the Marine Park and two minor ports are within it. Where ports occur in the Marine Park, the provision of clear environmental permit conditions provides certainty for the implementation of port developments. An improved understanding of cumulative impacts and development of guidelines to assess the effects of multiple impacts will increase certainty for the ecological system, as well as increasing certainty for adjacent and overlapping uses.

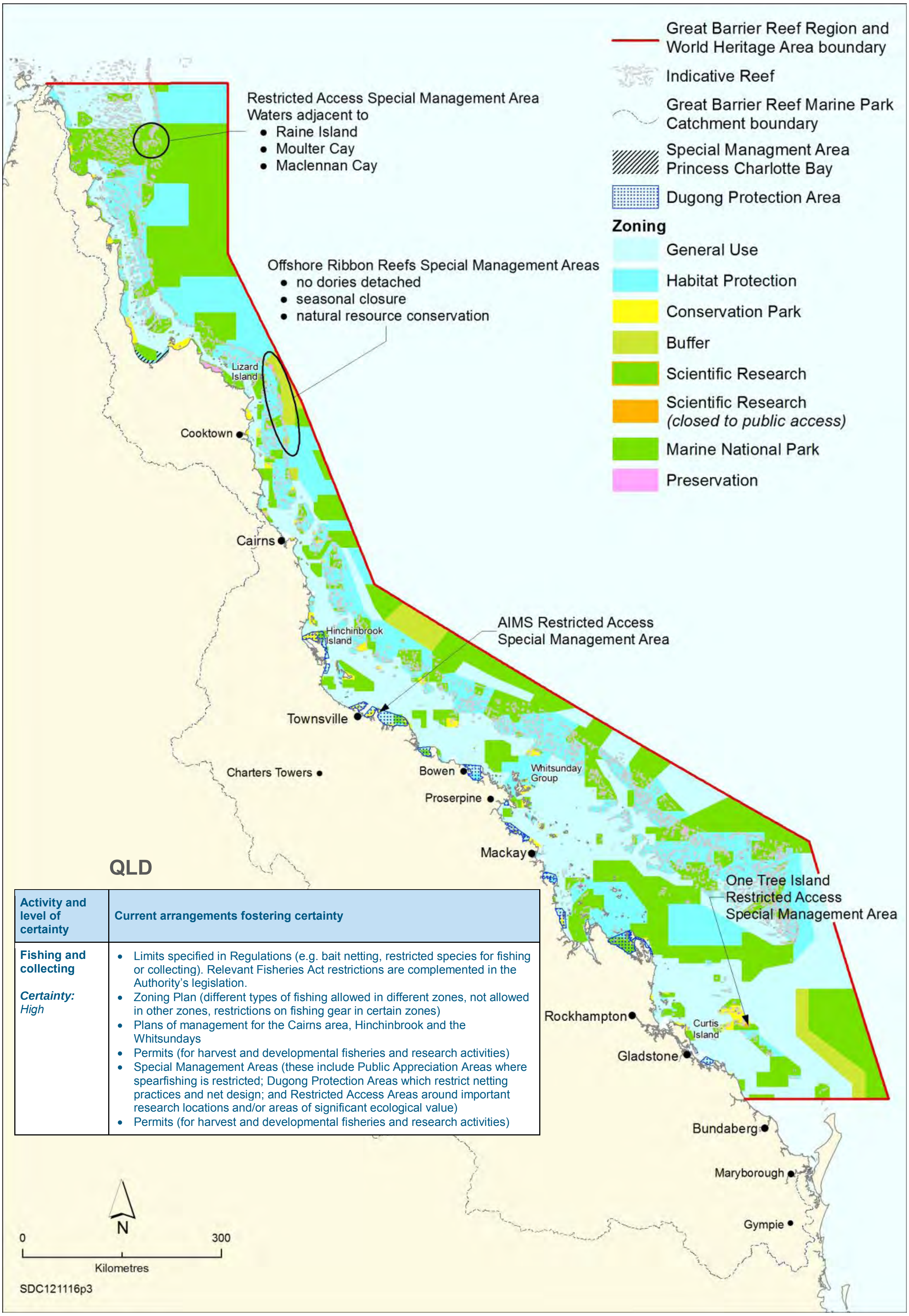
The independent assessment recognised that certainty for particular activities can never be absolute when operating in a changing natural environment about which understanding is continually improving and society's expectations are evolving. The spatial scale over which different activities operate is not uniform and neither are the multiple uses in any one location. Providing certainty will always depend to some extent on relevant considerations at the time. For Reef-dependent activities, certainty is strongly linked to the status of the environment, for example the connection between a healthy Reef and a healthy tourism industry. In addition, the assessors noted management of the Region needs to take into consideration the potential for actions arising from one activity affecting other activities in an area, either by affecting the activity directly or by altering the state of the ecological system on which it depends. They also recognised that industries and other users require flexibility in management arrangements to allow scope for adaptation to new technologies, changing market demand and changing environmental conditions.



Activity and level of certainty	Current arrangements fostering certainty
Tourism ***Certainty**: High*	• Zoning Plan (tourism and tourism structures such as pontoons allowed in all zones with a permit except Preservation Zones, where access is restricted) • Remote Natural Area establishes an area with the express intent that it be managed for its natural and undeveloped character largely free from structures and permanently moored facilities • Plans of management for the Cairns area, Hinchinbrook and the Whitsundays (The Cairns area and the Whitsundays attract about 80 per cent of tourism activity in the Region) • Permits (including permit conditions, e.g. frequency and access to locations) • Policies (including permit latency, permit allocation, recognition of Eco Certified high standard operations, contingency planning, structures, environmental impact management) • Site management arrangements for high use areas, areas with high conservation value or areas with conflicting activities • Site infrastructure (including moorings, no-anchoring areas and reef protection markers) • Cruise ship anchorages and transit areas

Figure 8.2 Certainty provided for tourism activities by the Authority's management arrangements

Plans of management and site management, in combination with other management arrangements, provide certainty about how tourism can be undertaken, especially in the most frequently used areas.



Activity and level of certainty	Current arrangements fostering certainty
Fishing and collecting *Certainty: High*	• Limits specified in Regulations (e.g. bait netting, restricted species for fishing or collecting). Relevant Fisheries Act restrictions are complemented in the Authority's legislation. • Zoning Plan (different types of fishing allowed in different zones, not allowed in other zones, restrictions on fishing gear in certain zones) • Plans of management for the Cairns area, Hinchinbrook and the Whitsundays • Permits (for harvest and developmental fisheries and research activities) • Special Management Areas (these include Public Appreciation Areas where spearfishing is restricted; Dugong Protection Areas which restrict netting practices and net design; and Restricted Access Areas around important research locations and/or areas of significant ecological value) • Permits (for harvest and developmental fisheries and research activities)

Figure 8.3 Certainty provided for fishing and collecting activities by the Authority's management arrangements

Zoning and Special Management Areas, in combination with other management arrangements, provide certainty about how fishing and collecting can be undertaken. The activities allowed in each zone, are set out in the activities guide (Figure 8.4).

ACTIVITIES GUIDE

(see relevant *Zoning Plans* and *Regulations* for details)

	General Use Zone	Habitat Protection Zone	Conservation Park Zone	Buffer Zone	Scientific Research Zone [2]	Marine National Park Zone	Preservation Zone
Aquaculture	Permit	Permit	Permit [1]	✗	✗	✗	✗
Bait netting	✓	✓	✓	✗	✗	✗	✗
Boating, diving, photography	✓	✓	✓	✓	✓ [2]	✓	✗
Crabbing (trapping)	✓	✓	✓ [3]	✗	✗	✗	✗
Harvest fishing for aquarium fish, coral and beachworm	Permit	Permit	Permit [1]	✗	✗	✗	✗
Harvest fishing for sea cucumber, trochus, tropical rock lobster	Permit	Permit	✗	✗	✗	✗	✗
Limited collecting	✓ [4]	✓ [4]	✓ [4]	✗	✗	✗	✗
Limited spearfishing (snorkel only)	✓	✓	✓ [1]	✗	✗	✗	✗
Line fishing	✓ [5]	✓ [5]	✓ [6]	✗	✗	✗	✗
Netting (other than bait netting)	✓	✓	✗	✗	✗	✗	✗
Research (other than limited impact research)	Permit	Permit	Permit	Permit	Permit	Permit	Permit
Shipping (other than in a designated shipping area)	✓	Permit	Permit	Permit	Permit	Permit	✗
Tourism programme	Permit	Permit	Permit	Permit	Permit	Permit	✗
Traditional use of marine resources	✓ [7]	✓ [7]	✓ [7]	✓ [7]	✓ [7]	✓ [7]	✗
Trawling	✓	✗	✗	✗	✗	✗	✗
Trolling	✓ [5]	✓ [5]	✓ [5]	✓ [5,8]	✗	✗	✗

PLEASE NOTE: This guide provides an introduction to Zoning in the Great Barrier Reef Marine Parks.

1. Restrictions apply to aquaculture, spearfishing and harvest fishing for aquarium fish, beachworm and coral in the Conservation Park Zone.
2. Except for One Tree Island Reef (SR-23-2010) and Australian Institute of Marine Science (SR-19-2008) which are closed to public access and shown as orange, all other Scientific Research Zones are shown as green with an orange outline.
3. Limited to 4 catch apparatus per person (eg. crab pots, collapsible traps or dillies).
4. By hand or hand-held implement and generally no more than 5 of a species.
5. Maximum of 3 lines/rods per person with a combined total of 6 hooks per person.
6. Limited to 1 line/rod per person and 1 hook per line. Only 1 dory detached from a commercial fishing vessel.
7. Apart from traditional use of marine resources in accordance with s.211 of the *Native Title Act 1993*, an accredited Traditional Use of Marine Resources Agreement or permit is required.
8. Pelagic species only. Seasonal Closures apply to some Buffer Zones.

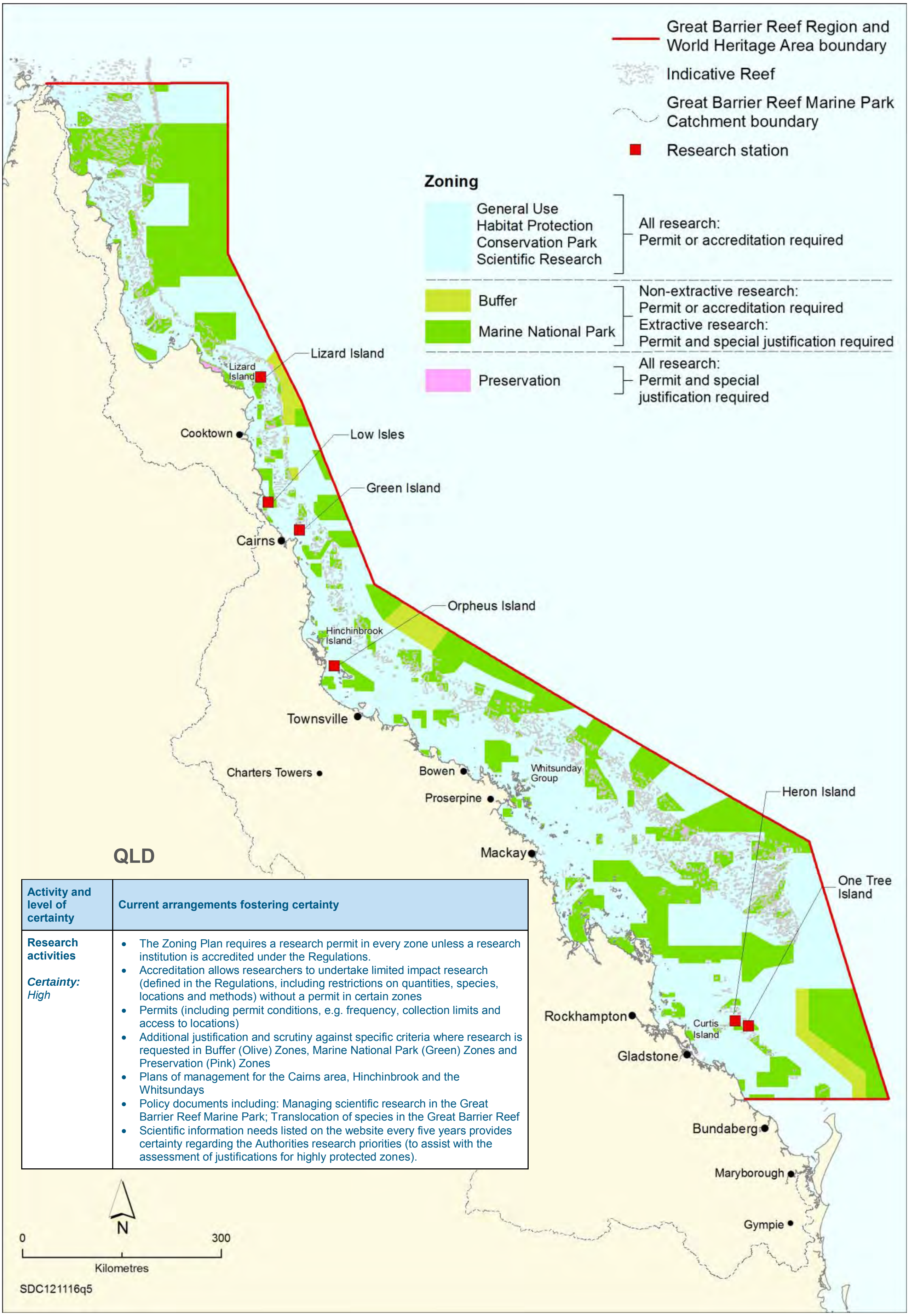
Detailed information is contained in the *Great Barrier Reef Marine Park Zoning Plan 2003* and *Regulations* and the *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004.*

- Permits are required for most other activities not listed above.
- Commonwealth owned islands in the Great Barrier Reef Marine Park are zoned "Commonwealth Islands Zone" - shown as cream.
- All Commonwealth Islands may not be shown.
- Special Management Areas may provide additional restrictions at some locations.
- The Zoning Plan does not affect the operation of s.211 of the *Native Title Act 1993.*

ACCESS TO ALL ZONES IS PERMITTED IN AN EMERGENCY.

Figure 8.4 Activities guide — an indication of what can be done in each zone

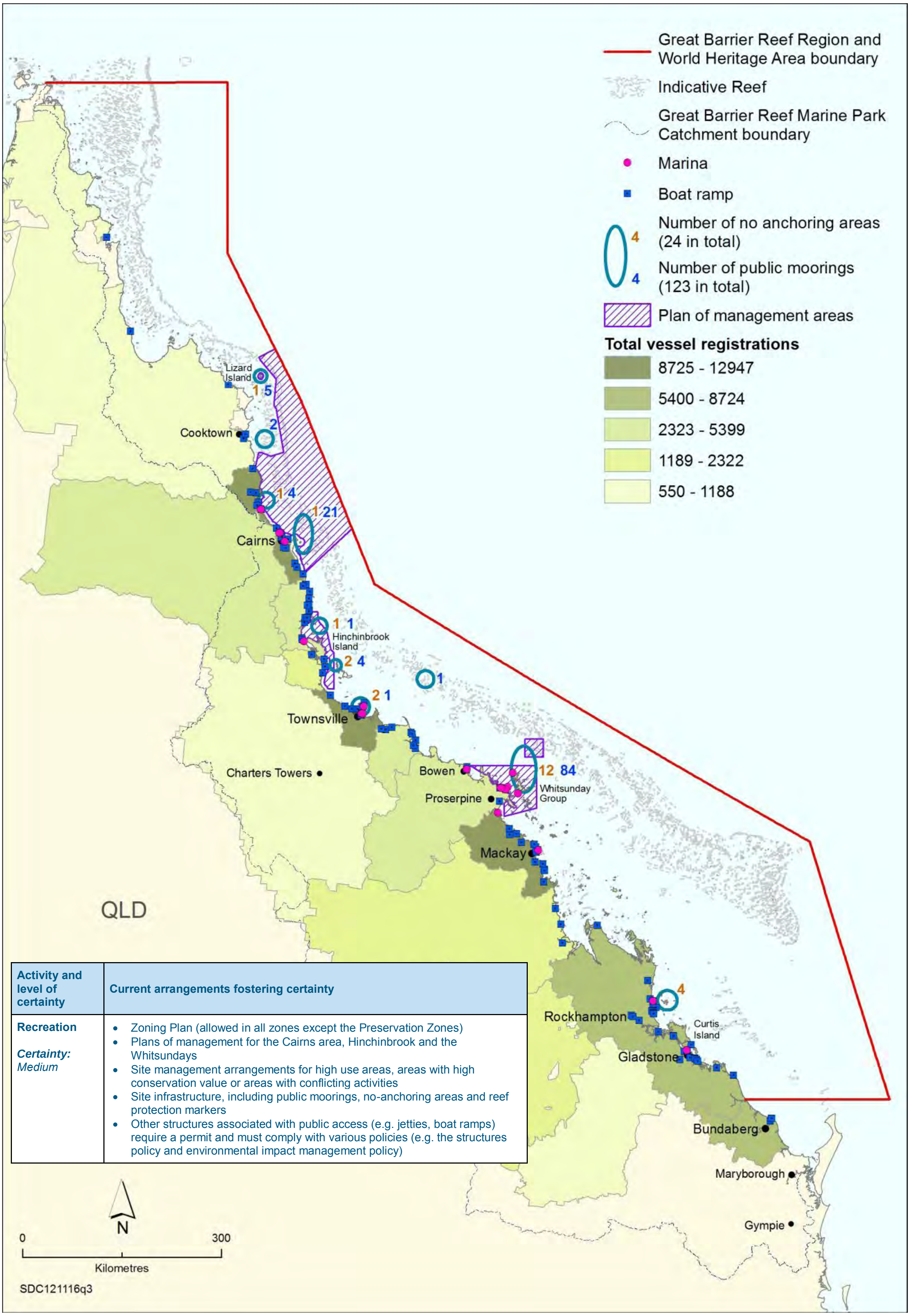
The activities guide appears on all zoning maps and provides introductory guidance as to what activities can occur in each zone and under what conditions (for example, maximum of three lines or rods per person with a combined total of six hooks per person when trolling in General Use and Habitat Protection zones).



Activity and level of certainty	Current arrangements fostering certainty
Research activities ***Certainty:*** *High*	• The Zoning Plan requires a research permit in every zone unless a research institution is accredited under the Regulations. • Accreditation allows researchers to undertake limited impact research (defined in the Regulations, including restrictions on quantities, species, locations and methods) without a permit in certain zones • Permits (including permit conditions, e.g. frequency, collection limits and access to locations) • Additional justification and scrutiny against specific criteria where research is requested in Buffer (Olive) Zones, Marine National Park (Green) Zones and Preservation (Pink) Zones • Plans of management for the Cairns area, Hinchinbrook and the Whitsundays • Policy documents including: Managing scientific research in the Great Barrier Reef Marine Park; Translocation of species in the Great Barrier Reef • Scientific information needs listed on the website every five years provides certainty regarding the Authorities research priorities (to assist with the assessment of justifications for highly protected zones).

Figure 8.5 Certainty provided for research activities by the Authority's management arrangements

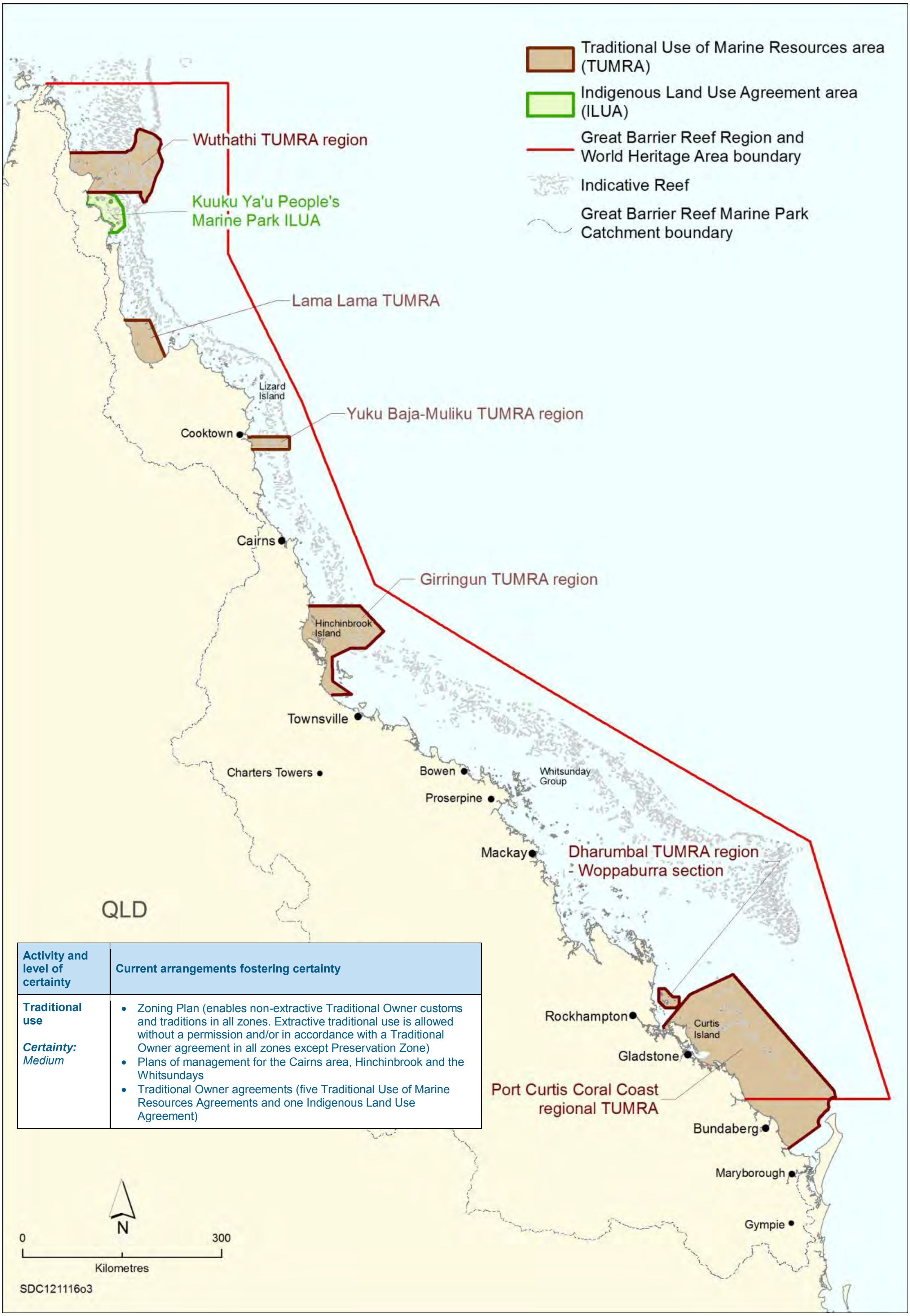
Zoning, accreditation and permits, in combination with other management arrangements, provide certainty about how research activities can be undertaken.



Activity and level of certainty	Current arrangements fostering certainty
Recreation ***Certainty:*** *Medium*	• Zoning Plan (allowed in all zones except the Preservation Zones) • Plans of management for the Cairns area, Hinchinbrook and the Whitsundays • Site management arrangements for high use areas, areas with high conservation value or areas with conflicting activities • Site infrastructure, including public moorings, no-anchoring areas and reef protection markers • Other structures associated with public access (e.g. jetties, boat ramps) require a permit and must comply with various policies (e.g. the structures policy and environmental impact management policy)

Figure 8.6 Certainty provided for recreation activities by the Authority's management arrangements

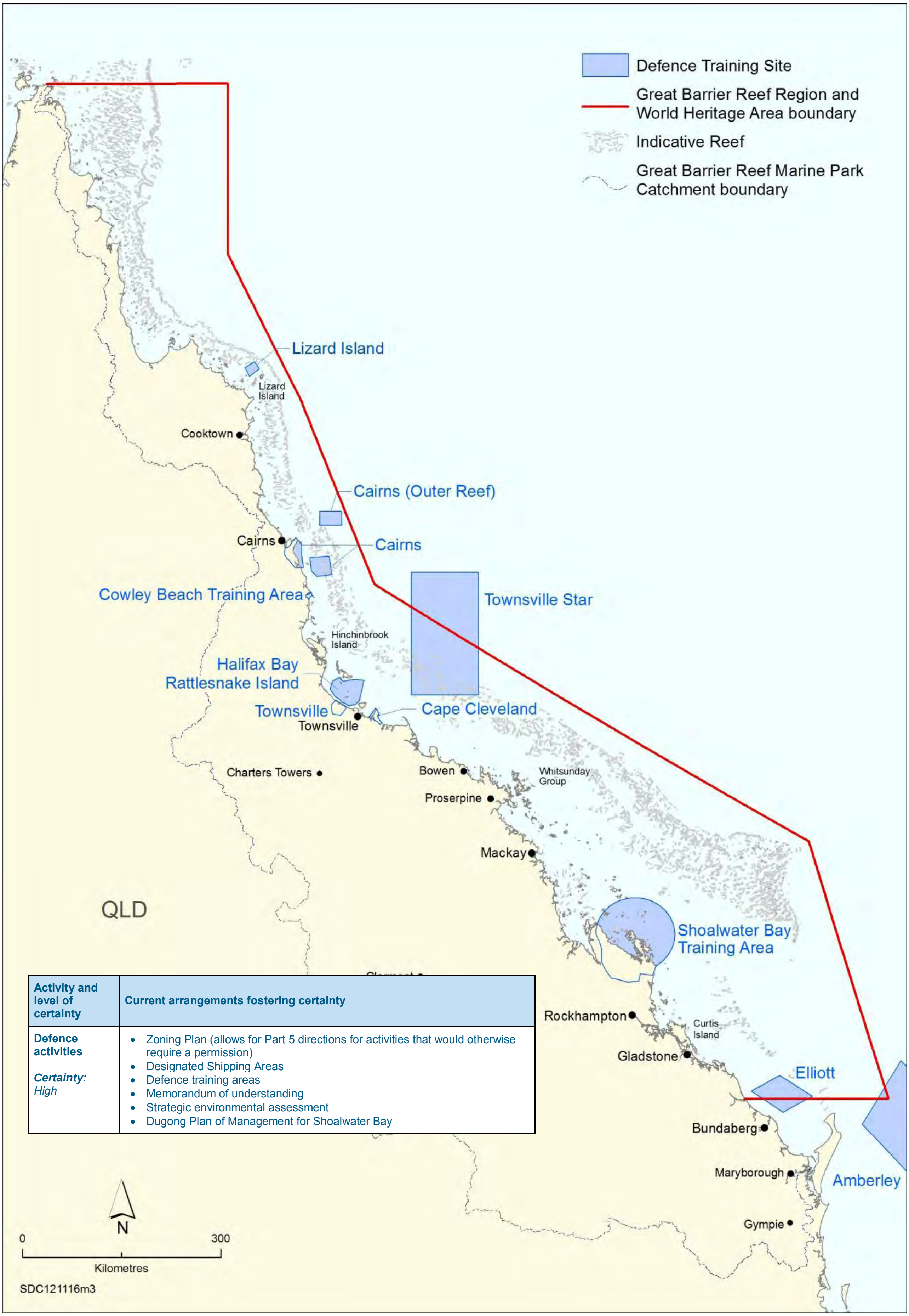
Plans of management, public moorings and no-anchoring areas, in combination with other management arrangements, provide certainty about how recreation activities other than fishing can be undertaken.



Activity and level of certainty	Current arrangements fostering certainty
Traditional use ***Certainty:*** *Medium*	• Zoning Plan (enables non-extractive Traditional Owner customs and traditions in all zones. Extractive traditional use is allowed without a permission and/or in accordance with a Traditional Owner agreement in all zones except Preservation Zone) • Plans of management for the Cairns area, Hinchinbrook and the Whitsundays • Traditional Owner agreements (five Traditional Use of Marine Resources Agreements and one Indigenous Land Use Agreement)

Figure 8.7 Certainty provided for traditional use by the Authority's management arrangements

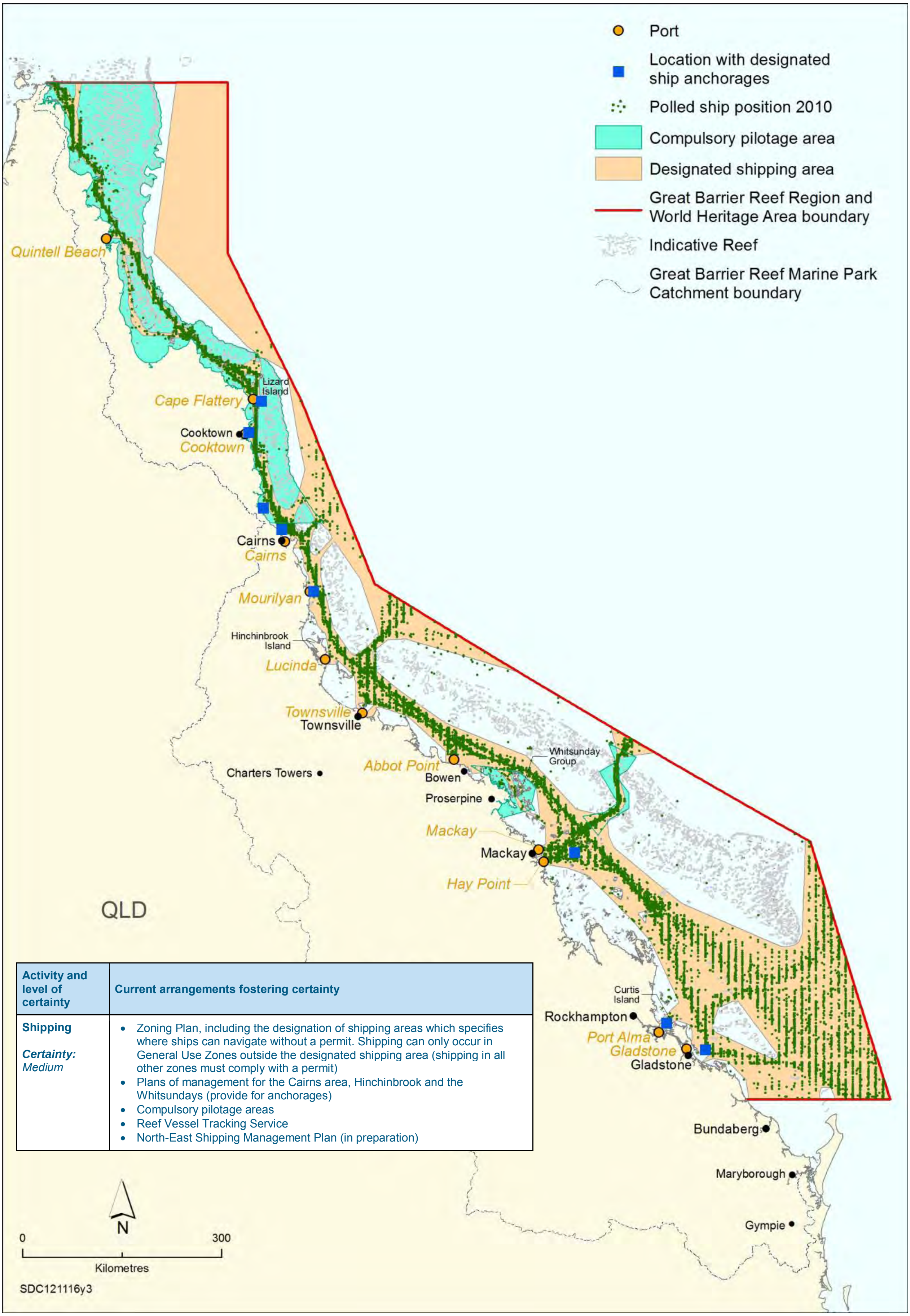
Traditional Use of Marine Resources Agreements and Indigenous Land Use Agreements, in combination with other management arrangements, provide certainty for Traditional Owners and opportunities for co-management of sea country.



Activity and level of certainty	Current arrangements fostering certainty
Defence activities ***Certainty:*** *High*	• Zoning Plan (allows for Part 5 directions for activities that would otherwise require a permission) • Designated Shipping Areas • Defence training areas • Memorandum of understanding • Strategic environmental assessment • Dugong Plan of Management for Shoalwater Bay

Figure 8.8 Certainty provided for defence activities by the Authority's management arrangements

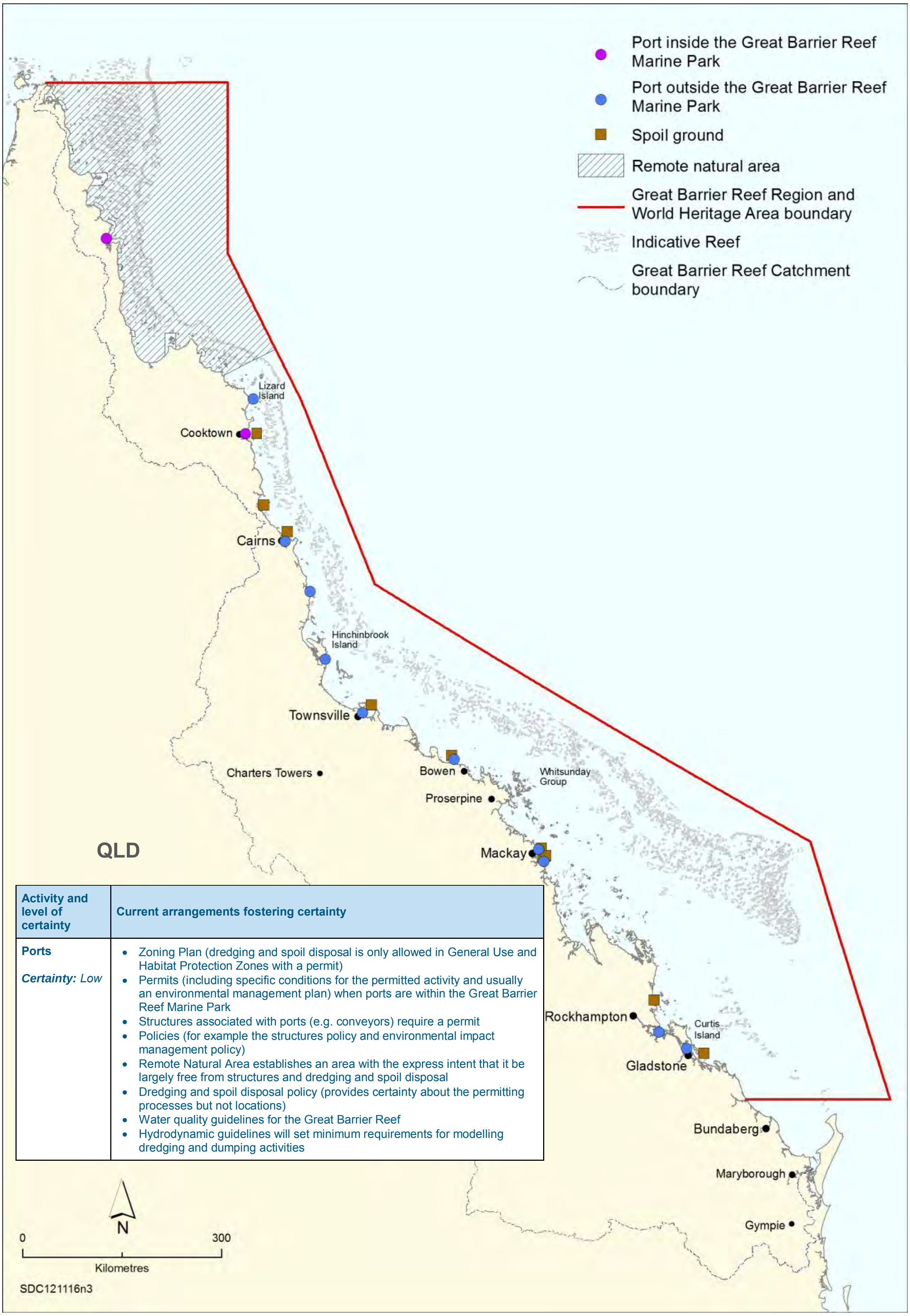
Designated defence training areas, in combination with other management arrangements, provide greater certainty about the conduct of defence activities in the Region.



Activity and level of certainty	Current arrangements fostering certainty
Shipping ***Certainty:*** *Medium*	• Zoning Plan, including the designation of shipping areas which specifies where ships can navigate without a permit. Shipping can only occur in General Use Zones outside the designated shipping area (shipping in all other zones must comply with a permit) • Plans of management for the Cairns area, Hinchinbrook and the Whitsundays (provide for anchorages) • Compulsory pilotage areas • Reef Vessel Tracking Service • North-East Shipping Management Plan (in preparation)

Figure 8.9 Certainty provided for shipping activities by the Authority's management arrangements

Shipping traffic is confined to Designated Shipping Areas in the Region. Compulsory pilotage and other measures increase navigational safety and reduce the risk of ship groundings. Ship anchorages are designated by Maritime Safety Queensland.



Activity and level of certainty	Current arrangements fostering certainty
Ports ***Certainty:*** *Low*	• Zoning Plan (dredging and spoil disposal is only allowed in General Use and Habitat Protection Zones with a permit) • Permits (including specific conditions for the permitted activity and usually an environmental management plan) when ports are within the Great Barrier Reef Marine Park • Structures associated with ports (e.g. conveyors) require a permit • Policies (for example the structures policy and environmental impact management policy) • Remote Natural Area establishes an area with the express intent that it be largely free from structures and dredging and spoil disposal • Dredging and spoil disposal policy (provides certainty about the permitting processes but not locations) • Water quality guidelines for the Great Barrier Reef • Hydrodynamic guidelines will set minimum requirements for modelling dredging and dumping activities

Figure 8.10 Certainty provided for port operations by the Authority's management arrangements

Only two ports are located within the Marine Park. A Remote Natural Area is designated in the north of the Marine Park to ensure the area is recognised and managed for its natural and undeveloped character, free from structures, and to restrict activities such as dredging.

8.6.4 Halt and reverse declines

In order to halt and reverse declines and enhance the condition of relevant matters of national environmental significance, the assessors considered that greater traction in threat reduction is needed. Improved threat reduction is, in turn, dependent on the adoption of significant changes to current policies regarding coastal development, resource use, control of other activities and sufficient resourcing to implement threat reduction programs in the field (for example, compliance and wider field management programs). The Authority's strengths in relation to halting and reversing declines was ensuring the Zoning Plan was complied with, and existing plans of management were fully implemented. For the Reef to be environmentally sustainable, illegal activities need to be identified and effectively controlled. The assessors highlighted that the Authority has additional work to do in updating existing and implementing new plans in areas that require them and developing policies that would lead to net conservation benefits.

An ineffective rating for the achievement of biodiversity outcomes was assigned to the Authority's management of climate change and extreme weather. The assessors indicated that despite significant progress in building the ecological resilience of the Reef, and the social and economic resilience of Reef industries, the Authority's work alone is currently ineffective at reducing the impacts of climate change and extreme weather. The future effectiveness of the Authority's work is dependent on successful global efforts to mitigate climate change. Recent information suggests that, so far, these are not sufficient to maintain conditions compatible with coral-dominated reef habitats in the Region.

The assessment outcomes in relation to halting and reversing declines are summarised in Table 8.24.

Table 8.24 Effectiveness of the Authority's management arrangements to halt and reverse declines

Indicator	Grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
4.1.1(g) halt and reverse any declines and enhance the condition of the relevant matters of national environmental significance, including mechanisms to deliver a 'net benefit' to the condition of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area					
Management is effectively addressing impacts and moving toward attainment of desired outcomes					Strengths: • Zoning Plan • Plans of management Weaknesses: • Plans of management (require updating and new plans in areas that need them). • Policy documents (to deliver net environmental benefits)
The outputs are on track to ensure the values of the Great Barrier Reef are protected (NOTE: Ineffective rating given with regard to climate change)					

8.6.5 Adapting to climate change

Despite significant progress in building the ecological resilience of the Reef, and the social and economic resilience of Reef industries, the assessors reported that the Authority's work cannot make the Region and its industries invulnerable to the impacts of climate change and extreme weather. The outlook for the Reef is poor, and addressing climate change is a local, national and global challenge. The integration of climate change throughout the Authority's core business was found to be largely occurring by building the capacity of external groups to respond to the implications of climate change. They highlighted that through the action plan, the concepts of risk and resilience have been cemented and have strongly influenced the Authority's *Strategic Plan*.

The assessment outcomes in relation to adapting to climate change are summarised in Table 8.25.

Table 8.25 Effectiveness of the Authority's management arrangements to adapt to climate change

Indicator	Grade: Effective	Grade: Mostly effective	Grade: Partially effective	Grade: Ineffective	Management tools
4.1.1(h) adapt to reasonable climate change scenarios					
The planning system for climate change and extreme weather addresses the major pressures and drivers impacting on the Great Barrier Reef's values					Strengths: • Policy documents (for example, *Climate Change Adaptation Strategy and Action Plan 2012–2017*) • Partnerships (Reef Rescue Land and Sea Country Indigenous Partnerships Program, *Climate Change Action Strategy* (tourism)) Weaknesses: • Policy documents (a number require updates to more explicitly integrate climate change and net conservation benefits policy)
Actions for implementation regarding climate change and extreme weather are clearly identified within the plan					
Clear, measurable and appropriate objectives for management of climate change and extreme weather have been documented					
The relevant managing agencies have developed effective partnerships with local communities and/or stakeholders to address climate change and extreme weather					

8.6.6 Integrating with government programs

The assessors noted that under the Great Barrier Reef Intergovernmental Agreement, the Authority and the Queensland Parks and Wildlife Service have effective joint permit arrangements which streamline management, improve certainty and provide consistency. They noted that this integration works extremely well. However, they highlighted management effectiveness challenges for those broadscale issues which are complex socially, biophysically and jurisdictionally. Some inconsistencies in planning systems remain on management of wastewater generated outside the Region (for example, in creeks or from the mainland). This has downstream effects on the Region. For agricultural activities, the assessors considered that Reef Plan, and the Authority's role in that plan, provides an effective, integrated approach to water quality improvement. However, the impact of changes to Queensland's Coastal Plan on downstream effects from land-based water quality is not known at this stage.

The assessment outcomes in relation to integrating with government programs are summarised in Table 8.26.

Table 8.26 Effectiveness of the Authority's management arrangements to integrate with government programs

Indicator	Grade: Effective	Grade: Mostly effective	Grade: Partially effective	Grade: Ineffective	Management tools
4.1.1(i) integrate with related local, Queensland and Australian government programs to protect and manage the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area					
There is consistency across jurisdictions when planning for relevant management topics					Strengths: • Partnerships (for example, Great Barrier Reef Intergovernmental Agreement • Compliance (joint Field Management Program) • Permits (joint permits with the Queensland Government) Weaknesses: • Management plans • Act and Regulations • Partnerships
There is a sound governance system in place to address protection and management of management topics					
Management of management topics are consistently implemented across the relevant jurisdictions					

8.6.7 Meeting Australia's international obligations

The Great Barrier Reef Marine Park Act and associated Regulations provide some legislative power to contribute to the protection of the world heritage property. The Authority has an advisory role to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities, which has a statutory responsibility to protect the Great Barrier Reef World Heritage Area. Risks and threats to the World Heritage Area have been more explicitly addressed in new periodic reporting processes for world heritage sites to which the Authority contributes.

The Authority's partnerships and planning across jurisdictions are not yet fully integrated to deliver desired outcomes for the World Heritage Area. In particular, the attainment of desired outcomes is weak for climate change and coastal development. Some inconsistencies across the planning systems of different jurisdictions remain in relation to management of wastewater generated outside the Region (for example, in creeks or from the mainland). This has downstream effects on the Region. The Authority's permit process is mostly effective at considering potential impacts to heritage. However, a reduction in educational opportunities (such as stopping the Authority's reef discovery training program) has led to a decline in the delivery of education on world heritage values and the Authority's obligations regarding the presentation of these values.

The assessment outcomes in relation to meeting Australia's international obligations are summarised in Table 8.27.

Table 8.27 Effectiveness of the Authority's management arrangements to meet Australia's international obligations

Indicator	Grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
4.1.1(j) meet Australia's international responsibilities in relation to the environment and protection of world heritage					
Relevant standards are identified and being met					Strengths: • Act and Regulations • Zoning Plan • Permits • Compliance • Partnerships (for example Intergovernmental Agreement) • Research and monitoring (for example, Outlook Report, world heritage periodic reporting) Weaknesses: • Management plans (integration and alignment across jurisdictions) • Partnerships (integration and alignment across jurisdictions) • Education and community awareness (world heritage and outstanding universal value)
Management is effectively addressing impacts and moving toward attainment of desired outcomes					
The outputs are on track to ensure the values of the Great Barrier Reef are protected					
The outputs are reducing the major risks and threats					
Use of the Great Barrier Reef is demonstrably environmentally sustainable					

8.6.8 Monitoring, evaluating and reporting

For a number of values (see Section 8.3), the independent assessors considered that the Authority has an insufficient understanding of their location, condition and trend. This reflects the vast area of the Region, its complexity and diversity. It affects the Authority's ability to ascertain the impacts of activities on these values and measure whether desired targets have been achieved. Since the *Outlook Report 2009*, a review of Reef Plan has provided better focus and direction for managers, including setting targets for water quality and land management improvement. The Authority's ability to address consequential and cumulative impacts, apply socio-economic and Indigenous knowledge, and set targets to benchmark performance are problematic for most management topics assessed. Targets and performance measures for coastal ecosystems are included in the Authority's *Biodiversity Conservation Strategy,*[22] but currently lack outcome-specific targets.

The assessment outcomes in relation to monitoring, evaluating and reporting are summarised in Table 8.28.

Table 8.28 Effectiveness of the Authority's management arrangements to monitor, evaluate and report

Indicator	Grade: Effective	Grade: Mostly effective	Grade: Partially effective	Grade: Ineffective	Management tools
4.1.1(k) monitor, evaluate and report on the: ii. impacts of activities, including the setting of targets to benchmark management					
There is effective performance monitoring to gauge progress towards the objective(s)			■		Strengths: • Partnerships (for example Reef Plan) • Research and monitoring (for example, Outlook Report, *Informing the outlook for Great Barrier Reef coastal ecosystems report*) Weaknesses: • Policy documents (setting targets, addressing consequential and cumulative impacts, applying socio-economic and Indigenous knowledge)
Relevant standards are identified and being met		■			
Targets have been established to benchmark management performance			■		

8.7 Effectiveness of specific measures to protect values

This section contains an assessment of the effectiveness of the Authority's current management arrangements to protect the Region's values. It is structured around the relevant criteria in item 4.1.1 of the terms of reference for the strategic assessment, which were also part of the assessment criteria for the independent review. The relevant criteria are:

a. identify the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, and determine their current condition and trend, including spatial and non-spatial approaches

k. monitor, evaluate and report on the:

   i. condition and trends of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area.

The grades were calculated by averaging the scores for each criterion across all management topics. A summary of the individual scores is provided in the full report of the assessment of management effectiveness, available on the Authority's website. The summary was reviewed and endorsed by the independent assessors.

8.7.1 Identifying values and determining their condition and trend

The Authority's understanding of the Region's values is strong for most management topics assessed. While knowledge of Indigenous values is improving within the Authority, the less tangible Indigenous heritage values such as traditional knowledge and maintenance of cultural practice are not well understood. For a number of historic heritage matters the Authority has insufficient understanding of their location, condition and trend.

The Authority's five-yearly Outlook Report's assessment of condition and trend of values provides a consistent benchmark for management. In addition, the Authority's development of comprehensive vulnerability assessments and *Informing the outlook for the Great Barrier Reef coastal ecosystems*[21] report have substantially contributed to an understanding of condition and trend. The Authority's *Scientific information needs for the management of the Great Barrier Reef Marine Park* report [33] identifies key information needed to better inform management of the area. This document, along with partnership agreements with key research institutions, provides an effective basis for research alignment which the assessors consider should deliver valuable outcomes for improved management.

The size, diversity and complexity of the Region means that the Authority's spatial understanding of the Region's values is limited in some places (for example inshore ecosystems) and for some attributes (for example, Indigenous heritage, recreational fishing and community benefits). In particular, spatial approaches to understand the extent and importance of elements of matters of national environmental significance, including the outstanding universal value, and essential processes on land and sea that maintain these values are not well developed. The Authority's knowledge about the condition and trend of aesthetic value, geological and geomorphological features of outstanding universal value remains a gap. Independent reports (completed in April 2013)[36,37] have assisted in developing a framework to enable assessment of these features; however, information on the condition and trend of these attributes is poor.

The assessment outcomes in relation to identifying matters of national environmental significance and determining their condition and trend are summarised in Table 8.29.

Table 8.29 Effectiveness of the Authority's management arrangements to identify values and determine their condition and trend

Indicator	Grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
4.1.1(a) identify the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, and determine their current condition and trend, including spatial and non-spatial approaches					
The values that underpin matters of national environmental significance in the Great Barrier Reef (including outstanding universal value of the World Heritage Area) are understood by managers					Strengths: • Partnerships (Reef Rescue Land and Sea Country Indigenous Partnerships Program) • Traditional Owner agreements • Research and monitoring (for example, Outlook Report, condition and trend for well-known and iconic species) Weaknesses: • Policy documents (for example, out-of-date recovery plans, policy) • Research and monitoring (for values associated with Indigenous heritage, historic heritage, community benefits and recreational fishing) • Spatial understanding of values relevant to matters of national environmental significance • Understanding of cumulative impacts on outstanding universal value
The current condition and trend of matters of national environmental significance (spatial and non-spatial) are known by managers					

8.7.2 Monitoring, evaluating and reporting of values

Where the Authority has a good understanding of values relevant to matters of national environmental significance (for example, some aspects of biodiversity), monitoring, evaluation and reporting is partially effective (see Table 8.29). Vulnerability assessments[14,15] and condition and trend assessments (through the Eye on the Reef program, Field Management Program and climate change activities) provide useful information on biophysical aspects of the environment, enabling benchmarking. With regard to community benefits, issues are considered under programs and policies developed by the Authority for other purposes. Currently there are no guidelines or benchmarks for social or economic impact assessments for the World Heritage Area. The assessors advised that an overarching strategy that outlines the objectives for community benefits, while showing the linkages across the programs, would clarify the Authority's roles and responsibilities. It would also provide an improved framework to assess management effectiveness with greater accuracy.

The assessment outcomes in relation to monitoring, evaluating and reporting are summarised in Table 8.30.

Table 8.30 Effectiveness of the Authority's management arrangements to monitor, evaluate and report on condition and trend

Terms of reference criteria	Indicator and grade				Management tools
	Effective	Mostly effective	Partially effective	Ineffective	
(k) monitor, evaluate and report on the: ***(ii) condition and trends of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area***					
There is effective performance monitoring to gauge progress towards the objective(s)					Strengths: • Partnerships (for example Reef Plan) • Research and monitoring (for example, Outlook Report, *Informing the outlook for Great Barrier Reef coastal ecosystems*) Weaknesses: • Policy documents (setting targets)
Relevant standards are identified and being met					
Targets have been established to benchmark management performance					

8.8 Effectiveness of specific measures to protect matters of national environmental significance

A summary of the effectiveness of the Authority's management arrangements to protect each of the matters of national environmental significance is presented in Table 8.31. The results are drawn from the independent assessment of management effectiveness. The summary was reviewed and endorsed by the independent assessors.

Table 8.31 Effectiveness of the Authority's management arrangements to protect each matter of national environmental significance

The overall outcomes of the independent assessment of management effectiveness are presented in the left-hand column. The summary for each matter of national environmental significance was reviewed and endorsed by the independent assessors.

Management effectiveness finding for each element	World heritage properties	Great Barrier Reef Marine Park	National heritage places	Commonwealth marine areas	Listed migratory species	Listed threatened species	Wetlands of international importance
Context*: Understanding of values, direct and indirect threats and stakeholders is strong for most management topics assessed — with the exception of Indigenous heritage, historic heritage, recreational fishing and community benefits. In particular, defence activities, tourism, research activities and water quality protection are well understood. This reflects a solid information and research base and a very mature understanding of the key values of the Great Barrier Reef in a national and international context, along with the direct and indirect threats to those values. Understanding of cumulative and consequential impacts, as well as condition and trend, is more variable. An understanding of stakeholders is consistently strong across all topics (in fact, it showed the strongest performance across the entire range of assessment criteria).*	An understanding of stakeholders is strong, however condition and trend, consequential and cumulative impacts and spatial approaches is limited.				The species involved are generally well understood, however there is a limited understanding of condition and trend, especially for listed migratory shorebirds. In particular, an understanding of consequential and cumulative impacts on listed species is limited.	Listed threatened species are well understood and their status, condition and trend are considered in the Authority's *Biodiversity Conservation Strategy* and vulnerability assessments. However, a greater understanding of the condition and trend of inshore species is needed (for example sharks and rays and shorebirds). Consequential and cumulative impacts are not well known.	Partnerships with the Defence Department have provided some condition and trend information (for example, the Strategic Environmental Assessment for Defence Activities). However, a greater understanding of, consequential and cumulative impacts is needed (for example underwater noise).
Planning: *Significant efforts have been made in planning for a number of issues such as biodiversity protection, coastal development and recreation. Some plans are still in draft form, considerably outdated or are yet to be fully implemented, although planning effectiveness is improving. In the case of coastal development, the Authority's development of the Coastal Ecosystems Assessment Framework is very positive, however the fractured nature of the planning regime is problematic and recent changes to coastal planning in Queensland have raised concerns.*	Planning for extractive activities is generally effective. However, lack of consistency across jurisdictions is currently the weakest aspect of planning. A lack of integration between the coastal zone and the Marine Park is affecting the effectiveness of plans to adequately protect and maintain habitats for conservation				A lack of consistency across jurisdictions is currently the weakest aspect of planning. While threat abatement plans, recovery plans and wildlife conservation plans are in place, some are considerably outdated. The *Biodiversity Conservation Strategy* and vulnerability assessments are	A lack of consistency across jurisdictions is currently the weakest aspect of planning. While threat abatement plans, recovery plans and wildlife conservation plans are in place, some are considerably outdated. Status and trend assessments prepared by the Authority indicate that many	The location of the Shoalwater and Corio Bays wetland predominantly within a defence training area fortuitously affords this area effective protection from many high risk impacts. The Strategic Environmental Assessment outlines responsibilities for the planning and implementation of

Management effectiveness finding for each element	World heritage properties	Great Barrier Reef Marine Park	National heritage places	Commonwealth marine areas	Listed migratory species	Listed threatened species	Wetlands of international importance
In the case of ports, the project specific nature of planning means that a Great Barrier Reef-wide strategic view to direct development and maintain and enhance values is generally not available. Recent plans for expanding the number and size of ports in response to mining industry growth in Queensland are of concern. Lack of resourcing means an updating of the Heritage Strategy and the preparation of heritage management plans has not been satisfactorily progressed. Lack of consistency across jurisdictions is the weakest aspect of planning.	of biodiversity and ecological and biological processes. Development of the North-East Shipping Management Plan is a strategic step forward to plan for and integrate actions across the Commonwealth marine area.				effective planning documents for listed migratory and threatened species.	species are continuing to decline. The *Biodiversity Conservation Strategy* and vulnerability assessments are effective planning documents for listed migratory and threatened species.	environmental protection measures during the planning and conduct of defence exercises. Comprehensive environmental management plans are in place for the Shoalwater Bay defence training area. Zoning in the Shoalwater and Corio Bays Area (outside the defence area) is the primary planning tool.
Inputs: *Adequacy of inputs is variable across management issues, being least effective for community benefits, coastal development, ports, shipping, commercial and recreational fishing, and historic heritage management. The adequacy of socio-economic and Indigenous knowledge is a problem for most issues and is among the worst performing criteria across the whole assessment. Secure resourcing is a significant ongoing issue for many management areas and a better understanding and documentation of management resource requirements is needed.*	Security and adequacy of resources are lacking in many areas and insufficient to address the scale of a number of issues (i.e. consequential or cumulative impacts, heritage and community benefits). Funding for the Field Management Program has been static since 2008 and declining in real terms. Funding has not kept pace with an increase in the protected area.				Adequacy of resources (see Great Barrier Reef World Heritage Area). A large majority of biophysical information on listed species is sourced from the research community and volunteer programs.	Adequacy of resources (see Great Barrier Reef World Heritage Area). A large majority of biophysical information on listed species is sourced from the research community and volunteer programs. For listed threatened species there is a better knowledge base and more targeted programs, however resources for these programs are not secure in the long-term (for example, Strandings database, Reef HQ turtle hospital).	Adequate biophysical information within defence training areas continues to be available for the Authority's management decisions (for example, hydrographic surveys improve knowledge of benthic habitats). The skills required to assess defence activities are limited to a few core staff. An increase in training and sharing of corporate knowledge is essential to ensure management of the wetland is effective.

Management effectiveness finding for each element	World heritage properties	Great Barrier Reef Marine Park	National heritage places	Commonwealth marine areas	Listed migratory species	Listed threatened species	Wetlands of international importance
Process: *Management processes are particularly strong for defence activities. They are weakest for coastal development, community benefits, commercial and recreational fishing, ports and Indigenous heritage. Addressing consequential and cumulative impacts, application of socio-economic and Indigenous knowledge, and setting of targets to benchmark performance are problematic for most issues. As was found in the Outlook Report 2009 assessment, the extent to which consequential and cumulative impacts are being addressed and the application of Indigenous knowledge remain the weakest indicators across the entire management effectiveness assessment. Stakeholder engagement and application of biophysical information are the strongest aspects of management across all issues. Note that none of the topics was scored 'ineffective'.*	Processes are strong where the Authority has lead management over a topic or where there is strong integration and aligned vision between jurisdictions (for example Reef Plan). A framework to address consequential and cumulative impacts is lacking. Stakeholder engagement continues to be one of the strongest aspects of management.				Significant recent progress has been made by completion of status, trend and vulnerability assessments for many key species and habitats. However, comprehensive targets need to be established and measured. The Marine Wildlife Stranding program remains an effective tool to respond to and monitor listed species incidents.		Comprehensive arrangements are in place for the protection of this wetland with the Department of Defence (i.e. Strategic Environmental Assessment). A framework to address consequential and cumulative impacts is still required.
Outputs: *Delivery of desired outputs has been weakest for coastal ecosystems, commercial and recreational fishing and ports. They are strongest in relation to climate change and extreme weather, defence, commercial marine tourism and research activities, with a noticeable improvement in the delivery of outputs relating to water quality management compared to the Outlook Report 2009. The knowledge base of the management agencies and community has consistently improved. While the majority of management programs are progressing satisfactorily, time frames frequently slip and it is not yet clear that the programs are achieving all their desired objectives. Note that none of the topics was scored 'ineffective'.*	While planning documents are in place for a number of matters, it is too early to judge the success of some of these (e.g. *Biodiversity Conservation Strategy*). Delivery of outputs and programs are strong for climate change and extreme weather and tourism Review and update of management plans has been delayed. The pace of development is affecting the capacity to adaptively manage				While planning documents are in place for a number of matters, it is too early to judge the success of some of these (e.g. *Biodiversity Conservation Strategy)*. Review and update of plans related to threatened species has been limited.		While planning documents are in place for a number of matters, it is too early to judge the success of some of these (e.g. *Biodiversity Conservation Strategy*). Environmental plans related to the Shoalwater and Corio Bays area are updated regularly in partnership with the Authority.

Management effectiveness finding for each element	World heritage properties	Great Barrier Reef Marine Park	National heritage places	Commonwealth marine areas	Listed migratory species	Listed threatened species	Wetlands of international importance
	and achieve outputs.						
Biodiversity outcomes: *When environmental outcomes are separated out from the broader outcome context, the biodiversity protection outcomes score drops to a partially effective rating, while the climate change and extreme weather outcomes score drops to an ineffective rating.*	Achievement of biodiversity outcomes is limited where drivers and activities that occur outside the Marine Park affect matters of national environmental significance. While all other elements of the management cycle may be effective, the achievements of desired outcomes for biodiversity protection are not being achieved. Despite significant progress in building the ecological resilience of the Reef, and the social and economic resilience of Reef industries, the current capacity of the Authority to influence outcomes is limited. The projected outlook in relation to climate change is poor.				Data indicates improvements in humpback whales numbers. However, five of the six species of turtles in the Great Barrier Reef have declined. Dugongs in the southern inshore area have also declined. While all other elements of the management cycle may be effective, the achievement of desired outcomes for biodiversity protection are not being achieved. Despite significant progress in building the ecological resilience of the Reef, and the social and economic resilience of Reef industries, the current capacity of the Authority to influence outcomes is limited. The projected outlook in relation to climate change is poor.	Five of the six species of turtles in the Great Barrier Reef have declined. Dugongs in the southern inshore area have also declined. While all other elements of the management cycle may be effective, the achievement of desired outcomes for biodiversity protection are not being achieved. Despite significant progress in building the ecological resilience of the Reef, and the social and economic resilience of Reef industries, the current capacity of the Authority to influence outcomes is limited. The projected outlook in relation to climate change is poor.	Achievement of biodiversity outcomes is limited where drivers and activities that occur outside the Marine Park affect matters of national environmental significance. While all other elements of the management cycle may be effective, the achievement of desired outcomes for biodiversity protection are not being achieved. Despite significant progress in building the ecological resilience of the Reef, and the social and economic resilience of Reef industries, the current capacity of the Authority to influence outcomes is limited. The projected outlook in relation to climate change is poor.

Management effectiveness finding for each element	World heritage properties	Great Barrier Reef Marine Park	National heritage places	Commonwealth marine areas	Listed migratory species	Listed threatened species	Wetlands of international importance
Overall outcomes: *Achievement of desired outcomes (values protected, threats reduced, long-term environmental and economic sustainability) is highly variable across issues. Objectives in relation to community understanding of issues and development of effective partnerships are being achieved. Overall, the greatest concern in relation to achievement of desired outcomes relates to climate change, coastal ecosystems, ports, commercial and recreational fishing, and water quality, where management is led by other agencies and outside the Authority's jurisdiction.*	In spite of good systems and processes, the long-term trend for Great Barrier Reef ecosystems is still poor, and the extent to which specific initiatives can effectively address particular problems will only become clear over time. This situation highlights the importance of robust performance monitoring and adaptive management.						

8.9 Summary of outcomes

- The effectiveness of the Authority's current management arrangements was independently assessed using the International Union for Conservation of Nature (IUCN) World Commission on Protected Areas evaluation framework. This framework has been widely applied around the world.
- The independent assessment found the Authority is working towards effective management in all areas, and there have been considerable improvements in a number of areas since the *Outlook Report 2009*.
- The assessment recognised the difficulties for the Authority in achieving positive outcomes on the ground, given the spatial and temporal scales of the threats facing matters of national environmental significance and the diminishing resource base to implement actions.
- The assessment highlighted that the Authority required greater traction in threat reduction for an improvement in outcomes. This is dependent on the adoption of significant changes to current policies regarding coastal development, resource use and control of other human impacts, as well as sufficient resourcing to implement threat-reduction programs in the field.
- The assessment found the Authority's management of activities within the Region for which it has direct responsibility is effective. It's significant management attention on tourism, which operates across much of the Region and is moderately complex, was identified as being effectively, primarily because of its direct jurisdictional control.
- The independent assessment highlighted that management effectiveness challenges for the Authority were evident for those issues which are broad in scale and complex socially, biophysically and jurisdictionally (that is, port activities, shipping, climate change and extreme weather, coastal development, water quality protection, commercial and recreational fishing and Indigenous heritage) or those that are poorly resourced (for example historic heritage).
- For the management topics of climate change and extreme weather, coastal development and water quality protection, the assessment identified particular management challenges in consistency of approaches across jurisdictions which impacts on planning.
- For commercial and recreational fishing, the assessment identified particular challenges for the Authority in the areas of monitoring and compliance, especially as they relate to addressing potential cumulative impacts.
- For Indigenous heritage, the management challenges faced by the Authority are particularly in areas of understanding the context and processes to better incorporate Indigenous heritage across the Authority's management arrangements.
- Inputs, process and outcomes were the elements of the management cycle where the Authority's current management arrangements were least likely to meet the endorsement criteria. Elements of context and planning in relation to biodiversity protection and water quality performed strongly, however the trend of this grade depended on the continuation of key programs.
- The independent assessment found the Authority generally has a good understanding of direct and indirect impacts and, where the Authority has a high level of control over activities, its effectiveness at avoiding, mitigating and adaptively managing impacts was effective or mostly effective. Its effectiveness at halting and reversing declines and enhancing the condition of relevant matters of national environmental significance was rated as less effective, especially for topics that originate beyond the Region and are jurisdictionally complex.
- The Authority's ability to address consequential and cumulative impacts, apply socio-economic and Indigenous knowledge, and set targets to benchmark performance was assessed as problematic for most management topics.
- The overall assessment results are summarised in Table 8.32. The independent assessors full report and recommendations are available on the Authority's website at www.gbrmpa.gov.au.

Table 8.32 Summary of management effectiveness results for management topics
The overall rating for outcomes relates to the Authority's effectiveness for all seven outcome criteria (that is, outcomes relating to social, economic, biodiversity and managerial aspects). The second outcome rating relates only to the effectiveness of achieving biodiversity outcomes separate from the influence of scores for other outcomes.

Understanding the table

Effective	Mostly effective	Partially effective	Ineffective
Effective: 81 to 100 per cent of optimal condition	**Mostly effective:** 51 to 80 per cent of optimal condition	**Partially effective:** 21 to 50 per cent of optimal condition	**Ineffective:** zero to 20 per cent of optimal condition

Management topic	Effectiveness of existing measures to protect and manage						
	Context	Planning	Inputs	Processes	Outputs	Outcomes: Overall	Outcomes: Biodiversity
Values							
Biodiversity	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Partially effective
Indigenous heritage	Partially effective	Mostly effective	Mostly effective	Partially effective	Mostly effective	Mostly effective	Mostly effective
Historic heritage	Partially effective	Partially effective	Partially effective	Mostly effective	Mostly effective	Partially effective	Partially effective
Community benefits	Partially effective	Mostly effective	Partially effective	Partially effective	Mostly effective	Mostly effective	Mostly effective
External impacts on values							
Climate change and extreme weather	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Partially effective	Ineffective
Water quality protection	Effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Partially effective	Partially effective
Coastal development	Mostly effective	Partially effective	Partially effective	Partially effective	Partially effective	Partially effective	Partially effective
Direct uses							
Tourism	Effective	Mostly effective	Mostly effective	Mostly effective	Effective	Effective	Mostly effective
Fishing – commercial	Mostly effective	Partially effective	Partially effective	Partially effective	Partially effective	Partially effective	Partially effective
Fishing – recreational	Partially effective	Mostly effective	Partially effective	Partially effective	Partially effective	Partially effective	Partially effective
Recreation	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective
Port activities	Mostly effective	Partially effective	Partially effective	Mostly effective	Partially effective	Partially effective	Partially effective
Shipping	Mostly effective	Mostly effective	Partially effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective
Defence activities	Effective	Effective	Effective	Effective	Effective	Effective	Effective
Research activities	Effective	Mostly effective	Mostly effective	Mostly effective	Mostly effective	Effective	Effective

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Chapter 9

Demonstration case studies

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Cover page image: A dugong (*Dugong dugon*)

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

4.1 Demonstration cases

4.2.1 Develop demonstration cases to assess in finer detail the effectiveness of the Program to protect and manage the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, and to guide improvements to the Program.

4.2.2 Demonstration cases are to be chosen by the Australian and Queensland governments. Criteria that will be used to guide this selection process include, but are not limited to:

- *a) where multiple impacts are acting or predicted to act upon a region, locality or value*
- *b) to examine a specific management approach or method to identify a set of values/attributes or to assess a range of impacts/pressures*
- *c) to demonstrate connectivity across coastal and marine systems*
- *d) to demonstrate the integration of environmental, social, cultural and economic benefits in decision making*
- *e) to improve understanding of factors affecting Great Barrier Reef ecosystem resilience*
- *f) where lessons or outcomes could transfer to other areas*
- *g) opportunities to build capacity for future management*
- h) *to examine the effectiveness of management across local, Queensland and Australian government jurisdictions.*

9 Demonstration case studies

The terms of reference for the strategic assessment provide for demonstration case studies to be undertaken. The purpose of the case studies is to assess in finer detail the effectiveness of current management arrangements to protect and manage the relevant matters of national environmental significance, including outstanding universal value, and to guide improvements to management arrangements. Demonstration cases also provide an opportunity to examine cumulative impacts on values at a local or regional scale and their wider implications for management by government agencies and the community.

This chapter sets out the case study topics and their alignment with the terms of reference. It presents the case studies, including their outcomes and potential improvements for future management. The technical reports that support each case study are available on the Authority's website at www.gbrmpa.gov.au. The *Ecological risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: technical report*[1] supports the East Coast Trawl Fishery case study.

9.1 Case studies selected

9.1.1 Topics chosen

The eight demonstration case studies are:

- dugongs
- corals
- islands
- Princess Charlotte Bay
- Cairns Planning Area
- Mackay Whitsunday — water quality improvement
- Keppel Bay
- East Coast Trawl Fishery.

The case studies examine individual values underpinning matters of national environmental significance (corals, dugongs and islands); major uses of the Region (tourism and fishing); a major management initiative (water quality improvement in the Mackay Whitsundays); and the combined effect of multiple uses on values in specific locations (Keppel Bay and Princess Charlotte Bay). The demonstration case studies on dugong, islands and Mackay Whitsunday water quality improvement have been prepared collaboratively with the Queensland Government for development of both strategic assessment reports.

A joint demonstration case study on shipping was also proposed, however this has been superseded by development of the North-East Shipping Management Plan. This assesses the effectiveness of current risk control measures and identifies new and enhanced control measures that will be required, commensurate with the projected shipping growth in the Region (see Section 5.4.6, in Chapter 5).

Recognising the extensive separate investigations on ports and their management being undertaken in parallel to the strategic assessment, a demonstration case study on ports was not carried out. As they have become available, the preliminary outcomes of these investigations have been taken into account in the strategic assessment. The investigations include:

- *Independent review of the Port of Gladstone*: This review was commissioned in response to the June 2012 decision of the World Heritage Committee. A panel of experts is examining and reporting on environmental management and governance arrangements for the port and may make recommendations to the Environment Minister relevant to the review's terms of reference. This may include recommendations relating to optimisation of port development and operations. At the time of writing this report, the Review was yet to conclude.
- *Improved dredge material management for the Great Barrier Reef Regio*n[2]: This has provided proposed strategies for improved material management for the major ports and one boat harbour/marina (Rosslyn Bay) in the Great Barrier Reef World Heritage Area. Independent consultants undertook the project under the Sustainable Regional Development Program, funded by the Australian Government.
- *Identification of impacts and proposed management strategies associated with offshore ship anchorages in the Great Barrier Reef World Heritage Area*[3]: This has identified environmental impacts and risks from anchorages for each port and potential management options to avoid and mitigate environmental, social and heritage impacts from existing and future ship anchorages, given likely increases in future shipping. This is also a Sustainable Regional Development Program project, undertaken by independent consultants.
- *Environmental best practice port development: an analysis of international approaches*: This has identified international benchmarks in the management of environmental impacts of ports and their potential application in an Australian context.

9.1.2 Meeting the selection criteria

Item 4.2.2 of the terms of reference for the strategic assessment sets out criteria to guide selection of demonstration case studies. The way in which each of the case studies meets these criteria is outlined in Table 9.1. Furthermore, the selection of case studies considered matters consistently raised by stakeholders, key risks identified in the *Great Barrier Reef Outlook Report 2009*[4]*,* a geographic spread of areas and the availability of sufficient information for a detailed analysis.

Table 9.1 Meeting the selection criteria for demonstration case studies	
Terms of reference criteria	**Demonstration case study**
a) Where multiple impacts are acting or predicted to act upon a region, locality or value	Place-based case studies such as Princess Charlotte Bay, Cairns Planning Area and Keppel Bay provide insight into areas where there are multiple impacts on a locality. The studies on dugongs, corals and islands examine multiple impacts on values.
b) To examine a specific management approach or method to identify a set of values/attributes or to assess a range of impacts/pressures	Each of the case studies examine a number of management approaches: from research and monitoring to policies, planning and compliance. The Cairns Planning Area case study examines the effectiveness of the plan of management for that area. The East Coast Trawl Fishery study examines the effectiveness of all management approaches for that fishery. The coral and dugong demonstration cases have incorporated qualitative impact assessment methods.
c) To demonstrate connectivity across coastal and marine systems	Connectivity across coastal and marine systems is addressed in all demonstration cases.
d) To demonstrate the integration of environmental, social, cultural and economic benefits in decision making	Each of the placed-based case studies examine how community benefits have been integrated into decision making, especially the Cairns Planning Area study. The trawl fishery case study considers the integration of social and economic considerations.
e) To improve understanding of factors affecting Great Barrier Reef ecosystem resilience	The case studies on dugong and corals are particularly relevant to an examination of resilience.
f) Where lessons or outcomes could transfer to other areas	All case studies provide lessons and outcomes that can be transferred to other areas.
g) Opportunities to build capacity for future management	The outcomes of all the case studies will inform capacity building for future management.
h) To examine the effectiveness of management across local, Queensland and Australian government jurisdictions	All the case studies address effectiveness of management.

9.2 Assessing management effectiveness

An assessment of the effectiveness of management has been undertaken by the Authority for each demonstration case (except the Mackay Whitsunday — water quality improvement and East Coast Trawl Fishery). These assessments were reviewed by the same consultants who undertook the independent review of management effectiveness[5] (see Chapter 8). Direct excerpts from their report are shown in this chapter in italics. For the Mackay Whitsunday — water quality improvement and East Coast Trawl Fishery, direct excerpts are reproduced from Chapter 8.

The assessment approach followed the framework for evaluating management effectiveness described in Chapter 8. Current management activities relevant to each stage of the management cycle (context, planning, inputs, process, outputs and outcomes) were considered. The effectiveness of the management arrangements to achieve desired results for each of the six elements were qualitatively assessed on a four point rating scale (81 to 100 per cent; 51 to 80 per cent; 21 to 50 per cent; one to 20 per cent) and graded (effective; mostly effective; partially effective; ineffective).

The scope of this assessment included management activities within the Authority's jurisdiction and any joint management arrangements with the Queensland Government (for example, joint Marine Park permitting, and joint compliance and enforcement through the Field Management Program).

The relationship between the demonstration cases and the management topics and tools assessed are summarised in Table 9.2 and Table 9.3.

Table 9.2 Matching demonstration case studies to management topics

Management topic	Dugongs	Corals	Islands	Princess Charlotte Bay	Cairns Planning Area	Mackay Whitsunday — water quality improvement	Keppel Bay	East Coast Trawl Fishery
Biodiversity protection	●	●	●	●	●	●	●	●
Indigenous heritage	●		●	●	●		●	
Historic heritage			●					
Community benefits	●	●	●	●	●	●	●	●
Climate change and extreme weather	●	●	●		●		●	●
Water quality protection	●	●			●	●	●	
Coastal development	●	●		●	●	●	●	●
Tourism		●	●		●	●	●	
Fishing — commercial	●			●	●		●	●
Fishing — recreational	●			●	●		●	
Recreation		●	●	●		●	●	
Port activities	●	●			●			
Shipping				●	●	●	●	
Defence activities	●							
Research activities	●	●	●				●	

Table 9.3 Matching demonstration case studies to management tools

Management tool	Dugongs	Corals	Islands	Princess Charlotte Bay	Cairns Planning Area	Mackay/Whitsunday — water quality improvement	Keppel Bay	East Coast Trawl Fishery
Act and Regulations	●	●	●	●	●	●		
Zoning Plan	●	●	●	●	●	●	●	●
Plans of management	●	●	●		●	●		
Permits		●	●	●	●	●	●	
Traditional Owner agreements	●		●	●			●	
Compliance	●	●	●	●	●	●	●	●
Site infrastructure		●	●		●	●	●	
Fees and charges					●			
Policy	●				●	●		
Partnerships	●	●	●	●	●	●		●
Stewardship and best practice	●	●	●	●	●	●	●	●
Education and community awareness	●	●	●		●	●	●	
Research and monitoring	●	●	●		●	●	●	●
Reporting	●	●	●			●		

9.3 Dugongs

9.3.1 Significance

The Great Barrier Reef World Heritage Area is home to a globally significant population of dugongs, which was one of the reasons why it was inscribed on the World Heritage List in 1981.[6] Dugongs, together with the seagrass habitats upon which they depend, contribute to the recognition of the Reef's outstanding universal value, including its significant ongoing ecological and biological processes, and significant natural habitats for the conservation of biological diversity.

Dugongs are of great cultural, spiritual and social importance, especially to the Reef's Traditional Owners. These large marine mammals are a matter of national environmental significance as a listed migratory species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and are listed as a marine species under that Act. Dugongs are listed as vulnerable under the *Nature Conservation Act 1992* (Qld) and as a protected species under the Great Barrier Reef Marine Park Regulations 1983.

Dugongs are found in the coastal waters of more than 40 countries and territories, but their status is either declining, locally extinct, or unknown in most of their range.[7] Australia's northern waters (from Moreton Bay in southern Queensland to Shark Bay in Western Australia) contain approximately one quarter of the world's dugong habitats. Australia is the only developed country with a significant dugong population, and with extensive areas of coastline at relatively low risk from coastal development.[8,9]

9.3.2 Key issues

Dugongs feed almost exclusively on seagrass and they must consume large quantities each day to fulfil their energy requirements.[10] The dugong's preference for inhabiting inshore areas exposes them to a range of human-related marine and land-based activities.[9]

As long-lived, slow-breeding animals, dugongs have slow rates of recovery from population declines. Survival of adult dugongs must be more than 90 per cent each year to maintain a population.[11] Population simulations based on adult survival estimates from manatees (the most closely related group of species) and empirical reproductive data from dugongs in the Torres Strait estimate the maximum population growth rate to be about one to six per cent annually.[12,13]

Currently, the greatest impacts on dugong populations in the World Heritage Area are habitat loss and degradation including impacts from: cyclone activity and extreme weather; nutrients, pesticides and sediment from catchment run-off; clearing or modifying of coastal habitats; coastal reclamation; direct impacts of dredging; dumping and resuspension of dredge material.[9] Dugongs are also affected directly by disease, their incidental capture in nets (death of discarded species from the commercial net fishery and the Queensland Shark Control Program), marine debris, boat strike, illegal fishing and poaching, and hunting for traditional use to varying degrees.[9]

Commercial harvesting, which began in Queensland in 1847, took a significant toll on the species, particularly south of Cooktown, where virtually all of the operations were based. While commercial dugong harvesting was a small industry, there were large harvests of the animals, especially in the late 1800s to 1930s. In some years more than 100 dugongs were harvested from Moreton Bay (south of the Region).[14] Harvesting was banned in Queensland in 1969.

The introduction and widespread use of monofilament fishing nets from about the 1960s also resulted in a significant incidental capture of dugong, prompting the progressive introduction of Dugong Protection Areas, coastal zoning and changes to net designs and gear over the past 20 years.

Despite management actions to protect them, dugong population numbers in the World Heritage Area south of Cooktown have not recovered. In fact, the numbers of dugongs have continued to decline since the early 1960s. By the 1990s, it was suggested dugong numbers had declined by more than 90 per cent along the coast of Queensland south of Cooktown.[9,15,16] Evidence of decline was derived retrospectively from their incidental catch in the Queensland Shark Control Program between 1962 and 1999, during which time 837 dugongs were killed.[17] The trends in the average number of dugongs caught in nets at 47 beaches showed a decline of 8.7 per cent per year between 1962 and 1999 (Figure 9.1), which was assumed to reflect the rate of population decline.[16,18] Initiatives began in 1992 to reduce this impact.[17] Baited hooks on drumlines have replaced shark nets in many localities. Drumlines still catch the targetted shark species, but catch considerably fewer dugongs and cetaceans.

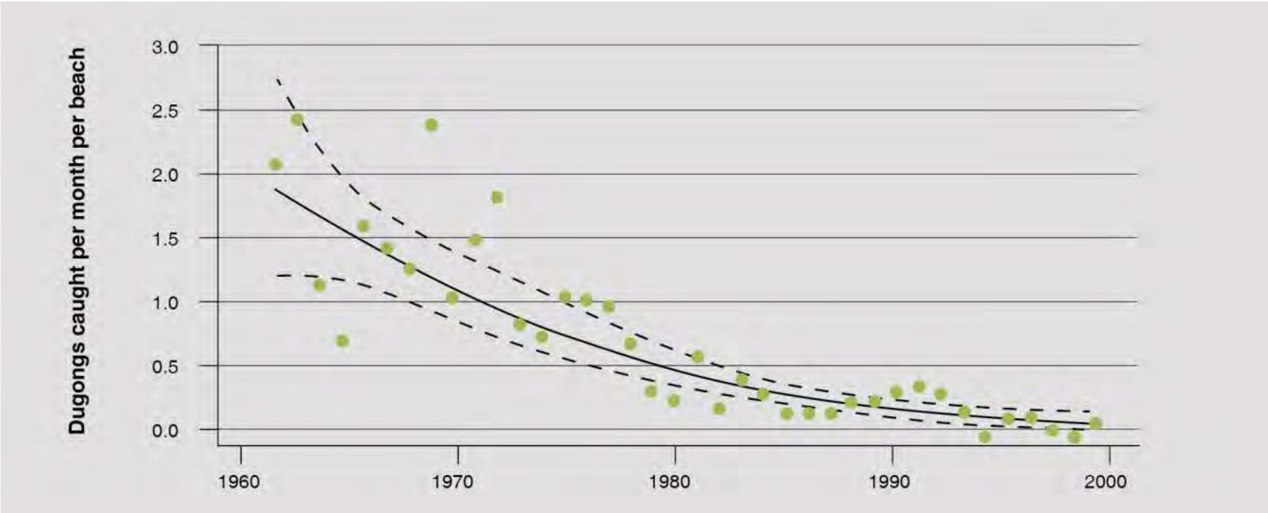


Figure 9.1 Dugongs caught in the Queensland Shark Control Program, 1962-1999

Profile of the annual estimated mean numbers of dugongs (log-linear model and 95 per cent confidence intervals) caught in the Queensland Shark Control Program from six shark netting contract areas at 47 beaches between Cairns and the Gold Coast for the period 1962 to 1999. The average number of dugongs caught per beach ranged from zero to five dugongs per month (green symbols), and showed a strong overall decline .[15] The estimated rate of decline averages 8.7 per cent per year. There is no statistical evidence that the changes to the program introduced after the 1992 review of practices[17] changed the pattern of declining catches up to 1999.

Aerial surveys suggested there were about 2000 dugongs in the World Heritage Area south of Cooktown in 2005 and that the decline had halted.[19] Although this was only a small fraction of pre-European levels, the population was thought to have stabilised.[4,19,20,21] However, widespread destruction of seagrass meadows (from heavy flooding and cyclone Yasi in 2010–11, coupled with two preceding years of higher than average rainfall and the chronic impact of poor water quality),[22,23] led to a further decline as dugongs died[24] or emigrated from the affected areas. Aerial surveys in 2011 revealed there were only approximately 600 animals in waters between the Daintree River and the southern limit of the World Heritage Area.[25] The condition of the southern population is assessed as poor and declining (with good confidence in both assessments).[4,19,20,21] In contrast, dugong populations south of the World Heritage Area in Hervey Bay and Moreton Bay have not declined since the previous aerial surveys in 2005.[25]

North of Cooktown, the current status of dugongs is considered to be good with a stable population trend (with good confidence in both assessments).[16,18,26,27,28] In 2006, the estimated population of dugongs between Cooktown and Cape York was approximately 8800.[18] Outside the World Heritage Area to the north, the population in the Torres Strait is estimated to be greater than 14,000 individuals.[18]

9.3.3 Current management and its effectiveness

Dugongs have been a focus of management agencies for many decades, with high level leadership from the Great Barrier Reef ministerial forum. In the 1980s, the Authority's zoning plans protected some important dugong habitats in Marine National Park (green) zones and Preservation (pink) zones. The level of protection was increased significantly in 1997 in response to the long-term decline in the dugong population south of Cooktown and the ongoing and unsustainable levels of interactions between dugongs and fishing nets and shark control nets.[29] These measures established 16 Dugong Protection Areas under Queensland fisheries legislation which imposed spatial and fishing gear restrictions and prohibited the use of some types of fishing nets.[30] Additionally, changing shark control nets to drumlines has reduced the number of interactions with dugongs.

Soon after, measures to protect seagrass habitats from trawling were introduced, as well as netting restrictions and net attendance rules to reduce the incidental capture of dugong within the East Coast Inshore Fin Fish Fishery. The use of nets in the Queensland Shark Control Program was also reviewed[17] and modified.[31] Other management arrangements were introduced by the Department of Defence for activities in the Shoalwater Bay Defence Training Area.[32] While there is limited traditional hunting of dugong as a native title right, some Traditional Owners have voluntarily adopted reduced levels of hunting under Traditional Use of Marine Resources Agreements, with some clans choosing not to hunt this species at all.

Dugong habitats were explicitly taken into consideration when the Great Barrier Reef Marine Park was rezoned in 2003.[33] As a result, approximately 96 per cent of high conservation value dugong habitats are highly protected, [34,35] and 24 per cent of known shallow water seagrass meadows are included in highly protected green zones which prohibit unpermitted extractive activities.[36] While it had been recognised for some time that shallow water seagrass meadows within Dugong Protection Areas are important to dugong and are at risk from declining water quality,[37] it is now also recognised that deeper water seagrass meadows are used by dugongs as a refuge and when preferred shallow water meadows are affected by floods or cyclones.[25] While a decline in shallow inshore seagrass meadows south of Cooktown is recorded, there are major gaps in our understanding of the condition, abundance and distribution of deepwater seagrass meadows. Major efforts to improve water quality through the *Reef Water Quality Protection Plan* (Reef Plan) are expected to have positive outcomes for seagrass in the medium term.[38,39]

The independent review of the Authority's assessment of management effectiveness concluded:

- **Context** is effective. *Evidence presented on legal status and reasons for designation of dugong as a matter of national environmental significance, status and trend in dugong population numbers and distribution; nature, extent and impact of threatening processes; stakeholder interests all indicate that the context of dugong conservation and management is well understood* by the Authority.
- **Planning** is mostly effective. *The demonstration case provides evidence of multiple levels of planning for dugong conservation over a 40-year period starting with the cessation of a commercial dugong fishery in 1969 and with a turtle and dugong conservation strategy first prepared in 1994.* Dugong Protection Areas *date back to 1997 and recovery plans* [Qld] *to 1999. Other plans, policies, regulations and strategies have been developed and implemented by Commonwealth and state agencies to address the major anthropogenic impacts on dugong. Protection and enhancement of dugong habitat has been addressed through the rezoning and water quality improvement plans. Management of impacts of coastal activities on the extent and condition of seagrass beds remains as an area where improved planning and regulation could improve prospects for the species.*
- **Inputs** are only partially effective. *Resources for key management actions (for example, mitigating impacts of coastal land management), field management (surveillance and compliance, emergency response) and monitoring of dugong populations and habitat condition are either currently inadequate or not secure in the long term.*
- **Process** is mostly effective. *Plans and strategies developed for dugong management are generally being implemented. An effective partnership with Indigenous people is being developed and the number of Traditional Use of Marine Resources Agreements is being extended to cover the main areas of relevance. The ways in which the plans and strategies are being implemented is appropriate. The methods used in surveillance and enforcement are of a high standard, but field management capacity to ensure a high level of compliance is lacking.*
- The delivery of **outputs** is mostly effective, however *implementation of relevant plans is being hampered by a shortage of resources.*
- Achieving desired **outcomes** overall is partially effective. *Concerns relating to the cumulative impacts of climate change and extreme weather and increased development in coastal ecosystems limit the effectiveness of planning and management measures introduced to conserve dugong populations in the Region.* **Biodiversity outcomes** for dugong management are partially effective. *Consideration of the southern population of dugong in the Great Barrier Reef Region alone would lead to a conclusion that management had been ineffective in conserving the species. However, the fact that the larger northern population is considered to be stable and in good condition means that the overall biodiversity assessment should be rated as partially effective.*

9.3.4 Outcomes and potential improvements

Dugong numbers today are the result of impacts and actions over a long time.[9] Temporal changes in local and regional dugong population estimates are compounded by large-scale dugong movements. This is a challenge for management because trends in numbers can take decades to detect with a high degree of statistical confidence, and it may take decades to gauge the effectiveness of management strategies.

Ongoing and effective management action in the World Heritage Area is required to protect dugong populations and, most critically, to halt and reverse the decline in the southern populations. Effective management will depend on minimising not only short-term or acute impacts, but also cumulative or chronic impacts that may seem insignificant in isolation. The influence of climate change and proposed urban and industrial expansion throughout the Region means greater engagement of all levels of government and the community will be needed to achieve recovery of dugongs. Because dugong movements can be substantial, habitat connectivity and integrity are critical, and management efforts must be coordinated across local, state, national and international levels to ensure dugongs are protected throughout their range.

Impacts of greatest significance to dugongs south of Cooktown are habitat loss and degradation from cyclone activity and extreme weather; sediment, nutrient and pesticides from catchment run-off; modification of supporting terrestrial habitats; coastal reclamation; dredging and dumping and resuspension of dredge material; disease; vessel strike and vessel disturbance; death from incidental capture in nets (commercial net fishery and shark control program); and marine debris. North of Cooktown, seagrass is exposed to fewer water quality-related impacts. There, impacts identified include habitat loss and degradation from cyclone activity and extreme weather, disease, incidental capture in nets (commercial net fishery), illegal fishing and poaching, and hunting for traditional use.

Mapping[34,35] and qualitative models[40] have been used to aid understanding of cumulative impacts on dugongs. The condition for dugong populations is projected to decline to very poor in the southern World Heritage Area, and to remain good in the north in coming decades. Model outputs based on a possible increase in the intensity of storms and ocean warming predict a likely downward trend in dugong populations, even with a possible reduction in nutrients and sediments (based on Reef Plan targets), unless direct human-induced dugong mortality from all sources is reduced at the same time. To enable population recovery in the World Heritage Area south of Cooktown, modelling[41] suggests an annual human-induced mortality limit of less than 10, with a target of zero.[16,19] This target will be very difficult to achieve — for example, five dugong deaths from human activities were reported south of Cooktown in 2011.[42] Sustainable limits for human-induced mortality have been estimated to be between 56 and 112 for dugongs in the World Heritage Area north of Cooktown (with recommendations to strive for the lower limit).[18]

Enhancing protection and restoration
A critical management action for dugongs across their range in the Great Barrier Reef is to maintain, enhance and restore the health of seagrass meadows, which they rely on for food. Risks to the main seagrass meadows in Dugong Protection Areas from poor water quality were identified in 2001, based on the best knowledge at that time. This issue is being addressed by actions under Reef Plan.[38] The importance of landscape connectivity between terrestrial and marine systems for maintaining healthy Great Barrier Reef inshore biodiversity has been recognised[43] with increased investment by the Australian Government under Reef Rescue 2013–2018.[44]

Minimising impacts
It is also critical that impacts on dugongs and their habitats are reduced and minimised. Strengthening a number of ongoing management actions is important and the wider community can play a more prominent role in formulation and implementation of management arrangements to recover dugong populations. For example, continuously improving net fishing techniques, technology and practices (such as, codes of practice) is important to reduce drowning in fishing nets.

Community action and compliance activities at a local and regional scale are needed to help reduce and minimise mortality or ill health of dugongs (for example, from vessel strike, marine debris, disease, noise and interference). Traditional Use of Marine Resources Agreements will continue to act as a valuable tool to facilitate sustainable traditional hunting and support the role of Indigenous communities and rangers in compliance and enforcement activities.

In addition, supporting the objectives of the Queensland Government's current net buyback program to reduce fishing effort in the East Coast Inshore Fin Fish Fishery is important, given remaining concerns about set mesh netting, the potential for the mortality of vulnerable species in nets, and some failures to report these interactions in the Lockhart River and Princess Charlotte Bay areas. Another potential initiative could include a revision of apparatus used in the Queensland Shark Control Program to further reduce risks to dugongs, while meeting the public safety imperative.

Improving adaptive management
Adaptive management requires an ongoing commitment to regular monitoring, evaluation and review of the abundance and distribution of dugong and seagrass to understand trends. A greater understanding of cumulative impacts, including impacts of extreme weather, should lead to an improvement in the adequacy of measures to avoid or mitigate impacts in important dugong areas. This could even include investigating ways of restoring and rehabilitating seagrass meadows.

Continuous improvement of best practice standards for all activities likely to affect dugong (for example, in relation to vessel operation, vessel waste management, recreational use, tertiary sewage treatment and re-cycling, urban storm water management, and erosion and sediment control) will help ensure activities are undertaken to the highest standard, based on the most up-to-date information. Part of this continuous improvement is the implementation of new technologies to reduce illegal fishing and increase compliance with fisheries management arrangements, as well as the synthesis of information on trends and regional and local differences. Traditional Use of Marine Resources Agreements will continue to be a valuable tool, providing for the exchange and incorporation of traditional ecological knowledge into management.

Continued commitment to scientific and community-based monitoring, reporting and stewardship programs will allow management agencies to understand the effectiveness of their actions. Such programs may include those with a focus on understanding movements of dugongs and condition of seagrass — providing real-time information to managers, industry and the public; long-term, structured, large-scale aerial surveys — providing information on population abundance, distribution and trends; and a better understanding of existing and emerging impacts on dugongs (for example, noise).

9.4 Corals

9.4.1 Significance

Corals contribute to the recognition of the Reef's outstanding universal value for all four of the natural criteria for World Heritage listing: exceptional natural beauty, significant geomorphic features, significant ongoing ecological and biological processes, and significant natural habitats for the conservation of biological diversity.

The Great Barrier Reef is the largest coral reef ecosystem in the world, stretching 2600 kilometres along the north-eastern coast of Australia. Coral reefs themselves cover an area of about 26,000 square kilometres and make up seven per cent of the Great Barrier Reef Marine Park. The Reef is also one of the world's most diverse ecosystems. A network of more than 2900 separate reefs forms 30 distinct reef bioregions (see Figure 4.4 in Chapter 4), comprising a total of 10 per cent of all the world's coral reefs.[45] The Reef's habitat complexity is founded on about 410 species of hard coral, which support a rich diversity of reef-associated species.[4]

The coral reef environment supports a range of Reef-dependent industries and uses, and directly underpins the community's cultural, social and economic wellbeing. The economic contribution to the Australian economy generated by tourism, recreation, commercial fishing and scientific research in the Reef catchment and the World Heritage Area in 2012 was $5.7 billion. It also supported about 69,000 full-time equivalent jobs.[46]

Globally, coral reefs are under serious pressure — 75 per cent of the world's coral reefs are currently threatened by local and global pressures, more than 90 per cent of the world's reefs will be threatened by 2030 and nearly all of them could be at risk in less than 40 years.[47]

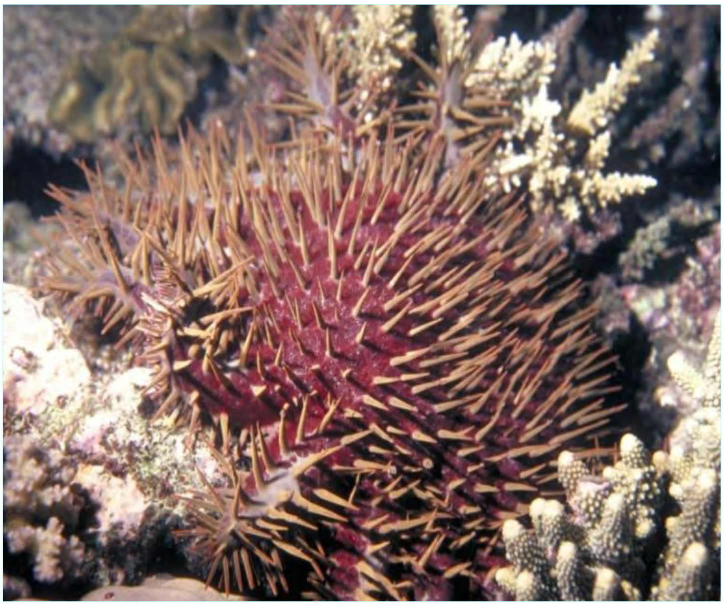
9.4.2 Key issues

Despite the Great Barrier Reef being recognised as one of the best managed coral reef ecosystems in the world,[48] research and anecdotal information indicates there have been substantial changes to coral cover and species composition on inshore fringing reefs dating from at least the 1920s[49](refer to Section 7.1.2 for an example and discussion of the decline of inshore reefs) and a 40 per cent decline in the past 27 years.[50,51,52] While there is debate over the exact extent, cause and severity of this loss,[50] there is no doubt that coral cover overall and specifically in some regions is declining.

Long-term monitoring by the Australian Institute of Marine Science since 1986 shows average hard coral cover across the Great Barrier Reef has declined from 28 per cent to 13.8 per cent — two-thirds of that loss has occurred since 1998.[53] A majority of the loss has been recorded since 2006 in central and southern regions of the Great Barrier Reef. North of Cooktown, coral reefs are in good condition, with hard coral cover remaining relatively stable over the past 27 years. The status of coral reefs in the Region reflects the pattern of extreme weather events, coastal development and water quality. There is no long-term data on the condition and trend of deep water (more than 30 metres) reefs.[54]

The major drivers of loss of coral cover on a Reef-wide scale are:

- Outbreaks of the crown-of-thorns starfish (*Acanthaster planci*).[55] Large-scale crown-of-thorns starfish outbreaks were first recorded in the 1960s.[56] Since then, there have been three major outbreaks (1962 to 1976, 1978 to 1990, 1993 to 2005[57]).
- Direct impacts of cyclones.[4,55] For example, cyclone Hamish was a major factor in reducing the average coral cover on southern offshore reefs in the Swains region of the World Heritage Area from 35 per cent in 2006 to 8 per cent.[53]
- Declining water quality in the Great Barrier Reef lagoon — including an increase in nutrients, pollutants, sediment and freshwater — from catchment run-off, urban and industrial discharge and dredge material disposal.[51,52,58] Coral disease has also emerged as a chronic problem for many southern inshore reefs after flood events.[59]
- Increasing sea surface temperatures, which have induced coral bleaching.[60,61]



Crown-of-thorns starfish (Acanthaster planci) on a coral reef

9.4.3 Current management and its effectiveness

Coral cover has declined throughout the Region, this is despite high community interest and concern for corals, comprehensive partnership programs with industry stakeholders, and increased efforts by managers to enhance coral reef resilience (particularly through improving water quality).

In the Great Barrier Reef Marine Park, the Authority has managed localised impacts on coral reef habitats from dredging, dredge material disposal, coral collection and anchoring through the Zoning Plan, permit conditions, plans of management, best practices and site management. In addition, the Authority is working in partnership with the Australian and Queensland governments through Reef Plan to halt and reverse the decline in water quality. This partnership focuses specifically on agricultural pollutants which account for about 90 per cent of the pollutant loads. The Australian Government recently recommitted a further $200 million to its Reef Rescue 2013–2018 initiative to enhance the Reef's resilience to climate change and catchment run-off. The Queensland Government has also announced it would continue its $35 million per year investment in Reef Plan.[38]

Other pressures on corals such as those derived from coastal development (for example local effects of urban and industrial discharge), port operations (for example through sedimentation) and shipping (such as impacts of spills and antifoulants) are predominantly outside the direct regulatory control of the Authority.

With regard to coral, the Authority's overall management effectiveness and effectiveness for biodiversity outcomes was endorsed by the reviewers as partially effective. The independent review of the Authority's assessment concluded:

- **Context** is effective. *The values and impacts of corals reefs is well understood as demonstrated by the large amount of scientific literature published about the corals in the Great Barrier Reef. Australia is recognised as a worldwide leader in coral research, much of which is focused on the Great Barrier Reef. Qualitative models are used to consider the potential for recovery or decline of the reefs under various scenarios, enabling guidance on potential management interventions*.
- **Planning** is mostly effective. *A range of planning tools including the Zoning Plan and Reef Plan are reasonably effective in protecting corals. The Region has been mapped into 30 Reef bioregions, providing good scientific-based evidence to support planning for biodiversity through the zoning plans. Planning for improving water quality, one of the key drivers impacting on corals, is through the Reef Plan.*
- **Inputs** are mostly effective. *There have been significant inputs into the protection of shallow water corals through Reef Plan, scientific research projects and community monitoring programs. However, the joint management program that is critical to the ongoing protection of the corals requires increased long-term funding that is adequate to undertake the required tasks.*
- **Process** is mostly effective. *Sound governance is evident through legislation, the intergovernmental agreement and effective stakeholder partnerships. Plans and strategies are being implemented appropriately. Monitoring of coral reef condition is undertaken in a systematic manner, with over 9000 reef health and impact surveys undertaken since 2009. Targets have been set for recovering coral cover.*
- **Outputs** are mostly effective. *Outputs to protect the values of corals including the representative protection of corals through the Zoning Plan, the reef protection markers, and improved water quality through the Reef Plan have been implemented.*
- **Outcomes** are partially effective*. Irrespective of the resources and outputs for protecting corals that have been implemented, coral cover is declining and this is predicted to continue. Many of the drivers that negatively impact on corals such as water quality are long-term issues and the improvements in water quality will take time to be reflected in improved coral cover.* The reviewers considered **Biodiversity outcomes** to be partially effective . *Although the inshore coral reefs south of Cooktown have experienced declines over the past* [27] *years, those north of Cooktown have remained relatively stable. One of the key drivers of coral loss in the southern region has been from the impact of cyclones (an example is the Swains Reef where modelled decline was from 38 to 8 per cent since 2006). However, there is evidence that the corals are recovering from the impact, with large numbers of coral recruits observed in recent surveys. Commitment to long-term improvement in water quality is necessary.*

9.4.4 Outcomes and potential improvements

Mapping and qualitative models[40] have helped managers understand cumulative impacts on corals. They have also provided guidance on management interventions that may be most effective at avoiding or mitigating impacts to build coral resilience and aid recovery.

Global climate change, poor water quality, and increasing prevalence and severity of extreme weather are continuing sources of environmental stress that cumulatively impede the recovery and resilience of coral reefs on the Great Barrier Reef. Consequently, with current management, the condition for corals is projected to decline to 'very poor' in the southern two-thirds of the Region, and to 'poor' in the northern third in coming decades.

Enhancing protection and restoration
Reducing impacts related to climate change (for example, increased sea temperature and cyclone severity) by ensuring the concentration of carbon dioxide in the atmosphere does not approach the threshold value of 430 parts per million is central to the long-term health and resilience of coral reefs.

So too is a whole of government approach to reversing declines in water quality. It is critical that water quality objectives are met, and that land clearing, dredging and disposal of dredge material do not adversely affect coral cover on inshore, mid-shelf, outer shelf and deep sea reefs.

Improving the consistency of and strengthening the application of water quality guidelines across the Great Barrier Reef World Heritage Area, including through regulatory and partnership approaches, would likely strengthen the adoption of best practices in activities like dredging and dredge material disposal.

Proactive site planning for high growth areas for recreation and other uses would provide certainty and targeted on-ground actions.

Restoring coral reefs following incidents such as vessel groundings or cyclones would help increase the resilience of the ecosystem as a whole. Such restoration could be guided by a policy that reviews current best practice and international developments in technology, methods and capacities.

Minimising impacts
Recognising that crown-of-thorns starfish outbreaks are the major cause of coral cover decline, returning outbreaks to their natural cycles is a major component of improving the condition of coral reefs. This requires a reduction of nutrients in Reef waters, direct control of crown-of-thorns starfish at the source of outbreaks and compliance with the zoning and spatial management arrangements.

Increasing investments in site infrastructure and compliance activities Reef-wide would assist with the prevention of direct damage of coral (for example, public moorings, reef protection markers, enforceable no-anchoring areas). As the adjacent coastal population continues to increase, catering for expanded use of the Region is critical.

Improving adaptive management
Integrated long-term monitoring of the condition and trend of coral reefs and understanding the adaptive capacities of coral reefs under a changing climate are required to ensure management actions are effectively reducing the impacts of highest risk to coral reefs. Another aspect to long-term monitoring is improving managing agencies' understanding of the social, cultural and economic benefits associated with coral reef habitats.

Maintaining managing agencies' close collaborations with recreational and commercial users of the Region (for example, tourism operators, commercial fisheries) to collect relevant data (for example through the Eye on the Reef monitoring program) will continue to allow early warnings of impacts such as crown-of-thorns starfish outbreaks or thermal bleaching events.

9.5 Islands

9.5.1 Significance

Islands contribute to all four of the natural criteria for which the World Heritage Area was listed in 1981: exceptional natural beauty, significant geomorphic features, significant ongoing ecological and biological processes, and significant natural habitats for the conservation of biological diversity.

There are about 1050 islands in the World Heritage Area — these are exceptionally diverse in terms of their geography, geomorphology and ecology. Islands are a unique component of the World Heritage Area and critical to its integrity. Interconnected reef and island ecosystems support some of the richest biodiversity on the planet. For example, continental islands and cays in the World Heritage Area support more than 200 bird species, many of which are in breeding colonies, while providing globally important nesting sites for marine turtles.

Islands function as important refugia for plants and animals, protecting them from impacts prevalent on the mainland, and some habitats are found only on islands of the World Heritage Area (such as *Pisonia* forests).[62] Islands are also key links in connecting terrestrial habitats along coastal and offshore areas. These connections are intricately dependent on the species which have evolved to live on islands. This is typified by the relationship between Wet Tropics rainforests, Great Barrier Reef islands, and the pied imperial pigeon (Figure 9.2). Other island bird species migrate or move between many countries across the South Pacific region and beyond.

In addition to their natural values, many islands have significant heritage values for Aboriginal and Torres Strait Islander peoples. They include a diversity of sites of archaeological and cultural significance such as fish traps, middens, rock quarries, story sites and rock art. Well-known examples are on Lizard, Hinchinbrook, Stanley, Cliff and Clack islands and in the Whitsundays where there are spectacular galleries of rock paintings. Many islands also have significant historic heritage values (historic lightstations, associated shipping and navigational history), while a number are a focus for research and defence training activities.

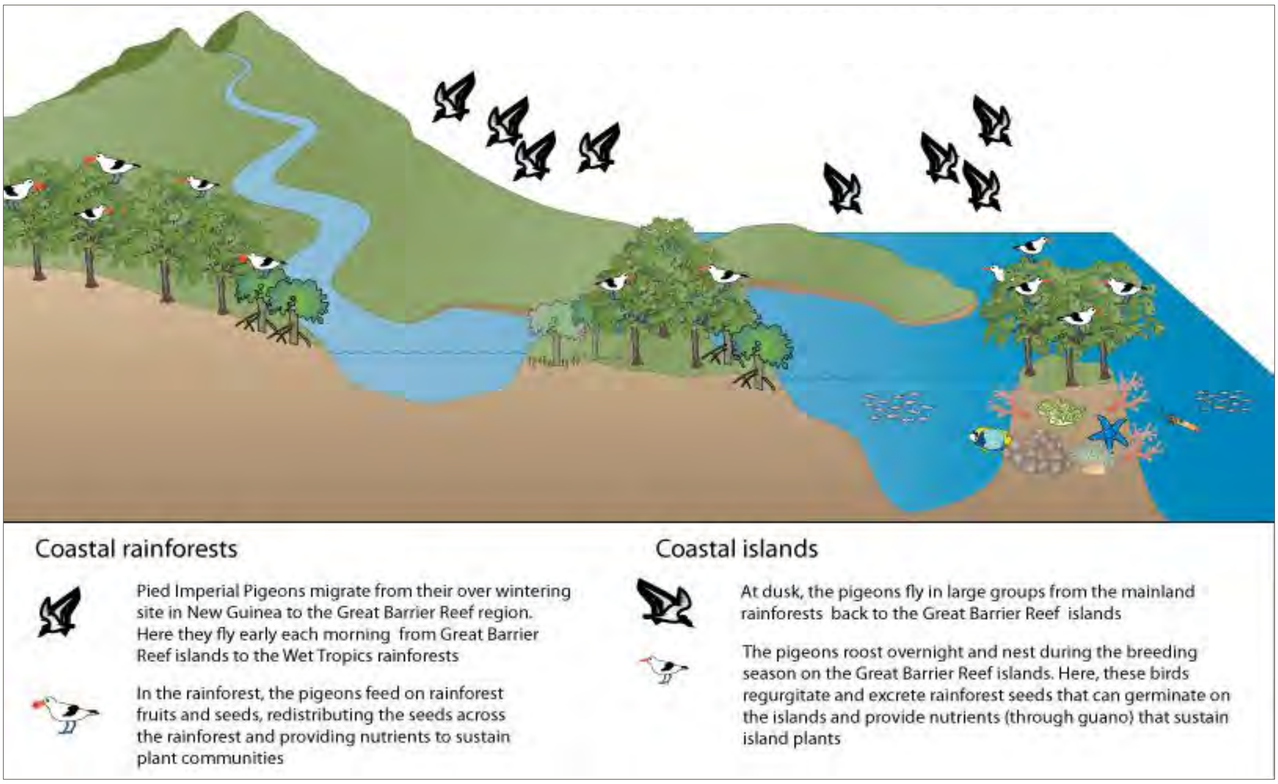


Figure 9.2 Relationships between the rainforest, islands and the migratory pied imperial pigeons
Reproduced from Informing the outlook for the Great Barrier Reef coastal ecosystems[43]

Islands in the World Heritage Area are important for tourism and recreation — 27 islands have resorts and/or residential communities, and many more have visitor facilities including campgrounds, walking trails and day use areas. An estimated 40 per cent of the 1.8 million tourists to the Great Barrier Reef in 2011 included an island destination in their visit.[46] Magnetic Island, near Townsville, includes a number of urban, village-type settlements wholly located within the World Heritage Area.

9.5.2 Responsibilities for islands

Management of the islands in the World Heritage Area is complex, and a range of tenures and management arrangements apply. Table 9.4 presents the tenures of a sample of 21 islands in the World Heritage Area. The State of Queensland has jurisdiction over approximately 980 islands. About 400 of these are protected areas (national parks), and tenure on the remainder includes leasehold, freehold, unallocated state land, Commonwealth or Deed-of-Grant in Trust land, or a combination of tenures.

Approximately 70 Commonwealth islands are part of the Great Barrier Reef Marine Park and are within the Commonwealth Islands Zone. Twenty-one of those 70 islands include navigational lights or lightstations, and in 1988 responsibility for management of those islands was transferred from the Australian Maritime Safety Authority to the Great Barrier Reef Marine Park Authority (the Authority). The Australian Maritime Safety Authority remains responsible for the operation of the navigational lights, and leases back this portion of land. The Department of Defence is responsible for all the remaining Commonwealth islands in the World Heritage Area, except Little Fitzroy Island which is owned by the Department of Finance and Deregulation.

9.5.3 Key issues

In general, the condition of islands is assessed as good and stable, with the exception that condition is deteriorating on some inner islands that are the subject of development activities in the southern World Heritage Area.[63] Many of the natural resource management issues on islands result from the legacy of past activities. Consequently, effective management needs to address past impacts as well as current and emerging threats to the islands and their surrounding marine ecosystems.

Key past and present impacts on the islands throughout the World Heritage Area include: historical guano mining activities; invasive plants and animal pests (for example goats, rats); altered and unmanaged fire regimes; impacts from visitation; increasing impacts of industrial and residential infrastructure; the degradation of cultural heritage (Indigenous and historic); and the consequences of climate change, leading to declines in cultural, ecological and aesthetic values. The diverse range of issues is illustrated by two examples, Raine Island and Lady Elliot Island.

Raine Island is a Queensland Government island and afforded the highest protection as a national park (scientific). It is one of the most remote islands in the World Heritage Area, located in its far north . Guano mining from 1890 to 1892 caused major changes to the island's geomorphology and hydrology, some of which are only now becoming apparent.[64] While Raine Island remains probably the most important seabird breeding site on the Great Barrier Reef, the island's seabird populations have been affected by a combination of historic activities and climate change. Eighty-four bird species have been recorded at Raine Island — five of these are considered uncommon or rare in Queensland. Sixteen species are known to breed on the island. A comparison of bird populations between 1979 to 1993 and 1994 to 2003 suggests a population decline in 13 of the 16 species over the 24-year period. The combined averages for all 16 species indicate the total rookery population has declined by about 16,000 birds or about 70 per cent.[65]

Table 9.4 Tenure of islands in the World Heritage Area

The Authority manages Kent Island, Pipon Island, Unnamed Island (Pipon Island Group), Russell Island, North Reef Island, Low Isles, Pine Islet, Lady Elliot Island, Albany Rock, Coppersmith Island, Hannah Island, Bailey Islet, Clerke Island, Coquet Island, Eshelby Island, Hannibal Island, High Peak Islet, Rocky Island and South Brook Island, together with parts of Dent and Penrith islands.

			Examples of islands																				
			Brampton Island	Curtis Island	Dent Island	Flinders Island	Forbes Island	Great Keppel Island	Green Island	Hamilton Island	Heron Island	Hinchinbrook Island	Keswick Island	Lady Elliot Island	Lizard Island	Magnetic Island	North Keppel Island	Orpheus Island	Quoin Island	Raine Island	Townsend Island	Triangular Island	Whitsunday Island
1050 islands within the Great Barrier Reef World Heritage Area	70 Commonwealth islands	Department of Defence (48 islands)																			●	●	
		Department of Finance (1 island)																					
		Great Barrier Reef Marine Park Authority (21 islands)			●									●									
	980 Queensland islands	National park (400 islands)	●	●					●		●	●			●	●	●	●	●	●			●
		Leasehold	●	●	●			●	●	●	●	●	●		●	●	●	●					
		Unallocated state land		●					●														
		Esplanade							●														
		Freehold	●	●											●	●							
		Aboriginal land					●																

The world's largest population of nesting green turtles (*Chelonia mydas*) is found on Raine Island.[66] Nightly nesting activity can involve more than 10,000 turtles. Today, a range of potential impacts are affecting turtle reproductive success including, but not limited to, tidal inundation of nests, changing sand distribution and consistency, and soil-borne pathogens. These can lead to a decline in nesting and hatching success.[67,68,69] Active management intervention is now taking place — a situation likely to become more commonplace as impacts related to climate change become more apparent, the condition of values decline and the capacity for natural recovery diminishes.

The southernmost island in the World Heritage Area, Lady Elliot Island is a Commonwealth island and an important site for seabird nesting. For example, *Pisonia* trees on the island are important as breeding habitat for black noddies, while ground-nesting crested terns, red-tailed tropicbirds and bridled terns are common.

From 1863 to 1873, Lady Elliot Island was cleared of vegetation and mined for guano. In 1969, a revegetation program began and a mixed cover of *Casuarina* and *Pisonia* trees was established, providing habitat for many bird species. The island now provides significant opportunities for visitors to view a large diversity of coastal birds. It is accessed mainly by airplane, with accommodation provided by an eco-certified tourism operation.

Lady Elliot Island, a Commonwealth island in the southern Great Barrier Reef

The heritage-listed lightstation at Lady Elliott Island contains a lighthouse and a cluster of associated service buildings. Many of the buildings are constructed of asbestos which may pose an environmental and occupational health and safety risk if buildings fall into disrepair. Lady Elliot Island lightstation is on the Commonwealth Heritage List and a management plan has been developed for the heritage conservation of the site.

9.5.4 Current management and its effectiveness

The degree of active management for islands in the World Heritage Area varies widely. They are covered by a variety of tenures (leasehold, freehold, unallocated state land, Commonwealth, and Aboriginal land) and are managed by a range of agencies. Many that are not part of the protected area estate have important values such as seabird rookeries.

Queensland islands (excluding protected area islands)

Queensland islands that are not part of the protected area estate are multiple-use areas that support a range of activities and industries, such as tourism and residential. They are subject to an evolving range of Queensland Government regulatory tools, including legislation and ongoing management programs. The Queensland Government is committed to ensuring that planning and development of non-protected area islands is appropriately managed to ensure the World Heritage Area retains the values for which it was declared, and that it continues to be one of the best managed areas in the world.

The Queensland Government's coastal management, planning and development framework applies its islands. This includes legislation, plans, policies and programs that combine to provide a comprehensive regulatory and management system. Their purpose is to provide Queensland Government oversight and regulation of development on these islands, particularly in regard to activities associated with major developments that are expected to occur on islands, for example tourism developments.

Leasehold islands are subject to specific terms of use which dictate the kind of activities that may occur. Activities or uses that have the potential for negative effects are mitigated through lease conditions. Freehold island owners are subject to their environmental duty of care under Queensland and Australian government legislation, such as protecting native species (for example, the Nature Conservation Act (Qld)) or not undertaking actions that may have an impact on matters of national environmental significance.

Queensland national park islands and Commonwealth islands

Key challenges in managing national parks and Commonwealth islands include resource limitations, the remote location of many islands (where visits by field staff may total only a few hours per year) and the ecological and jurisdictional complexities. These challenges were recognised and resulted in the establishment of joint management arrangements and a formal partnership between the Australian and Queensland governments through the former 1979 Emerald Agreement and the current *Great Barrier Reef Intergovernmental Agreement 2009*. For more than 30 years, this partnership has delivered on-ground management activities through a field management team comprising Queensland and Australian government agencies. Participants in field management include the Queensland Parks and Wildlife Service, Border Protection Command, Customs National Marine Unit, Commonwealth Director of Public Prosecutions, Australian Federal Police, Australian Maritime Safety Authority, Queensland Boating and Fisheries Patrol, and Queensland Police Service.

A large range of planning tools is available to manage islands, including complementary state and Commonwealth zoning (with specific zoning for all Commonwealth islands and Special Management Areas), joint field management business plans, Great Barrier Reef Marine Park plans of management, and Queensland Government national park management plans and management statements.

However, there are many instances when state and Commonwealth legislation is not complementary for waters adjoining islands (such as for seabird closures). In addition, there are no state plans in place to mirror the Authority's plans of management for intertidal waters adjoining islands. While about 400 islands are protected as national parks, there are some islands with high nature conservation value not under protected area tenure (for example, Douglas Islets).

Monitoring of coastal birds, turtles, pests and weeds is undertaken to assess the condition and trend of key species and habitats. Controlling or eradicating pest plants and animals is risk-based and effective at locations where resources are focused (for example, successful eradication of feral pigs from Wild Duck Island, removal of rats from Boydong Island, and controlling outbreaks of scale insects responsible for the destruction of *Pisonia* forests on Tryon Island). In an island context, this is significant because it shows eradication of introduced species is an achievable outcome — with concerted effort, pest programs can be finite and deliver enduring conservation benefits. However, to remain effective, these programs must be coupled with a strong focus on quarantine and surveillance, as preventing adverse environmental impacts is more cost-effective than managing or reversing them.

The Authority and the Department of Defence have responsibility for the protection of natural, historic and cultural heritage values on the 70 Commonwealth-owned islands. Regimes are in place to provide an overarching level of management for these islands (for example, zoning, regulations, surveillance and enforcement). However, a lack of information in a readily accessible format makes it difficult to monitor and assess the condition of those values and in some cases has contributed to delays in the preparation of heritage management plans.

Some cultural heritage sites on islands are known to be degrading, for example Pine Islet lightstation which is closed to public access due to asbestos issues. Long-term maintenance of heritage sites on islands is expensive, particularly for European heritage (for example the Queensland heritage listed Raine Island tower and the Commonwealth heritage listed Lady Elliot Island lightstation). The agency responsible for Commonwealth heritage sites listed under the *Environment Protection and Biodiversity Conservation Act 1999* must make plans to protect and manage heritage values and must not contravene those plans. Plans have been or are under development for Commonwealth heritage listed sites within the World Heritage Area.

Significant progress in island protection and conservation has been made in recent years in partnerships with Traditional Owners, especially through the collaborative development of Traditional Use of Marine Resources Agreements and Indigenous Land Use Agreements. Specific Indigenous compliance partnerships have also been progressed on Cape York Peninsula. Australian Government Reef Rescue funding has been a key driver of this progress.

The independent review of the Authority's assessment concluded:

- **Context** is mostly effective. *Values underpinning matters of national environmental significance for islands are well documented and understood by managers, with management plans or management statements that articulate the values and threats for the islands developed. The geological basis of islands: mangrove islands, continental islands, and reef islands or coral cays influence the management issues associated with each island. Mapping of regional* *ecosystems and identification of endangered ecosystems has occurred for most islands. The islands vary significantly in their visitation and development profiles.*

- **Planning** is mostly effective. *A range of planning processes is in place to manage the islands, and vary depending on the jurisdictional responsibilities. Plans include the Zoning Plan (including restricted access areas and public appreciation areas), local government planning, Queensland Parks and Wildlife Service management plans, Cairns, Whitsunday and Hinchinbrook Plans of Management and TUMRAs* [Traditional Use of Marine Resources Agreeements]. *Overall, the planning arrangements on islands to protect the values are in place, and are implemented appropriately*.
- **Inputs** are partially effective. *Significant long-term financial commitments from both the Australian and Queensland governments are required if priority actions to achieve agreed objectives are to be implemented. This is particularly important for high value locations that are remote and difficult to access.*
- **Process** is mostly effective. *Good governance through the intergovernmental agreement and joint management program, as well as strong stakeholder engagement is in place. Monitoring programs such as the coastal bird monitoring strategy, turtle monitoring, pest and weed programs, and specific vegetation programs such as the impact of the invasive ants in the Pisonia forests on Tryon Island are undertaken to assist management decisions and gauge the impact of management actions.*
- **Outputs** are mostly effective. *Activities relating to island management have generally progressed well, and in accordance with the respective work programs, such as the Field Management Program. Examples include the successful eradication of feral pigs from Duck Island, and removal of rats from Boydong Island. Limited resourcing is seeing a reduction in time spend on remote and isolated islands, and it is expected that this will also impact on the capacity to deliver the work programs.*
- **Outcomes** are mostly effective. *Management activities are reducing the short-term immediate risks and threats. However, they are not comprehensively addressing issues such as changes in beach profiles due to climate change and severe weather*. **Biodiversity outcomes** are mostly effective. *Specific actions to address the impacts of changes to beach profiles that affect high value biodiversity outcomes such as turtle breeding on Raine Island have been implemented. However, this has not been comprehensively considered across all islands.*

9.5.5 Outcomes and potential improvements

The overall condition for islands is projected to remain good in the coming decades, but pressures will increase from climate change and on inner islands in the southern World Heritage Area that are subjected to ongoing pressures from development and use.

The following potential improvements relate to protected area islands in the World Heritage Area (for example Queensland national parks or other conservation tenures, and islands that are part of the Great Barrier Reef Marine Park), representing up about 30 per cent of the total of 1050 islands. Many of the identified management improvements would also benefit the remaining 700 islands not part of the protected area estate and managed under other tenures.

Enhancing protection and restoration
Island protected areas will continue to provide visitor opportunities that support the tourism industry and a broad and expanding range of recreational use. As the coastal population increases, so too will the demand for visitor opportunities and the associated facilities required to support use and minimise its effect on island and reef ecosystems. Improving pro-active regional and site-specific planning (including for site infrastructure) would provide certainty for recreational and tourism opportunities and sustain visitor enjoyment, environmental quality and the economic benefits of healthy, well-presented islands.

Indigenous and historic heritage values associated with islands are an increasing focus for protection and restoration activities. Improving managing agency capacity to undertake cultural heritage management activities would assist in the delivery of legislated obligations.

A focussed program for Traditional Owner partnerships specifically related to island protected area management would complement progress already made through partnerships with Traditional Owners.

Encouraging an engaged and supportive community is vital to the long-term protection of the Great Barrier Reef World Heritage Area, including its islands. The Queensland Government has initiated a program to increase the support that community volunteers can provide to management of the State's protected areas.

Minimising impacts
On-ground management actions are essential in ensuring effective management of protected area islands, whether this is maintaining visitor infrastructure, managing pest plants and animals and fire, or active adaptive management works to remove or reduce threats to vulnerable species such as marine turtles and seabirds.

Improved field management resources, personnel and fit-for-purpose vessels to deploy to all protected area islands at the frequency and duration required for effective on-ground management would improve the protection of natural, social and economic values of island protected areas.

With increasing visitation to islands, the risk of exotic plant and animal pest incursions is likely to increase. The present management framework is effective at controlling or eradicating pest plants and animals at locations where resources are focussed on resolving specific issues. However, there is a need to increase the focus on quarantine and preventative measures and surveillance activities. Prevention or early detection and treatment for island pests is better and less expensive than restoration after an incursion. While there remain many historic pest legacy issues requiring management action, the factors that drive island pest introductions are escalating.

Improving adaptive management
Maintaining the natural, economic and social values of Great Barrier Reef islands relies on a good knowledge of values, identifying changes and trends and managing threats to these values. The key known threats to the natural, economic and social values of World Heritage Area's islands are: the ecosystem consequences of a changing climate; invasive plant and animal pests; altered and unmanaged fire regimes; impacts to island natural and recreational values if human use is not well-managed; and the degradation of cultural heritage (Indigenous and non-Indigenous).

While managers generally understand most of the potential threats to protected area island ecosystem integrity, the capacity to consistently monitor and report on island condition and trend and to plan response treatments strategically across the World Heritage Area is constrained. Improving the capability to monitor and report on the condition and trend of islands over the long term would support a complete adaptive management approach for islands and deliver more resilient island ecosystems. It would also complement the existing marine ecosystem condition and trend monitoring arrangements, providing a more holistic ecosystem assessment of the World Heritage Area.

A fundamental principle for managing island protected areas is maintaining healthy ecosystems. This approach is consistent with that recommended in *Australia's Biodiversity and Climate Change Vulnerability Assessment* (2009) which states under the strategy of Building Resilience: '….*the single most important adaptation strategy is the maintenance of well-functioning ecosystems*.' This focus on resilience-based management of islands should continue as an important component. Climate change amplifies the disturbance regime in natural systems, with no exception regarding impacts on island ecosystems. Predicting the impacts on island over the next 25 years is difficult; and the capacity to adapt management arrangements to respond to emerging issues or outbreaks is important.

Continued complementarity of management approaches between the Commonwealth and Queensland protected areas (such as uniformity in any management arrangements and regulations across the Commonwealth and state marine parks and adjoining protected area islands) provides certainty for visitors as well as continuing the long-standing joint field management arrangements in the World Heritage Area.

9.6 Princess Charlotte Bay

9.6.1 Significance

Princess Charlotte Bay, located at the base of Cape York Peninsula (Figure 9.3). The Lama Lama people are the Traditional Owners for the land and sea country extending from the Massey River in the north, around Princess Charlotte Bay, to the Normanby River in the south. The Authority acknowledges the continuing sea country management and custodianship of the Great Barrier Reef by Traditional Owners.

The area is recognised for its high biodiversity values. It contributes to all four of the natural criteria for which the World Heritage Area was listed in 1981: exceptional natural beauty, significant geomorphic features, significant ongoing ecological and biological processes, and significant natural habitats for the conservation of biological diversity. The relatively unspoilt nature of the remote area contributes to its high aesthetic value.[70] The area is of high conservation value for largetooth (previously freshwater) and green sawfish,[71] estuarine crocodiles,[72] dugongs,[35] green turtles[67] and Australian snubfin and Indo-Pacific humpback dolphins[73]. In addition, the last known verified specimen of the critically endangered speartooth shark was recorded in 1982 from the Bizant River which flows into the bay.[71] All these species are matters of national environmental significance.

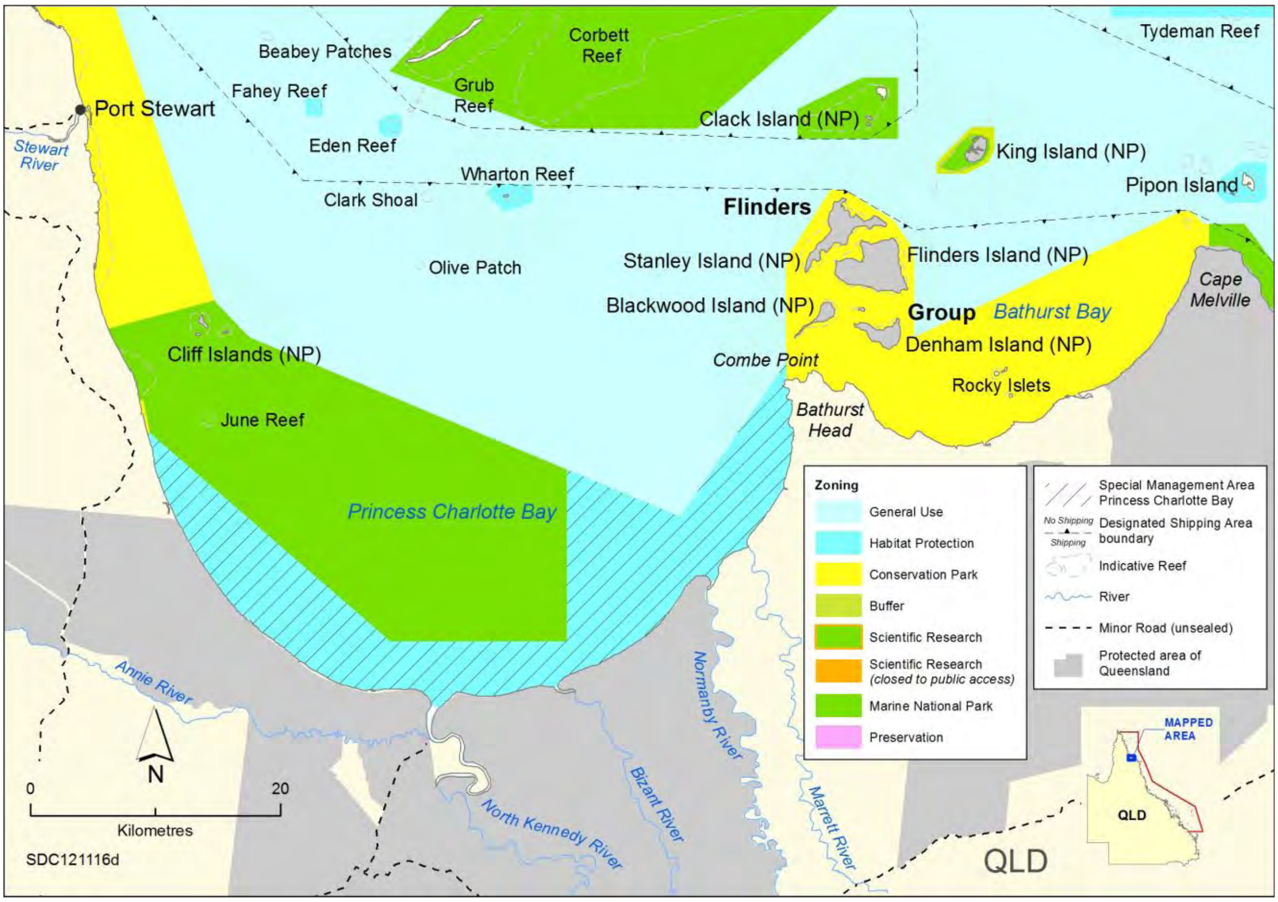
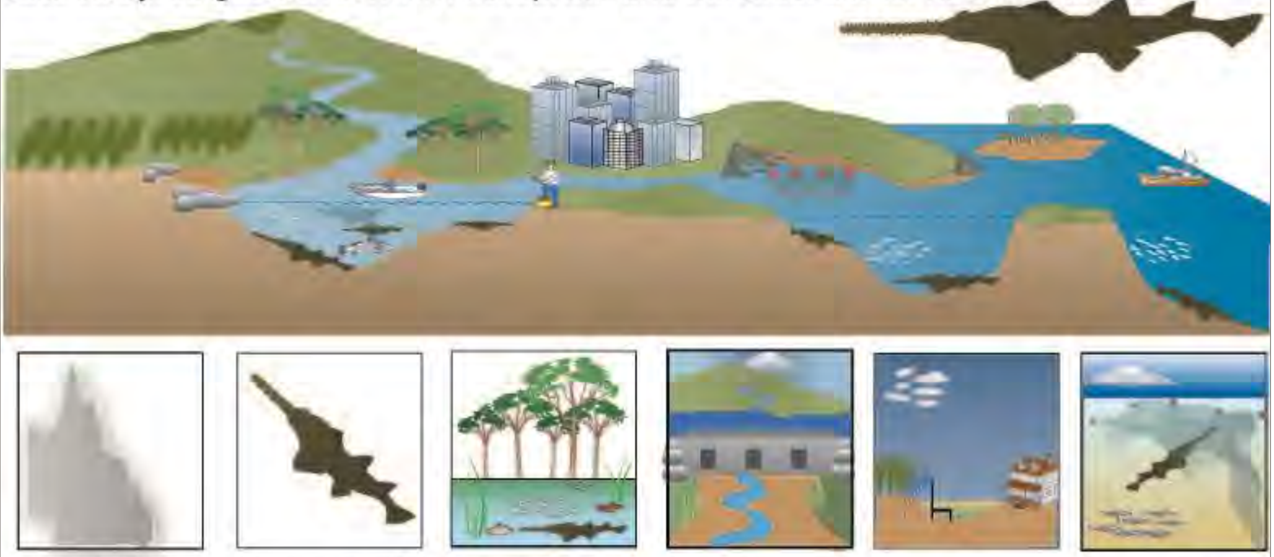


Figure 9.3 Princess Charlotte Bay

Princess Charlotte Bay is one of the largest tidal wetland systems in Cape York Peninsula. Extensive and interconnected mangrove forests[74,75] and seagrass meadows[74,76,77] provide important fish habitat. Recreational, commercial and Indigenous fishers target barramundi, king and blue threadfin salmon, grunter, mangrove jack and mud crabs. The bay is also the northern extent of most commercial gill-net and crab fishing activities in the World Heritage Area.

The surrounding national parks, Cape York Peninsula Aboriginal Land, state reserves, nationally important wetlands and other lands are characterised by diverse, expansive and relatively undisturbed natural landscapes, including coastal areas, river systems and floodplains, lowlands and wetlands,[78] notwithstanding some declines.[79] It is the connectivity between terrestrial, aquatic and marine ecosystems which differentiates the Cape York catchment from other catchments adjacent to the World Heritage Area. Connectivity is required to complete the life cycle of many species, typified by the largetooth (freshwater) sawfish (Figure 9.4), which is now rarely found further south.

Case study: Largetooth sawfish *Pristis pristis* and the Great Barrier Reef catchment



Largetooth sawfish (formerly named freshwater sawfish, *Pristis microdon*) were once distributed throughout Queensland river systems as far south as Townsville. Now, they have a very reduced range and, on the east coast are mostly found in the unmodified rivers of far northern Queensland. Consequently they are now fully protected.

The Largetooth sawfish lives in both freshwater and marine habitats. Adult females give birth in the coastal estuaries and the newborns migrate upstream to the freshwater reaches of rivers to avoid predators such as sharks. These juveniles stay here until seven years of age when they migrate to spend more time in estuarine and marine environments.

During the dry season when river flow slows and the water temperature drops, sawfish move into warmer deepwater pools.

Our need for water for crops has led to the construction of dams and bores. These change the seasonal flows of surface and groundwater, sometimes resulting in periodic drying of rivers. Run-off from the land containing nutrients and chemicals flow into the pools making the pools unsuitable for the sawfish.

Changes in the way we use the land has affected the sawfish. Land modification is resulting in significantly more sediments flowing into rivers and streams (four to ten times natural levles). Dams change the flow intensity. Weaker flows fail to move sediments downstream, causing the deepwater pools to fill with sediment.

Commercial and recreational fishers catch sawfish in nets and when line fishing. The toothed rostrum of sawfish can easily become tangled in fishing nets set for barramundi and other species and in mesh nets set for the protection of bathers at popular beaches.

Figure 9.4 Life cycle of the largetooth sawfish
Reproduced from *Informing the outlook for Great Barrier Reef coastal ecosystems* [43]

The agricultural land uses adjacent to Princess Charlotte Bay are grazing of natural areas and forestry.[43] They are considered to be well managed and, if these land use practices continue at the same intensity and spatial extent, they are unlikely to adversely affect biodiversity values in the area.

The area has very high Indigenous values and cultural significance.[80] The Flinders Island group contains Aboriginal rock art sites, shell middens and stone arrangements. The rock art on Stanley, Flinders and Clack islands is of international significance.

9.6.2 Key issues

For the values which underpin matters of national environmental significance, Princess Charlotte Bay's remote location has provided protection from many of the impacts acting elsewhere in the World Heritage Area. However, the area is identified as the Field Management Program's highest compliance risk because of the very high potential for interaction between fishing (legal and illegal) and species of conservation concern.

The area's remoteness also poses logistical challenges which restrict research and monitoring activities. Long-term data is only available for dugongs,[18] and to a lesser extent seagrasses[76] and some coral reefs.[81] This makes assessing and responding to changes in the distribution, abundance and status of species and habitats very difficult.

Emerging issues of significant concern are:

- potential development in the catchment and associated facilities
- the intensification of agriculture in northern Australia, which is likely in the next 25 years[82]
- visitation to culturally sensitive sites.

9.6.3 Current management and its effectiveness

The majority of the adjacent area is gazetted National Park or Cape York Peninsula Aboriginal Land (Lama Lama, Rinyirru [Lakefield] and Cape Melville National Parks) and jointly managed under the Running Creek, Lilyvale, Rindoparr, Rinyirru and Kalpower Indigenous Land Use Agreements. Traditional Owners are on-country and are best placed to deploy management strategies to provide strong outcomes. The following section refers to the evaluation of current government management and its effectiveness. However, it is acknowledged that Traditional Owners have managed Princess Charlotte Bay on-country well before western systems were implemented and that they continue to do so through cultural practices and traditional ecological knowledge.

Princess Charlotte Bay is within the Remote Natural Area of the Great Barrier Reef Marine Park, which provides recognition and management of the area for its natural and undeveloped character. The purpose of the Remote Natural Area is to ensure the area remains in a state largely unaltered by works and facilities, and to provide opportunities for quiet appreciation and enjoyment. The Remote Natural Area does not include a small area to the north of Bathurst Head in the vicinity of the Flinders Island group.

Management of fishing is a priority in Princess Charlotte Bay. The area from north of Port Stewart around to Bathurst Heads is a Fish Habitat Area under the *Fisheries Act 1994* (Qld) and *Fisheries Regulation 2008* (Qld), which aims to protect critical fish habitat against physical disturbance from coastal development.

The zoning arrangements for Princess Charlotte Bay include a Special Management Area to reduce the threat to dugongs and other species of conservation concern from drowning in commercial set mesh nets (with flow-on benefits to other marine animals) (see Figure 9.3). This unique arrangement requires commercial fishers to obtain written permission to use or enter the area for netting (other than bait netting). Since 2009, the Queensland Government has also closed to commercial netting three waterways which flow into Princess Charlotte Bay (North Kennedy, Bizant and Normanby rivers).

The environmental benefits of these fishery closures depend on compliance. The Field Management Program undertakes land-based patrols, complemented by large vessel patrols from Cairns. Helicopter-based patrols since 2011 are an effective surveillance option, but expensive and limited. Patrolling is weather-dependent and resources for these activities are declining. It is suspected there is significant illegal fishing in the area.

Illegal activities can be reported through the Eyes and Ears incident reporting program, in which Indigenous rangers participate. This is but one example of the increasing ways Traditional Owners are working with government to collaboratively manage natural resources within their country. Another example is the Lama Lama Traditional Owners working with the Authority to develop a Traditional Use of Marine Resources Agreement to enhance sustainable management systems, strategies and practices on country (see Chapter 3).

The independent review generally endorsed the assessment by the Authority and concluded:

- **Context** is effective. *Values underpinning matters of national environmental significance are well documented and understood by managers, due in part to its high ecological, traditional and socio-economic values. Condition and trend of a number of species are monitored. The marine habitats and species have been reasonably well researched and documented.*
- **Planning** is effective. *The demonstration case study provides a number of examples of planning systems and zoning that assist with addressing the protection of the values of Princess Charlotte Bay, including Marine National Park, Habitat Protection, Special Management Areas and Conservation Park zones. Complementary systems of protected area management across the marine and terrestrial interface assist with the protection of the values.*

- **Inputs** are partially effective. *Resources for dedicated training of Indigenous rangers have been significant, however resources to enforce the planning schemes is only partially effective, due to a variety of factors including the isolation and remoteness of the area. In particular, compliance officers face practical and logistical difficulties.*
- **Process** is mostly effective. *Sound governance is evident through the intergovernmental agreement, and complementary terrestrial and marine park zoning. Effective partnerships are in place with Traditional Owners.*
- **Outputs** are mostly effective. *Outputs such as the reduction in net fishers to four would suggest a better result than partially effective. Similarly the largely stable dugong population in the area indicates outputs have been mostly effective. Results from management programs such as the Zoning Plan, the Special Management Areas, the declared fish habitat areas,* [and] *the Reef Rescue program have been mostly effective in managing Princess Charlotte Bay.*
- **Outcomes** overall are mostly effective. *Management activities have been effective to date in protecting the values of Princess Charlotte Bay, as evidenced* [by] *ongoing high, intact biodiversity values. The greatest threat to Princess Charlotte Bay is potentially from the proposed Wongai Coal mine project which is yet to be approved.* **Biodiversity outcomes** are effective. *The intactness and integrity of Princess Charlotte Bay is evidence of effective biodiversity outcomes, although the remoteness and relative inaccessibility plays a significant role in this outcome.*

9.6.4 Outcomes and potential improvements

The projected increase in economic development of the adjacent catchment area is likely to increase pressure on the biodiversity and heritage values of Princess Charlotte Bay, which are predicted to decline in condition in the coming decades. Contributing factors include the current outbreak of crown-of-thorns starfish in the area; extreme weather events that are likely to affect the condition of coral reefs and other habitats; and likely clearing and modifying of additional land in the catchment for agriculture. The improvements in catchment management of land currently used for agriculture are expected to improve inshore marine water quality through reducing sediment loads in flood events and reducing base loads of contaminants during lower flow periods. However, improvements in marine water quality and associated coral reef condition are likely to be slow, with lags in ecosystem responses and potentially long recovery periods.

Outcomes for biodiversity, heritage values and socio-economic benefits would benefit from the following management improvements.

Enhancing protection and restoration
Incorporating cumulative impact considerations into management decision making within the area, especially in relation to integrity and connectivity in line with the Remote Natural Area, would create a more holistic and consistent approach.

Ongoing support and resourcing for the implementation of the Lama Lama Traditional Use of Marine Resources Agreement (and other sea country partnership initiatives in the area) and appropriate training and resourcing for Indigenous rangers to conduct assessments of natural resources within their country would provide benefits to the biodiversity of the area as well as to Indigenous heritage sites and community benefits to Traditional Owners.

Minimising impacts
Direct impacts on the values of Princess Charlotte Bay could be addressed by reducing risks to species of conservation concern from both legal and illegal netting activity; ongoing compliance patrols in the Special Management Area, including additional resourcing for night-time surveillance technologies to address illegal fishing activities; and implementing safeguards to manage the impacts of increasing recreational fishing effort on species and habitats including from the harvest of fish, vessel strikes, anchor damage and disturbance to wildlife.

Improving adaptive management
The protection of the area's values relies on improved understanding, mapping and systematic evaluation of its biodiversity, and Indigenous and historic heritage values. In addition, an improved understanding of the patterns of commercial and recreational use would allow for proactive planning to meet the needs of those uses.

Integrated monitoring is crucial to inform management about conditions and trends of the area's values and to continuously assess the effectiveness of management actions.

Regular reporting on the status of values and management effectiveness will allow management to be adapted over time and to changing conditions.

9.7 Cairns Planning Area

9.7.1 Significance

Cairns is the principal city of far northern Queensland. The city is located on the east coast of Cape York Peninsula on the coastal strip between the Coral Sea and the Great Dividing Range. The area offshore Cairns contributes to all four of the natural criteria for which the World Heritage Area was listed in 1981: exceptional natural beauty, significant geomorphic features, significant ongoing ecological and biological processes, and significant natural habitats for the conservation of biological diversity. It is well known for its spectacular reefs, abundant wildlife (including whales, dolphins, turtles, dugong and seabirds) and the neighbouring Wet Tropics World Heritage Area, all of which contribute to its high aesthetic value.[70]

This unique environment 'where the rainforest meets the Reef' is an important part of the lifestyle and identity of many of the residents, including the Traditional Owners who have ongoing connections with land and sea country.

Recreational activities such as boating, fishing, scuba diving, snorkelling and yachting are widespread. The area also supports commercial fishing, a growing cruise shipping industry and commercial ports servicing far northern communities.[83]

Tourists snorkelling at Low Isles

Tourism is the major economic driver for the Cairns region. The outstanding universal value of the coastal and marine environment, along with the proximity of the reefs and islands to the coast, draws about 50 per cent of the Great Barrier Reef Marine Park's almost two million tourist visits to the area each year. A wide array of nature-based visitor experiences is provided by tourism operators, ranging from cruise ships and live-aboard vessels to day trips on high speed catamarans, kayaking tours and game fishing.

Recognising the intensive tourism activity around Cairns, the Authority prepared the Cairns Area Plan of Management[84] in 1998. The plan's objective is 'to protect and conserve this environmentally significant area, while allowing reasonable opportunities for access and use'.

The area covered by the plan is referred to as the Cairns Planning Area. It extends from Lizard Island in the north to the Frankland Islands in the south (Figure 9.5). The planning area includes many places, biological communities and species of high biodiversity, heritage and socio-economic value. The plan identifies the values that require protection, the main impacts affecting them and the management strategies required to address these issues.

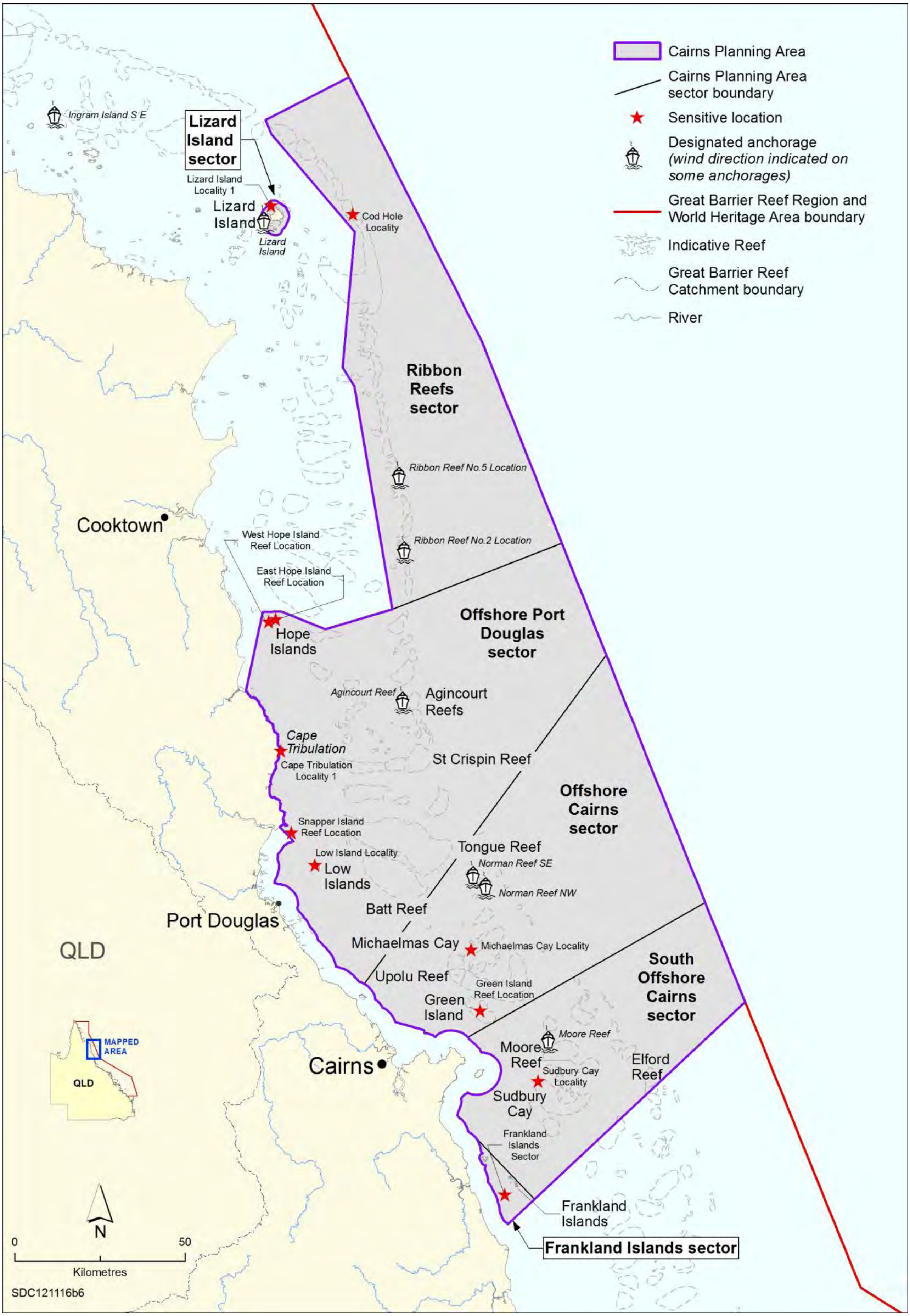


Figure 9.5 Cairns Planning Area

This demonstration case study highlights the complexity of managing cumulative impacts from tourism in an intensively used area in a way that protects biodiversity and provides certainty for a variety of tourism activities.

9.7.2 Key issues

Tourism plays a key role in presenting the outstanding universal value of the Great Barrier Reef to visitors. Tourism operators that help protect and present the World Heritage Area to a consistently high standard are recognised by the Authority through the High Standard Tourism program. These operators are independently certified under Ecotourism Australia's ECO Certification Program to the Ecotourism or Advanced Ecotourism levels.

The plan of management recognises the sustainability of this Reef-dependent industry relies on maintaining the environmental and socio-economic values of the area's reefs, cays and waters, as well as the biodiversity these habitats support. A healthy ecosystem also underpins commercial fishing and recreational activities. A focus of the plan is to minimise cumulative impacts predominantly associated with intensive tourism. In particular, the plan seeks to address impacts on heritage, wildlife and the environment associated with intensive tourism use and the potential conflicts between tourism operations and other users.

The suite of management arrangements employed within the planning area is complex, and understanding and applying these management tools is challenging for users. As the plan only applies to a small portion of the Great Barrier Reef Region, management tools and intent do not, on occasion, align well with those in adjoining areas.

9.7.3 Current management and its effectiveness

The Cairns Area Plan of Management operates in conjunction with a broad range of management tools, but focuses on issues specific to the area, its species and communities at a regional scale. While the plan addresses the area’s intensive tourism activity, it complements the suite of management tools used to manage tourism throughout the Marine Park.

Implementation of the plan began in 1998. Since then it has been reviewed every two to three years, although the last review was in 2008. The plan addresses potential impacts and conflicts in the planning area associated with intensive use through:

- limiting group sizes at locations
- establishing special management arrangements at 11 sensitive locations
- limiting the number of private moorings, pontoons and other structures
- limiting noisy activities
- establishing reef anchorages, no-anchoring areas and public moorings
- capping the number of tourism operations (vessels and aircraft).

Joint management arrangements with the Queensland Government (such as permitting, site infrastructure management and compliance) in place since 1979 and current under the *Great Barrier Reef Intergovernmental Agreement 2009*[85] significantly increased jurisdictional consistency across land and sea. The Queensland Government and the Authority have jointly approved some site management plans, which are non-statutory policy documents; however the Cairns Area Plan of Management has not been approved by the Queensland Government. Reciprocal recognition of planning tools by the Authority and the Queensland Government would improve consistency of management.

The plan and the permitting system employed to manage tourism operations partially address conflicts between tourism and other activities. However, conflicts between recreational and commercial fishers, and between Traditional Owners and other users, are now emerging in the planning area.[83]

The plan has been mostly effective in managing cumulative use by the tourism sector.[5] However, the cumulative impacts from all uses (including recreational use, fishing and shipping) in the planning area are neither the intended focus nor the intended outcome of the plan. The protection of the planning area's values from these impacts is reliant upon other management tools.

Poor water quality (as a result of land management practices in the catchment) correlates with an increased frequency of crown-of-thorns starfish outbreaks.[86] In the past, these outbreaks have severely affected coral cover, a key value of the Cairns Planning Area upon which the tourism industry is heavily reliant. While significant improvements have been made in halting and reversing the decline in water quality, an accelerated program is necessary for the future.

The independent review of the Authority's assessment concluded:

- **Context** was effective — *Values underpinning* matters of national environmental significance *are well documented and understood by managers, as are the regional and local risks and threats which are the subject of ongoing engagement with regional stakeholders.*
- **Planning** is mostly effective. *A robust planning system is in place but its effectiveness is constrained by the complexity of governance issues with all levels of government needing to be critically involved as well as an array of narrowly focused industry and interest groups. Agreeing on clear and measurable objectives which give rise to priority actions implemented consistently across jurisdictions in these circumstances remains a challenge. Note that the plan of management addresses overall level of use (within context of an already heavily used region) but there is little evidence in the plan that it considers or manages cumulative impacts — little or no discussion of this in the plan, no identification of which potential cumulative impacts are of concern and no consideration of associated monitoring to manage this issue — but the demonstration case text suggests that the* Plan *does address cumulative impacts.*
- **Inputs** are mostly effective*. Achieving cross-jurisdictional consistency is always going to be resource intensive. Collaborative governance requires significant long-term financial commitments from all parties if priority actions to achieve agreed objectives are to be implemented.*
- **Process** is partially effective. *The individual components of governance are sound with the individual responsibilities of the different levels of government clear, but the complexity which derives from the number of levels of government involved makes consistent delivery of on-ground results difficult.*
- The delivery of **outputs** assessed by the Authority as effective was not endorsed by the reviewers*. 'Mostly effective' would seem to be a more accurate assessment given that while individual programs or activities may have progressed in accordance with timeframes and plans, there is only limited evidence presented that the results have achieved their stated objectives. The fact that* the Authority *no longer provides tourism industry training in a key tourism region, that the field management program is significantly reduced, that planning and policy tools for tourism have not been updated all suggest that a rating of effective is too high.*
- **Outcomes** overall are mostly effective. *Management activities are certainly reducing the major risks and threats but fall short of categorically ensuring either the economic or environmental sustainability of the use of the Reef.* Finally, **biodiversity outcomes** are only partially effective. *While risks and threats are reduced, management is only part of the way to being on track to ensure that the values of the Great Barrier Reef are protected.*

Much of the Great Barrier Reef catchment is forecast to experience annual population growth rates of 1.6 per cent or higher in the near future,[83] and this is expected to result in increased recreational use in the planning area. In recent years, regional catchment planning has attempted to identify and conserve regional values, while allowing for growth.

Given the likely impacts from climate change, coastal development and water quality, it seems unlikely that the current plan alone will be effective in protecting the area's values in the future and in providing certainty for Reef-dependant uses such as tourism, commercial fishing, traditional use and some recreational activities.

9.7.4 Outcomes and potential improvements

The Cairns Area Plan of Management has been mostly effective in managing the cumulative impacts of the most intensive tourism area in the Marine Park. However, the condition of biodiversity, heritage values and community benefits are projected to decline in the planning area in the absence of improved management arrangements to address regional impacts (particularly from water quality and coastal development, which are outside the scope of the plan); protection of at-risk marine and terrestrial habitats; and maintenance or restoration of landscape connectivity to ensure functional terrestrial and marine ecosystems.

To improve management of Reef-related activities and resilience in the planning area, potential measures could include the following actions.

Enhancing protection and restoration
The resilience of the ecosystem would be improved and values better protected by:

- Improving protection for at-risk marine and terrestrial habitats and maintaining or restoring landscape connectivity to ensure functional terrestrial and marine ecosystems
- Strengthening proactive planning to enhance environmental protection, ecosystem resilience and tourism and recreation values, and to respond to projected changes in patterns of use as a result of population growth in the catchment.
- Improving understanding and presentation of world heritage values, including outstanding universal value, by the tourism industry and visitors to the planning area.

Minimising impacts
Impacts on values would be reduced by:

- Continuing to reduce crown-of-thorns starfish outbreaks, through targeted control activities at source reefs and high value tourism sites and improving water quality.
- Increasing awareness and application of best practices by recreational users, tourism operators, commercial fishers and Traditional Owners.
- Expanding engagement and stewardship programs including a mechanism for auditing and reviewing identified minimum operating standards and requirements.
- Strengthening field management, compliance and enforcement.
- Reducing impacts on biodiversity through the installation of site infrastructure (for example, no-anchoring areas, public moorings, reef protection markers, signs).

Improving adaptive management
The capacity of the Authority to adapt its management to changing circumstances in the planning area would be improved by:

- Regularly reviewing and aligning management tools across the Australian and Queensland governments to ensure currency, consistency, effectiveness and simplicity.

9.8 Mackay Whitsunday — water quality improvement

9.8.1 Significance

The decline in the quality of water entering the Great Barrier Reef from adjacent catchments is one of the most significant impacts on the health of the Reef.[4] This demonstration case study explores how the Queensland and Australian governments are working to halt and reverse the decline in the quality of water entering the Reef. Specifically it highlights some of the work being done to improve the quality of water flowing from the Mackay Whitsunday region (Figure 9.6).

It documents actions delivered through the joint Australian and Queensland government's Reef Water Quality Protection Plan (Reef Plan),[39] including the Commonwealth's Reef Rescue initiative, Queensland's development of best management practices, and management of land use to minimise run-off. It also includes the work of the regional natural resource management bodies in developing a regional water quality improvement plan with water quality targets linked to the Authority's water quality guidelines and Queensland's Environmental Protection Act and policies.

9.8.2 Key issues

Many of the pressures on water quality reflect the land use pattern in the catchment. The dominant land uses are grazing (56 per cent), sugarcane production (19 per cent) and national parks and reserves (17 per cent) (Figure 9.7).[87] In the last decade, understanding of the impact of water quality on the Reef has changed. It has moved from a debate on whether an impact is actually occurring to a consensus that declining water quality has degraded many inshore reef areas. There is evidence that parts of the Great Barrier Reef are now experiencing nutrient enrichment,[52,88,89] high phytoplankton biomass,[52,90] potential changes in the phytoplankton food web structure, increased competition at the coral reef level, and changes in food webs as demonstrated by the proliferation of crown-of-thorns starfish in areas regularly exposed to nutrient loads stemming from human activities.[57,86]

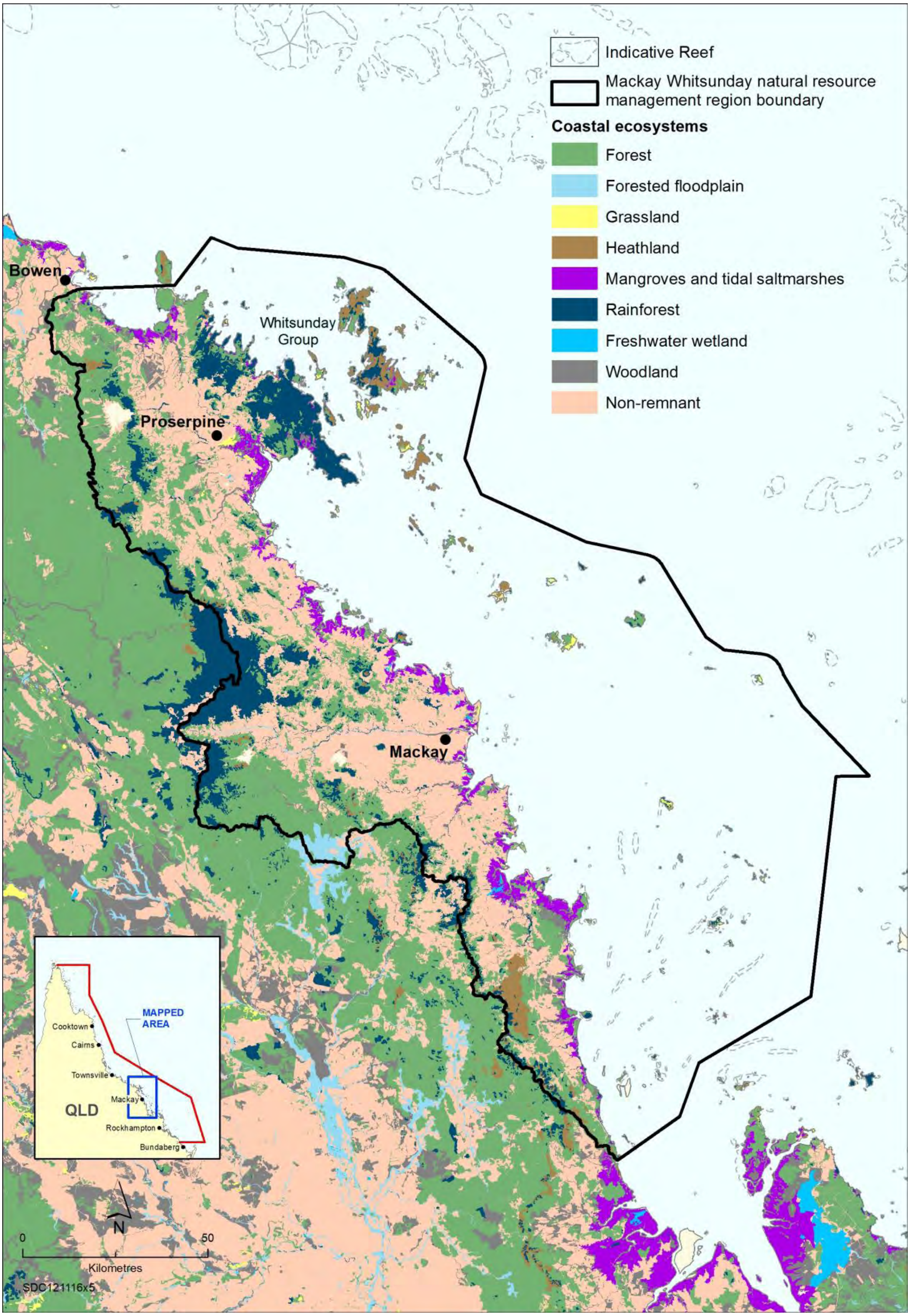
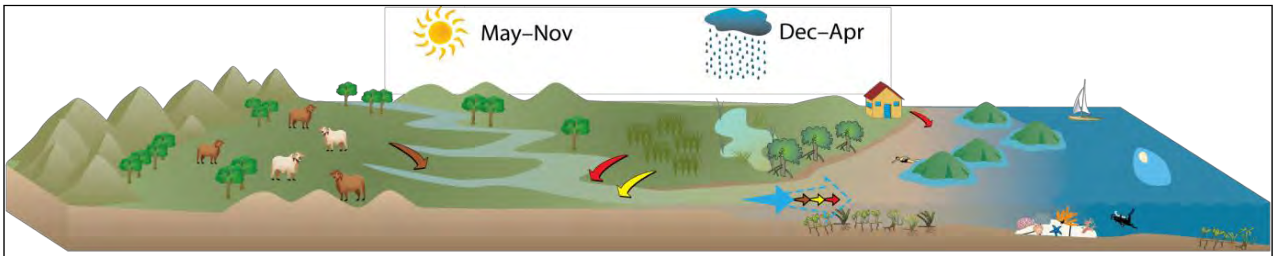


Figure 9.6 Coastal ecosystems in the Mackay Whitsunday natural resource management region, 2009

The majority of vegetation in the catchment is classed as 'non-remnant', that is it has been modified to the extent that it is no longer recognised as a functioning habitat. Much has been changed from forest to grassland for grazing purposes (based on *Informing the outlook for Great Barrier Reef coastal ecosystems*[43]).



Mackay–Whitsunday Paddock to Reef conceptual diagram
The Mackay–Whitsunday catchment is a small, steep catchment, with most rainfall occurring at the top of the catchment and drier areas along the coastal floodplain. The landscape is largely rural and is dominated by summer monsoonal rains delivering sediments, nutrients, and pesticides to the inshore and sometimes offshore portions of the reef in pulsed flows. Grazing is the largest single land use, with sugarcane, natural areas, and wetlands making up the remaining land use. Urban centres such as Mackay and Proserpine are located on the coastal strip. Habitats include wetlands, fringing and offshore reefs, intertidal, subtidal, and deep water seagrass, and mangrove habitats. The continental islands (Whitsunday group) are important for tourism.

Figure 9.7 Conceptual diagram of land use in the Mackay Whitsunday region
From *Reef Plan First Report Card* [87]

9.8.3 Current management and its effectiveness

There is a range of policies, plans and programs which identify the environmental values that rely on good water quality. Each of these tools — brought together under Reef Plan — perform a different function as shown in Table 9.5.

Table 9.5 Mechanisms for identifying and protecting water quality values

Water quality improvement plan	Environment protection (water) policy	Great Barrier Reef water quality guidelines	Queensland water quality guidelines
• identifies water quality values important to the community • informs regional natural resource management	• identifies water quality objectives to enhance or protect environmental values • links to land use planning and development assessment	• sets guidelines for water quality in the Reef to maintain marine ecosystem health	• sets guidelines for water quality that maintain freshwater ecosystems health

The Mackay Whitsunday water quality improvement plan provides the mechanism for identifying high risk areas for the range of pollutants, the targets to achieve the environmental values and water quality objectives identified by the community, and the links to the actions needed to achieve them. The plan guides investment into critical areas for improving water quality linked to aquatic and marine assets.[91] It also defines and uses best management practice frameworks to guide a continuous improvement process. These frameworks, based on the ABCD land condition framework, were developed with each of the industry partners and implemented by community stakeholder working groups.

Reef Plan was established by the Australian and Queensland governments in 2003 to halt and reverse the decline in water quality from diffuse agricultural sources by 2013. It was updated in 2009 after the release of a scientific consensus statement on water quality in the Great Barrier Reef which stated that current management interventions were not effectively solving the problem and that accelerated action was needed. It was updated again in 2013 with a renewed focus on best practice, more coordinated capacity building services and continued collaborative effort by both governments in close partnership with industry and landholders.

The long term goal of Reef Plan 2013 is to ensure that by 2020 the quality of water entering the Reef from broad scale land use has no detrimental impact on the health and resilience of the Great Barrier

Reef. It includes targets by 2018 to reduce anthropogenic end-of-catchment dissolved inorganic nitrogen by at least 50 per cent, anthropogenic end-of-catchment loads of sediment and particulate nutrients by at least 20 per cent and end-of-catchment pesticide loads by at least 60 per cent. It includes a number of direct actions to avoid and mitigate the impacts of catchment run-off from agricultural sources, which is the greatest contributor of pollutant loads entering the Great Barrier Reef lagoon. This includes water quality grants under the Australian Government's Reef Rescue program, the Queensland Government's Reef Protection Regulations, education and extension services, and management of public land (Figure 9.8).

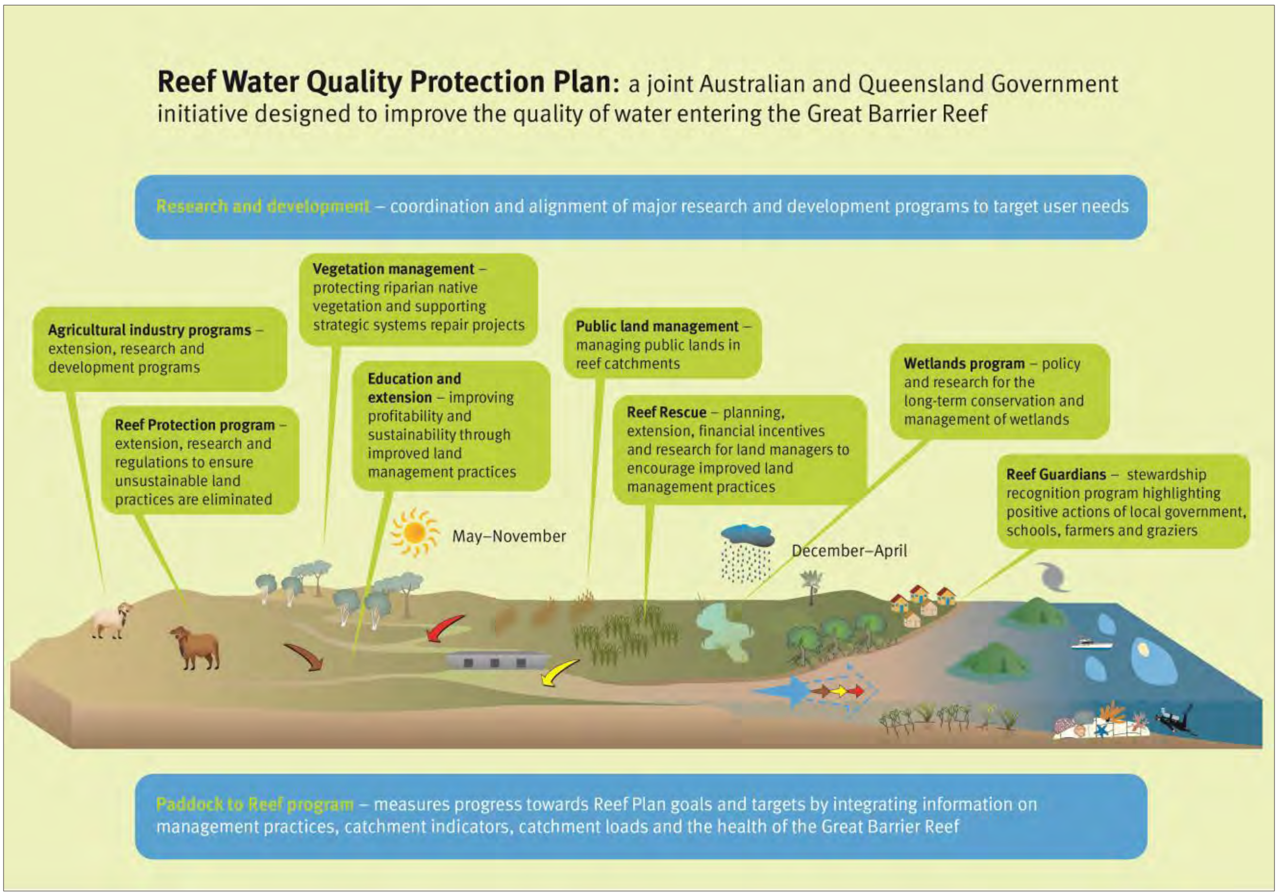


Figure 9.8 Key components of the *Reef Water Quality Protection Plan*[39]

The reviewers assessed the effectiveness of the Authority's management of water quality across the whole Reef; this is provided in detail in the preceding chapter (Chapter 8). The assessment, which is also relevant to the Mackay Whitsunday region, includes the following key points: *The most significant contribution to water quality decline in the Great Barrier Reef is from activities outside the Marine Park associated with agricultural practices. This limits the Authority's capacity to take direct action with respect to water quality decline.*

- **Context** is effective. *The values that underpin the matters relevant to water quality are well understood by the Authority. While many of the direct and indirect impacts of poor water quality are well known, knowledge is not as comprehensive concerning the consequential and cumulative impacts of water quality.*
- **Planning** is mostly effective. *Since the Outlook Report 2009, a review of Reef Plan has provided better focus and direction for managers including the Authority, including targets for water quality and land management improvement.* W*ater quality guidelines* for the Great Barrier Reef Marine Park[92] *and the development of a Coastal Ecosystems Assessment Framework*[93] *by the Authority set limits for water entering the Marine Park and provide a framework for assessment of ecosystem services within the basins located in the catchment with a focus on improving the health and resilience of the Reef.*

- **Inputs** are mostly effective. *The Authority has allocated significant resources into understanding the water quality issues from a biophysical aspect, though information is still limited with respect to the socio-economic impact of loss of ecosystem services from poor water quality.*
- The delivery of **outputs** is mostly effective. *The Authority monitors the long-term health of key marine ecosystems and the condition of water quality in the inshore lagoon.*
- **Outcomes** overall and **biodiversity outcomes** are partially effective. *The Authority's management of water quality is through legislation and permits for point source discharges into the Marine Park, as well as undertaking the marine monitoring functions of Reef Plan[38]. The Authority engages with key stakeholders and has expanded the Reef Guardian program (which commenced with schools and local councils), to include farmers, graziers and fishers. However, as the management of water quality leaving the Great Barrier Reef catchment is significantly within the Queensland Government's jurisdiction, the Authority can only work with the community and stakeholders to encourage best practice land management.*

9.8.4 Outcomes and potential improvements

The development of the Mackay Whitsunday Water Quality Improvement Plan, and its environmental values and water quality objectives, is critical to restoring and then maintaining the ecological values of the area's waterways and the Reef, and to identifying actions to achieve this. Measures to improve water quality and environmental values are linked to the water quality guidelines developed for the Great Barrier Reef Marine Park[94] and Queensland waters.[95] This establishing of thresholds linked to management tools has been shown to be a very effective measure for addressing the cumulative pressures and impacts of development on water quality. They establish a baseline for healthy systems against which development can be assessed and actions can be taken to halt further decline. They can also be used as a guide in restoring a system to a healthy state.

Recent research on coral decline on the Great Barrier Reef[53] reinforces the need to continue improving water quality to help restore outbreaks of crown-of-thorns starfish to natural cycles. A range of laws and policies are in place to regulate the various sources of pollutants. The package of water quality management tools, coordinated through Reef Plan, demonstrates how government, working with industry and the community, can address the very complex issue of poor water quality. The second Reef Plan report card, which represents the first year (2009–10) of significant full investment in on-ground actions, shows reasonable progress towards Reef Plan's targets.[96] As such, there is an expectation that the target of halting and reversing the decline in the quality of water entering the Reef is achievable; however, this is just the first step towards achieving the much more ambitious target that the quality of water entering the Reef from broad scale land use has no detrimental impact on the health and resilience of the Great Barrier Reef. This would effectively meet the requirement of the Authority's water quality guidelines for maintaining a healthy and resilient Great Barrier Reef.

Initial progress towards achieving healthy waters in the area covered by the Mackay Whitsunday Water Quality Improvement Plan is encouraging. The most recent Reef Plan 2011 report card, released in July 2013, showed that in the Mackay Whitsunday region, total nitrogen, sediment and pesticide loads have been reduced by 13 per cent, 6 per cent and 31 per cent respectively. This is a significant achievement since 2008–09, with the area demonstrating the biggest percentage reduction of all regions for nutrients and pesticides, the two most important pollutants in this region. A diverse range of stakeholders has demonstrated the expertise and commitment to achieving critical water quality improvements. However, ultimate success will require a range of ongoing actions.

Enhancing protection and restoration
Taking action to improve water quality represents one of the best opportunities to improve the condition of the Great Barrier Reef World Heritage Area, while providing improved resilience to other impacts such as those related to a changing climate. There is a need for increasing emphasis on a whole-of-ecosystem approach to restoring catchment ecosystem health and connectivity, including wetland ecological functions.

Minimising impacts
A long-term commitment by the Australian and Queensland governments to resourcing water quality improvement initiatives is a key requirement in minimising water quality impacts on the values of the Region. Recognising that emphasis remains on reducing the impacts of broadscale land use, an increasing focus on programs aimed at improving all sources of pollutants (such as urban and

industrial discharges) affecting water quality in the catchment and the Region would further reduce impacts.

Improving adaptive management
A commitment to ongoing monitoring and review of the overarching Reef Plan and the more regionally-based Mackay Whitsunday Water Quality Improvement Plan would improve the ability to measure effectiveness of management and adapt the relevant programs.

9.9 Keppel Bay

9.9.1 Significance

Keppel Bay is a broad bay on the Capricorn Coast in central Queensland, at the mouth of the Fitzroy River in the southern Great Barrier Reef World Heritage Area (Figure 9.9). The Keppel islands are located in the shallow basin in the north of Keppel Bay, 15 to 20 kilometres off the coastal town of Yeppoon. The Capricorn Coast is the traditional land of the Dharumbal people, and the Woppaburra people are the Traditional Owners of the Keppel Bay islands.

The area contributes to all four of the natural criteria for which the World Heritage Area was listed in 1981: exceptional natural beauty, significant geomorphic features, significant ongoing ecological and biological processes, and significant natural habitats for the conservation of biological diversity. Unusually high coral cover and fish diversity, a vast array of habitats, strong cultural value for Traditional Owners, significant historic heritage, a growing coastal population and extensive access by the community to the local environment make Keppel Bay and islands ecologically, culturally and socially significant, and of high aesthetic value.[70]

The reefs in the area are primarily fringing inshore coral reefs, surrounding the continental islands and rocky outcrops. The islands are under the jurisdiction of the Queensland Government. Fifteen of them (excluding Great Keppel, Pumpkin and Wedge islands) are surrounded by the Marine National Park zone, while one (Peak island) is within the Preservation zone (Figure 9.9).

Within the area Peak Island, Outer Rock and Egg Rock were identified as 'special and unique sites' during the Representative Areas Program conducted to inform the 2003 rezoning of the Marine Park.[97]

The area is adjacent to the internationally recognised Shoalwater and Corio Bay Area wetland — a matter of national environmental significance.

The bay and the islands are home to 34 listed threatened species and 54 listed migratory species. Its fauna and flora includes:

- three species of inshore dolphin (Australian snubfin, Indo-Pacific humpback and Indo-Pacific bottlenose). The population of the endemic Australian snubfin dolphin is one of the largest known to occur in the World Heritage Area and is at the southernmost extent of its range[98]
- humpback whales, sharks and stingrays
- four species of turtle (flatback, green, loggerhead and hawksbill). Peak Island is one of four major nesting sites for the flatback turtle along the Great Barrier Reef[99]
- one of only a handful of continental island groups on the Reef where sea snakes occur in significant numbers.[100]

Keppel Bay and islands was chosen as a demonstration case study to examine the cumulative impacts from climate change and extreme weather, rapid coastal development, and high recreational and commercial use.

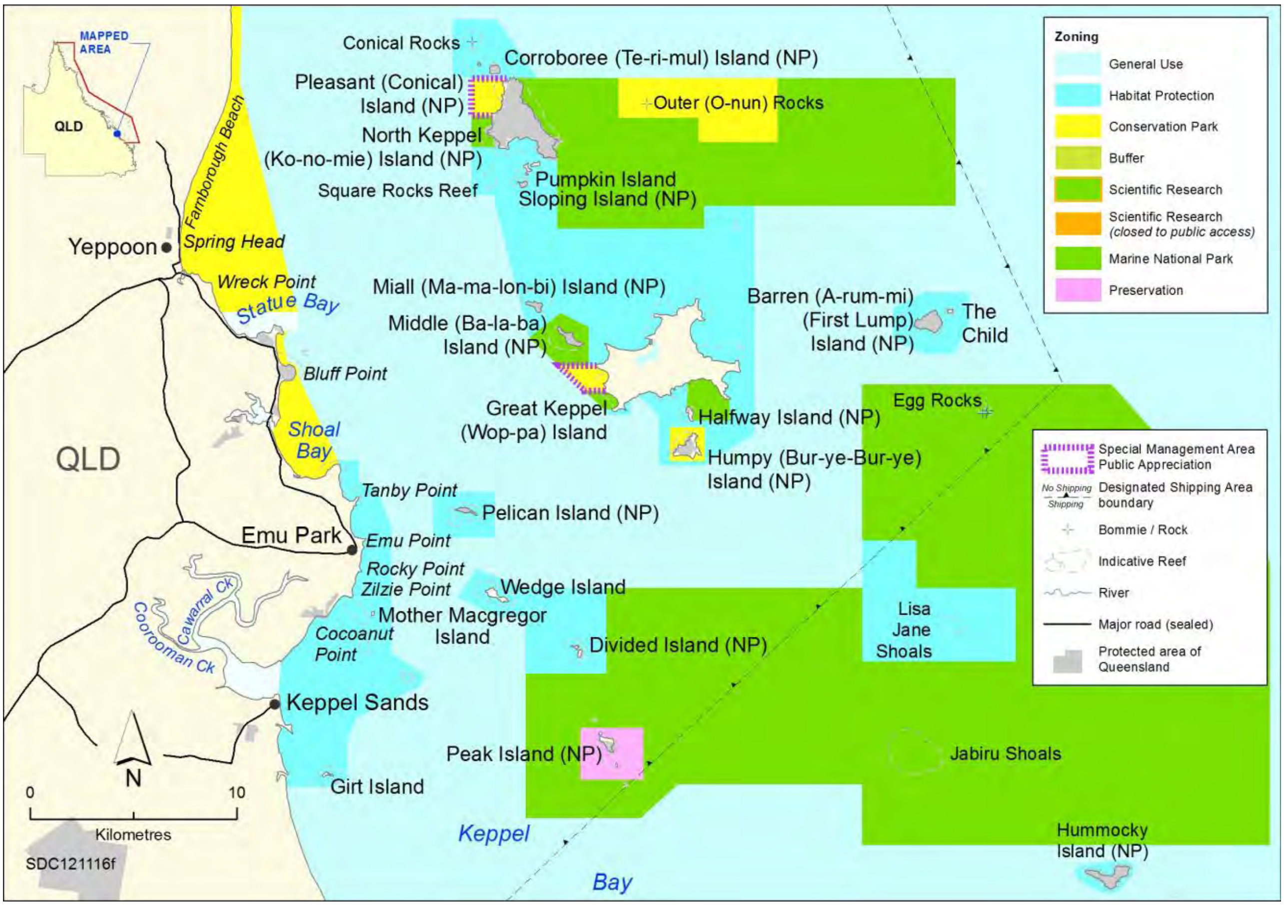


Figure 9.9 Keppel Bay and its islands
Perforated and Flat islands are not shown

9.9.2 Key issues

Many of the habitats in the adjacent Fitzroy River catchment have been modified. Overall, vegetation loss from clearing within the Fitzroy natural resources management region totals more than 89,000 square kilometres.[43]

The Capricorn Coast region, which includes Keppel Bay and islands, is developing rapidly. Since 2000, there has been an increase in tourism (although activity is still below the peaks of the late 1980s and 1990s), and an increase in recreational boating.[101] The Keppel islands are famous for their white sandy beaches and fringing coral reefs and are extensively used for recreational purposes. The largest island is Great Keppel Island, which covers an area of 14.5 square kilometres. It has had a small tourist resort for many years. The Australian and Queensland governments have approved a new marina and expanded tourism development on the island. It is proposed to include a hotel, villas and apartment accommodation, an 18-hole golf course, an upgrade and expansion of the current airstrip, a 250-berth marina at Putney Beach, the restoration of an historic homestead to a research and exhibition centre, and a range of services and utilities to support the resort including a submarine power cable, waste collection and a water treatment plant.

Assessments are currently underway on applications seeking approval to develop new port infrastructure and loading facilities at Port Alma at the mouth of the Fitzroy estuary, including transhipping facilities offshore near Peak Island. These proposals sit in the context of the very high ecological and heritage values of Keppel Bay; the cumulative impacts in the bay of major floods over successive years which delivered significant loads of sediments, nutrients and pesticides from existing agricultural areas; population growth and expanding urban activity in the catchment; an increase in coastal development; and proximity to a major and rapidly expanding port (Port of Gladstone).

The reef communities of Keppel Bay are exposed to a range of environmental pressures. They have been affected by cyclones, flooding and bleaching events over the past 20 years. Prior to the 2011 flood, the Keppel Bay reefs retained an extraordinarily high coral cover — greater than 50 per cent average hard coral cover in 2010[102] — especially given their southern inshore location.

Sea surface temperature anomalies caused severe coral bleaching in 1998, 2002 and 2006.[60,102] The remarkable recovery from the 1998 and 2002 bleaching events and from historic floods demonstrates a high resilience.[103] However, expectations of recovery are less optimistic after almost 40 per cent of corals were lost from the 2006 bleaching event and subsequent, almost annual, flooding between 2007 and 2011.[104]

The discharge from the Fitzroy River exposes affected marine habitats to elevated sediments, nutrients and pesticides as well as large volumes of freshwater, which reduces the salinity of the affected marine waters. Freshwater inundation from a flood in 2011 affected a large proportion of inshore reefs to a depth of at least two metres. The proportion of macroalgae has also increased significantly on several of the inner reefs, while large reef areas have lost the majority of their hard coral cover.

In 2012, the condition and trend of reefs in the Keppel Bay varied greatly. To date, there are no signs of recovery of affected coral communities, and the regional assessment of coral reef condition in this area is poor and declining.[104]

9.9.3 Current management and its effectiveness

Management in the World Heritage is underpinned by the best available science, much of which is conducted in the Keppel area. These studies have provided evidence that the Zoning Plan is an effective ecosystem-based management tool — when there is high compliance, there is an increase in the abundance of coral trout and stripy snapper in Marine Park zones which then act as a source of fish for nearby General Use zones.[105]

In addition to the Zoning Plan, specific threat abatement actions (such as no-anchoring areas, declared fish habitat, a Traditional Use of Marine Resources Agreement and two Public Appreciation Special Management Areas) are in place to maintain biodiversity, heritage values and community benefits in the area.

The Authority is also partnering with the Australian and Queensland governments in delivering Reef Plan to improve the water quality of the Fitzroy catchment through actions such as incentives, education and extension (see Mackay Whitsunday case study, Section 9.8).

The independent review of the Authority's assessment concluded:

- **Context** is mostly effective. *The Authority has reasonable knowledge of the values and key impacts affecting the Keppel Bay region, such as tourism and recreation, fishing, water quality and coastal development. Knowledge of the consequential and cumulative impacts of increased shipping and proposed port development is still being developed.*
- **Planning** is mostly effective. *The demonstration case study provides a number of examples of planning that support the protection of the Keppel Bay area, including zoning plans, specific threat abatement plans with no-anchorage areas, declared fish habitat, Reef Plan; a Traditional Use of Marine Resources Agreement is in place, and two Public Appreciation* [Special Management] *Areas are in place. Stakeholders are strongly engaged, and the joint Field Management Program is in place. Development of a plan of management could address the increased use of the area. Work to manage wastewater from non-agricultural sources (such as mine discharges) is also required to complement the progress made with the Reef Plan.*
- **Inputs** are partially effective. *Resources for key management actions (for example mitigating impacts of coastal land management), field management (surveillance and compliance, emergency response) and planning for increased recreational use and access are either currently inadequate or not secure in the long term.*
- **Process** is mostly effective. *Effective partnerships with stakeholders and the community are in place, and the joint management arrangements with the Queensland Parks and Wildlife Service ensure consistency in permitting and compliance. The ways in which the plans and strategies are being implemented is appropriate, and there is a sound biophysical and socio-economic knowledge base for decision making.*
- **Outputs** are mostly effective. *Outputs which influence the management effectiveness of the Keppel Bay region include strong stakeholder partnerships, the Recreational Management Strategy and the Great Barrier Reef Biodiversity Conservation Strategy. The strategy*

emphasises the importance of the Keppel Bay region for the protection of the Australian snubfin dolphin population.

- **Outcomes** are mostly effective overall. *Issues of multiple use and development within the area are reasonably well managed, and effective partnerships are in place to address impacts of activities on matters of national environmental significance.* **Biodiversity outcomes** are partially effective. *Severe weather and flooding have limited the recovery of corals, although the populations of the vulnerable flatback turtles and Australian snubfin dolphin are stable.*

9.9.4 Outcomes and potential improvements

The condition of matters of national environmental significance in Keppel Bay is projected to decline in coming decades due to the cumulative impacts of climate change, water quality and increasing use.

Enhancing protection and restoration
Building resilience by reducing cumulative impacts will improve the capacity of the ecosystem to withstand the projected effects of a changing climate. While further degradation is unlikely to be avoided altogether, the extent of damage over coming decades is likely to be influenced by the effectiveness of local management to reduce stress to reefs from degraded water quality, anchor damage, overfishing or other pressures. This requires the maintenance of strong linkages between people of the Keppel region and the surrounding marine environment and strong local support for initiatives that aim to build the resilience of reefs in the area.

Further initiatives to manage pollutants from non-agricultural sources (such as urban and industrial discharges, dumping and resuspension of dredge material) are required to complement the progress made by Reef Plan and to improve conditions for ecosystem recovery.

The area's diversity of habitats, ease of accessibility and range of activities, combined with the projected significant increases in future use, point to the need for a plan of management. Plans of management for other areas in the Region have provided greater certainty around where specific uses may occur, the types of activities allowed, the conditions under which activities may proceed and circumstances where impacts are likely to be unacceptable.

Minimising impacts
The installation and maintenance of site infrastructure will be fundamental to protecting biodiversity values and community benefits derived from this unique natural area.

Improving adaptive management
The protection of the area's biodiversity values relies on an improved understanding and spatial assessment of the distribution and abundance of species and habitats and supporting ecosystem processes. Better mechanisms for aligning and sharing information are also essential to ensuring management actions are considered using the best available information.

There is a need to identify more fully the area's Indigenous and historic heritage values. There is also a need for better long-term socio-economic information and an improved understanding of the patterns of commercial and recreational use in the Keppel Bay area, especially to inform planning and site infrastructure improvements.

Ongoing monitoring is crucial to effective management, providing information on conditions and trends, supporting assessments of management effectiveness and informing adaptive management.

9.10 East Coast Trawl Fishery

9.10.1 Significance

The East Coast Trawl Fishery is an example of a fishery making good progress in addressing environmental impacts to Great Barrier Reef values.

The Queensland trawl fishery has a gross value of production of approximately $100 million, supplying about 8000 tonnes of seafood including prawns, scallops, Moreton Bay bugs and squid. It also directly employs more than 1500 people and provides social and economic benefits to coastal communities along the Queensland east coast.

Trawl fisheries globally and in Australia have been a focus of environmental concern — largely due to the physical impacts when fishing gear is towed on or near the seabed, and because the small mesh used in prawn trawl gear results in bycatch of animals which are discarded, often dead or with a low chance of survival. In the Region, other concerns include the incidental catch of species of conservation concern (for example sea snakes).[4,106]

In the Region, the trawl fleet operates in coastal, lagoon floor and upper continental slope habitats, which support a great diversity of marine life. Trawling interacts with hundreds of non-target species to varying degrees. Some productive prawn grounds are trawled intensely each year; other areas are trawled much less frequently. If not appropriately managed, this fishing activity has the potential to harm inshore and offshore habitats, species and ecological processes. However, improved practices and current trawl fishing effort levels — which are less than half those of the maximum in 1997 — mean overall ecological risks from trawling in the Region have been reduced.

9.10.2 Key issues

The commercial trawl fishery developed in the 1950s and has undergone a succession of changes (Figure 9.10).

Over the past 20 years, annual trawl fishing effort has decreased, the fleet has become smaller, and habitat protection through zoning has increased. Trawling is allowed in 34 per cent of the Marine Park. Only about seven per cent of the Marine Park is trawled more than once per year. In addition, the trawl industry has adopted improved fishing practices such as bycatch reduction devices and turtle excluder devices which allow large animals, including marine turtles and some sharks, to escape. These changes have significantly reduced ecological risks.

At the same time, research has provided a better understanding of seabed habitats in non-reef areas, trawling impacts and the recovery for seabed habitats and species; the status of some resource species; trawl bycatch; and protected species interactions with the fishery.[106,107,108,109,110,111,112] However, there remain some challenges for the trawl fishery such as excess fishing capacity of approximately 40 per cent, a few high ecological risks for some species and habitats, and low profitability.[107,113] These remaining challenges put pressure on fishing businesses and regional communities.

From an economic perspective, the trawl fishery currently has too many operators for all individual businesses to be viable. This is reflected in both the profitability of businesses operating in the fishery and in the number of businesses that have chosen to simply not work at all in recent years. While the economic circumstances are unlikely to change into the future, there is a risk that if all operators chose to fish then pressure on individual stocks may become unsustainable.

Better control of trawl fishing effort would likely improve the economics of the fishery and the ecological impacts, since effort levels are a key driver of future ecological risk and impacts from trawling.[107,112]

The current management rules cap overall possible effort and restrict fishing efficiency, such as maximum horsepower for engines and net length restrictions, as well as setting fishing season opening and closing dates. However, improvements are possible. Options for change have been in development since late 2009 and will be considered by the public, fishers and all levels of government prior to approval by the Queensland Government which is expected in the near future.

Several aspects of the trawl fishery may be vulnerable to climate change.[114] Rising sea temperatures and altered ocean currents may send some species southwards, while challenges are posed by the prospect of changing rainfall patterns (and thus changing nutrient inputs), as well as floods, ocean acidification and more intense cyclones.

The trawl fishery may be affected by coastal development and port expansions. Some trawl fishing grounds (which are all in General Use zones, as are ports) have become inaccessible to trawling because they are now used for anchoring many large ships[3]. Fishers report the seabed topography and productivity may be changed by anchoring and that changes in bathymetry may compromise the safe and optimal operation of trawl equipment[3]. Also, port expansions (including reclamation and dredging) may lead to direct loss of grounds. Reduced water quality may be an additional factor, such as through resuspension of sediments and contaminants, potentially affecting productivity for filter-feeding species like scallops. The seafood industry is dependent on access to resources, and the productivity of seafood resources and their market value are influenced by the health and reputation of the Great Barrier Reef.

Ecological risks from trawling in the Great Barrier Reef Region

The trawl industry has reduced overall risks to the Great Barrier Reef over the past two decades.

Under current practices and trawl fishing effort levels (which are less than half those of the maximum in 1997), overall ecological risks from trawling in the Great Barrier Reef Region are relatively low, with most species, habitat types and the broader ecosystem at low or intermediate–low risk from trawling.

- This low risk profile largely resulted from a combination of: 1) those species, habitats and broader ecosystems exposed to prawn trawling in the Great Barrier Reef having characteristics that give them a degree of resilience to impacts, including from fishing; 2) the relatively low effort exerted by the trawl fishery in recent years leading to relatively low pressure at the scale of the Great Barrier Reef ecosystem under current circumstances; and 3) the extensive knowledge base for the fishery and Great Barrier Reef.
- The low risk profile does not infer that trawling *per se* represents a low risk to marine habitats. The assessment took into account current fishing effort levels and the full suite of management arrangements in place, including protected area management and very fine spatial scale data on the distribution of fishing effort.
- There is no certainty that this level of impact will not increase in the future because much higher levels of fishing effort are allowable under current fishery management arrangements. Even though there is a cap on trawl effort levels within the World Heritage Area, this mechanism would be ineffective at preventing a very substantial increase in fishing pressure, as the amount of effort allowed under the cap is double the amount actually used in 2011.
- Investment in environmental research has provided a robust basis for assessing ecological risks. Access to fishery observer and research information, including previously unpublished data on discards and incidental catches in the trawl fishery, improved confidence in the ecological risk assessment.
- There are some remaining ecological risks posed by the otter trawl fishery. In particular, high risks were identified for 11 species of skates and rays, two species of sea snakes, a poorly-known upper continental slope habitat (90 to 300 metres depth) in the southern Great Barrier Reef and the plant and animal communities there. The by-product species, Balmain bugs, were at intermediate to high risk.
- The fishery still has a substantial interaction with sea snakes. Research and extension work has identified improvements to bycatch reduction devices that can be highly effective at excluding sea snakes, but these are yet to be fully adopted across relevant areas of the fishery.
- No sharks or shark products are allowed to be retained from the Queensland trawl fishery for conservation reasons, and turtle excluder devices allow large animals including some sharks to escape. However, smaller sharks and those with a flattened body form (such as many rays) are still being caught in trawl nets, landed on deck and then discarded. Larger animals are also occasionally caught (for example, green sawfish through entanglement).
- Survival of sharks and rays after trawling is often poor, with fishery observer data indicating immediate survival is only 35 per cent on average, while only 17 per cent are released alive in the deepwater trawl sector.
- The high risk rating for the deepwater habitat was precautionary due to the lack of knowledge about this area. About half of this area receives consistently high levels of trawl fishing effort. Additional ecological and biological information is required to more confidently assess the risks posed by the fishery in this area.
- The trawl fishery is diverse and while some of the remaining ecological risks were found to be fishery-wide, others are specific to fishery sectors. For example, all sectors interact with one or more of the sharks and rays that were assessed as being at high risk, and the red-spot king prawn sector accounted for most of the incidental trawl fishing mortality for sea snakes.

Data from *Ecological risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: summary report*.[1]

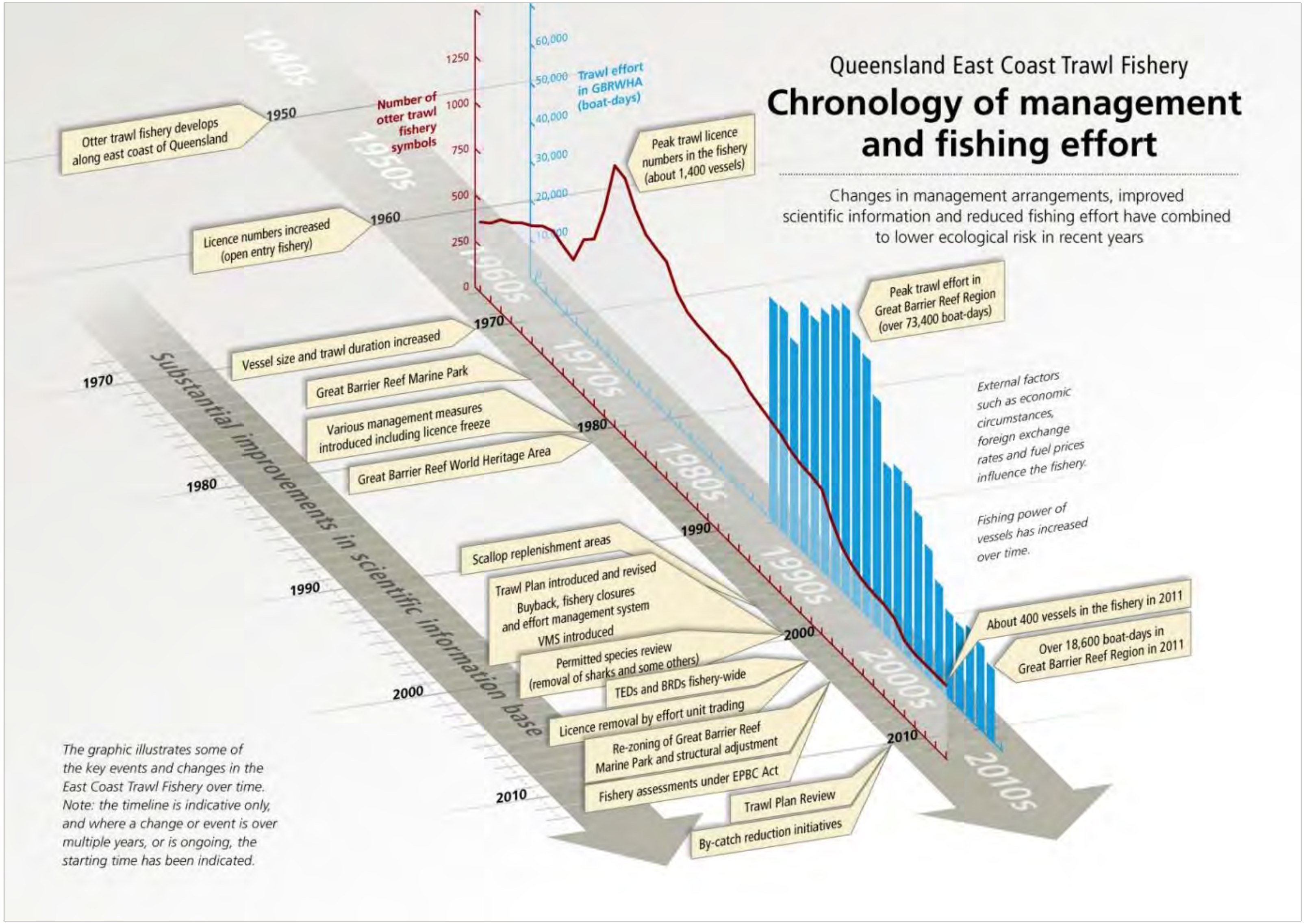


Figure 9.10 Chronology of the Queensland East Coast Trawl Fishery
Data from *Ecological risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park*[1]

9.10.3 Current management and its effectiveness

The trawl fishery is directly managed by Fisheries Queensland within the Queensland Department of Agriculture, Fisheries and Forestry. In addition to fisheries legislation, trawling activities in the Great Barrier Reef Region must comply with the Zoning Plan and other environmental laws. The operation of the fishery has been assessed against national environment law since 2004.[115] An independent assessment of management effectiveness for commercial fishing in the Region was completed in 2009,[116] and aspects of this were examined again in 2013 to inform the strategic assessment.

A major review of trawl fishery management arrangements has been underway since 2010; completing this review is a priority of the current Queensland Government. This review process has two advisory groups that provide advice to Fisheries Queensland. The technical advisory group consists of representatives from the commercial fishing industry, recreational fishing, the Authority, conservation organisations, trawl fisheries management, and institutions with science and economic expertise. The scientific advisory group consists of members with expertise in trawl fishing, seafood processing and marketing, economics, science and management. Between 2010 and 2012, these groups examined in detail the pressures facing the industry and considered what the different stakeholders want for the future of the fishery, including legislative requirements.[117,118]

All advisory group members reached a consensus position[119] on the need for change and the type of management change required to develop a profitable, ecologically and socially sustainable trawl fishery for Queensland into the future. The agreed solution was:

- a significant reduction in trawl fishing effort (structural adjustment) to improve profitability and manage ecological risks
- new management rules that change or remove rules that restrict efficiency and that control fishing effort to profitable levels and at optimal times.

It was also agreed that total allocated effort in the fishery must be reduced below current levels of real effort before restrictions on efficiency can be lifted, and that environmental safeguards must be maintained.

Use of a satellite-based vessel monitoring system for the last decade has enabled close monitoring of the trawl fleet's activities, resulting in improved compliance and major benefits for fishery assessments. This detailed spatial information was used to confirm that Great Barrier Reef Marine Park zoning, complemented by Queensland zoning, effectively protected representative seabed habitats and associated biodiversity at levels consistent with the conservation targets underlying the 2003 rezoning of the Marine Park.[120,121] Protection through zoning is also an important measure which acts to limit spatial expansion of the trawl fishery and potential risk to the ecosystem.[107] Risks and impacts have been reduced over the last decade or more, but there is no certainty that the level of impact will not increase again in the future because current fishery effort controls are ineffective.[107]

A number of fishers have voluntarily adopted fishing practices that have less of an environmental impact and which go beyond those required by the Regulations. For example, new prawn trawling otter boards, designed and adopted by some fishers, reduce physical impacts on the seabed and also reduce towing resistance and fuel usage. Additionally, many fishers have been actively working with the Queensland Department of Agriculture, Fisheries and Forestry to trial and improve bycatch reduction devices. This work is helping to inform the optimum selection of these devices for different sectors of the fishery.[106,122]

The Authority is actively helping the industry face future challenges from climate change and extreme weather through measures such as adaptation planning workshops.[123] Some of the responses proposed by stakeholders through these workshops included modernising the trawl fleet and its operations, creating a more flexible fisheries management policy framework, diversifying income streams, developing more forward-looking business strategies, and introducing real-time fisheries data collection.

Effective management of trawling and public confidence in the sustainability of the fishery requires good information, including fishery observer programs, improved reporting via logbooks and ongoing risk monitoring (including analysis of trawl effort patterns).

The effectiveness of the Authority's management of commercial fishing was addressed by the independent reviewers, and is provided in detail in Chapter 8. In brief, the management effectiveness of commercial fishing (including trawl) of the Authority was rated as partially effective for all assessment criteria except context, where it was mostly effective.

The Authority has a regulatory role in the management of commercial fishing through its Zoning Plan, Regulations and permits for a limited number of Queensland managed commercial and developmental fisheries. While the Authority has a direct role in ensuring that fishing is ecologically sustainable in the Marine Park it has an advisory role on the management of commercial fisheries and works with other agencies to improve fisheries management. Commercial fisheries arrangements in the Reef are accredited against national sustainability guidelines. The Authority is involved in this role in an informal advisory capacity only. As identified in the Outlook Report 2009, the Authority has a good understanding of commercial catch information. Cumulative impacts associated with commercial fishing are reasonably well known. The recent ecological risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef found the overall ecological risks from trawling are relatively low, but there are some high ecological risks for deep water skates, several rays, and sea snakes.[107]

A reduction in trawl fishing effort of more than 40 per cent between 2005 and 2009, driven by prevailing economic conditions rather than management intervention, has significantly reduced the ecological risk from trawling. However, higher effort levels are still allowable under existing management arrangements. Further reductions in trawl bycatch and other efforts to reduce risks for species of conservation concern are important for the sustainability of the fishery.

9.10.4 Outcomes and potential improvements

There has been a significant reduction in the risks and impacts to the values of the Great Barrier Reef since the introduction of a management plan for the trawl fishery in 1999 and subsequent management actions (see Figure 9.10).

Challenges facing the fishery are increasingly better understood, and an ecosystem-based approach to management is being put into practice. Some successful trawl fishery initiatives, such as the vessel monitoring system and improved gear design to reduce bycatch, have resulted in substantial environmental benefits.

Notwithstanding the significant progress made by the fishery, current management arrangements for trawling are only partially effective at delivering environmental, economic and social outcomes.

Enhancing protection and restoration
Reaching consensus on desirable changes was an important step in the review of trawl fishery management arrangements. As a result, an opportunity has been identified for future arrangements that would provide net environmental benefits, make a major contribution to protecting the Great Barrier Reef and maintain biodiversity. This will also set the industry on a better path for the future and support a number of coastal and regional communities.

Minimising impacts
Further actions are required to mitigate the remaining ecological risks — a high priority is reducing incidental catch and death rates of sea snakes and smaller individuals of sharks and rays.[107] Potential risk mitigation strategies have been considered through the recent review processes and may include managing fishing effort, strengthening compliance, supporting research to address knowledge gaps, optimising the use of current bycatch reduction devices, supporting other initiatives to reduce interactions with protected species, and measures that limit fishing pressure on other by-product species.

Improving adaptive management
The trawl industry is starting to plan for future challenges such as climate change, and some fishers are preparing their businesses. Such future planning may also help with other challenges facing the fishery and help support a healthy marine environment into the future.

9.11 Summary of outcomes and guidance for future management

Along the length of the Region, values, impacts and risks vary. The case studies identify a suite of issues common across the Region (for example, impacts from extreme weather, catchment run-off, degradation of coastal ecosystems and direct use).They also show that the way these issues interact with other activities and values varies from place to place. Regional and local approaches, based on local knowledge and actions, will therefore be central to protecting and managing the values relevant to matters of national environmental significance.

The demonstration case studies also highlight that connectivity within and between terrestrial and marine ecosystems are critical to the health and resilience of the World Heritage Area.

The finer detail assessment of the effectiveness of current management arrangements to protect and manage the relevant matters of national environmental significance demonstrates the need for a suite of management actions to address impacts affecting values across the Region. For each of the case studies, enhancing protection and restoration, minimising direct impacts and improving adaptive management are common themes for potential improvements. These actions range from initiatives that apply across the whole Region, to more regional and local approaches.

Collectively, the demonstration case studies highlight the following pathways for future management.

Being proactive:

- Tackling climate change is fundamental to protecting key habitats such as coral reefs and species such as dugongs which rely on seagrass meadows.
- Clear but adaptable management approaches are required to deal with extreme weather such as flooding and cyclones; and coral bleaching.
- Greater investment and planning is required, particularly in areas of high growth. Aligning, rationalising and updating management tools such as plans of management, policies and permits will make management more outcome-focused, collaborative, responsive and adaptive.
- Increased field management capacity is required to address impacts and improve compliance (both education and enforcement). This recognises that the remoteness of much of the Region protects some values, while simultaneously making management intervention difficult.

Partnerships are the key:

- Strengthening efforts to improve water quality entering the Reef from its catchment remains a priority for restoring fundamental processes, such as sedimentation and nutrient cycling, which in turn affect the health and recovery of many habitats and species.
- Strong partnerships across all levels of government are vital to addressing the many cross-jurisdictional issues associated with the protection and management of marine ecosystems.
- Cooperative management approaches between governments, Traditional Owners, stakeholders and the community are an effective way to address impacts and declines in condition at a local scale.
- Cooperative management arrangements with Traditional Owners and programs to support their involvement in protecting and managing Indigenous heritage values will enhance overall protection and management of the Region's values.

Foundational activities underpin management:

- Long-term integrated monitoring and reporting across all the Region and for a range of habitats and species is required to track the condition of the Region's values and inform adaptive management.
- Reef-wide standards for data collection and sharing are required to improve data use across a range of scales and to make the information more accessible for managers and the public.
- Improved understanding about Indigenous and historic heritage values and community benefits derived from the Region is needed to improve their consideration in decision making.

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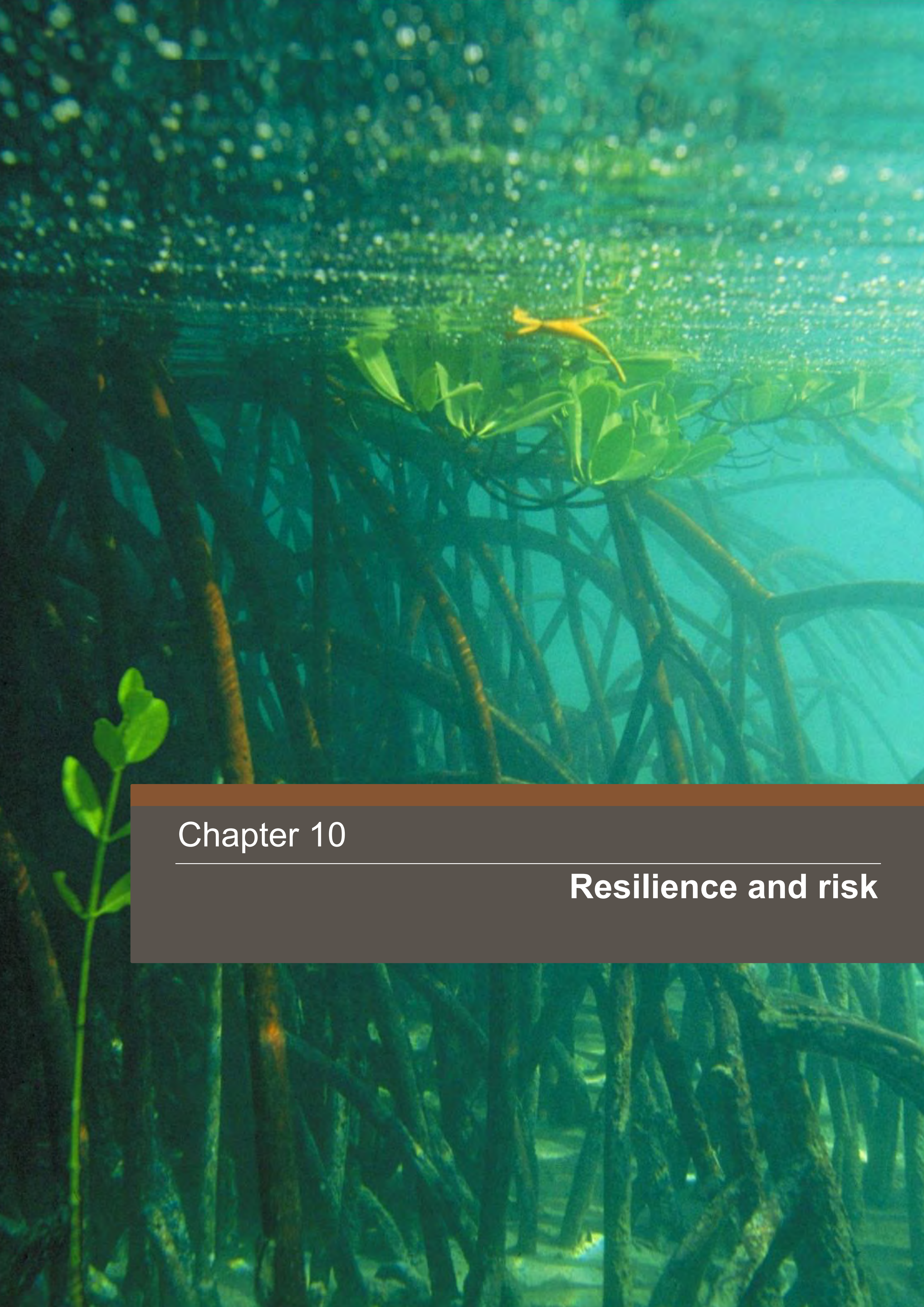
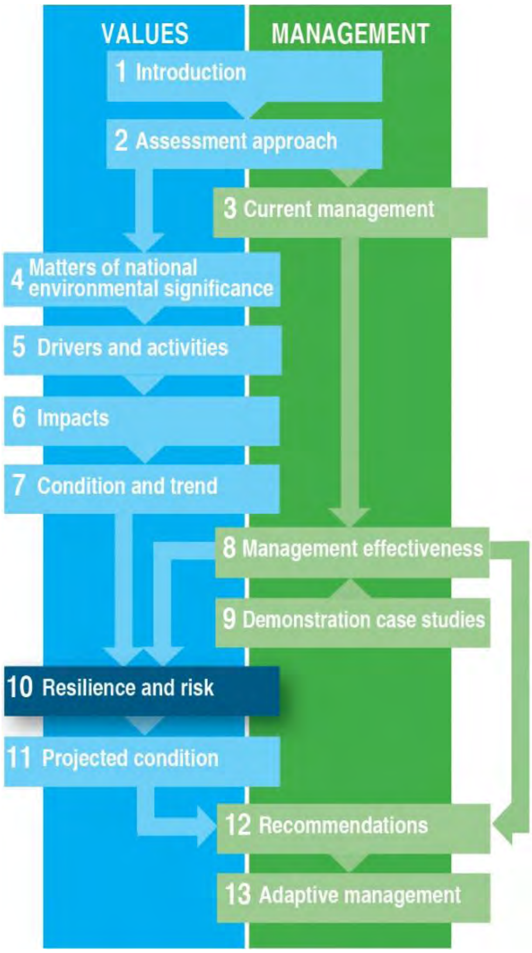


Chapter 10

Resilience and risk



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Extract from Great Barrier Reef Region Strategic Assessment terms of reference

5. Projected condition of matters of national environmental significance

5.1 Describe the projected condition of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, based on an evaluation of*…:*

....

d) an understanding of ecosystem resilience

e) an assessment of overall risks to the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area.

10 Resilience and risk

10.1 Understanding resilience

Ecosystem resilience refers to the capacity of an ecosystem to withstand or recover from disturbances and impacts, and maintain key functions without collapsing to a different state. Resilience is not about the single, static ecological state, but rather the capacity of an ever-changing, dynamic system to return to a healthy state.[1,2,3]

Tropical marine ecosystems such as the Great Barrier Reef are subject to a wide range of natural and human-related impacts, such as cyclones, crown-of-thorns starfish outbreaks or pollution, which may damage components of the system. Resilient ecosystems are able to withstand or recover from those impacts, if given sufficient time. Understanding the capacity of the ecosystem to absorb or recover from these threats is crucial to the long-term protection of the Reef's values.[4]

A key aspect of resilience is the cumulative interactions between impacts — different impacts may combine or even exacerbate each other (synergise), so that the cumulative impacts may be far greater than any individual impact.[5,6] This has two important consequences: first, the need to manage all impacts to reduce cumulative impacts, and that reductions in one impact may reduce the effects of other impacts, potentially providing time to address less accessible impacts such as those caused by climate change.[7,8]

There is no comprehensive information on the resilience of the Great Barrier Reef Region (the Region), largely due to the vast extent and complexity of the ecosystem, and because resilience is a complex property that is difficult to measure. The following description of the current understanding of resilience is based on available information. Although many elements of the ecosystem probably remain resilient, the emergent picture is that the resilience of the ecosystem as a whole is being significantly and incrementally eroded, and that this erosion is increasing.

10.1.1 Factors that affect ecosystem resilience

The extensive body of work[1,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26] on ecosystem resilience highlights a number of factors important in understanding the concept and its implications:

- Resilience includes the capacity of the system to either resist (absorb) an impact, or to recover from that impact.
- Although the resilience of the ecosystem is distinct from its health or state, they are related — a degraded system may have less capacity to recover if populations are too depleted to supply enough new recruits (for example, larvae or seeds).
- Systems with high levels of diversity, key functional species and a level of functional redundancy are likely to have greater resilience.[12,27] High levels of diversity provide more diverse capacities for adapting to or recovering from new threats. The key functional species play an important role in maintaining the ecological processes underlying resilience (for example herbivorous fishes on coral reefs).
- Networks of elements, for example habitats, may have greater resilience because the connectivity between elements enhances recovery after disturbances.

- A critical aspect of resilience is thresholds or tipping points, whereby an ecosystem that is subject to ongoing impacts may undergo sudden large changes in response to relatively small increases in impacts. For example, a reef subject to excess inputs of nutrients and sediments may retain high coral cover, but lose recruitment of new corals. If a storm reduces the coral cover, the lack of recruitment may mean the reef is not able to recover, and so it suddenly changes state. Such tipping points are intrinsically very difficult to predict, making them very difficult to avoid.
- The resilience of a system is strongly linked to the spatial and temporal scales being considered — an individual reef may have lost its resilience, but as part of a connected network, the overall system may retain resilience and be able to maintain its functions. If sufficient reefs become degraded, the loss of resilience may transfer up to the larger scale, degrading the resilience of the overall system. Thus, a regional scale collapse may become detectable only gradually, as an emergent property of smaller scale changes. Changes like this are very susceptible to the 'shifting baselines' phenomenon (that is, changes occur gradually and piecemeal, and hence are not recognised and responded to).
- Resilience is a property of complex systems, and is itself a complex property, making it very difficult to measure or monitor directly (in contrast to monitoring the state of the system).
- Together, the difficulty of measuring resilience, the nature of tipping points and scale dependence means loss of resilience and environmental degradation are easy to deny and hard to respond to. Thus, managing for resilience requires a sufficiently precautionary approach. Resilience is especially important for risks that are difficult to predict and/or where there is insufficient knowledge of management responses.[28]
- The resilience of ecosystems is very strongly linked to the resilience of social and economic systems that depend on them, and vice versa. For example, fishing and tourism on the Great Barrier Reef depend closely on healthy and resilient ecosystems for their businesses, just as resilient industries have the capacity to operate in ways that support the health of the ecosystem. Also, the resilience of the Region's Indigenous and historic heritage values and community benefits are tightly linked to the resilience of its biodiversity.
- Building the resilience of the ecosystem, such as by reducing local and regional impacts, is a key strategy in addressing the effects of climate change on the ecosystem, but it will not be sufficient. Although it may buy time for the Reef, there is no doubt that direct actions to reduce global carbon emissions are essential for the long-term health of the Great Barrier Reef ecosystems.

10.2 Resilience of key values of biodiversity

10.2.1 Coral reefs and corals

Coral reefs, the iconic habitat of the Great Barrier Reef, are showing major declines in resilience. Naturally, coral reefs, and corals specifically, have an impressive ability to recover from disturbances such as cyclones, crown-of-thorns starfish outbreaks or coral bleaching. There is recent evidence for quite spectacular recovery of coral reefs at local scales,[20] and reefs in the northern part of the Reef have shown substantial recovery.[29]

However, emerging evidence is increasingly clear that, over the long-term and over a broad scale, coral reefs in the southern two-thirds of the Great Barrier Reef are being gradually but seriously damaged by disturbances and are not recovering sufficiently between disturbances, resulting in the overall long-term (decadal scale) decline in coral cover.[15,29] This loss of resilience is most profound on inshore reefs, where recent evidence suggests reefs are failing to recover from disturbances over the past few decades.[30] This is despite evidence that those reefs had maintained their resilience over many hundreds of years. The loss of resilience is strongly correlated in time with degraded water quality after European settlement.[30]

The causes of this loss of resilience are likely to include direct and indirect effects of a range of impacts, such as catchment run-off, crown-of-thorns starfish outbreaks, and impacts related to climate change, such as increased sea temperatures and ocean acidification, and are almost certainly exacerbated by the broadscale loss of abundance, leading to reduced reproduction and connectivity (see the demonstration case study on corals, Section 9.4). Significantly, it is likely that this loss of resilience reflects degradation of both resistance and recovery.

10.2.2 Seagrass meadows

Available evidence suggests a serious loss of resilience for many inshore seagrass meadow habitats, especially for the area south of the Daintree River. Not only has there been major loss of area and abundance of seagrasses in recent years (that is, poor condition), but low or negligible reproductive capacity (loss of seed banks within some meadows) and high tissue nutrient levels (indicating reduced growth due to eutrophic conditions) also suggest loss of resilience.[31] This is further exacerbated by a loss of species diversity and a dominance of rapid growing species over habitat-forming species of seagrass. The severity of the losses in abundance is likely to have led to a loss of connectivity between seagrass meadows and consequently a probable loss of genetic diversity. There is very little information about the resilience of deepwater seagrass meadows, although there is concern about the effects of recent extreme weather events.[31]

10.2.3 Lagoonal habitats

There is limited information on the resilience of many lagoonal habitats (such as shoals, *Halimeda* banks, sponge gardens, and muddy and sandy seafloor areas), although it is reasonable to assume that resilience varies considerably among habitat types. Some evidence can be gathered from Great Barrier Reef studies of the habitats' resistance of and recovery from trawling as a proxy for physical disturbance generally.[32,33,34,35,36] Many habitat elements, especially soft sediments, show fairly good resistance to damage and recovery from damage. However, structural elements of some other habitat types, such as sponge gardens, are relatively fragile (low resistance) and very slow to recover, taking decades.[35,36] Even relatively deep areas may be strongly affected in extreme weather events: for example, during Cyclone Yasi in 2011, the wreck of the Yongala, at more than 20 metres deep, was all but stripped bare of a century of growth of sponges and sea fans. Importantly, these more fragile habitat patches may be disproportionately important in ecological terms, as critical links for cross-shelf connectivity of fish or other animal populations, making them in turn critical to the overall resilience of the Region.[37] Notwithstanding these lines of evidence for resilience to physical disturbance, there is very little knowledge of resilience to other impacts, such as excess nutrients related to run-off, herbicides, sedimentation and turbidity, or climate impacts such as increased temperature, acidification or changes to ocean currents.

10.2.4 Deep water and continental slope habitats

The deep areas of the Region are much less well understood than the lagoonal areas, and there is little knowledge of their resilience. Evidence from studies in other parts of the world suggests that deepwater benthos is very slow growing and hence slow to recover from physical damage (decades). Many taxa are also relatively fragile and easily depleted by activities such as trawling.[38,39,40,41] Although the exposure to direct impacts (such as trawling) may be relatively limited for much of the continental slope, some deeper areas are intensively trawled (such as in the south-east of the Region). In the longer term, such deep water and continental slope habitats may be vulnerable to climate-related changes, such as increased temperature, and changes to ocean currents, upwelling patterns and ocean chemistry including acidification. Recent evidence suggests deepwater habitats may provide a refuge from disturbances acting on shallow water systems, thus potentially aiding the resilience and recovery of these systems.[42]

10.2.5 Inshore habitats

The inshore habitats of the Region, especially adjacent to the developed coast south of about Port Douglas, are subject to the most intensive and diverse impacts (see Chapter 5 and 6). This has resulted in more intense degradation in those areas, as well as undermining the resilience of many of the habitats.[43] However, the extent of that loss varies considerably between locations and habitat types. Inshore habitats are most affected by terrestrial run-off of nutrients, sediments and pesticides, are most directly affected by coastal development, and are subject to the most intense direct uses such as recreational and commercial fishing, including trawling. Coastal, estuarine and inshore habitats provide a wide range of ecological and ecosystem services, such as providing nursery areas and supporting key stages in the life cycles of various commercially harvested fish and crustacean species.[43] Many of those services depend critically on connectivity between coastal waterbodies and the sea, yet many of those connections have been seriously damaged or lost due to coastal development and intensive use of land and marine ecosystems. Further, many of the animals that use these inshore habitats are especially vulnerable to loss of these habitats and to the impacts that cause that loss (for example, dugongs feeding on inshore seagrass meadows).

10.2.6 Bony fishes

Evidence suggests some target fish species such as coral trout can recover relatively quickly after protection from fishing impacts,[44,45] largely due to their fast growth and high rates of reproduction. Other target fish species (for example flowery cod) have characteristics such as late maturity, aggregation spawning and long life spans (over 40 years) which make them more susceptible to depletion by fishing and slower to recover.[46,47] Additionally, recent evidence suggests resilience may be significantly eroded if the species is subject to intense and large-scale disturbance, such as the recent series of extreme weather events.[48] This erosion is likely to be exacerbated by cumulative impacts, especially climate change impacts,[49,50,51,52] and emphasises the need to manage fisheries to protect their resilience.

10.2.7 Dugongs

Some species of conservation concern have life cycles which make them less resilient to impacts. For example, dugongs are relatively slow growing, have low reproductive rates, have restrictive dietary requirements (almost exclusively seagrasses) and are highly vulnerable to a wide range of direct impacts (refer to the demonstration case study on dugong, Section 9.3). Historic depletion has strongly exacerbated this vulnerability, as has the species' dependence on inshore habitats where these impacts are most intense. In the inshore areas of the southern two-thirds of the Region, this low resilience is now further exacerbated by serious declines in seagrass habitats due to poor water quality and extreme weather events.[53] It is unlikely that dugong populations will be able to recover over reasonable time scales without very strong management intervention to improve water quality and seagrass habitat, while also reducing all other sources of mortality.[54]

10.2.8 Marine turtles

Marine turtles have life histories which result in relatively high vulnerability to many impacts.[55] In particular, reproduction is dependent on beach nesting, a vulnerable part of their life cycle, especially in areas of intensive coastal development.[56] Several species are also vulnerable as bycatch in fisheries, although recent management is proving effective at reducing this mortality.[57] Although some species have been seriously compromised by these and other impacts, green turtles are considered sufficiently abundant (at least in the southern Region) to be able to recover relatively well from population declines when major threats to their populations are removed or addressed.[54,58] This is important given the very high mortality rates from loss of seagrass meadows during extreme weather in recent years (refer Section 7.1.3).

10.2.9 Sharks and rays

Most species of sharks and rays have life-histories which make them less resilient than many reef fishes.[59] Some species, especially inshore species such as sawfishes and reef species such as the grey reef and white tip reef sharks, have declined severely due to fishing and habitat loss; their low reproductive rates mean populations are not resilient in the face of these impacts.[60] Some species are highly mobile, potentially making them vulnerable to loss of inshore habitats despite their wide range.[61] However, other species of sharks are thought to be at lower risk because their growth rates are able to balance the effects of the impacts on their populations.[59,62]

10.3 Overall ecosystem resilience

While the Great Barrier Reef Region may be one of the most resilient tropical marine ecosystems in the world[16,63], there is concern that its resilience is being seriously, and increasingly rapidly, eroded. Due largely to the size and complexity of the ecosystem and because resilience is difficult to measure, there is no comprehensive information on the resilience of the Region. However, the available information is of concern: there is increasing evidence of loss of resistance and recovery capacity, although the extent of that loss varies considerably between ecosystem components (for example, dugong versus fish populations) and between localities (for example, inshore southern region compared to offshore northern region).

The loss of ecosystem resilience cannot be attributed to any single cause, but is almost certainly the consequence of cumulative impacts from all the different activities and drivers, and their accumulation through time. The loss of resilience is of serious concern, given the critical role of resilience in allowing the Region's ecosystem to resist the increasing effects of climate change-related impacts.

The integrity of the ecosystem as a whole is a key aspect of both its resilience and its outstanding universal value, yet that integrity is progressively undermined as increasing examples of degraded resilience accrue at smaller scales: that is, as increasing numbers of system sub-components lose their resilience, the likelihood increases of the overall system undergoing a critical change of state.[23,24,64]

It is of particular concern that several of the most significant impacts on ecosystem resilience, and those least effectively managed (see Chapter 8), operate at broad scales. For example, degraded water quality affects all the habitats and species in much of the southern region, so that the impacts interact across those different elements of biodiversity. Further, as the state of the system changes, attributes that confer resilience to a healthy ecosystem may come to undermine the resilience of the compromised system. For example, while the nature of the coral reefs on the Great Barrier Reef as a network of reefs distributed across the Region allows connectivity for corals and fishes, it also provides connectivity for pest species such as crown-of-thorns starfish.

System resilience also depends on the frequency of disturbances (and hence, the length of the intervening recovery periods) as this affects the extent of recovery between disturbances. If disturbances are too frequent, their impacts will accumulate through time. Two of the major causes of coral loss on the Great Barrier Reef, cyclones and crown-of-thorns starfish outbreaks, are being exacerbated by human activities. Cyclone intensity in the Region is expected to increase as a result of climate change,[65,66,67,68,69] and there is strong evidence that increased nutrients in catchment run-off is contributing to the increased frequency of crown-of-thorns starfish outbreaks.[70]

The emerging loss of ecosystem resilience is particularly critical in the context of the projected major increase in severe effects of climate change impacts. As these effects worsen, it is very likely that interactions between climate and other impacts will have increasingly serious consequences. Further, current evidence suggests climate change trajectories remain on course for increasingly serious impacts. Managing for resilience is most important in situations where there is uncertainty about risks and appropriate management responses[28] — the combined consequences of climate change and local and regional impacts on the Great Barrier Reef present such a situation. Maintaining the resilience of the Great Barrier Reef ecosystem will require major increases in effort to reduce local impacts and global climate change.

10.4 Active restoration of ecosystem resilience

Overall, major improvements are needed to restore and protect the resilience of the Great Barrier Reef. Previously, the approach to managing resilience has been to focus on supporting the natural resilience of the ecosystem and allowing it to restore its own processes and functions. However, available evidence strongly suggests this strategy has underestimated the extent of the cumulative impacts on the system, and that additional new and stronger approaches will be required.

This is especially true in the face of climate changes already occurring, and the further changes that will result without more effective mitigation of emissions.

Such approaches include more proactive intervention to restore ecosystem functions after disturbances, but there are several important cautions to be noted:

- It is critical that the causes of degradation, including climate change, are addressed in combination with interventions to restore functions. Without addressing the causes, restoration is unlikely to be effective in the long term, whereas combined actions may provide synergistic benefits.
- The costs of restoration are likely to be far greater than the costs of prevention.[71] The clear consequence is that major investment in resilience now is very likely to dramatically reduce future costs.
- At present there is limited capacity and knowledge for such restoration interventions, and little knowledge of the potential risks. Investment in significant research and development would be required to develop the expertise for such interventions in a timely and environmentally responsible manner.

Future attention could focus on major causes of ecosystem decline and on restoring the positive aspects of connectivity within the ecosystem, especially at the land–sea (coastal) interface, and on reducing the frequency and/or impact of major disturbances, wherever feasible. For example, one of the most direct paths to rebuilding coral populations and their dependent communities would be to suppress further crown-of-thorns starfish outbreaks by improving water quality and by developing more effective direct control measures.[29,72] Restoring the positive aspects may include coral transplantation at high value tourism sites.

Finally, active restoration of resilience will need to explicitly address the cumulative impacts on the Reef, and to do so in the context of predicted climate change. This requires:

- a broad portfolio approach, to comprehensively and effectively address all impacts. Such an approach will provide the most effective combined benefits for resilience, whereas only addressing one or two key impacts is not likely to be successful
- a major increase in management efforts across that broad portfolio
- consideration by management of how to best manage resilience while also preparing to manage a system that may well experience climate-driven transformational change in some or all of its elements.

10.5 Social and cultural resilience

Social resilience enables societies and individuals to adapt to changing circumstances by learning, storing knowledge and being creative in problem solving.[73] Indigenous systems of heritage conservation and management, including the continuation of cultural practices and retaining and creating traditional ecological knowledge, maintain cultural resilience. Understanding feedbacks between people and nature is critically important in protected area management, enabling appropriate decisions to be made about managing the Region's natural system, while at the same time maintaining options for current and future generations of Reef-dependent industries and communities.[72]

The condition and future of the Great Barrier Reef ecosystem is important for many people including Traditional Owners whose dynamic heritage integrates nature, society and culture. Reef-dependent tourism and commercial fishing are dominated by people who work in their industries because they feel strongly connected to the Reef.[74]Commercial fishing on the Great Barrier Reef is a lifestyle choice for most fishers, who have been in the industry for a long time, and cannot imagine doing anything else.[75]

The resilience of the Great Barrier Reef ecosystem is closely linked to the resilience of the communities and industries of the Region, especially for the fishing and tourism industries. There has been a significant increase in available information in this area, and considerable effort to help Reef-dependent industries improve their resilience in the face of climate change.[76] Importantly, many of the impacts on the Reef are influenced strongly by social and economic drivers, such as population changes. Increasing our understanding of these mechanisms is important to our capacity to manage for resilience.

By understanding social resilience and Reef-dependency, managers can better promote the Region as an integral part of community life. For example, community benefits derived from the Region, such as a sense of wellbeing associated with living in the Reef catchment, may inspire active stewardship which in turn helps reduce impacts such as habitat clearing and water quality decline.[72]

10.6 Assessing risks on the Region's values

To assess the risks to the Great Barrier Reef ecosystem posed by the 40 impacts set out in Chapter 6, the Australian Standard for Risk Assessment (AS/NZS ISO 31000:2009) was followed.

The likelihood and consequence of each predicted impact are ranked on the five-point scale set out in Table 10.1. An overall risk level for each impact over the next 25 years is determined, based on a combination of its likelihood and consequence (Table 10.2).

The assessment is based on the information previously presented in this report, including the current trends in drivers and activities (Chapter 5), the effects of the identified impacts (Chapter 6), the current state of the Region's values (Chapter 7), the effectiveness of current management (Chapters 8) and current resilience of the ecosystem (see above). For this reason, references have not been included in the following tables as they are cited in the chapters referred to above.

The assessments are presented in relation to the broad categories of values relevant to matters of national environmental significance outlined in Chapter 4, namely biodiversity (Section 10.7), geomorphological features (Section 10.8), Indigenous heritage values (Section 10.9) and historic heritage values (Section 10.10).Likely risk to future community benefits are not presented. Although community benefits are closely linked to biodiversity values, the risks to future community benefits are difficult to predict, particularly because societal attitudes, values and expectations (see 'shifting baselines' in Section 7.1) and the ways communities adapt in response to changes in the environment are constantly evolving. Only the impacts relevant to each broad category are included in the assessment.

The implications for each matter of national environmental significance is summarised in Section 10.11.

Table 10.1 Gradings for likelihood and consequence

A standard set of criteria allows the comparison of different types of threats within the one risk assessment, based on the likelihood and consequence of each threat. Adapted from the *Great Barrier Reef Outlook Report 2009*.

Likelihood	Expected frequency of a given threat
Almost certain	Expected to occur more or less continuously throughout a year
Likely	Not expected to be continuous but expected to occur one or more times in a year
Possible	Not expected to occur annually but expected to occur within a 10-year period
Unlikely	Not expected to occur in a 10-year period but expected to occur in a 100-year period
Rare	Not expected to occur within the next 100 years

Consequence	Extent of the impact based on current management	
	Broad scale	**Local scale**
Catastrophic	Impact is clearly affecting, or would clearly affect, the nature of the value over a wide area. Recovery periods greater than 20 years likely.	
Major	Impact is, or would be, significant at a wider level. Recovery periods of 10 to 20 years likely.	Impact is, or would be, extremely serious and possibly irreversible to the condition of a value. Condition of the affected value possibly irretrievably compromised.
Moderate	Impact is, or would be, present at a wider level. Recovery periods of 5 to 10 years likely.	Impact is, or would be, extremely serious to the condition of a value and possibly irreversible over a small area. Recovery periods of 10 to 20 years likely.
Minor	Impact is, or would be, not discernible at a wider level. Impact would not impair the overall condition of the value, including sensitive populations or communities, over a wider level.	Impact is, or would be, significant to the condition of value at a local level. Recovery periods of 5 to 10 years likely.
Insignificant	No impact or if impact is, or would be, present then only to the extent that it has no discernible effect on the overall condition of the value.	No impact or if impact is, or would be, present then only to the extent that it has no discernible effect on the overall condition of the value.

Table 10.2 Combining likelihood and consequence for overall risk

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost Certain	Low	Medium	High	Very high	Very high
Likely	Low	Medium	High	High	Very high
Possible	Low	Low	Medium	High	Very high
Unlikely	Low	Low	Low	Medium	High
Rare	Low	Low	Low	Medium	High

10.7 Risks to biodiversity

The future risks of each of the 40 impacts identified in Chapter 6 to biodiversity in the Region are presented in Table 10.3.

Table 10.3 Projected risks to biodiversity in the Region over the next 25 years

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Climate change				
Altered ocean currents: A major change in oceanic currents of the Great Barrier Reef over the next 25 years is unlikely. However, an increase in the speed and southern extent of the East Australian Current has already been observed. Major changes to ocean currents would have widespread and potentially irreversible implications for biodiversity. **Likelihood:** Unlikely .... **Consequence:** Major		■		
Cyclone activity: Cyclones, a natural process in tropical regions, are predicted to become more severe, but less frequent, under current climate change scenarios. Severe cyclones have significant broadscale effects, with recovery times of at least 10 to 20 years. **Likelihood:** Possible .... **Consequence:** Major			■	
Increased sea temperature: The average annual sea surface temperature is almost certain to continue to rise over the next 25 years. Regardless of the variation in climate scenarios, it is predicted that by 2035 the average sea surface temperature will be warmer than any previously recorded. Higher temperatures will affect the nature of the entire ecosystem over a broad scale. **Likelihood:** Almost certain .... **Consequence:** Catastrophic				■
Ocean acidification: If trends in global levels in carbon dioxide concentrations continue, in 25 years concentrations could reach more than 450 parts per million. This is anticipated to have widespread effects on coral reef systems. Over the next 25 years, projections suggest the waters of the Great Barrier Reef are almost certainly going to become more acidic. Regardless of the rate of change, recent evidence indicates that even relatively small changes in ocean acidity reduce the capacity of corals and other calcifying organisms to build skeletons and shells, which in turn reduce their capacity to create habitat for reef biodiversity in general. **Likelihood:** Almost certain .... **Consequence:** Major				■
Rising sea level: Projected increases in sea level are almost certain over the next 25 years. This will have a noticeable effect on coastal and shallow water habitats and species at a broad scale. **Likelihood:** Almost certain .... **Consequence:** Moderate			■	
Catchment run-off				
Increased freshwater inflow: Future climate projections for northern Queensland suggest an increase in rainfall variability, that is, wetter wet seasons and drier dry seasons. While average annual rainfall may not vary greatly, there may be one or more flood events a year with larger flood plumes. This would have significant consequences for inshore areas exposed to flood plumes and inshore productivity cycles. **Likelihood:** Likely .... **Consequence:** Major			■	
Nutrients from catchment run-off: Ongoing improvements in catchment management are likely to reduce nutrient loads in catchment run-off in the future. However, there is likely to be a significant lag time between changes in agricultural practice and measurable water quality improvements in the Region. It is projected that nutrients will continue to enter and remain in the Region over the next 25 years with potentially catastrophic consequences on biodiversity. **Likelihood:** Almost certain .... **Consequence:** Catastrophic				■

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Outbreak of crown-of-thorns starfish: Reductions in nutrient loads in catchment run-off may reduce the number of juvenile crown-of-thorns starfish that reach adulthood. Regardless, the presence of an active outbreak on the Reef at any given time is considered likely over the next 25 years, resulting in continued coral mortality. The cumulative effects of a range of impacts are severely compromising the ability of coral reefs to recover from outbreak events. **Likelihood:** Likely ... **Consequence:** Catastrophic				■
Pesticides from catchment run-off: Ongoing use of pesticides in the catchment means the Region will almost certainly experience pesticides from catchment run-off over the next 25 years. Continued progress towards targets for reducing pesticides in catchment run-off may reduce the consequences in the Region itself, but pesticides are expected to have extremely serious consequences to some estuarine, seagrass and freshwater ecosystems, resulting in flow-on impacts to biodiversity in the Region. **Likelihood:** Almost certain ... **Consequence:** Moderate			■	
Sediments from catchment run-off: Although improved practices and restoration of riparian vegetation in many catchment areas has reduced sediment load, sediment will continue to be transported to and remain in the Region. Similar to nutrients from catchment run-off, improvements in agricultural practices may take some time to become evident in water quality within the Region due to the lag time of sediments passing through the system and into sinks within the marine system. Projected increased rainfall variability may also contribute to sediment loads through the erosion of top soils during flood events. Consequences of sedimentation for marine life will depend on the concentration and duration of exposure, however there are likely to be major effects on biodiversity. **Likelihood:** Almost certain ... **Consequence:** Catastrophic				■
Urban discharge: Projected increases in urban development will make discharges such as sewage and stormwater almost certain over the next 25 years. As regulations require sewage to be tertiary treated, sewage discharge is likely to have only minor effects. **Likelihood:** Almost certain ... **Consequence:** Minor		■		
Industrial discharge: Discharges of wastewater from industrial development and mining that could have irreversible effects over a small area of the Region are possible, but are not expected to occur annually. **Likelihood:** Possible ... **Consequence:** Moderate		■		
Degradation of coastal ecosystems				
Acid sulphate soils: The projected continuation of coastal development makes the future risk of exposure of potential acid sulphate soils possible. Once disturbed, if not treated, acidic water and heavy metals would continue to be released during rain events over decades if not longer, causing effects that may be irreversible in a small area. **Likelihood:** Possible ... **Consequence:** Moderate		■		
Artificial barriers to flow: Artificial barriers in the catchment will continue to affect estuarine systems and connectivity. **Likelihood:** Almost certain ... **Consequence:** Moderate			■	
Atmospheric pollution: Projected increases in urban and industrial development are likely to increase the local contribution of atmospheric pollution, including the potential for more frequent impacts from coal dust at loading ports. Within the next 25 years, atmospheric pollution may start to affect some values, however effects are expected to be only minor. **Likelihood:** Possible ... **Consequence:** Minor	■			
Coastal reclamation: Projected increases in industrial and urban development make the risk of further coastal reclamation possible. While effects would be localised, the ecosystem in that area would be irretrievably compromised. **Likelihood:** Possible ... **Consequence:** Moderate		■		

Summary of potential impacts	Risk			
	Low	Medium	High	Very high
Light impacts (artificial): Growth in shipping, and urban and industrial development is likely to increase the amount of artificial light. The main known risk of artificial light is its effect on turtle hatchlings' orientation. Other minor effects include the orientation of pelagic species around vessel lights. **Likelihood:** Likely .... **Consequence:** Minor				
Modifying supporting terrestrial habitats: An expected increase in and intensification of grazing and projected growth in urban and industrial development makes the likelihood of modifying supporting terrestrial habitats almost certain. However, understanding has increased about the need to ensure protection of coastal ecosystems and their ecosystem services. The consequence to the Region's values is likely to be major over a broad scale. **Likelihood:** Almost certain .... **Consequence:** Major				
Direct use				
Dredging: Continued development of new ports and port expansions would require capital and ongoing maintenance dredging. While maintenance dredging is expected to occur at least one or more times in a year, capital dredging is not expected to occur annually. The consequence for biodiversity within the footprint of the dredging site would be serious and possibly irreversible. **Likelihood:** Likely (maintenance) / Possible (capital) .... **Consequence:** Minor (maintenance) / Moderate (capital)				
Dumping and resuspension of dredge material: The dumping of dredge material is not continuous; however the frequency of dumping and resuspension of dredge material (from both capital and maintenance dredging) is likely to increase with continued development of new ports and port expansions. The resuspension of significant volumes of sediment could affect the condition of values over a broad scale adding further pressure to already declining inshore ecosystems. **Likelihood:** Likely (maintenance) / Possible (capital) .... **Consequence:** Minor (maintenance) / Moderate (capital)				
Exotic species and diseases: Despite technological improvements for better detection, projected increases in shipping makes the transport of exotic species and diseases possible. The consequence would depend on the species or disease but is likely to be serious in a small area such as a marina or port. **Likelihood:** Possible .... **Consequence:** Moderate				
Extraction — death of discarded species (species of conservation concern): Bycatch reduction devices have significantly reduced the incidental catch of turtles in the trawl fishery. Death of discarded and incidentally caught species of conservation concern across all fisheries and the Queensland Shark Control Program is almost certain, with major consequences for their populations. **Likelihood:** Almost certain .... **Consequence:** Major				
Extraction — death of discarded species (species not of conservation concern): The discard of non-retained catch from fishing activities and the Queensland Shark Control Program are predicted to occur continuously throughout the next 25 years with broadscale consequences for populations of species commonly caught. **Likelihood:** Almost certain .... **Consequence:** Moderate				
Extraction — fishing spawning aggregations: While a number of fish spawning aggregations are currently protected, some fishing effort is targeted at unprotected aggregation. Targeting spawning aggregations can have implications for future population sizes of the species. **Likelihood:** Likely .... **Consequence:** Moderate				
Extraction — herbivores (dugong and turtle): Traditional hunting of marine turtles and dugongs is currently managed in a number of areas under Traditional Use of Marine Resources Agreements, and there is the aim of implementing more agreements in the next 25 years. Although not continuous through the year, traditional hunting is likely to occur several times a year with potential effects at a small scale. **Likelihood:** Likely .... **Consequence:** Minor				

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Extraction — herbivores (take of herbivorous fish): Current take of herbivorous fish is low and is unlikely to become very common in the next 25 years. The consequence of removing herbivorous fish from reef ecosystems would be major if extraction was sufficient to cause an ecological phase shift from a coral-dominated system, especially given the predicted effects of climate change. **Likelihood:** Unlikely ..... **Consequence:** Major		■		
Extraction — lower order predators: Trends in fishing effort are predicted to remain stable with effects not discernible at a broad scale. There could be greater consequences for slow-breeding species. **Likelihood:** Almost certain..... **Consequence:** Minor		■		
Extraction — lower trophic orders: Commercial, recreational and traditional fisheries that extract lower trophic orders are projected to continue throughout the next 25 years, with the potential for the trawl fishery effort to increase under current management arrangements. The resilience and biology of these species generally allows them to be sustainably extracted if appropriately managed. **Likelihood:** Almost certain..... **Consequence:** Minor		■		
Extraction — top order predators: Some shark species extracted through the East Coast Inshore Fin Fish Fishery have life history traits that lend themselves to sustainable exploitation. Other top predators are slow breeding and extraction is likely to have at least moderate consequences. The network of no-take zones has already benefited populations of some predators. However, for larger, more mobile predators, benefits are limited. **Likelihood:** Almost certain..... **Consequence:** Moderate			■	
Illegal fishing and poaching: Declining global fish stocks are likely to increase the demand on Australian fisheries. This, in turn, will increase the incentive for illegal foreign and domestic fishing activity. The consequence is likely to be major at a broad scale. Trends in illegal fishing and poaching are poorly known, but increasing illegal activity could have major consequences, particularly for sensitive areas and species. **Likelihood:** Almost certain..... **Consequence:** Major				■
Marine debris: Ocean currents transport debris around the world's oceans making the Reef vulnerable to many debris from both local and more distant sources. Given the rapid increase in plastic production globally, the longevity of this material and the disposable nature of plastic items, plastic marine debris is likely to persist over the next 25 years and to be present at a broad scale within the Region. **Likelihood:** Almost certain..... **Consequence:** Moderate			■	
Noise pollution: Projected increases in shipping and the continuation of increases in port development and recreational boat ownership mean underwater man-made noise is likely to be continuous over the next 25 years. Little is known about the effects of noise on the Region's species but evidence from elsewhere indicates that effects can be broad scale with serious consequences close to some sources. **Likelihood:** Almost certain..... **Consequence:** Moderate			■	
Outbreak of disease: The causes of disease are difficult to ascertain but are likely to be varied. For example, outbreaks of coral disease have been linked to increased sea temperature, making further outbreaks possible. Consequences will vary depending on the disease and duration of outbreak but could have moderate effects at a broad scale. **Likelihood:** Possible..... **Consequence:** Moderate		■		
Outbreak or bloom of other species: Changes in ecological processes as a result of other impacts may cause population explosions of some species. Considering outbreaks and blooms to date, the risk would be significant to a sensitive population or community at a local scale. However, there is a high level of uncertainty. **Likelihood:** Likely..... **Consequence:** Minor		■		

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Physical damage — fishing: Current levels of trawling activity pose low risk to shallow (<90m) habitats at a Reef-wide scale, given existing protection through zoning, but local effects may be higher in intensely trawled areas. Consequences could increase if trawl fishing effort increases under more favourable economic conditions. **Likelihood:** Almost certain ... **Consequence:** Minor				
Physical damage — other: If recreational vessel ownership continues to increase without a corresponding increase in supporting infrastructure and education, it is likely anchor damage will increase. Over the next 25 years, there is likely to be damage from anchors, small vessel groundings, diving and snorkelling throughout the year. The impact could be significant at the areas of impact. **Likelihood:** Almost certain ... **Consequence:** Minor				
Physical damage — Ship grounding: Despite projected increases in shipping and reports of skipper fatigue, it is considered that current management of shipping, including the vessel tracking service, significantly reduces the risk of groundings. They are, therefore, not predicted to occur every year but possibly once in 10 years. Groundings can have severe impacts on biodiversity at the site with long recovery periods, and longer term and broader scale effects due to dispersal of anti-fouling paint. **Likelihood:** Possible ... **Consequence:** Moderate				
Spill — large chemical: Although a large chemical spill is unlikely, the effects on biodiversity could be extremely serious and possibly irreversible at a local scale. Consequences would vary depending on the type and amount of spill and are considered major given current management and response plans. **Likelihood:** Unlikely ... **Consequence:** Major				
Spill — large oil: While shipping is projected to increase, recent improvements in management make the potential for a large oil spill unlikely. The physical smothering of plants and animals, combined with oil toxicity and its chemical reactions with water, mean a large spill is likely to have serious and persistent effects for several years. **Likelihood:** Unlikely ... **Consequence:** Major				
Spill — small chemical and oil: Small chemical and oil spills are likely to occur frequently in the Region. Projected increases in the number of ships and other vessels are likely to increase the risk in the next 25 years. Effects on sensitive marine life could be significant in the area of the spill, with consequences depending on size and type of spill. **Likelihood:** Almost certain ... **Consequence:** Minor				
Vessel strike on wildlife: Continuing growth in shipping and recreational boating increases the potential for vessel strikes on wildlife. Surface-breathing animals are most at risk but the impact would not be discernible at the ecosystem level. **Likelihood:** Likely ... **Consequence:** Minor				
Waste discharge from a vessel: Increases in vessel traffic will mean there is likely to be more vessel-based waste discharge over the next 25 years. Effects on biodiversity are anticipated to be minor under current management arrangements. **Likelihood:** Almost certain ... **Consequence:** Minor				
Wildlife disturbance: Projected increases in population and a continuation of current increases in recreational vessel ownership, particularly in southern and central areas, is likely to lead to an increase in disturbance of wildlife from the presence of boats, snorkelling and diving activities and access to islands. The increase may cause some localised effects, for example on nesting seabirds. **Likelihood:** Almost certain ... **Consequence:** Minor				

10.8 Risks to geomorphological features

The future risks of relevant impacts to geomorphological features in the Region (see Chapter 6) are presented in Table 10.4.

Table 10.4 Projected risks to geomorphological features in the Region over the next 25 years

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Climate change				
Altered ocean currents: Altered ocean currents could influence the sediment transport pathways with flow-on effects to geomorphological features. Increased velocity or change in direction of currents could alter erosion processes on islands, shorelines and river deltas. Changes to tidal jets that deliver nutrients from deeper waters will control the location of *Halimeda* banks. **Likelihood:** Unlikely .... **Consequence:** Minor	■			
Cyclone activity: Cyclone-induced damage is of concern to coral reefs as a geomorphological feature. Increased severity of cyclones reduces the resilience of corals and affects their capacity to recover from cumulative impacts. Cyclones are also likely to affect islands, shorelines and river deltas. **Likelihood:** Possible........ **Consequence:** Moderate		■		
Increased sea temperature: Increased sea temperatures are predicted to be of minor consequence to the affected geomorphological features, such as coral reefs, seagrass and *Halimeda* banks. Reef building may slow or halt and erosive processes may begin. Loss of seagrass may lead to increased sediment movement. **Likelihood:** Almost certain........ **Consequence:** Minor		■		
Ocean acidification: Ocean acidification is likely to affect the geomorphological features reliant upon calcifying species, such as coral reefs and *Halimeda* banks. Erosional processes may dominate, and features that are protected by reefs may be indirectly impacted such as shorelines. Sediments may be produced at lower rates and with less durability, affecting reef islands. **Likelihood:** Almost certain........ **Consequence:** Moderate			■	
Rising sea level: Rising sea level could potentially affect islands, shorelines and coral reefs that are unable to grow fast enough to maintain their shallow depth. **Likelihood:** Almost certain........ **Consequence:** Insignificant	■			
Catchment run-off				
Increased freshwater inflow: Flood events have potential to rearrange river deltas and affect the health of reef-building corals and seagrass meadows. **Likelihood:** Likely........ **Consequence:** Minor		■		
Nutrients from catchment run-off: Increased nutrients from catchment run-off will have minor effects on the geomorphological features, such as coral reefs and *Halimeda* banks. Increased nutrients can promote macroalgae growth on coral reef features which can, in turn, affect slow or halt the reef building process. **Likelihood:** Almost certain........ **Consequence:** Minor		■		
Outbreak of crown-of-thorns starfish: Coral mortality caused by a crown-of-thorns starfish outbreak will have an effect on coral reef features, halting growth and promoting erosional processes. **Likelihood:** Possible........ **Consequence:** Minor	■			
Sediments from catchment run-off: Increased sediment will have an effect on geomorphological features reliant upon photosynthetic species such as coral reefs and seagrass meadows. It could also infill palaeochannels, burying the feature. **Likelihood:** Almost certain........ **Consequence:** Moderate			■	

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Degradation of coastal ecosystems				
Coastal reclamation: Reclaimed areas experience changes in sediment composition and can alter ocean currents which affect sediment transport. There is also potential that geomorphological features in reclaimed areas are directly affected. **Likelihood:** Possible .... **Consequence:** Moderate				
Direct use				
Dredging: Dredging can result in direct effects on geomorphological features at the site of dredging. It can also have flow-on effects to features and geomorphological processes by changing sediment transport pathways through dredged channels. **Likelihood:** Likely .... **Consequence:** Minor				
Dumping and resuspension of dredge material: Dumping and resuspension of dredge material can affect geomorphological features such as coral reefs by restricting light and smothering them. Sediment may also settle in palaeochannels. **Likelihood:** Almost certain .... **Consequence:** Minor				
Physical damage — fishing: Little is known of the current impacts of deep sea trawling on deeper water geological features, but the consequences could be moderate. **Likelihood:** Possible .... **Consequence:** Moderate				
Physical damage — other: Anchors can cause physical damage to shallow water geomorphological features at the site of contact, with potentially long-term consequences on their shape and function. **Likelihood:** Almost certain .... **Consequence:** Minor				
Physical damage – Ship grounding: The grounding of a large vessel has the potential to damage geomorphological features at the site with long-term effects on the function and shape of the feature. Given the scale of the potential impact relative to the size of most geomorphological features, the overall consequence would be minor. **Likelihood:** Possible .... **Consequence:** Minor				

10.9 Risks to Indigenous heritage values

The future risks of each of the 40 impacts identified in Chapter 6 to Indigenous heritage values in the Region are presented in Table 10.5.

Table 10.5 Projected risks to Indigenous heritage values in the Region over the next 25 years

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Climate change				
Altered ocean currents: Any effects on biodiversity will have direct effects on cultural values. Many species are totems for Traditional Owners and have cultural significance for customary practice, lore, story and songlines. **Likelihood:** Unlikely .... **Consequence:** Major				

Summary of potential impacts	Risk: Low	Medium	High	Very high
Cyclone activity: Severe cyclones can affect culturally important sites (including sacred sites) and places of historic Indigenous significance. **Likelihood:** Possible .... **Consequence:** Major			■	
Increased sea temperature: The effect of increased sea temperature on the entire ecosystem over a broad scale will also have a major effect on Indigenous cultural values. **Likelihood:** Almost certain........ **Consequence:** Major				■
Ocean acidification: The effects on coral reefs and related ecosystems from ocean acidification will change the environment and will consequently affect Indigenous heritage values. **Likelihood:** Almost certain........ **Consequence:** Major				■
Rising sea level: Rising sea level could affect coastal and shallow water historical cultural sites, as well as cause changes to custom. Loss of access to fish traps, burial sites (which may be in coastal sand dunes), or rock art located in beach caves will have adverse consequences to cultural practices. **Likelihood:** Almost certain........ **Consequence:** Moderate			■	
Catchment run-off				
Increased freshwater inflow: Increased flood events are likely to affect seagrass meadows, driving animals such as turtle and dugong to leave areas in search of food. These movements would have significant localised effects on cultural values. This is in addition to the changes in the environment that occur with major flooding events. **Likelihood:** Likely........ **Consequence:** Major			■	
Nutrients from catchment run-off: Any impacts that affect the Region's water quality, and consequently marine plants and animals, will have an impact on Indigenous heritage values. **Likelihood:** Almost certain........ **Consequence:** Moderate			■	
Outbreak of crown-of-thorns starfish: Little is known of the potential effects of outbreaks of crown-of-thorns starfish to Indigenous cultural values, but they are likely to be similar to those on biodiversity. **Likelihood:** Possible........ **Consequence:** Moderate		■		
Pesticides from catchment run-off: Any impacts that affect the Region's water quality, and consequently marine plants and animals, will have an impact on Indigenous heritage values. **Likelihood:** Almost certain........ **Consequence:** Minor		■		
Sediments from catchment run-off: Any impacts that affect the Region's water quality, and consequently marine plants and animals, will have an impact on Indigenous heritage values. **Likelihood:** Almost certain........ **Consequence:** Moderate			■	
Urban and industrial discharge: Urban and industrial discharge is already having an adverse effect on cultural practices. High concentrations of heavy metals due to polluted water are found in the liver of culturally significant species such as dugong and turtle. Any increase in discharge will continue to place cultural values and practices at further risk. **Likelihood:** Likely........ **Consequence:** Moderate			■	
Degradation of coastal ecosystems				
Acid sulphate soils: Localised effects of run-off from exposed acid sulphate soils can have significant effects on Traditional Owner cultural values. Impacts on fish and other marine resources from acid water and heavy metals would impact on the subsistence lifestyles that many Traditional Owners still practice today. **Likelihood:** Possible........ **Consequence:** Moderate		■		

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Artificial barriers to flow: Change caused by construction of artificial barriers continues to alter and disrupt cultural connections for Traditional Owners. Physical changes to the environment not only disrupt species composition and abundance, but can affect cultural sites (e.g. burial sites, birthing sites). **Likelihood:** Almost certain ... **Consequence:** Moderate			■	
Atmospheric pollution: Atmospheric pollution may have minor effects on cultural values overall, but could have more significant effects in localised areas. **Likelihood:** Possible ... **Consequence:** Minor	■			
Coastal reclamation: Without adequate consultation with Traditional Owners, reclamation on culturally significant sites would be possible and the values would be irretrievably compromised. **Likelihood:** Possible ... **Consequence:** Major			■	
Light impacts (artificial): Artificial lighting can reduce survival rates of turtle hatchlings which could have flow-on impacts on cultural values such as traditional hunting. **Likelihood:** Likely ... **Consequence:** Minor		■		
Modifying supporting terrestrial habitats: Even relatively small changes to land and seascapes have very significant consequences for cultural values. Cultural observances, customs, storylines and songlines can be lost by changes to terrestrial habitats. **Likelihood:** Almost certain ... **Consequence:** Major				■
Direct use				
Dredging: Dredging near coastal islands and in port areas can disturb culturally significant sites. The disturbance of burial sites or sacred sites has catastrophic effects on Indigenous cultural values. **Likelihood:** Likely ... **Consequence:** Major			■	
Dumping and resuspension of dredge material: Dumping or resuspension of dredge material in areas with undiscovered heritage sites and features is possible but would have only minor consequences. **Likelihood:** Almost certain ... **Consequence:** Moderate			■	
Exotic species and diseases: The consequence would depend on the species or disease but could have serious effects to Indigenous heritage values in the local area. **Likelihood:** Possible ... **Consequence:** Moderate		■		
Extraction —death of discarded species: Many discarded species have a cultural significance to Traditional Owners as either a food source, totem or for customary practice. Any decrease in species populations has a significant effect for Traditional Owners. **Likelihood:** Almost certain ... **Consequence:** Major				■
Extraction —fishing spawning aggregations: Changes to population sizes of species targeted by fishing spawning aggregations would have subsequent effects on Indigenous heritage values connected to those species. **Likelihood:** Likely ... **Consequence:** Moderate			■	
Extraction — herbivores: Traditional hunting for turtle and dugong is likely to continue and has a positive impact on Indigenous heritage values. **Likelihood:** Likely ... **Consequence:** (Positive)				
Extraction — lower order predators: Localised effects from the extraction of lower order predators by commercial and recreational fishing can cause changes to customary practice if Traditional Owners have to fish or collect in non-traditional areas. **Likelihood:** Almost certain ... **Consequence:** Moderate			■	
Extraction — lower trophic orders: Localised effects from the extraction of lower trophic orders by commercial and recreational fishing extraction can cause changes to customary practice if Traditional Owners have to fish or collect in non-traditional areas. **Likelihood:** Likely ... **Consequence:** Moderate			■	

Summary of potential impacts	Low	Medium	High	Very high
Extraction — top order predators: Top order predators are totems for many Traditional Owners. The exploitation of these animals and localised impacts on populations will affect the cultural values of Traditional Owners with sea country estates. **Likelihood:** Almost certain ... **Consequence:** Moderate			■	
Illegal fishing and poaching: Changes in species numbers and biodiversity directly affect Traditional Owners' ability to practice customary lore, use their cultural tools and technology, and follow cultural observances. **Likelihood:** Almost certain ... **Consequence:** Major				■
Marine debris: As well as entangling and killing culturally important marine animals and birds, marine debris washes up in culturally important and sacred sites. **Likelihood:** Almost certain ... **Consequence:** Moderate			■	
Noise pollution: Little is known of the potential effects of increased noise on Indigenous cultural values, but they are likely to be similar to those on biodiversity. **Likelihood:** Almost certain ... **Consequence:** Minor		■		
Outbreak of disease: Outbreaks of disease such as coral disease and fibropapilloma in turtles can affect cultural practices, customs and lore. Outbreaks that may seem moderate at a broad scale could have significant impacts at a smaller, more local level. **Likelihood:** Possible ... **Consequence:** Moderate		■		
Outbreak or bloom of other species: Little is known of the potential effects of outbreaks or blooms of other species to Indigenous cultural values, but they are likely to be similar to those on biodiversity. **Likelihood:** Likely ... **Consequence:** Minor		■		
Physical damage — fishing: Any damage caused to culturally significant sites would seriously affect Indigenous heritage values. Customs and story and songlines for those damaged areas would be lost or have to change. **Likelihood:** Possible ... **Consequence:** Moderate		■		
Physical damage — other: Culturally significant sites (including sacred sites, burial sites and sites that have storylines associated with them) can be affected by damage to the seafloor and its habitats. **Likelihood:** Almost certain ... **Consequence:** Minor		■		
Physical damage — Ship grounding: Many reefs have strong cultural value to Traditional Owners. Song and storylines are connected to them and in some cases they are sacred sites. The destruction and damage caused by ship grounding would be major and long term. **Likelihood:** Possible ... **Consequence:** Moderate		■		
Spill — large chemical: A large chemical spill that affects biodiversity would have a flow-on effect to the cultural values of Traditional Owners. Localised extinctions could have extremely serious and possibly irreversible effects on cultural practice, observances, story and songlines and places of cultural significance at a local scale. **Likelihood:** Unlikely ... **Consequence:** Major		■		
Spill — large oil: Impacts on animals and land and seascapes from a large oil spill would have a similarly negative effect on Indigenous heritage values. **Likelihood:** Unlikely ... **Consequence:** Major		■		
Spill — small chemical and oil: This localised effect could have significant impacts on Indigenous heritage values for those connected to that sea country. **Likelihood:** Almost certain ... **Consequence:** Minor		■		
Vessel strike on wildlife: As the species most affected are culturally significant, the impact on cultural values is significant at a local scale. **Likelihood:** Likely ... **Consequence:** Minor		■		

Summary of potential impacts	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Waste discharge from a vessel: The minor effects of waste discharge from a vessel on biodiversity will have flow-on effects on Indigenous heritage values. **Likelihood:** Almost certain ... **Consequence:** Minor		■		
Wildlife disturbance: Changes to animal behaviour caused by the presence of boats or people can change the nature of customary practice, affect sites of cultural importance and change storylines. **Likelihood:** Almost certain ... **Consequence:** Moderate			■	

10.10 Risks to historic heritage values

The future risks of relevant impacts to historic heritage values in the Region (see Chapter 6) are presented in Table 10.6.

Table 10.6 Projected risks to historic heritage values in the Region over the next 25 years

The risk assessment applies to buildings and structures of historic heritage value.

Summary of potential impacts and their risk parameters	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Climate change				
Altered ocean currents: A major change in ocean currents is likely to have only minor effects on heritage values such as shipwrecks. **Likelihood:** Possible ... **Consequence:** Minor	■			
Cyclone activity: Severe cyclones can have major impacts on heritage sites and features such as shipwrecks, lighthouses and World War II sites. The severity of cyclones is likely to increase in the future. **Likelihood:** Possible ... **Consequence:** Major			■	
Increased sea temperature: Increased sea temperatures could accelerate the natural degradation of historic heritage sites. **Likelihood:** Possible ... **Consequence:** Minor	■			
Ocean acidification: Ocean acidification could have an effect on shipwrecks, but it is likely to be insignificant. **Likelihood:** Almost certain ... **Consequence:** Insignificant	■			
Rising sea level: Rising sea level is likely to have some minor effects on coastal and shallow water historic heritage sites. **Likelihood:** Likely ... **Consequence:** Minor		■		
Degradation of coastal ecosystems				
Atmospheric pollution: Atmospheric pollution may have minor effects on heritage such as lighthouses and World War II sites. **Likelihood:** Possible ... **Consequence:** Minor	■			

Summary of potential impacts and their risk parameters	Risk: Low	Risk: Medium	Risk: High	Risk: Very high
Coastal reclamation: Coastal reclamation on or close to a heritage site is not likely to happen in a 100-year period. If it were to happen, for example on an undeclared heritage site, it would have major consequences. **Likelihood:** Rare ... **Consequence:** Major				
Modifying supporting terrestrial habitats: Modifying terrestrial habitats could affect undiscovered heritage sites. **Likelihood:** Possible... **Consequence:** Moderate				
Direct use				
Dredging: Dredging in areas with undiscovered heritage sites and features is unlikely but would have major consequences. **Likelihood:** Unlikely ... **Consequence:** Major				
Dumping and resuspension of dredge material: Dumping of dredge material in areas with undiscovered heritage sites and features is possible but would have only minor consequences. **Likelihood:** Possible... **Consequence:** Minor				
Marine debris: Marine debris such as discarded fishing nets can potentially become entangled on submerged historic sites, potentially degrading their heritage value. **Likelihood:** Rare ... **Consequence:** Minor				
Physical damage — fishing: It is possible for trawlers to accidentally damage undiscovered heritage sites and features, which could have serious effects for the site or feature. **Likelihood:** Possible... **Consequence:** Moderate				
Physical damage — other: Small vessel groundings and anchor damage to heritage sites or features is possible over the next 25 years, with moderate consequences. **Likelihood:** Possible... **Consequence:** Moderate				
Physical damage — Ship grounding: A ship grounding in an area with a heritage site is not likely to happen in a 100-year period but would have major consequences. **Likelihood:** Rare ... **Consequence:** Major				
Spill — large chemical: A large chemical spill would present a risk to heritage sites and features if the spill was close to the site. **Likelihood:** Unlikely ... **Consequence:** Moderate				
Spill — large oil: It is not likely in the next 25 years that an oil spill will have an effect on heritage sites or features. **Likelihood:** Rare ... **Consequence:** Insignificant				
Spill — small chemical and oil: The risk of small chemical and oil spills affecting heritage sites is considered insignificant. **Likelihood:** Rare ... **Consequence:** Insignificant				
Waste discharge from a vessel: Waste from vessels could possibly affect historic heritage sites over the next 25 years, however the effects would not be discernible. **Likelihood:** Possible... **Consequence:** Insignificant				

10.11 Summary of risks to matters of national environmental significance

A summary of the likely future risks affecting each matter of national environmental significance is provided in Table 10.7.

Table 10.7 Summary of projected risks to matters of national environmental significance in the Region

Matter of national environmental significance	Implications of highest risk impacts
World heritage properties	The implications for the Great Barrier Reef World Heritage Area are the same as for the Marine Park. In addition, risks that occur in the World Heritage Area but outside the Marine Park (such as Queensland islands and internal waters and port areas) will have implications on the property's resilience, outstanding universal value and integrity. The Region's ecological and biological processes; natural beauty and phenomenon; and habitats for conservation of biodiversity are dependent on the condition of its biodiversity values. Therefore projected high and very high risks for biodiversity values will present an equivalent for the attributes underpinning the property's outstanding universal value. The sources of these high and very high risks continue to be climate change, catchment run-off, degradation of coastal ecosystems and direct use. While overall risk to attributes underpinning the major stages of Earth's evolutionary history are relatively low, projected increases in the intensity of cyclones, increased sediment, dredging and dumping of dredge material, physical impacts from fishing and ocean acidification are likely to pose the greatest risks. In addition, the risks identified would likely affect the property's integrity as its overall condition declines.
Great Barrier Reef Marine Park	About three-quarters of the major to catastrophic risks assessed as almost certain to affect the Marine Park's values over the next 25 years originate outside the Region, including impacts on a global scale (for example those related to climate change) and those originating in the catchment (for example from catchment run-off and the degradation of coastal ecosystems). While management of risks that originate within the Marine Park may help respond to impacts and restore resilience, the future health of the values relevant to the Marine Park depends to a large degree on avoiding and mitigating risks arising beyond its boundaries. Some of the most significant risks arising from direct use— illegal fishing and poaching, and death of discarded species — have implications for the population health of target species and recovery of species of conservation concern. Other very high risks — such as dumping and resuspension of dredge material and outbreak of crown-of-thorns starfish — affect keystone species such as corals, which support a variety of life in the Region.
National heritage places	The implications for Great Barrier Reef as a national heritage place are the same as for the Great Barrier Reef World Heritage Area.
Commonwealth marine area	The implications for the Commonwealth marine area are the same as for the Marine Park.
Listed migratory and listed threatened species	Many listed migratory and listed threatened species rely on coastal and island habitats for feeding and breeding (e.g. marine turtles, dugong, some sharks, inshore dolphins, sawfish, some seabirds and shorebirds). This makes them more vulnerable to high risks such as modifying supporting terrestrial habitats, dredging-related impacts and illegal fishing and poaching. The migratory nature of many of these species means they may spend some of their life outside the Region, beyond the protection of the Marine Park.
Wetlands of international importance	The size and integrity of the Shoalwater and Corio Bays Area and its location within a defence practice area means it is less likely to be affected by many of the high risks (except climate change). Over the next 25 years, the area may provide an important refuge to many species (including listed and migratory species).

10.12 Summary of outcomes

- The Great Barrier Reef Region remains one of the most resilient tropical marine ecosystems in the world, however there is increasing evidence that its resilience is being seriously eroded.
- The loss of ecosystem resilience cannot be attributed to any single cause, but is almost certainly the consequence of impacts from the different activities and direct drivers, and their accumulation through time.
- Coral reefs, seagrass meadows and other inshore habitats have lost some of their resilience due to declines in condition, continuing impacts and a loss of connectivity. Dugongs have lower resilience due to historic depletion, low rates of reproduction and loss of seagrass habitats.
- The emerging loss of ecosystem resilience is particularly critical given the projected major increase in the severity of impacts related to climate change.
- The Region faces a range of increasing risks into the future. The principal sources of the impacts assessed as high and very high risk remain climate change, catchment run-off, degradation of coastal ecosystems and direct use.
- For all the Region’s values, impacts associated with climate change such as ocean acidification, increased sea temperatures and rising sea level are likely to become more severe into the future. Therefore, these impacts pose an increasing risk to the Region’s values.
- Legacy impacts, such as the extraction of herbivores (for example, the dugong harvest fishery which stopped operating in 1969), and many of the impacts of fishing have a reduced future risk due to improved management.
- Although there have been few large oils spills and no large chemical spills recorded in the Region and these events remain unlikely in the future, the consequence of a large spill would be major.
- Geomorphological features are most likely to be at risk from ocean acidification, sediments from catchment run-off, dumping and resuspension of dredge material, and physical impacts of fishing.
- The close connections between biodiversity values and Indigenous heritage values mean the projected risk for many impacts is equivalent for both sets of values. Examples include illegal fishing and poaching, nutrients from catchment run-off and rising sea level which are rated as high risk for both biodiversity and Indigenous heritage values. However, in some cases the assessments of risk differ because of differences in perspective.
- None of the impacts assessed were rated as presenting a very high risk to historic heritage values. Only two present a high risk — cyclone activity and ocean acidification.

A summary of the likely future risks affecting the Region’s values is provided in Table 10.8 to Table 10.11 for biodiversity, geomorphological features, Indigenous heritage values and historic heritage values respectively.

Table 10.8 Summary of projected risks to biodiversity values over the next 25 years

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain		• Extraction — lower order predators • Extraction — lower trophic orders • Physical damage —fishing • Physical damage — other • Spill — small chemical and oil • Urban discharge • Waste discharge from a vessel • Wildlife disturbance	• Artificial barriers to flow • Extraction —death of discarded species (most species) • Extraction — top order predators • Marine debris • Noise pollution • Pesticides from catchment run-off • Rising sea level	• Extraction — death of discarded species (species of conservation concern) • Illegal fishing and poaching • Modifying supporting terrestrial habitats • Ocean acidification	• Increased sea temperature • Nutrients from catchment run-off • Sediments from catchment run-off
Likely		• Extraction — herbivores (dugong and turtle) • Light impacts (artificial) • Outbreak or bloom of other species • Vessel strike on wildlife	• Extraction — fishing spawning aggregations	• Increased freshwater inflow	
Possible		• Atmospheric pollution	• Acid sulphate soils • Coastal reclamation • Dredging • Dumping and resuspension of dredge material • Exotic species and diseases • Industrial discharge • Outbreak of disease • Ship grounding	• Cyclone activity	• Outbreak of crown-of-thorns starfish
Unlikely				• Altered ocean currents • Extraction — herbivores (fish) • Spill — large chemical • Spill — large oil	
Rare					

Projected risk	Low risk	Medium risk	High risk	Very high risk

Table 10.9 Summary of projected risks to geomorphological features over the next 25 years

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	• Rising sea level	• Dumping and resuspension of dredge material • Increased sea temperature • Nutrients from catchment run-off • Physical damage — other	• Ocean acidification • Sediments from catchment run-off		
Likely		• Dredging • Increased freshwater inflow			
Possible		• Outbreak of crown-of-thorns starfish • Ship grounding	• Coastal reclamation • Cyclone activity • Physical damage — fishing		
Unlikely		• Altered ocean currents			
Rare					

Projected risk	Low risk	Medium risk	High risk	Very high risk

Table 10.10 Summary of projected risks to Indigenous heritage values over the next 25 years

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain		• Noise pollution • Pesticides from catchment run-off • Physical damage — other • Spill — small chemical and oil • Waste discharge from a vessel	• Artificial barriers to flow • Dumping and resuspension of dredge material • Extraction — lower order predators • Extraction — top order predators • Marine debris • Nutrients from catchment run-off • Rising sea level • Sediments from catchment run-off • Wildlife disturbance	• Extraction —death of discarded species • Illegal fishing and poaching • Increased sea temperature • Modifying supporting terrestrial habitats • Ocean acidification	
Likely		• Light impacts (artificial) • Outbreak or bloom of other species • Vessel strike on wildlife	• Extraction — lower trophic orders • Extraction — fishing spawning aggregations • Urban and industrial discharge	• Dredging • Increased freshwater inflow	
Possible		• Atmospheric pollution	• Acid sulphate soils • Exotic species and diseases • Outbreak of crown-of-thorns starfish • Outbreak of disease • Physical damage — fishing • Ship grounding	• Coastal reclamation • Cyclone activity	
Unlikely				• Altered ocean currents • Spill — large chemical • Spill — large oil	
Rare					

Projected risk	Low risk	Medium risk	High risk	Very high risk

Table 10.11 Summary of projected risks to historic heritage values over the next 25 years

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	• Ocean acidification				
Likely		• Rising sea level			
Possible	• Waste discharge from a vessel	• Altered ocean currents • Atmospheric pollution • Dumping and resuspension of dredge material • Increased sea temperature	• Modifying supporting terrestrial habitats • Physical damage — other • Physical damage — fishing	• Cyclone activity	
Unlikely			• Spill — large chemical	• Dredging	
Rare	• Acid sulphate soils • Artificial barriers to flow • Spill— small chemical and oil • Spill — large oil	• Marine debris		• Coastal reclamation • Ship grounding	

Projected risk	Low risk	Medium risk	High risk	Very high risk

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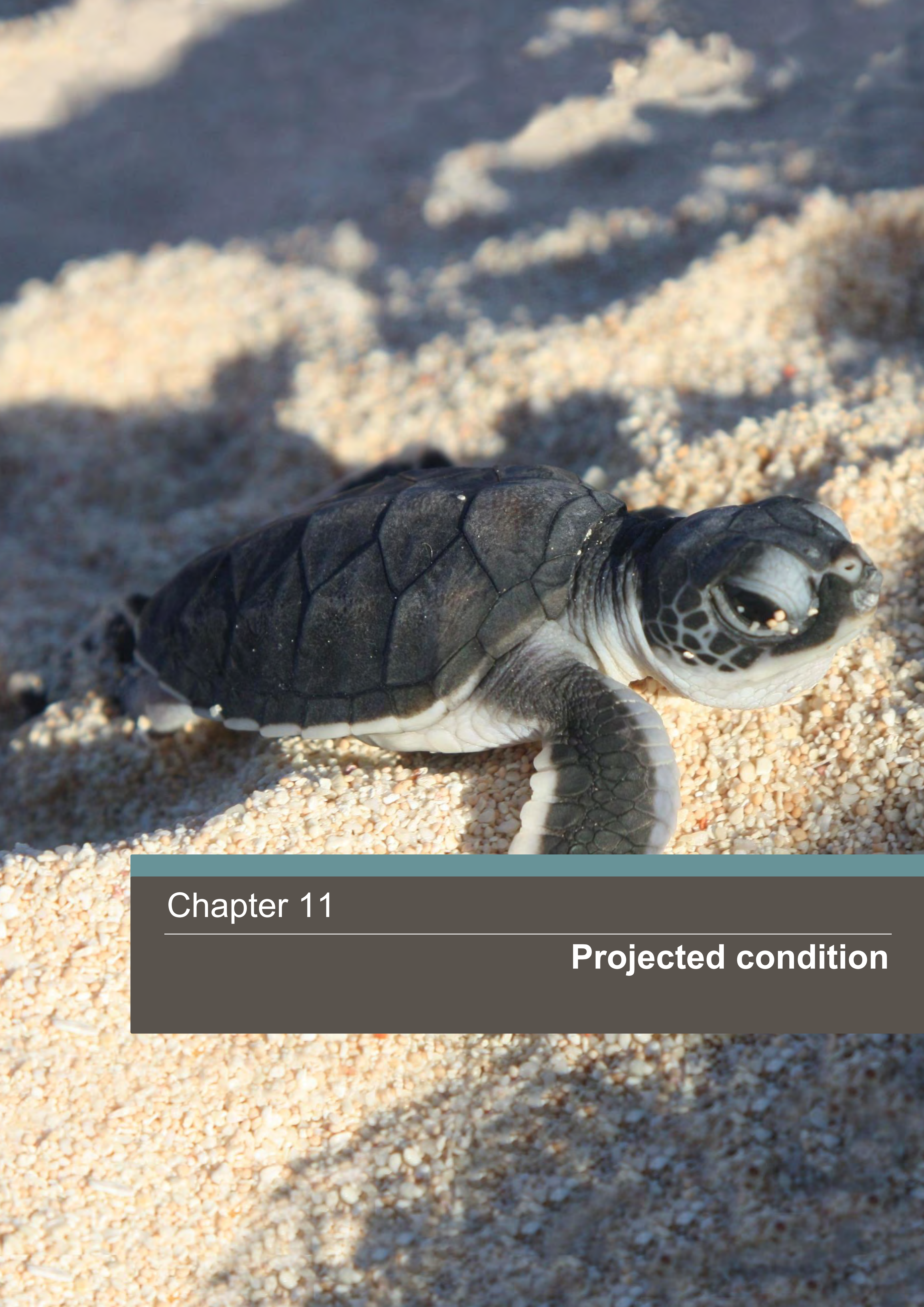
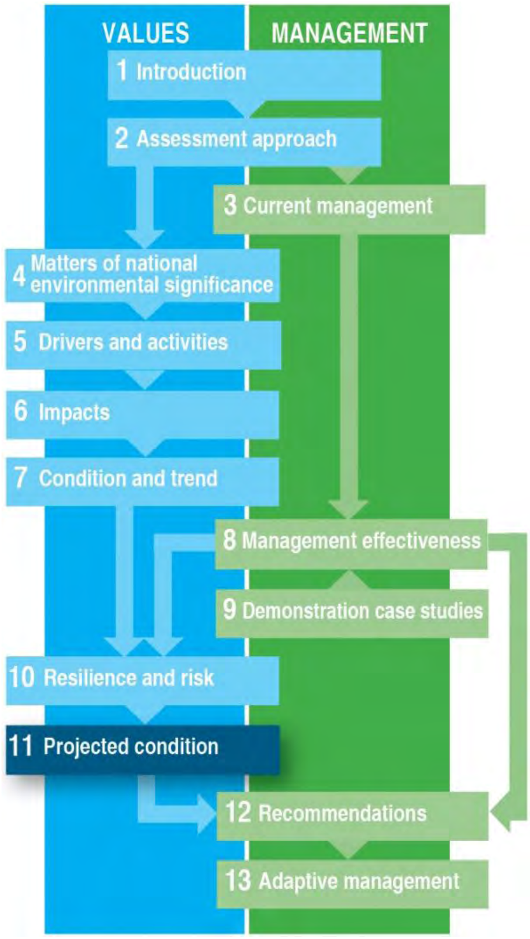


Chapter 11

Projected condition



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Cover page image: Green turtle hatchling

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

5. Projected condition of matters of national environmental significance

5.1 **_Describe the projected condition of the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, based on an evaluation of their:_**

a) current status and trends

b) actual and potential impacts

c) the effectiveness of the Program to protect the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, and manage impacts

d) *an understanding of ecosystem resilience*

e) *an assessment of overall risks to the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area.*

11 Projected condition

The projected condition of matters of national environmental significance in the Region is affected by a wide range of variables and is difficult to predict. Information presented in the previous chapters provides a basis for analysing likely condition into the future:

- The assessment of condition and trend of values (Chapter 7) provides an understanding of the current state of each of the values underpinning matters of national environmental significance and their recent trend. The systematic assessment undertaken, which takes into account the past and present impacts (Chapter 6), allows the values of most concern to be identified.
- The independent assessment of the effectiveness of current management (Chapter 8) provides an understanding of the strengths and weaknesses of current management arrangements. It forms an important contribution to developing projected condition as the future predictions assume that these arrangements remain unchanged.
- An understanding of ecosystem resilience (Chapter 10) informs consideration of how strongly the values of most concern are likely to bounce back from current and future impacts.
- The assessment of risk (Chapter 10) analyses the future likelihood and consequence of the identified impacts on values relevant to matters of national environmental significance. The risk of each impact is assessed separately, allowing the impacts that are likely to be of highest risk to be identified. This analysis is a vital component in developing projected condition and focusing future management activities.

In this chapter a summary of the findings of the previous chapters is provided, followed by an assessment of the likely future condition of the Great Barrier Reef Region and values and attributes relevant to matters of national environmental significance.

11.1 Current condition and trends of values

The current condition and trend of the values and attributes relevant to matters of national environmental significance are assessed in Chapter 7. The condition of many of the values relevant to matters of national environmental significance has declined. Many values are assessed as being in poor or very poor condition and this declining trend is continuing. In addition, it is assessed that the condition of some of the values rated as being in good condition is deteriorating. The overall condition of only two elements — estuarine crocodiles and humpback whales — is assessed as having improved.

The values of most concern generally occur in the southern two-thirds of the Great Barrier Reef Region and coincide with areas where connections between coastal and marine systems have been interrupted or modified and where the condition of supporting ecological processes is deteriorating.

11.2 Effectiveness of current management

An independent assessment considered the effectiveness of the Authority's existing measures to protect and manage the Region, examining both 15 major management topics addressed by the Authority (Chapter 8) and a series of demonstration case studies (Chapter 9).

11.2.1 Broadscale assessment

The broadscale assessment recognised the difficulties in achieving positive outcomes on the ground, given the complex nature, large extent and long timescale of the threats and the increasing gap between the growth in management resources and the growth in issues to be addressed.

Management effectiveness was assessed to be strongest on issues limited in scale or intensity and presenting only minor or moderate complexity, such as defence and research activities. Tourism, which operates across much of the Region and is moderately complex, was also found to be effectively managed.

Management effectiveness challenges were most evident for those broadscale issues which are complex socially, biophysically and jurisdictionally. These included Indigenous heritage, climate change and extreme weather, water quality protection, coastal development, port activities, shipping, and commercial and recreational fishing.

The independent assessment reported many of the issues and key values are well understood and that stakeholder engagement was consistently strong across the management topics. Having adequate resources, implementing adequate processes and achieving desired outcomes were the elements where the Authority's current arrangements were generally assessed as least effective.

Addressing cumulative and consequential impacts and applying Indigenous knowledge to management were the weakest indicators of effectiveness across the entire assessment.

11.2.2 Outcomes of demonstration case studies

In addition to the broadscale assessment that considered the entire range of the Authority's management activities, a more detailed understanding of effectiveness was achieved through a series of demonstration case studies. Outcomes particularly relevant to developing the projected condition for the Region include:

- the value of addressing the many cross-jurisdictional issues through strong partnerships across all levels of government, especially having a common goal
- the importance of using all the management tools available to address complex use and environmental issues
- the effectiveness of cooperative management approaches between governments, Traditional Owners, stakeholders and the community in addressing impacts and declines in condition at a local scale
- the importance of cooperative management arrangements with Traditional Owners
- the significance of remoteness — protecting some of the Region's values, while at the same time making management intervention difficult.

11.3 Ecosystem resilience

The capacity of an ecosystem to withstand or recover from disturbances and impacts, and maintain key functions, is an important component in determining its future. Resilience is not about the single, static condition of an ecosystem, but its capacity to absorb or recover from impacts.

A key aspect of resilience is that different impacts may combine or even exacerbate each other so that the cumulative impacts may be far greater than any individual impact. This has two important consequences: first, the need to manage all impacts to reduce cumulative impacts; and second, reductions in one impact may reduce the effects of other impacts, potentially 'buying time' to address less accessible impacts, such as those related to climate change.

There is limited information on ecosystem resilience for the Great Barrier Reef Region, largely due to the vast extent and complexity of the ecosystem, and because resilience is a complex property which is difficult to measure. The resilience of the Great Barrier Reef ecosystem is discussed in Chapter 10, based on the best available information.

Overall, while the Region may be one of the most resilient tropical marine ecosystems in the world, there is increasing concern that its resilience is being seriously, and increasingly rapidly, eroded. The extent of loss varies considerably between components and localities. It is almost certainly the consequence of many different impacts accumulating through time and in different locations.

It is of particular concern that several of the most significant pressures on resilience, and those least effectively managed , are broad in scale. For example, degraded water quality significantly affects most of the habitats and species in inshore areas in the southern two-thirds of the Region and, to a lesser extent, in the northern third. Further, as the state of the system changes, attributes that confer resilience to a healthy ecosystem may begin to undermine resilience in a compromised system. For example, the network of coral reefs distributed across the Region confers vital connectivity for corals and fishes, but it also provides similar connectivity for destructive outbreaks of other species such as crown-of-thorns starfish.

Ecosystem resilience is also affected by the frequency of disturbance. The length of time available for recovery before the next disturbance occurs is a factor in the amount of recovery between disturbances. If disturbances are too frequent, their effects will accumulate through time. Two of the major causes of coral loss on the Great Barrier Reef — cyclones and crown-of-thorns starfish outbreaks — are thought to be increasing in intensity and frequency respectively.

Coral reefs are susceptible to a range of impacts and their ability to recover is being reduced

The emerging loss of resilience is particularly critical in the context of the projected major increase in severity of impacts related to climate change. As these impacts increase, it is very likely that interactions between other impacts and those related to climate change will have increasingly serious consequences for the resilience of the Region’s ecosystem.

11.4 Overall risks to values

A detailed assessment of the values relevant to the matters of national environmental significance is presented in Chapter 10. This includes consideration of the likelihood and consequence of each predicted impact, in relation to biodiversity, geomorphological features, and Indigenous and historic heritage values.

The impacts likely to present a high or very high risk to the matters of national environmental significance have their origin in a number of factors. These may originate well beyond the boundaries of the Region:

- climate change
    - cyclone activity
    - increased sea temperature
    - ocean acidification
    - rising sea level
- catchment run-off
    - increased freshwater inflow (also linked to climate change)
    - nutrients in catchment run-off
    - outbreaks of crown-of-thorns starfish, linked to higher concentrations of nutrients
    - sediments in catchment run-off
    - urban and industrial discharge
- degradation of coastal ecosystems
    - artificial barriers to flow
    - modifying supporting terrestrial habitats
    - coastal reclamation
- direct use of the Region
    - extraction — death of discarded species
    - wildlife disturbance
    - dredging
    - dumping and resuspension of dredge material
    - extraction — lower trophic orders, lower order predators and top order predators
    - extraction — fishing spawning aggregations
    - illegal fishing and poaching
    - marine debris
    - noise pollution

11.5 Future scenarios

As outlined in previous chapters, drivers, activities, past and current impacts and future risks do not operate independently, but are intertwined in a complex web of cumulative effects. The qualitative models used in Chapter 6 to assess cumulative impacts on coral reefs, seagrass and dugong can also be employed to account for and predict how future drivers and activities are likely to have an effect throughout the entire network of ecosystem interactions. Recognising the models are preliminary and subject to further expert review, they are a first step in an examination of the likelihood of changes in condition as a result of future changes in some of the most serious impacts. This type of analysis can enhance understanding of likely projected condition and inform recommendations to improve future management.

As part of the Sustainable Regional Development Program project *Great Barrier Reef resilience decision framework*[1], the method of Hosack et al.[2] has been used to consider cumulative impacts from multiple sources, as well as to compare alternative models of ecosystem function.

The resultant Bayesian Belief Networks shown later in this section follow a standard format. The top rows contain the ecosystem variables (for example, *Acropora* coral species, crown-of-thorns starfish and seagrass meadows) in either a state of increase, unchanged or decrease. The bottom row contains the inputs — the drivers, activities or impacts that may influence the system (for example, ocean warming or nutrients). These also have the three states: increase, unchanged or decrease. The likely response of an ecosystem variable is affected by the state of each input, that is whether or not there is a significant change to that input in the system. For instance, in the first scenario (Figure 11.1 A), the model variables are set so that there is no significant change in the concentrations of nutrients, turbidity and sedimentation, or the frequency of intense storms (that is, it is likely the variables will remain unchanged). However, for ocean warming the likelihood has been altered, with an equal likelihood given to both a significant increase and no change.

11.5.1 Coral reef scenarios

Coral reefs are part of a complex set of interactions, affected by a range of activities and drivers. A simplified qualitative representation of the interactions and linkages is presented in Chapter 6, Figure 6.27. To reflect this complexity and the different hypotheses of ecosystem function in relation to coral reefs, four alternate models of coral reefs were examined as part of the resilience decision framework project and predictions of likely responses generated. A more detailed explanation of the models, including a comparison of outcomes from the four alternate models, is presented in the technical report supporting the coral demonstration case study available at www.gbrmpa.gov.au.

Figure 11.1 presents the outcomes of one of the models — assuming a positive link between nutrients and crown-of-thorns starfish populations, and between sediments and herbivorous fish.

The outcomes of the modelling can be summarised as:

- **Scenario A:** A 50 per cent chance of an increase in ocean warming is likely to lead to an approximate 50 per cent chance of a decrease in coral cover and coral dependent species as a result of bleaching impacts. This symmetry of input and response is a result of the relatively simple cause-and-effect pathway between ocean warming (bleaching) and coral cover.
- **Scenario B:** A 50 per cent chance of an increase in the frequency of intense storms is likely to lead to an approximate 50 per cent reduction in coral cover. The responses of corals, fish and invertebrates are predicted to be similar to the previous scenario, with crown-of-thorns starfish, macroalgae and herbivorous fishes having an equal likelihood of increasing or not changing, and turf algae and coral recruitment having an equal likelihood of decreasing or not changing. The pathways for this cause-and-effect relationship are more numerous and diffuse than scenario A, but nonetheless result in a similar response for corals and coral dependent fishes and invertebrates.
- **Scenario C:** A simultaneous increase in ocean warming and storm events intensifies the predicted decline in coral cover and fish and invertebrates. All other predictions for variables remain unchanged from scenarios A and B.
- **Scenario D:** Even with simultaneous increases in the likelihood of ocean warming and intensity of storm events, improvements to water quality can make a significant difference to the likely future condition of coral reef variables. Under this scenario there is a considerable increase in the probability of increases in corals, coral recruitment and coral dependent fish and invertebrates and a decrease in macroalgae. The modelled improvements to water quality are based on the *Reef Water Quality Protection Plan*[3] targets for strong reductions in nutrients and moderate reductions in sediments. These are expressed as an 80 per cent likelihood of a significant decrease in nutrients and 50 per cent likelihood of a significant decrease in turbidity and sediments. Additional modelling shows that these results are robust, regardless of the coral reef model used.

Testing these four scenarios for coral reefs adds weight to the projections that climate change variables such as ocean warming and the increased intensity of storm events are likely to substantially affect the future condition of reefs in the Region. Importantly, it also demonstrates the likely effectiveness of improving water quality in the Region as a means of improving the resilience of coral reefs to climate change and other impacts.

Although coral reefs on the Great Barrier Reef remain among the most well managed in the world, it is important to understand that simply removing pressures will not automatically lead to recovery, especially if the Reef degrades to a point beyond its natural resilience level (a phase shift).[4,5] A large proportion of coral reefs around the world are degraded to such a degree that recovery is highly unlikely, including many of the reefs in the Caribbean.[6,7]

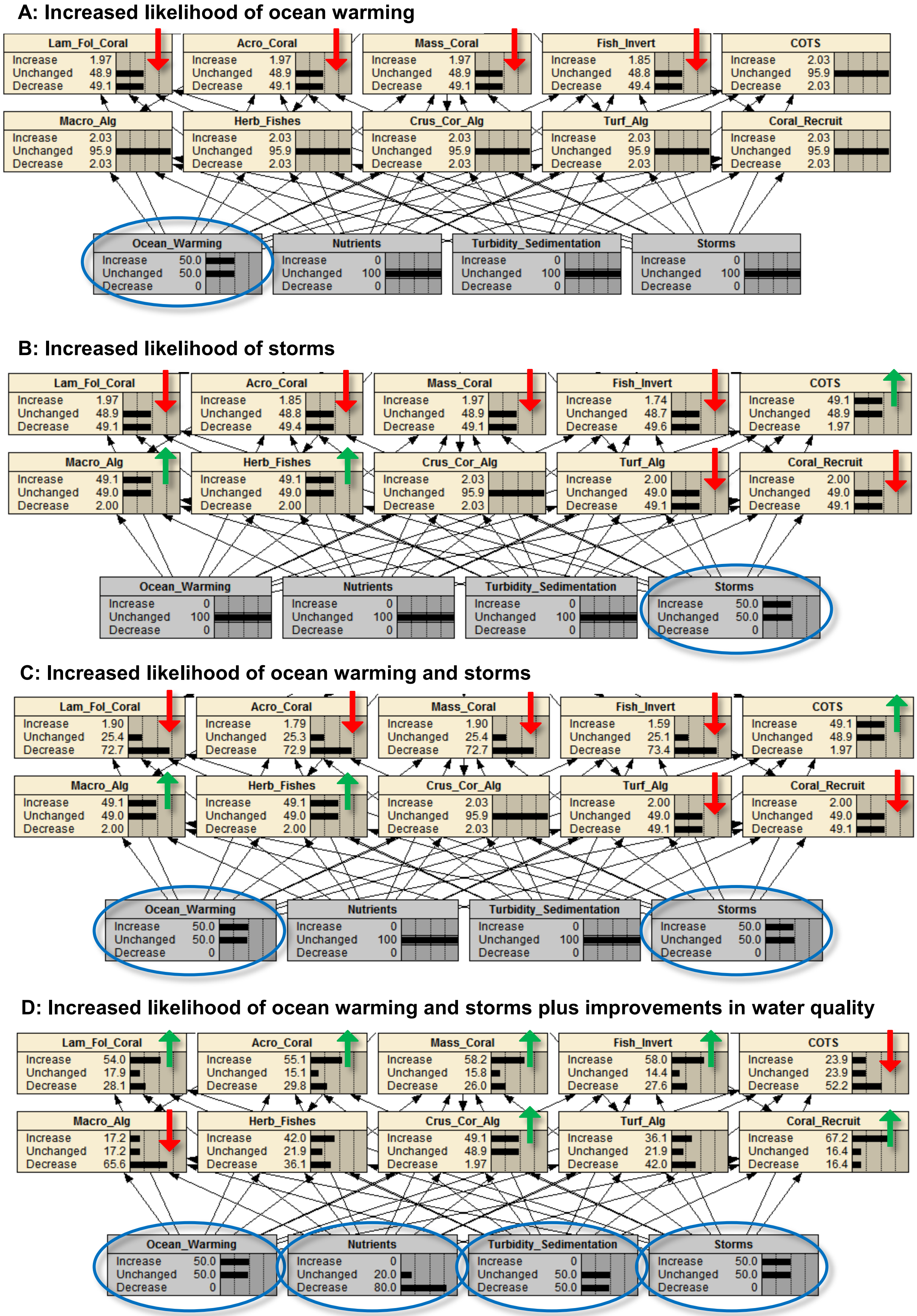


Figure 11.1 Future modelled changes in the condition of coral reefs

Four major factors affecting coral reefs are varied (blue circles) to illustrate likelihood of change in outcomes for the key components of a coral reef ecosystem (red and green arrows).

11.5.2 Seagrass meadow scenarios

As with coral reefs, seagrass meadows are made up of a complex set of interactions, involving a multitude of species and affected by a range of activities and drivers. They are especially important as a habitat for listed species such as dugongs and green turtles. A simplified qualitative representation of the interactions and linkages for seagrass meadows is presented in Chapter 6, Figure 6.28. Again, to reflect this complexity and the different hypotheses of ecosystem function in relation to seagrass meadows, four alternate models were tested in the resilience decision framework project.[1]

Figure 11.2 presents the outcomes of the modelling for the seagrass meadow model that includes a negative effect from epiphytes (a plant which grows upon another but doesn't derive food or water from it) to seagrass (from shading effects on seagrass growth), and dugong populations regulated by additional factors not specified in the model.

The outcomes of the modelling can be summarised as:

- **Scenario A:** A simultaneous increase in structural damage, erosion and ocean warming results in an ambiguous response for many variables. There is an increased likelihood that seagrass species with higher growth rates and shorter life spans (known as *r* strategy species) will be more abundant and a decrease in marine turtles, likely as a result of impacts on their nesting beaches and changes to incubation conditions, rather than food availability.
- **Scenario B:** The cumulative effects of an increase in structural damage, erosion and ocean warming, operating simultaneously with improvements to water quality, results in predictions for many variables similar to those in scenario A. There is more variability in the outcomes, with dugongs having a slightly greater likelihood for either increasing or decreasing, mirroring the likelihoods for change in seagrass abundance. The assumptions made about water quality improvement were the same as those in scenario D for coral reefs above.

Scenario C relates to dugong populations and is discussed below.

Recognising the relative simplicity of the model and the level of understanding of the interactions taking place between all the components of the seagrass meadow habitat, testing of the three scenarios illustrates the complex interactions within this habitat and the variability in the likely responses to changes in the factors affecting it. The results suggest climate change impacts such as ocean warming and increased structural damage and erosion may increase the likelihood of a shift in seagrass species away from slow-growing, long-lived species (known as *K* strategy species) to shorter-lived, faster growing pioneer species (*r* strategy species).

11.5.3 Dugong scenarios

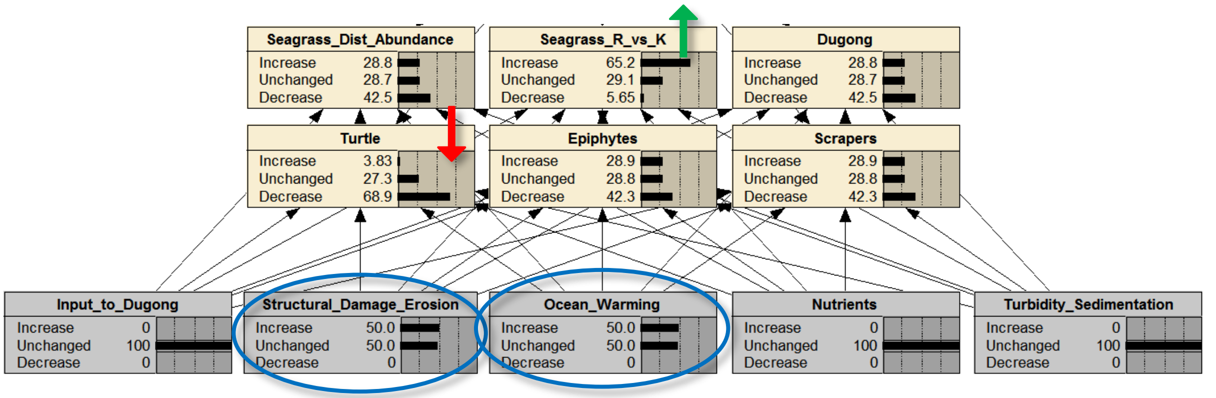
The same qualitative model was employed to investigate future implications for dugong populations as for seagrass meadows, recognising the close interconnections between the species and its habitat.

In summary, the outcomes of the modelling depicted in Figure 11.2 with respect to dugongs are:

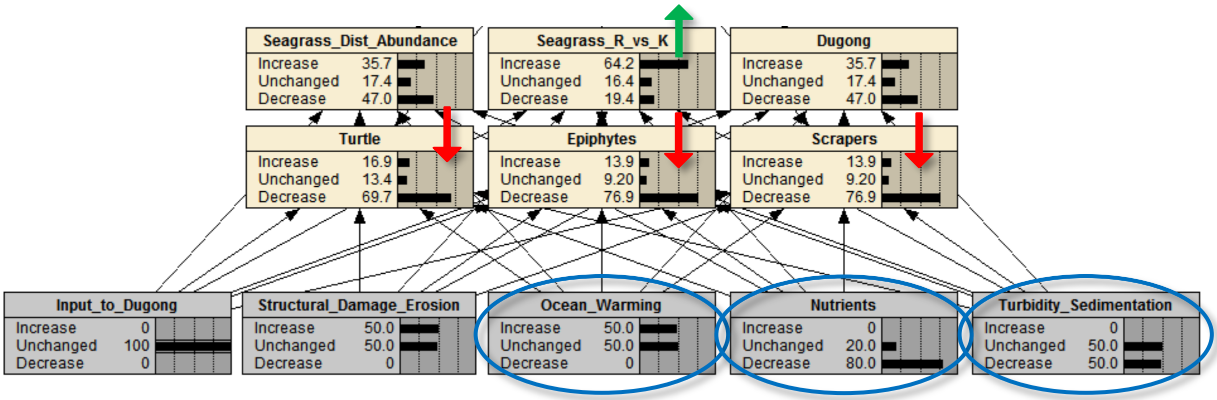
- **Scenario A:** A simultaneous increase in structural damage, erosion and ocean warming results in variable outcomes for dugongs with only a 60 per cent chance of increasing or not changing.
- **Scenario B:** The cumulative effects of an increase in structural damage, erosion and ocean warming, operating simultaneously with improvements to water quality, results in even more variability in the outcomes for dugongs.
- **Scenario C:** An increased likelihood of dugongs surviving other causes of mortality combined with changes in the other variables similar to scenario B results in a reversal in the predicted fate of dugongs, which now have a much greater chance of increasing.

While the outcomes of testing these three scenarios for dugong populations are ambiguous, the outcomes of scenario C suggest improving the condition of seagrass meadows on which dugong depend and continuing to reduce the mortality of dugongs from man-made sources, such as incidental take and vessel strike is important.

A: Increased likelihood of ocean warming and storms



B: Increased likelihood of ocean warming and storms plus improvements in water quality



C: Increased likelihood of ocean warming and storms plus improvements in water quality and increased dugong survival

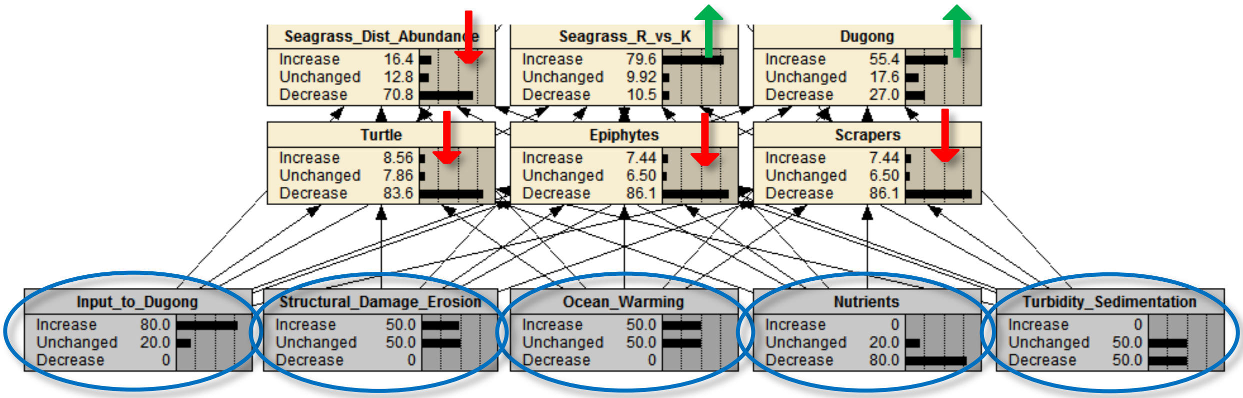


Figure 11.2 Future modelled changes in the condition of seagrass meadows and dugongs
Five major factors affecting seagrass meadows are varied (blue circles) to illustrate likelihood of change in outcomes for the key components of the ecosystem (red and green arrows). The effect of an increased likelihood of dugongs surviving other causes of mortality (abbreviated as Input_to_Dugong) is an additional variable tested in scenario C.

11.6 Projected condition

11.6.1 The future of the Great Barrier Reef

The Great Barrier Reef is no longer at a crossroad as reported in the *Outlook Report 2009*. The health of the Great Barrier Reef is declining, particularly in inshore areas south of Cooktown, and management is not keeping pace with the cumulative impacts that are acting on the system. The causes of decline are known and the potential for restoration is strong provided more than a 'business-as-usual' approach is adopted. Improving the Reef's resilience now is also the best approach to managing the effects of climate change in the future.

The past decade of extreme weather events has taken its toll on the Reef. The frequency of cyclones and floods has reduced the capacity of the Reef ecosystem to recover from these and other disturbances such as outbreaks of crown-of-thorns starfish. Legacy issues, such as broadscale catchment clearing and commercial harvesting of iconic species, are still affecting the Reef. Some of these issues go back decades, even to the 1800s, and their impacts are likely to continue long into the future.

The impacts outlined in this report do not operate in isolation but overlap and interact with each other. Their accumulation through time and over an ever-increasing area is diminishing the ecosystem's ability to bounce back. There is increasing evidence that both the ecosystem's resistance and its capacity to recover is being lost, although the extent of that loss varies considerably between ecosystem components (for example, dugong compared to some fishes) and between localities (for example, the inshore southern two-thirds of the Region compared to places offshore and further north).

The declining condition of the Great Barrier Reef and its loss of resilience cannot be attributed to any single cause — it is almost certainly the result of cumulative impacts.

It is of particular concern that the most serious risks to the Region's values, and those least effectively managed, operate at broad scales. They originate well beyond the Region and affect an area much larger than the Region.

Climate change remains the most serious long-term risk facing the Reef and is likely to have far reaching consequences for the Region's environment. Future climate change predictions indicate sea level rises and temperature increases will continue and the ocean will become gradually more acidic. Extreme weather events are predicted to increase in severity. These changes will have dramatic effects on the health and resilience of the Reef. The impacts of climate change will be amplified by the Reef's declining resilience and the accumulation of other impacts. In turn, the effects of climate change will exacerbate the effects of other impacts, potentially accelerating the decline in the condition of Region's values.

The urgent need to limit global warming to two degrees Celsius above pre-industrial levels has been recognised by almost 200 nations.[8] At present, global emissions are not on track to achieve such a target,[9] and even a two degree Celsius rise would be a very dangerous level of warming for coral reef ecosystems, including the Great Barrier Reef, and the people who derive benefits them.[10] To ensure the Reef remains a coral-dominated system, the latest science indicates global average temperature rise would have to be limited to 1.2 degrees Celsius.[10,11]

Water quality in the Region has declined markedly, especially in inshore areas adjacent to the developed coast. Agricultural practices in the Great Barrier Reef catchment are improving, leading to reduced nutrient and sediment loads entering the Reef through catchment run-off. However, there is likely to be a significant lag time before there are measurable water quality improvements in the Region, with sediments and nutrients projected to continue affecting biodiversity for the next 25 years or so. The continuation of Reef Rescue funding until 2018 to support ongoing reductions in the amount of nutrients and sediments entering the Reef from the catchment will assist continued improvement in the Region's water quality. Potential changes to the present broadscale land clearing legislation could affect the gains made in the catchment and add to the loads entering the Region. With continued pesticide use in the catchment, it is almost certain they will also be a component of catchment run-off over the next quarter of a century. Of major concern is the effect that pesticides will have on freshwater and estuarine systems in the catchment that support the biodiversity of the Reef.

There is increasing evidence that current trends for crown-of-thorns starfish outbreaks are likely to continue over the next 25 years, contributing further to coral mortality. The Reef's ability to recover from outbreak events has been severely compromised by cumulative impacts. Current understanding of the relationship between crown-of-thorns starfish and water quality indicates future improvements in the Region's water quality will likely reduce the frequency of outbreaks in the future.

Modifying terrestrial habitats that support the Great Barrier Reef is likely to continue, based on the expected increase and intensification of agriculture and projected increases in urban and industrial development. It is predicted the flow-on effects, especially in areas close to the coast, will continue to present a very high risk to the Region's values, for example through changes to water quality and connectivity.

The impacts of incidental catch continue to have a major impact on species of conservation concern although the trawl fishery has significantly reduced its incidental catch of marine turtles and other non-retained bycatch species by using improved equipment. Death of discarded and incidentally caught species of conservation concern across all fisheries and the Queensland Shark Control Program is almost certain, with major consequences for their populations. As most species discarded are significant for Traditional Owners either as food, a totem or for customary practice, this impact is likely to have a major effect on their cultural values.

The operation and expansion of ports requires initial capital and ongoing maintenance dredging. Approval of all port development proposals currently being assessed would significantly increase the volume of dredge material disposal in the Great Barrier Reef World Heritage Area. Of key concern is the effects of redistribution and resuspension of sediments which affects habitats such as coral reefs and seagrass meadows and a range of species.

The cumulative effects of impacts highlight the need to manage all of them to reduce stresses on the system. However, many of the activities and drivers having the most effect are outside of the Authority's control — climate change being an obvious example — which limits its capacity to respond directly to the threats.

Managing the multiple pressures that are affecting the Reef requires a multi-pronged and multi-disciplinary approach. It is clear that a business as usual approach to managing the impacts affecting the Great Barrier Reef will not be enough. North of Cooktown there is a need to focus on safeguarding the Reef's health. In contrast, restoring the condition of values of concern and halting and reversing impacts on those values will be the key themes for restoring Reef health in the southern two-thirds of the Region.

A concerted international effort to reduce global climate change, combined with action at the national and local levels to build the Reef's resilience by reducing direct and indirect impacts, is our best insurance for protecting one of nature's most outstanding masterpieces.

11.6.2 Projected condition of the Reef's values

The projected condition of the Region's values is assessed in Table 11.1 to Table 11.3, based on the assessments of condition, impacts, resilience, risk and management effectiveness presented in previous chapters. This analysis is used to inform the recommendations for improvement to management presented in Chapter 12. It also forms the basis for a new outcome-based approach to management by the Authority — one which is focused on working with all parties to collectively achieve the outcomes needed to ensure the future of the Great Barrier Reef.

The projected condition of community benefits will, in part, be based on the condition of the Region's biodiversity, geomorphological features, and Indigenous and historic heritage values; however community benefit values are also dependent on social, cultural and economic drivers that are difficult to predict. Given these dependancies and variability, projected condition has not been assessed for community benefits.

Table 11.4 presents a summary of the projected condition for each of the matters of national environmental significance relevant to the Region.

Table 11.1 Projected condition of biodiversity values

The projected condition grade for each key value and attribute relevant to matters of national environmental significance (MNES) is a grade of best fit across all elements of the value. If a number of the elements are likely to have a 'poor' projected condition then the group is assigned this grade, even if some are likely to have a better projected condition.

Understanding the table

Very good: The values are likely to remain healthy and resilient for the foreseeable future with strong recovery in threatened species and at damaged locations. Additional management intervention is not required to maintain the values.	**Good:** With only minor additional management intervention, the values are likely to remain generally healthy and resilient for the foreseeable future, with only some values showing signs of significant deterioration.	**Poor:** Without significant additional management intervention, some of the values will deteriorate in the next 25 years and only a few values are likely to be healthy and resilient in the longer term.	**Very poor:** Without urgent and effective additional management intervention, the values are likely to deteriorate rapidly with the loss of most values in the longer term.

	Projected Condition			
	Very good	Good	Poor	Very poor
Overview: The health of the Great Barrier Reef ecosystem is declining, particularly in inshore areas south of Cooktown. Without urgent and effective additional management intervention the Region's biodiversity values are likely to continue to deteriorate. A decade of extreme weather events has severely affected many habitats and species and has reduced the capacity of the Reef to recover from these and other ongoing impacts. Legacy issues continue to affect the Reef.				

Key values and attributes	Projected Condition			
	Very good	Good	Poor	Very poor
Coral reefs and corals: Coral reefs in the northern third of the Region are currently in good condition. Those in the southern two-thirds of the Region are in poor or very poor condition. Ongoing impacts from cyclones, bleaching events associated with increased sea temperatures, poor water quality and increased frequency of crown-of-thorns starfish outbreaks mean they are not able to recover between disturbances. Their condition is likely to deteriorate further given the increasing risks from climate change, coastal ecosystem degradation and time frames for achieving water quality improvements, combined with their lack of resilience. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				
Seagrass meadows and seagrasses: Seagrass meadows in the northern third of the Region are currently believed to be in very good condition. Those in the southern two-thirds of the Region are known to be in poor or very poor condition. Increased nutrients, sediments and freshwater combined with recent cyclone damage have seriously affected their condition and reduced their resilience. Timeframes to realise improvements in water quality and increased effects from climate change impacts are likely to cause further declines in condition. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; Commonwealth marine area; national heritage place; listed migratory and threatened species; wetlands of international importance.				

Key values and attributes	Projected Condition: Very good	Projected Condition: Good	Projected Condition: Poor	Projected Condition: Very poor
Islands: While islands are generally in good condition, the introduction of pest species has affected many and those close to population centres are under pressure. All islands are likely to be significantly affected by rising sea levels and cyclone activity. Cays are particularly vulnerable to altered ocean currents with ramifications on species using cays to roost and nest. Modified fire regimes have also altered island ecosystems. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and listed threatened species; wetlands of international importance.				
Beaches and coastlines: Many beaches and coastlines adjacent to the developed coast have been modified, affecting coastal habitats and processes. Economic and population growth is likely to drive further changes in adjacent beaches. Predicted increases in sea level and cyclones will affect the coastline, and recovery from these disturbances is likely to be poor where natural coastal processes have been disrupted. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine areas; listed migratory and threatened species; wetlands of international importance.				
Mangrove forests and mangroves: Mangrove forests and mangroves are currently stable and their abundance is being maintained; however, as the population increases, there is likely to be further pressure on undeveloped coastal mangrove habitats. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				
Lagoon floor: Although it is likely that the lagoon floor is in good condition and stable, there has been no long-term monitoring and there is likely to be some effects of trawling and extreme weather. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place;Commonwealth marine area; listed migratory and listed threatened species.				
Shoals: Shoals remain in good condition throughout the Region due to their relative isolation from human impacts and are unlikely to be exposed to increased risks in the future. Shoals have been affected previously by ship groundings; however, the current management of shipping is considered effective at minimising this risk of groundings. The effect of climate change on shoals is unknown. Shoals are likely to remain in good condition. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species.				
***Halimeda* banks:** This habitat is poorly studied, but is likely to be in very good condition given its isolation from land-based impacts and its level of protection from trawling. However, it is at risk from climate change as increased ocean acidity is likely to reduce the rate of calcification. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species.				
Continental slope: Much of the habitat remains undisturbed and is therefore likely to be in very good condition. A deepwater trawl fishery operating in the south-east of the Region is likely to have some physical impacts on the continental slope but little is known of the interaction. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place;Commonwealth marine area.				
Open waters: The inshore open water habitat in the southern two-thirds of the Region is in poor condition, particularly as a result of catchment run-off. Time lags in sediments and nutrients reaching the Region and sinks of such pollutants within the Region mean it may be decades before the positive effects of improved land management in the catchment are realised. Resuspension of pollutants, for example during cyclones and after dumping of dredge material, degrades the quality of the open water habitat. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				

Key values and attributes	Projected Condition			
	Very good	Good	Poor	Very poor
Terrestrial habitats that support the Great Barrier Reef: Losses and modification of terrestrial habitats in the catchment have affected the Region's environment and coastal integrity. The profound nature of many of these changes mean that natural recovery of ecosystem function is unlikely and significant intervention would be required to restore key components. Rising sea level and cyclones will affect tidal habitats and recovery from these disturbances is likely to be poor where terrestrial habitats have been degraded. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				
Macroalgae: Based on the limited information about macroalgae in the Region it is considered to be in very good condition. As coral reefs become increasingly degraded by cumulative impacts, fleshy macroalgae is likely to become more dominant. There may be enhanced rates of photosynthesis and growth, and increased carbon storage in some fleshy macroalgae species. Projected increases in ocean acidity are likely to affect calcification rates in calcareous algae, limiting reef growth and strength. A shift to an algal-dominated system would have major implications to future coral reef recovery. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species.				
Benthic microalgae: There is limited information about the current and projected future condition of benthic microalgae, however they are assumed to have been undisturbed and in good condition and are likely to remain stable. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area.				
Other invertebrates: Rising sea temperature and ocean acidification will have significant effects on the condition and functioning of other invertebrates (i.e. those other than coral). The majority of invertebrates are likely to be in good condition with strong resilience, including fisheries species. The changing inshore environment in the southern two-thirds of the Region will continue to affect some invertebrates, including through dumping of dredge spoil and physical damage to the seafloor. There is evidence that reduced water quality is a factor in the increased frequency of crown-of-thorns starfish outbreaks, with serious effects on coral reefs. Consequential impacts from increased shipping (for example, cargo spills and groundings) have the potential to affect invertebrates on a local scale. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				
Plankton and microbes: Little is known about the current and projected future status of plankton and microbes in the Region, although there are concerns about the effects of water quality, marine debris (particularly microplastics) and climate change. Improvements to land practices are likely to improve water quality, although there may be a significant lag period before improvements are observed. Altered ocean currents have the potential to change the abundance and distribution of plankton, which would have flow-on effects to higher trophic levels. Increased sea temperatures and ocean acidification are also likely to affect the abundance, distribution and calcification of some plankton. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species.				
Bony fish: While most fish populations are considered to be in very good or good condition, some targeted species are under significantly more pressure in southern areas, with some especially vulnerable. The combination of fishing pressure, coastal habitat degradation, climate change and extreme weather may undermine this for some species. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				

Key values and attributes	Projected Condition: Very good	Good	Poor	Very poor
Sharks and rays: Overall sharks and rays are considered to be in poor condition. Some species are vulnerable to impacts with slow recovery rates or their migratory patterns expose them to impacts outside the Region. Coastal and inshore specialists are the most affected by activities within and adjacent to the Region (for example, dwarf sawfish, freshwater sawfish and green sawfish — all of which are listed threatened species). Further habitat modification, illegal fishing, death as discarded catch and any unsustainable extraction are risks into the future. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory species and threatened species.				
Sea snakes: Some sea snake species are taken as incidental bycatch in the trawl fishery, but the effects on the populations are poorly understood. Continued incidental take of some species in this fishery and predicted declines in habitats such as coral reefs are likely to affect sea snake populations in the future. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area.				
Estuarine crocodile: Estuarine crocodiles occur in most coastal waters in the Region. They are also regularly reported at mid-shelf and some offshore islands. The species is steadily recovering from previous population declines, with no recorded expansions in its range. Its projected condition is likely to be very good. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory species.				
Marine turtles: Each species of marine turtle has a different status. They are vulnerable to a range of impacts, from marine debris and incidental take to declines in seagrass habitats. Some are affected by impacts occurring outside the Region (for example, coastal development adjacent to flatback turtle nesting beaches at Peak Island). Green turtle populations have been stressed by recent declines in seagrass meadows, but the population is expected to absorb the impact. Past population losses, declines in supporting habitats and loss of nesting habitat reduce the resilience of marine turtle populations. Continuing pressures on the populations, including beyond the Region, make it likely that the condition of some species will continue to deteriorate. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and listed threatened species (all species).				
Seabirds: Some serious declines have been recorded in seabird nesting populations. Although all seabirds are vulnerable to impacts of climate change, it is the offshore and pelagic-foraging seabirds that are most at risk. Listed migratory seabirds are particularly vulnerable. Marine debris will continue to be a risk to many species. Changes to coastal habitats affect some coastal nesting species. Given seabird nesting and feeding habits, they are likely to have a poor capacity to recover after impacts. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and listed threatened species.				
Shorebirds: Shorebird populations are generally in poor condition throughout the Region, and are seriously affected by changes in supporting coastal habitats, including changes in tidal flow. Sea level rise will increasingly affect habitats used by shorebirds. Many are listed migratory species and are subject to impacts well beyond the Region. Shorebird resilience is likely to be poor and any recovery is likely to be slow. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; listed migratory species.				

Key values and attributes	Projected Condition: Very good	Good	Poor	Very poor
Whales: Listed species such as the blue, fin and sei whales are rarely sighted within the Region and very little is known about their movements or use patterns there. Humpback whales are the most commonly sighted listed marine mammal in the Region. The east Australian population is recovering from severe depletion by commercial whaling in the 20th century. The greatest risks for listed migratory whale species over the next 25 years are likely to come from outside the Region. Nevertheless, risks within the Region such as direct disturbance from defence activities, collision with large vessels, entanglement and marine debris may affect the species. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed threatened and listed migratory species.		■		
Dolphins: The Indo-Pacific humpback and Australian snubfin dolphin are listed migratory species and are likely to be in decline. The resilience of these species is assessed as poor due to continuing pressures on their inshore habitats combined with low reproductive rates. Continued development within and adjacent to their habitat is likely to increase future risks to these species. Little is known about other dolphin species. Their lesser reliance on inshore habitats is likely to mean they are less affected by future impacts to those habitats. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory species.			■	
Dugongs: Dugong populations in the southern two-thirds of the Region have declined substantially in recent decades, most recently as a result of extreme weather events. The species' ability to recover is very poor due to the massively reduced population, loss of seagrass habitats and low reproduction rates. Recent management has reduced man-made impacts on the southern population but it is unlikely to recover unless all such mortality is eliminated. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory species.				■

Table 11.2 Projected condition of geomorphological features

The projected condition grade for each key value and attribute relevant to matters of national environmental significance (MNES) is a grade of best fit across all elements of the value. If a number of the elements are likely to have a 'poor' projected condition then the group is assigned this grade, even if some are likely to have a better projected condition.

Understanding the table

Very good: The values are likely to remain healthy and resilient for the foreseeable future with strong recovery at damaged locations. Additional management intervention is not required to maintain the values.	**Good:** With only minor additional management intervention, the values are likely to remain generally healthy and resilient for the foreseeable future, with only some values showing signs of significant deterioration.	**Poor:** Without significant additional management intervention, some of the values will deteriorate in the next 25 years and only a few values are likely to be healthy and resilient in the longer term.	**Very poor:** Without urgent and effective additional management intervention, the values are likely to deteriorate rapidly with the loss of most values in the longer term.

	Projected Condition			
	Very good	Good	Poor	Very poor
Overview: The long time periods associated with changes to geomorphological features means most changes in the condition of the related biological systems may take many decades to be reflected in the Region's geomorphological features. However, some features, such as reef islands, can change and disappear in relatively short periods. Overall, it is likely the condition of some features, such as coral reefs, islands, shorelines and river deltas, will deteriorate over the next 25 years. Deeper, more distant features, such as submarine canyons and channels, are likely to be less affected by cumulative human impacts but may still be impacted by climate change-related impacts such as ocean acidification.				

	Projected Condition			
Key values and attributes	Very good	Good	Poor	Very poor
Coral reefs: Increasing risks from climate change and coastal habitat degradation and continuing impacts from catchment run-off combined with their lack of resilience are likely to result in further declines in coral cover. As a result, coral reef features are likely to change in their appearance and become more susceptible to erosion. Their overall structure is unlikely to change significantly. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area.				
Islands and shorelines: Rising sea level and intense cyclones will continue to affect islands and shorelines and recovery from these disturbances is likely to be poor where natural coastal processes have been disrupted. High islands are likely to suffer the least from impacts. Unvegetated sand cays are likely to experience the greatest changes but it will be difficult to determine the degree of change as they are naturally dynamic features. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory species and threatened species; wetlands of international importance.				
Channels and canyons: Although little is known about submarine canyons, karstic channels and blue holes, their depth and distance from shore mean they are likely to be in very good condition and stable into the future. Palaeochannels are found closer to the coast and are therefore more exposed to any impacts from human activity. The future effects of climate change on channels and canyons are unknown. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area.				
River deltas: It is likely that some river deltas have been affected by coastal development, changed sediment loads from the catchment, and artificial barriers to flow. These effects are likely to continue into the future, however river deltas are dynamic features and likely to remain in fairly good condition. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area.				
***Halimeda* banks:** *Halimeda* banks are poorly studied, but it is likely the features are in good condition given the isolation from land-based impacts and level of protection from trawling. Increases in ocean acidification are likely have an effect on the calcification rates of *Halimeda*, with long-term implications for the future of the geomorphological feature. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area.				

Key values and attributes	Projected Condition: Very good	Good	Poor	Very poor
Seagrass meadows: Seagrass meadows in the northern third of the Region are currently believed to be in very good condition. Those in the southern two-thirds of the Region are in poor or very poor condition. Increased nutrients, sediments and freshwater, combined with recent cyclone damage, have seriously affected their condition and reduced their resilience. Continuing poor water quality and increased effects from climate change impacts are likely to cause further declines in condition which will have an impact on seagrass meadows as a geomorphological feature and their associated role in trapping and stabilising sediment. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory species and threatened species; wetlands of international importance.			■	

Table 11.3 Projected condition of Indigenous and historic heritage values

The projected condition grade for each key value and attribute relevant to matters of national environmental significance (MNES) is a grade of best fit across all elements of the value. If a number of the elements are likely to have a 'poor' projected condition then the group is assigned this grade, even if some are likely to have a better projected condition.

Understanding the table

Very good	Good	Poor	Very poor
Very good: The values are likely to remain healthy and resilient for the foreseeable future with strong recovery at damaged locations. Additional management intervention is not required to maintain the values	**Good:** With only minor additional management intervention, the values are likely to remain generally healthy and resilient for the foreseeable future, with only some values showing signs of significant deterioration	**Poor:** Without significant additional management intervention, some of the values will deteriorate in the next 25 years and only a few values are likely to be healthy and resilient in the longer term.	**Very poor:** Without urgent and effective additional management intervention, the values are likely to deteriorate rapidly with the loss of most values in the longer term

Indigenous heritage values

	Projected Condition: Very good	Good	Poor	Very poor
Overview: Indigenous heritage values are assessed as currently being in poor condition overall. It is likely these values will continue to deteriorate, based on inextricable connections between Indigenous culture and the Reef environment and the increasing pressures of coastal development.			■	

Key values and attributes	Projected Condition			
	Very good	Good	Poor	Very poor
Cultural practices, observances, customs and lore: Traditional Owners with connections to the Region maintain their cultural practices and customs in relation to the Region and this is likely to continue into the future. **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				
Indigenous sacred sites, sites of particular significance, places important for cultural tradition: Sacred sites and other sites of cultural significance are under pressure in many coastal areas in and adjacent to the Region. These values are likely to continue to be affected, primarily through coastal ecosystem degradation, direct use of the Region and climate change. Others are intact and likely to continue to be well managed by Traditional Owners into the future. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; wetlands of international importance.				
Indigenous stories, songlines, totems and languages: Direct use of the Region and other activities are likely to continue to affect Indigenous stories, songlines, totems and languages (for example, shipping and modifying supporting terrestrial habitats). **Relevant MNES:** World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; listed migratory and threatened species; wetlands of international importance.				
Indigenous structures, technology, tools and archaeology: It is expected that Traditional Owners will continue to fulfil their traditional responsibilities to use and manage specific Indigenous structures, tools and sites. While Traditional Owners may have adopted new tools and technologies, the cultural practice of activities such as hunting and gathering of resources will continue to be a major component of Indigenous heritage. **Relevant MNES**: World Heritage Area; Great Barrier Reef Marine Park; national heritage place; Commonwealth marine area; wetlands of international importance.				

Historic heritage values

	Projected Condition			
	Very good	Good	Poor	Very poor
Overview: Historic heritage values are assessed as currently being in good condition overall. Some historic values, such as shipwrecks, are well studied and are likely to remain in good condition. However, limited knowledge about other historic heritage values means their projected condition is difficult to predict.				

Key values and attributes	Projected Condition: Very good	Good	Poor	Very poor
Places of historic significance — historic shipwrecks: There is a comprehensive understanding of the historic shipwrecks of the Region (i.e. those greater than 75 years). Known wrecks have been systematically recorded as part of the Australian National Shipwrecks Database, with some 470 historic shipwrecks recorded within the Region. They are likely to remain in good condition. **Relevant MNES:** Great Barrier Reef Marine Park; Commonwealth marine area.		■		
Places of historic significance — World War II features and sites: The features and sites of significance in relation to World War II include shipwrecks, aircraft wrecks, unexploded ordnances and features on islands. Generally, they have been identified but little is known of their current and, hence, projected condition. **Relevant MNES:** Great Barrier Reef Marine Park; Commonwealth marine area.		■		
Places of historic significance — lightstations: While some lightstations are maintained or restored, others are deteriorating. The materials used and construction techniques of some make them vulnerable to deterioration. Increased cyclones and rising sea level are likely to present an increasing risk to these structures. **Relevant MNES**: Great Barrier Reef Marine Park; Commonwealth marine area.			■	
Places of historic significance — other: Other places of historic significance in the Region include Endeavour Reef, sites of turtle and dugong factories, and Mrs Watson's cottage on Lizard Island. Most are poorly recorded and their current and, hence, projected condition is not well understood. **Relevant MNES:** Great Barrier Reef Marine Park; Commonwealth marine area.		■		
Places of scientific significance: Areas of scientific significance are generally well recorded and maintained. However, as with the overall condition of the Great Barrier Reef, the condition of some sites continues to decline. **Relevant MNES:** Great Barrier Reef Marine Park; Commonwealth marine area.		■		
Places of social significance — iconic sites: The condition of some iconic sites has deteriorated. As many are associated with coral reefs, future risks to that habitat are likely to also affect their condition. The defined area of such sites makes it more feasible to undertake management intervention to maintain their condition. **Relevant MNES:** Great Barrier Reef Marine Park; Commonwealth marine area.		■		

Table 11.4 Projected condition of matters of national environmental significance

The projected condition grade for each matter of national environmental significance (MNES) is a grade of best fit across all elements of each matter. If a number of the elements are likely to have a 'poor' projected condition then the group is assigned this grade, even if some are likely to have a better projected condition.

Understanding the table

Very good: The values are likely to remain healthy and resilient for the foreseeable future with strong recovery at damaged locations. Additional management intervention is not required to maintain the values	**Good:** With only minor additional management intervention, the values are likely to remain generally healthy and resilient for the foreseeable future, with only some values showing signs of significant deterioration	**Poor:** Without significant additional management intervention, some of the values will deteriorate in the next 25 years and only a few values are likely to be healthy and resilient in the longer term	**Very poor:** Without urgent and effective additional management intervention, the values are likely to deteriorate rapidly with the loss of most values in the longer term

Key values and attributes	Projected Condition: Very good	Projected Condition: Good	Projected Condition: Poor	Projected Condition: Very poor
World heritage properties, including outstanding universal value: Many elements that make up the outstanding universal value of the Great Barrier Reef World Heritage Area are in good condition but declining. While the condition of some attributes such as humpback whales has improved, others have experienced serious declines since 1981. The natural beauty of most of the Region remains intact, however its underwater aesthetic value has declined in southern inshore areas. Recognising the increasing threats facing the Great Barrier Reef environment, the future condition of the world heritage property is projected to be poor.			■	
The Great Barrier Reef Marine Park: The Marine Park is exposed to impacts that occur both within and adjacent to its boundaries (for example, climate change, catchment run-off, coastal ecosystem degradation). While direct use of the Marine Park, in most cases, is considered ecologically sustainable, the cumulative effect of all impacts from within the Marine Park and beyond has resulted in this matter being in poor condition in its southern two-thirds. Its condition is likely to deteriorate further in the future. The close connections between the natural environment and Indigenous heritage values means that these are also likely to deteriorate into the future. As a multiple-use protected area, there are diverse and numerous social and economic (community) benefits derived from the Marine Park environment. Their future condition will depend in large part on the condition of the areas natural environment.			■	
National heritage places: National heritage listing of the Great Barrier Reef is based on its recognition as a world heritage property. The values that underpin this matter of national environmental significance are the same as those identified for the world heritage property and the overall projected condition is the same.			■	
Commonwealth marine areas: The Commonwealth marine area extends beyond the Region, into the Torres Strait and Coral Sea, and to the south of the Region. The values, risks and projected condition relevant to this matter of national environmental significance in the Region are the same as those for the Great Barrier Reef Marine Park.			■	
Listed migratory species: The very nature of migratory species is that they move, often large distances. This means that most of the Region's listed migratory species spend significant amounts of time outside the Region and hence are exposed to impacts that may not occur within the Region. Within the Region, migratory species are likely to be at risk from climate change, degradation of coastal ecosystems, catchment run-off and commercial fishing. Catastrophic nesting failure has already been recorded for some seabirds. Australia-wide declines in shorebirds of between 70 and 80 per of cent have been recorded in the past 24 years and the poor resilience of most species, combined with continuing impacts, means the projected condition of these species in the Region is poor.			■	
Listed threatened species: All of the listed threatened species found within the Region move outside the Region, often over large distances, including internationally, and are therefore exposed to impacts beyond the Region. The greatest risks for the listed threatened species over the next 25 years are likely to come from: commercial fishing, climate change, coastal development, habitat loss and catchment run-off. Their current poor status, combined with the generally low resilience mean that the projected condition for the Region's threatened species is poor.			■	
Wetlands of international importance: The Shoalwater and Corio Bays wetland area is in very good condition which can be attributed mainly to its restricted access as a defence training area. It is likely that its current condition will mean that the area is better able to recover from future widescale impacts that may affect the area, such as those from climate change and catchment run-off.		■		

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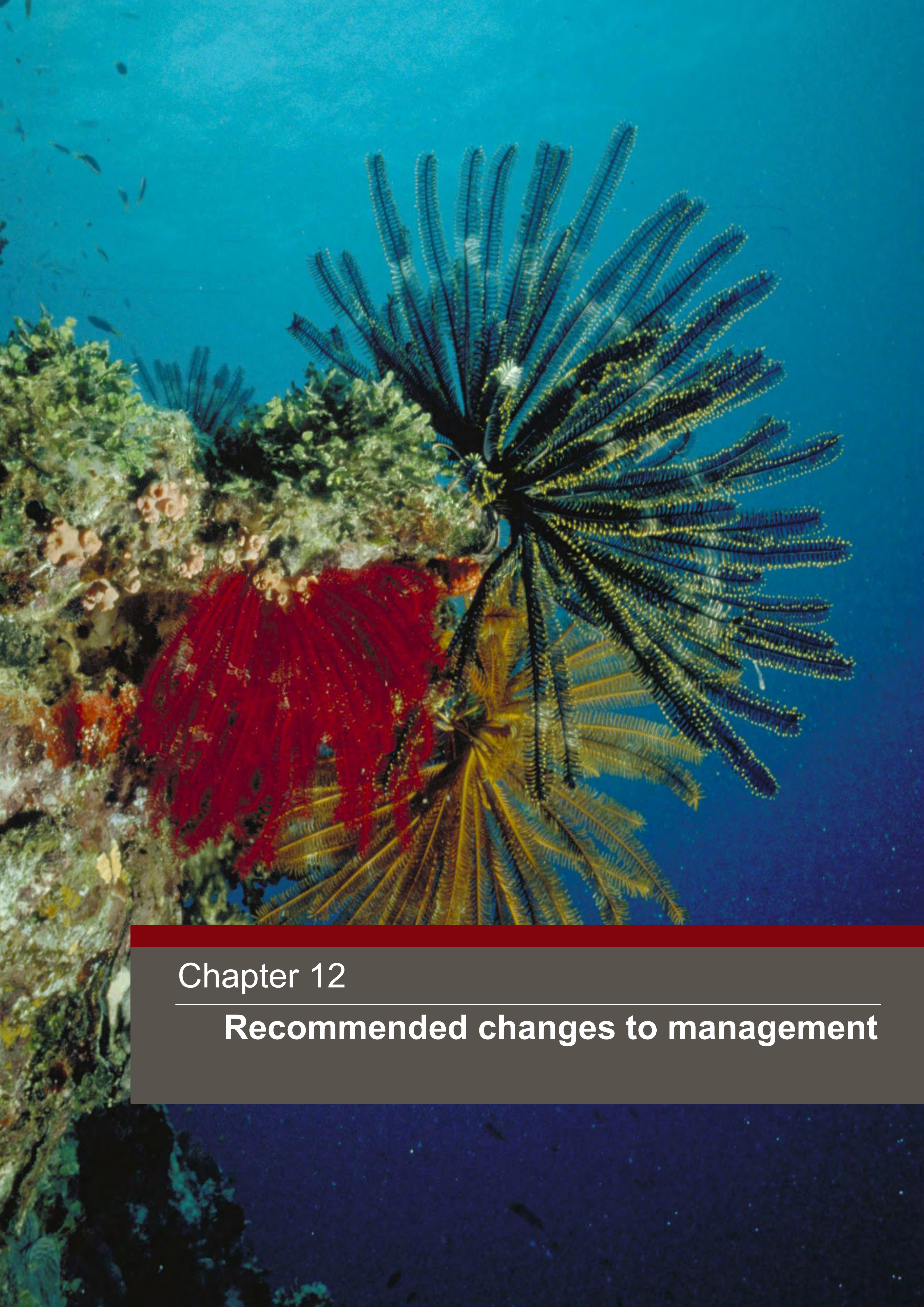
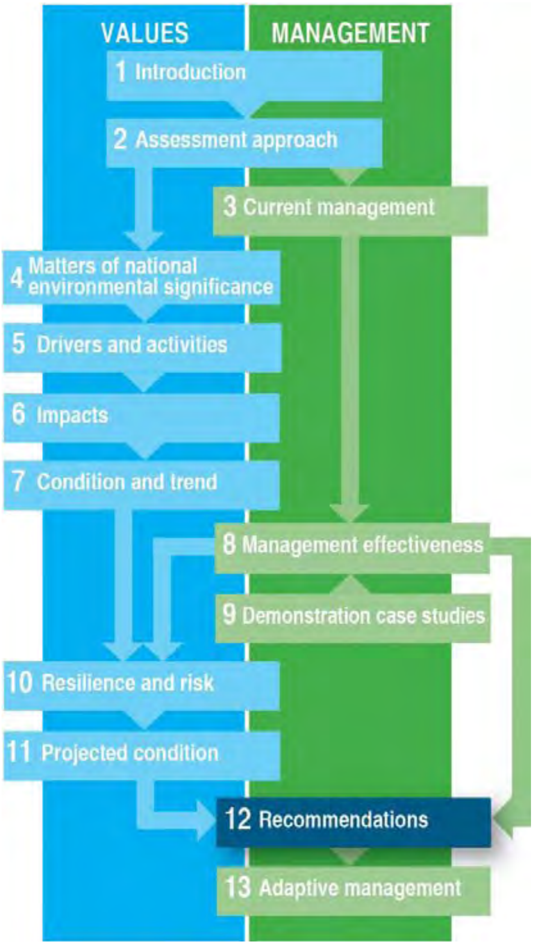


Chapter 12

Recommended changes to management



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Cover page image: Featherstars, Manta Ray Drop-off at Bait Reef

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

6.1 Recommendations for changes to the Program

6.1.1 Recommend changes to the current Program to improve its effectiveness to deliver its objectives, including outcomes that protect the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area. Recommendations for improvements should specifically address the matters listed in section 4.1.1.

6.1.2 Consistent with section 6.1.1 above, recommend improvements to related local, state and national government programs.

Note: In this report 'current Program' is referred to as 'current management arrangements'

12 Recommended changes to management

This chapter provides the recommended improvements to the management arrangements of the Great Barrier Reef Marine Park Authority (the Authority), in partnership with other government agencies where relevant, to protect and manage matters of national environmental significance relevant to the Great Barrier Reef Region (the Region).

The recommendations are designed to strengthen protection of matters of national environmental significance and guide improvements to the management of impacts, including actions required to avoid, mitigate, offset and adaptively manage.

The recommendations guide development of the accompanying Program Report for the Region which sets out the Authority's future management. Public consultation on the strategic assessment provides the community with an opportunity to comment on the proposed recommendations. Their subsequent implementation would be subject to normal government legislative and policy development processes.

12.1 How recommended improvements were identified

The recommended improvements are based on the findings of the strategic assessment. They include specific consideration of the outcomes from:

- the assessment of impacts (past and present, plus future risk) to matters of national environmental significance (Chapters 6 and 10)
- the assessment of the condition and trend of values and attributes relevant to matters of national environmental significance (current and projected) (Chapters 7 and 11)
- the independent review of management effectiveness (Chapter 8)
- outcomes from demonstration cases (Chapter 9)
- the identification of key information gaps and processes to address them (Sections 6.10 and 7.7)

Their development has also been informed by the results of recent Sustainable Regional Development Program projects (see Chapter 2) and relevant recent recommendations of the World Heritage Committee (see Chapter 1).

12.2 The need to strengthen the Authority's management

Through the *Great Barrier Reef Marine Park Act 1975*, the Authority has a clear and long-standing responsibility to protect and manage the Great Barrier Reef. Over the past three decades the Authority has established a strong and comprehensive set of management arrangements to protect the Reef, adapting them in response to emerging issues and improved understanding.

The independent assessment of management effectiveness presented in Chapter 8 found the Authority's management of activities within the Region for which it has direct responsibility is effective and its actions have delivered benefits for the Reef's resilience. The assessment highlighted that more is required to halt and reverse observed declines in Reef health, especially in addressing impacts arising outside the Region.

Effective future protection of matters of national environmental significance in the Region relies on the integration and strengthening of management measures, with a focus on protecting the Great Barrier Reef environment as a whole.

Managing the multiple impacts affecting the Reef requires a comprehensive and coordinated approach across all levels of government. A concerted international effort to reduce global climate change combined with action at national, state and local levels to build the Reef's resilience by reducing impacts is considered the best insurance for protecting the outstanding universal value of the Great Barrier Reef. By working together with an ecosystem approach, the Region's values, including its outstanding universal value, can be protected, conserved, presented and transmitted to future generations.

The strategic assessment highlights the success of cooperative actions to 'halt and reverse the decline' of water quality entering the Region, coordinated through the *Reef Water Quality Protection Plan* (Reef Plan). Extension and adaption of this model across a range of high risk impacts and key values is likely to be an effective approach to improving environmental outcomes for the Region.

There is also a need to actively restore habitats and ecosystem processes which support the Reef's biodiversity, recognising regional and local differences in the condition of values and in the type and severity of the impacts affecting them. In the northern third of the Region, the values relevant to matters of national environmental significance are generally in good and very good condition and the impacts affecting them are less severe. For that area, the aim should be to maintain and enhance the Reef's health. In contrast, in the southern two-thirds, where values are mostly in poorer condition and impacts are more severe, restoring the condition of values and reducing impacts should be the primary aim. Critically, there is a need to improve management of cumulative impacts and develop mechanisms which will deliver net conservation benefits across the Region.

Recognising the varied sources of impacts on the Region's values and the range of parties contributing to their reduction, it is considered that the definition of a comprehensive set of desired outcomes for the Region's values would provide a strong basis for identifying and prioritising actions to improve environmental condition. It would also guide decision making on development proposals likely to affect the Reef. The outcomes could be supported by measurable targets to gauge success. A clear target-driven management framework was one of the key recommendations of the World Heritage Committee in 2012 (see Chapter 1).

There is a need to improve understanding and protection of heritage values within the Region, together with the community benefits derived from the Region's environment. Consideration of these values needs to be integrated into planning and assessment decision making.

12.3 Recommended improvements

In line with the terms of reference, recommended improvements to the Authority's management arrangements are presented, as well as recommended improvements to related local, state and national government programs.

12.3.1 Recommended improvements to the Authority's management arrangements

Based on the findings of the strategic assessment presented in the preceding chapters, the recommended improvements to the Authority's management arrangements are focused on:

- improving identification and consideration of the values relevant to matters of national environmental significance, including Indigenous and historic heritage values and the community benefits derived from the Region's environment
- improving the assessment of impacts on the Region's values, particularly understanding and managing cumulative impacts
- better avoiding impacts on the Region's values, including through improving compliance with the Authority's management arrangements and strengthening best practice and stewardship activities
- improving actions to mitigate impacts on the Region's values

- establishing arrangements for offsetting those impacts which cannot be avoided or mitigated so that there is a net benefit to the Region's values
- providing a management framework that sets out outcomes and targets for the Region's values and progressively incorporates ecosystems thresholds as understanding improves
- supporting protection and restoration activities that enhance the Region's values and build resilience, including an emphasis on cooperative regional actions linked to adjacent catchments
- coordinating and integrating relevant monitoring activities to better inform adaptive management
- improving governance arrangements for key development activities
- adapting to climate change.

The recommended improvements to the Authority's management arrangements are outlined in Table 12.1.

Table 12.1 Recommended improvements to the Authority's management arrangements

The identified strengths and weaknesses and the resulting recommended improvements are based on the findings of the strategic assessment.

Strengths	Weaknesses	Recommended improvements
Identifying matters of national environmental significance		
The Authority's focus on the Marine Park matter of national environmental signifcance means that values relevant to other matter of national environmental signifcance, in particular biodiversity values, are implicitly considered in decision making	Explicit consideration of all matters of national environmental signifcance in decision making and the need to strengthen consideration of heritage values and community benefits	**REC1:** Explicitly incorporate consideration of all values relevant to matters of national environmental significance, including elements of the property's outstanding universal value, into the Authority's programs, plans and policies
Bioregional mapping provides a strong foundation for management. Development activities and commerical use are well mapped.	The spatial distributions of most species and habitats are poorly collated, syntheseised and mapped. Limited understanding of connectivity and ecological processes operating at local, regional and Reef-wide scales.	**REC2:** Improve spatial mapping capabilities to support planning and assessment decision making, including the range of values mapped and public availability
Monitoring and research programs have provided a good understanding of the status and trend of many biodiversity values	Further work is required to identify and understand the aesthetic and superlative natural phenonema which make up the world heritage property	**REC3:** Work closely with Australian and Queensland government agencies to help identify values of the Great Barrier Reef World Heritage Area that are not easily represented and measured such as aesthetic values
Ecological knowledge held by Traditional Owners. Strong collaborative relationships with Traditional Owners, including through the development of Traditional Use of Marine Resources Agreements	Existing information is restricted to a limited number of locations within the Region	**REC4:** Collaborate with Traditional Owners to undertake an assessment of the Indigenous heritage values of the Region

Strengths	Weaknesses	Recommended improvements
Ecological knowledge held by Traditional Owners. Strong collaborative relationships with Traditional Owners, including through the development of Traditional Use of Marine Resources Agreements	There is a need for policies and systems to guide the collection, handling and sharing of culturally sensitive information	**REC5:** Develop and implement knowledge management systems for Indigenous and historic heritage information, including a protocol for managing culturally sensitive information and improved information sharing arrangements
Marine Park has been managed as a multiple use area since its inception	There is little systematic monitoring of community benefits derived from the Region	**REC6:** Improve understanding of the role the Great Barrier Reef plays in the life of the community
Assessing impacts on matters of national environmental significance		
There is a rigorous and well established process in place supported by legislation for assessing projects that may impact matters of national environmental signifcance	There are no established standards or guidelines to assist proponents and decision makers consider and address cumulative impacts	**REC7:** Work closely with Australian and Queensland government agencies to improve understanding and management of cumulative impacts from activities within and adjacent to the Region and provide clearer guidance on how proponents and decision makers should address cumulative impacts in assessments
Intergovernmental agreement provides a strong foundation for complementary joint permit assessment and approval processes	There is currently significant duplication in assessment processes across jurisdictions. The complexity of processes presents significant challenges to public engagement in decision-making	**REC8:** Streamline assessment processes across jurisdictions and seek to have a more coordinated approach to community consultation
Avoiding impacts matters of national environmental significance		
Complementary zoning arrangements provide a strong basis for coordinated management and protection of matters of national environmental signifcance Tourism impacts are well understood and managed	Tourism management is administratively complex. Plans of management require updating and complementary arrangements across jurisdications (particularly intertidal areas) need improved alignment.	**REC9:** Improve alignment between the Authority's and Queensland Government's protected area and tourism management arrangements and look for opportunities to streamline
Existing plans of management for high use areas	Absence of site planning in high growth areas to manage potentially conflicting use and increasing pressures on values	**REC10:** Develop and implement plans of management in areas of the Great Barrier Reef Marine Park that have high growth for recreation and other uses
Technical expertise in coastal ecosystems and water quality Policy on dredge spoil disposal and hydrodynamic modelling	No regulatory provisions that set out where ports can be developed within the Region	**REC11:** Support development of a Queensland ports strategy that concentrates port development around long-established major ports in Queensland, and encourage port master planning
The zoning plan provides the basis for managing activities within the Region	There is a lack of strategic planning for marinas along the Great Barrier Reef coast	**REC12:** Promote a strategic approach to the development and operation of marinas and other access infrastructure along the Great Barrier Reef coast

Strengths	Weaknesses	Recommended improvements
The Great Barrier Reef's natural, Indigenous and historic heritage values are recognised as an important component of the Region as reflected in main object of the Great Barrier Reef Marine Park Act	Lack of recognition and statutory protection of some heritage values Current heritage strategy is outdated Need for improved alignment and complementarity in statutory protection arrangements across jurisdictions	**REC13:** Review and update the *Great Barrier Reef Marine Park Heritage Strategy* to guide management actions to strengthen recognition and protection of heritage values
Existing Reef Guardian and High Standard Tourism programs provide a strong platform for uptake of stewardship activities	Consistency in defining best management practice standards and implementation of continuous improvement measures Inconsistent uptake of practices across and within sectors	**REC14:** Promote, recognise and encourage stewardship and best practice efforts by community, industry and government
Existing network of moorings and reef protection markers protect values in some high use locations	Inadequate resources available to meet increasing demand for reef protection infrastructure	**REC15:** Support increased investment in site infrastructure to protect matters of national environmental significance in the Great Barrier Reef Region
Effective cross-jurisdictional arrangements are in place through the joint Australian and Queensland government compliance program	Lack of real time vessel tracking. Current penalties are not providing sufficient deterrent for repeat offenders.	**REC16:** Improve compliance through more effective surveillance and compliance activities, access to latest technology, increased coordination across jurisdictions and strengthened powers to prevent repeat offending
Effective systems and frameworks for managing protected area estate in the World Heritage Area	Lack of sufficient controls for island biosecurity and on-ground management actions to protect and maintain island natural integrity	**REC17:** Support a collaborative, Reef-wide management strategy for islands and contribute to its development and implementation
Mitigating impacts on matters of national environmental significance		
Water quality guidelines provide a sound basis for the assessment of impacts on plants and animals in the Marine Park	Water quality guidelines do not address regional specific requirements or account for cumulative impacts. Primary research on the effects of cumulative impacts is not currently available.	**REC18:** Update and strengthen the Great Barrier Reef Marine Park water quality guidelines to address a broader range of habitats and species and account for cumulative impacts
Hydrodynamic guidelines provide a sound basis for the assessment of potential impacts associated with dredging	Current guidelines do not account for longshore drift, resuspension and inter-annual variability in currents. Absence of an agreed model to predict hydrodynamic conditions.	**REC19:** Improve the effectiveness of the Authority's hydrodynamic guidelines as a decision making tool by requiring consideration of a greater range of environmental factors, and regularly reviewing them to reflect improvements in understanding.
Some ecosystem thresholds for coral reef ecosystems have been defined	Limited understanding of critical ecosystem thresholds for a range of habitats and species. Primary research on ecosystem thresholds is not currently available.	**REC20:** Support research on critical ecosystem thresholds, with a focus on inshore biodiversity and associated ecosystems
Existing environmental impact assessment framework for the Great Barrier Reef	Potential impacts of underwater noise on Great Barrier Reef species are not well understood No standards or guidelines have been developed for the management of underwater noise impacts in the Region	**REC21:** Improve understanding and the Authority's management of the impacts of noise on species, particularly at-risk and inshore species

Strengths	Weaknesses	Recommended improvements
Reef Plan is successfully reducing nutrient loads from the catchment to the Reef Crown-of-thorns starfish control program has been successfully trialled and implemented locally	The time lags expected before improvements in catchment run-off are reflected in Reef water quality.	**REC22:** Reduce crown-of-thorns starfish outbreaks by continuing to improve water quality and through a long-term control program
Offsetting impacts on matters of national environmental significance		
Sound regulatory basis for requiring offsets	Lack of strategic approach and coordination between jurisdictions Uncertainty for proponents and the public regarding offsetting requirements	**REC23:** Develop a policy and supporting mechanisms to facilitate strategic and collaborative implementation of offsets across jurisdictions
Improved knowledge of actions likely to deliver environmental benefits	As above	**REC24:** Inform implementation of Australian and Queensland government offsets policies and restoration programs by identifying actions that will maximise the delivery of environmental benefits to the Region
Enhancing matters of national environmental significance		
Systematic framework to identify values and impacts	Primary research to support the setting of targets	**REC25:** Establish a management framework with clear outcomes and targets for the protection of values and the management of impacts, including cumulative impacts
Two strategic assessments have been undertaken There is international attention on the Reef's future	No explicit overall program to coordinate efforts to enhance matters of national environmental signifcance	**REC26:** Develop and implement a long-term sustainability plan for the Great Barrier Reef in cooperation with Australian and Queensland government agencies to better coordinate programs designed to manage and improve the condition of the Reef
Existing partnership arrangements provide a strong foundation for effective engagement with other government regulators	Many of the high risk impacts affecting the Reef are outside of the Authority's jurisdictional control	**REC27:** Strengthen engagement with all relevant partners to facilitate actions that maintain and enhance the condition of values and reduce impacts, particularly in relation to climate change, catchment run-off, degradation of coastal ecosystems and direct use (see Section 12.3.2 below)
Strong collaborative relationships between the Authority and Traditional Owners, including through the development of Traditional Use of Marine Resources Agreements	Lack of an overarching framework to promote and coordinate the contributions of Traditional Owners to management and to guide management of Indigenous heritage values in the Region	**REC28:** Develop a comprehensive management framework and an Indigenous heritage strategy for Traditional Owner use and management of the Great Barrier Reef
Network of Local Marine Advisory Committess and strong working relationships with local government, industry and experts	Lack of regional data on condition and trend of many values	**REC29:** Adopt regionally-based cooperative approaches to protect inshore biodiversity hotspots — supporting local actions and encouraging cooperation

Strengths	Weaknesses	Recommended improvements
Significant expertise is available to undertake research	Despite significant progress in the alignment of management and research needs, gaps remain in a number of key areas	**REC30:** Improve alignment and coordination of strategic research priorities and strengthen partnerships between the Authority and research institutions to facilitate the delivery of critical research needs
Monitoring and evaluation		
Significant expertise in monitoring available from a range of sources	Lack of overarching strategy and coordination of monitoring across the Great Barrier Reef Lack of standardised procedures and protocols for data collection, handling and interpreation	**REC31:** Implement an integrated monitoring, reporting and adaptive management program for the Great Barrier Reef World Heritage Area, including more explicit reporting on the condition and trend of matters of national environmental significance
Baseline level of understanding of human and natural impacts to marine megafauna	Limited data available on species of conservation concern	**REC32:** Maintain and improve monitoring, investigation and data management relating to critical species and habitats
A long-term socio-economic program is currently under development	A lack of systematic monitoring of social and economic values	**REC33:** Support implementation of a long-term social and economic monitoring program to improve understanding of changing use, investment and values
Governance		
Intergovernmental agreement provides a strong foundation for an integrated and colloborative approach to management	Cross jurisdictional governance arrangements for development activities which span the catchment and the Region (for example, ports and associated activities)	**REC34:** Contribute to the development of improved governance arrangements for the management and coordination of development activities that affect the Great Barrier Reef
Adapting to climate change		
Wide body of expert information available on potential climate change impacts	Lack of clear explanations of the implications of climate change for the Reef's future	**REC35:** Communicate the implications of climate change impacts for the Great Barrier Reef and the critical need to halt increasing concentrations of global greenhouse gases and restore them to levels that will support growth, recruitment and recovery processes of the Great Barrier Reef ecosystem
Data is available on the likely impacts of climate change, including increased magnitude of extreme weather events Initiatives such as tourism contingency planning	Policies require updating to reflect improved knowledge	**REC36:** Ensure the impacts of climate change and extreme weather are appropriately considered in the Authority's management decisions
Industry intiatives to reduce emissions, for example in the tourism industry	Limited uptake of initiatives across and withn sectors	**REC37:** Encourage reduction of greenhouse gas emissions in the Great Barrier Reef Region in partnership with industry and communities
Industry initiatives to scope and adapt to climate change, for example the tourism industry	Limited understanding among users of the likely effects of climate change on their businesses and activities	**REC38:** Support initiatives to build the capacity of management agencies and Reef users to adapt and respond to climate change and extreme weather events

12.3.2 Recommended improvements to related local, state and national government programs

One of the key findings of the strategic assessment is that most of the serious risks to the Region's values operate at broad scales, originating well beyond the Region or outside the Authority's management responsibilities. The interconnected and overlapping jurisdictional framework for managing these and other issues relevant to the Region (see Chapter 3) means that much of what is needed to protect and restore the Region's values relies on the actions of other government agencies and bodies. As a result, one of the key roles of the Authority is collaborating with and influencing its management partners to improve environmental outcomes in the Region.

The above recommendation for the Authority to *strengthen its engagement with all relevant partners to facilitate actions that maintain and enhance the condition of values and reduce impacts, particularly in relation to climate change, catchment run-off, degradation of coastal ecosystems and direct use* requires the Authority to enhance its partnerships and cooperative arrangements with all levels of government, as well as Traditional Owners, industry sectors and other stakeholders. It requires the Authority to more clearly communicate the outcomes required for a healthy Great Barrier Reef and to provide strong support and advice to those taking decisions and undertaking actions that may affect the Region's future.

Consistent with the terms of reference, the following is a description of potential avenues for improvements in related local, state and national government programs. It is noted that any such recommended improvements are the view of the Authority and not necessarily those of the other relevant agencies.

Climate change
Severe degradation of key Great Barrier Reef values, especially coral reefs, is forecast to occur before the middle of the century unless global concentrations of atmospheric carbon dioxide are reduced towards 350 parts per million. This would prevent temperature, ocean acidity, sea level and extreme weather events exceeding the resilience capacity of the ecosystem. Ultimately, the outlook for the Great Barrier Reef is likely to be determined by the concentration of greenhouse gases in the Earth's atmosphere.

The enormity of issues relating to climate change means actions are required at all levels across the globe. It is important to continue to work with other Australian Government agencies and relevant partners to highlight the critical need to halt increasing concentrations of greenhouse gases and the implications for the Reef of impacts related to climate change. It is also important to lead by example and encourage industries and the community to be active partners in reducing greenhouse gas emissions in the Region and adapting and responding to the effects of climate change.

Catchment run-off
Catchment run-off, particularly from rural diffuse sources, is one of the key sources of impacts on the Region's values, and much is being done under the joint *Reef Water Quality Protection Plan 2013* (Reef Plan) to reduce the loads of pollutants entering the Region. These management interventions are showing positive trends and actions to reduce water quality impacts and improve ecosystem health need to continue and be accelerated where possible. It is recommended that the Authority continue to work with the Queensland Government and other relevant partners in relation to catchment run-off, including seeking to enhance outcomes through:

- actively promoting the uptake of improved land management practices to more rapidly achieve Reef Plan targets
- responding to sub-regional differences in water quality impacts in the Region by supporting development and implementation of further regionally-based water quality improvement plans for the catchment
- encouraging strong linkages between water quality improvement initiatives and actions to protect and restore inshore biodiversity in the Region
- supporting consideration of expanding the scope of Reef Plan to incorporate other sources of pollutants (for example urban and industrial activities) to provide a sound coordination mechanism
- encouraging the strengthened application of water quality guidelines across the Great Barrier Reef World Heritage Area so that there is a consistent approach in the application of standards and best practice guidelines.

Degradation of coastal ecosystems

Coastal ecosystems play a vital role in supporting the values of the Region. In the southern two-thirds of the catchment, historic land use changes have resulted in the loss and degradation of many coastal ecosystems. This has seriously changed hydrological and ecological processes — in particular affecting the Reef's water quality and species that rely on coastal areas. There is evidence that thresholds for ecosystem health have been exceeded in much of the southern two-thirds of the Region, particularly inshore, and there is a need to further reduce impacts from all sources. The northern Great Barrier Reef provides a refuge for many species and a buffer to pressures experienced further south.

It is recommended the Authority continue to enhance collaborative actions with Queensland and local governments and other relevant partners in relation to protecting and restoring supporting coastal ecosystems, including through:

- communicating the findings of the Authority's coastal ecosystem basin assessments and management case studies and encouraging their use in determining priorities for protecting and restoring coastal ecosystems and in taking actions likely to improve Great Barrier Reef health and resilience. This would help ensure available resources are employed most effectively; for example, by informing the Australian Government when developing offsets, and by guiding natural resource management bodies when planning basin restoration actions
- promoting and supporting protection of remaining intact systems within the Great Barrier Reef catchment, as identified through the outcomes of the basin assessments and the management case studies
- communicating the importance of functioning coastal ecosystems to Reef health through a position statement on the maintenance and restoration of critical coastal ecosystems, including identifying actions likely to have significant effects, and promoting a whole-of-ecosystem approach to management of the Reef and its catchment
- better informing relevant Queensland and local government coastal planning and decision-making frameworks about the findings of the Authority's technical reports and coastal ecosystem basin assessments with the aim of achieving clearer linkages between catchment development and ecosystem health outcomes.

Direct use — port activities

Port activities can directly and indirectly affect the Region's values on a local or wider scale. While most port infrastructure along the Great Barrier Reef coast is outside the Region, the environmental footprint associated with access channels and ship anchorages extends into the Region.

In order to improve environmental outcomes for port activities, there is a need to adopt a strategic approach to port development and to enhance collaboration with the Queensland Government, other Australian Government agencies, port corporations and relevant partners, including through:

- improving certainty regarding the location of ports and reducing further fragmentation of coastal ecosystems through a Queensland ports strategy that concentrates port development to around long-established major ports in Queensland
- supporting a strategic approach to the planning, assessment and management of port development, including long-term integrated planning for the network of trading ports on the Great Barrier Reef coast, with a view to achieving environmental, social and economic sustainability at a Reef-wide scale
- contributing to the development of improved governance arrangements across Great Barrier Reef ports aimed at strengthening coordination between responsible agencies across all jurisdictions, focusing on efficient and sustainable development of ports and associated activities
- improving understanding and management of environmental impacts from dredging and dredge material disposal in the Great Barrier Reef World Heritage Area, recognising the current uncertainty surrounding the duration, intensity and extent of predicted dredge material plumes, and their impacts on the Region's values. In particular by:
    - exploring with proponents and government agencies all alternatives which may avoid and reduce the need for dredging and dredge material disposal and provide better environmental outcomes
    - ensuring dredging and dredge material disposal decisions take account of the Great Barrier Reef hydrodynamic and water quality guidelines, and do not exceed ecosystem thresholds

- working with port corporations, other agencies and proponents to identify and address critical information needs, and to promote research and development into innovative best practice arrangements to mitigate cumulative impacts of port activities within the Region.

Direct use — shipping

Vessel visitation to ports within the Great Barrier Reef World Heritage Area is predicted to substantially increase in coming decades. The draft *North-East Shipping Management Plan* sets out a strong basis for collaboratively managing shipping and reducing potential risks in the Region. The Authority supports the actions outlined in the plan and will work with the Australian Maritime Safety Authority, Maritime Safety Queensland and other relevant partners to implement the final plan.

Direct use — fishing

All commercial fisheries have made significant progress towards achieving better sustainability outcomes in the Region over recent years. Some issues remain and the need to continue to work with the Queensland Government and other relevant partners to improve environmental outcomes is recognised, including:

- improving compliance arrangements to reduce illegal fishing — an impact that continues to undermine the benefits derived from the *Great Barrier Reef Marine Park Zoning Plan 2003* and the sustainability of the Region's fisheries. In particular, the Authority recognises the importance of implementing real-time vessel tracking of the commercial fishing fleet and improving the effectiveness of penalties for illegal activity as a deterrent
- promoting further research and development into better gear technologies designed to reduce interactions with protected species and other bycatch, and examining options to legislate use of new bycatch reduction devices and strategies that display significant reductions in bycatch
- supporting actions to reduce effort in Great Barrier Reef fisheries to ensure long-term ecological, social and economic sustainability. There is evidence of excess fishing capacity in some Reef-related fisheries, and current management controls for some fisheries in the Region cannot prevent overfishing at a regional scale or a stock level, or control ecological risks.
- improving protection of key herbivorous fish. This is based on the key ecological role they have in preventing a shift from coral reefs to algal-dominated systems after disturbances, as demonstrated in other coral reef systems where reduced populations of these fish have contributed to reef decline. While herbivorous fish are not currently generally targeted by fishers in the Region, it is considered that their protection would provide valuable insurance for reef recovery following future extreme weather events and incidents (for example, coral bleaching, cyclones, crown-of-thorns starfish outbreaks)
- improving collection, access and sharing of fisheries data across all relevant agencies
- fostering further uptake of best practice and stewardship within the Reef's fisheries, including in the recreational fishing sector

Direct use — tourism and recreation

Continuing the close and effective partnerships that have been developed with relevant government agencies, the tourism industry and the community is recognised as an important ingredient in maintaining effective management, including actions aimed at:

- streamlining tourism management arrangements across all jurisdictions, recognising the opportunities to improve alignment between existing management tools (for example, plans of management, policies and permits), and the value to both managing agencies and the industry of a contemporary and business-focused management approach
- promoting the presentation of the Reef's values in partnership with the tourism industry, including through training and development of educational material. The tourism industry has a central role in meeting Australia's international obligation to present the values of the world heritage property. At the same time, increased understanding and appreciation of the Reef's outstanding universal value will assist in building support for the Region's protection
- fostering further uptake of best practice and stewardship within the Reef's tourism industry, building on the continuing success of the High Standard Tourism program
- improved planning and site infrastructure in existing and emerging high use areas to avoid potential conflicts of use across a range of uses and manage predicted increase in recreational use

- promoting a strategic approach to the development and operation of marinas and other access infrastructure along the Great Barrier Reef coast
- improving understanding of tourism and recreational use and the benefits derived, including through supporting implementation of a long-term socio-economic monitoring program.

12.4 Recommendations of the coastal zone assessment

As part of the complementary strategic assessment of the adjacent coastal zone, the Queensland Government has made a number of recommendations to improve management. Some of these overlap and are consistent with the Authority's recommendations, for example, development of an outcomes-based framework, a long-term sustainability plan, an integrated monitoring program and improved understanding and management of cumulative impacts. The alignment between the two sets of recommendations is presented in Table 12.2.

As illustrated in the recommended improvements set out in Section 12.3 above, the Authority is committed to continuing its close partnership with Queensland Government agencies in achieving improved outcomes for the Great Barrier Reef.

Table 12.2 Alignment between the recommended improvements of the Authority and the Queensland Government

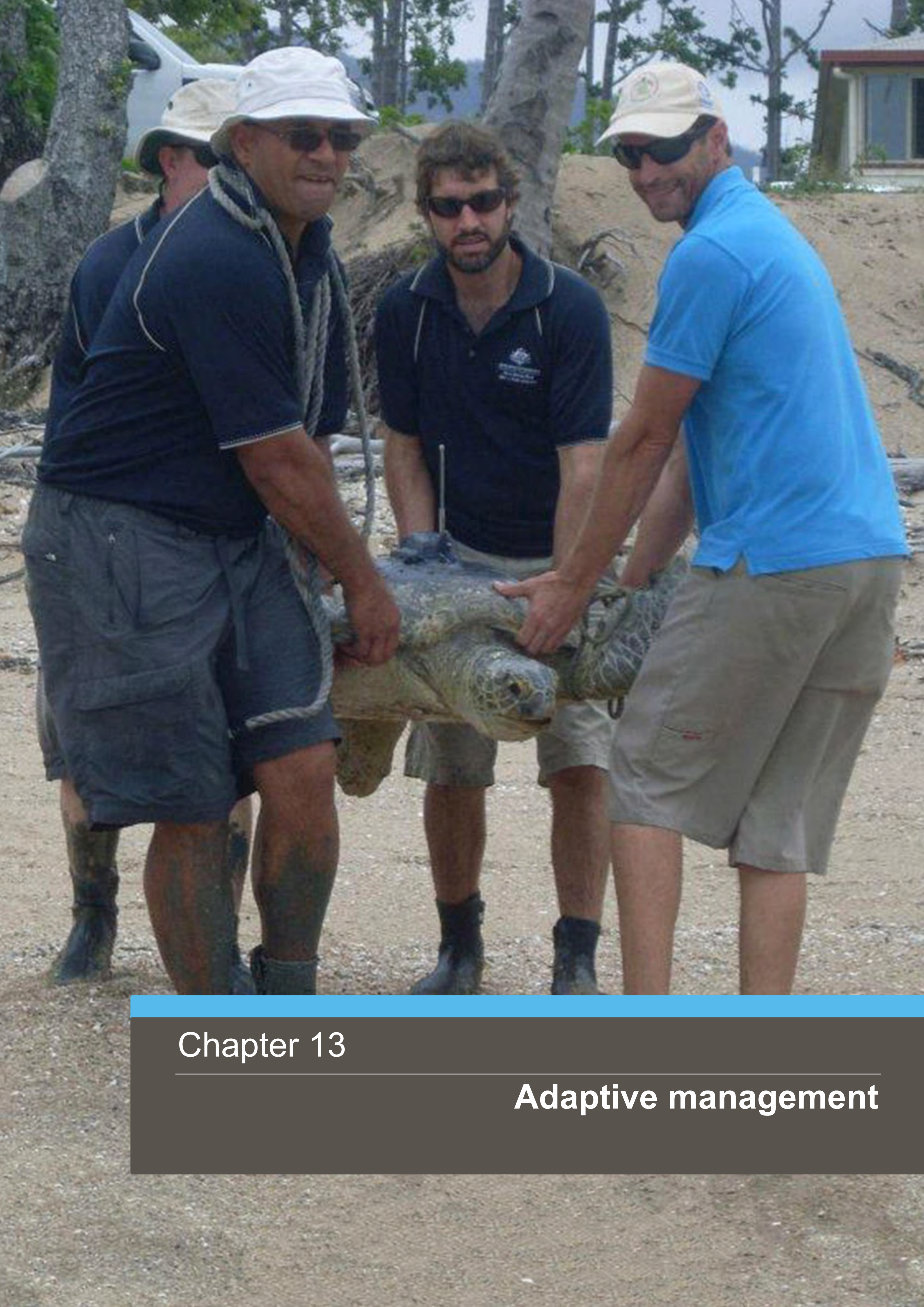
There is strong alignment between the recommended improvements of the Authoirty as set out in this chapter and those of the Queensland Government in the strategic assessment of the adjacent coastal zone. The different jurisdictions and different terms of reference mean that some recommendations are relevant to only one assessment.

Authority recommended improvements	Queensland Government recommended improvements
Identifying matters of national environmental significance	
REC1: Explicitly incorporate consideration of all values relevant to matters of national environmental significance, including elements of the property's outstanding universal value, into the Authority's programs, plans and policies	**REC1:** More explicitly incorporate consideration of matters of national environmental signifcance into the planning and development assessment system and provide clearer guidance on how matters of national environmental signifcance should be considered **REC2:** Ensure that mapping is readily available in order to inform local planning and is provided in such a way that the specific values at the site can be understood
REC2: Improve spatial mapping capabilities to support planning and assessment decision making, including the range of values mapped and public availability	**REC5:** Seek to include additional information in the mapping system, particularly for: • intertidal and inshore coastal ecosystems where information is currently limited; • threatened ecological communities; and • migratory species
REC3: Work closely with Australian and Queensland government agencies to help identify values of the Great Barrier Reef World Heritage Area that are not easily represented and measured such as aesthetic values	**REC3:** Work closely with the Great Barrier Reef Marine Park Authority and the Australian Government to help identify values of the Great Barrier Reef World Heritage Area that are not easily mapped
REC4: Collaborate with Traditional Owners to undertake an assessment of the Indigenous heritage values of the Region	**REC 4**: Work with the Great Barrier Reef Marine Park Authority and Traditional Owners to undertake an assessment of the Indigenous heritage values of the Great Barrier Reef World Heritage Area.
REC5: Develop and implement knowledge management systems for Indigenous and historic heritage information, including a protocol for managing culturally sensitive information and improved information sharing arrangements	

Authority recommended improvements	Queensland Government recommended improvements
REC6: Improve understanding of the role that the Great Barrier Reef plays in the life of the community	See REC3
Assessing impacts on matters of national environmental significance	
REC7: Work closely with Australian and Queensland government agencies to improve understanding and management of cumulative impacts from activities within and adjacent to the Region and provide clearer guidance on how proponents and decision makers should address cumulative impacts in assessments	**REC6:** Work closely with the Department of the Environment and the Great Barrier Reef Marine Park Authority to improve understanding of cumulative impacts within and adjacent to the Great Barrier Reef and provide clearer guidance on how proponents and decision makers should address cumulative impacts in impact assessments
REC8: Streamline assessment processes across jurisdictions and seek to have a more coordinated approach to community consultation	**REC7:** Streamline assessment processes across jurisdictions and seek to have a more coordinated approach to community consultation
Avoiding impacts on matters of national environmental significance	
REC9: Improve alignment between the Authority's and Queensland Government's protected area and tourism management arrangements and look for opportunities to streamline	**REC10:** Improve alignment between Queensland and the Great Barrier Reef Marine Park Authority protected area and tourism management arrangements and pursue opportunities to streamline
REC10: Develop and implement plans of management in areas of the Great Barrier Reef Marine Park that have high growth for recreation and other uses	
REC11: Support development of a Queensland ports strategy that concentrates port development around long-established major ports in Queensland, and encourage port master planning	**REC9:** Implement arrangements to concentrate port development around long-established major ports in Queensland, and encourage port master planning which includes community engagement
REC12: Promote a strategic approach to the development and operation of marinas and other access infrastructure along the Great Barrier Reef coast	
REC13: Review and update the *Great Barrier Reef Marine Park Heritage Strategy* to guide management actions to strengthen recognition and protection of heritage values	
REC14: Promote, recognise and encourage stewardship and best practice efforts by community, industry and government	
REC15: Support increased investment in site infrastructure to protect matters of national environmental significance in the Great Barrier Reef Region	
REC16: Improve compliance through more effective surveillance and compliance activities, access to latest technology, increased coordination across jurisdictions and strengthened powers to prevent repeat offending	**REC 11:** Improve compliance through increased coordination across jurisdictions to prevent repeat offending.
REC17: Support a collaborative, Reef-wide management strategy for islands and contribute to its development and implementation	**REC12:** Support a collaborative, Reef-wide management strategy for islands and contribute to its development and implementation
	REC8: Commit to filling the remaining gaps in regional plans and establish a timetable for completion

Authority recommended improvements	Queensland Government recommended improvements
Mitigating impacts on matters of national environmental significance	
REC18: Update and strengthen the Great Barrier Reef water quality guidelines to address a broader range of habitats and species and account for cumulative impacts	**REC13:** Work closely with the Australian Government to establish standard matters of national environmental significance conditions that should be applied to certain types of development that give confidence that impacts will be mitigated as far as possible
REC19: Improve the effectiveness of the Authority's hydrodynamic guidelines as a decision making tool by requiring consideration of a greater range of environmental factors, and regularly reviewing them to reflect improvements in understanding	
REC20: Support research on critical ecosystem thresholds, with a focus on inshore biodiversity and associated ecosystems	
REC21: Improve understanding and the Authority's management of the impacts of noise on species, particularly at-risk and inshore species	
REC22: Reduce crown-of-thorns outbreaks by continuing to improve water quality and through a long-term control program	
Offsetting impacts on matters of national environmental significance	
REC23: Develop a policy and supporting mechanisms to facilitate strategic and collaborative implementation of offsets across jurisdictions	**REC14:** Review Queensland's approach to offsets to ensure more strategic outcomes that help deliver a net benefit overall. Seek to align a new offsets approach to the Commonwealth offsets policy and proposed Reef Trust where possible
REC24: Inform implementation of Australian and Queensland government offsets policies and restoration programs by identifying actions that will maximise the delivery of environmental benefits to the Region	
Enhancing matters of national environmental significance	
REC25: Establish a management framework with clear outcomes and targets for the protection of values and the management of impacts, including cumulative impacts	**REC18:** Work with the Great Barrier Reef Marine Park Authority and the Australian Government to identify agreed outcomes for matters of national environmental signifcance that can be monitored over time to assess the effectiveness of management
REC26: Develop and implement a long-term sustainability plan for the Great Barrier Reef World Heritage Area in cooperation with Australian and Queensland government agencies to better coordinate programs designed to manage and improve the condition of the Reef	**REC15:** Develop and implement a long-term sustainability plan for the Great Barrier Reef World Heritage Area in cooperation with the Australian Government to better coordinate programs designed to manage and improve the condition of the Reef
REC27: Strengthen engagement with all relevant partners to facilitate actions that maintain and enhance the condition of values and reduce impacts, particularly in relation to climate change, catchment run-off, degradation of coastal ecosystems and direct use	**REC16:** Consider expanding the scope of Reef Plan to incorporate other sources of pollutants (e.g. urban, port) to provide a sound coordination mechanism
REC28: Develop a comprehensive management framework and an Indigenous heritage strategy for Traditional Owner use and management of the Great Barrier Reef	

Authority recommended improvements	Queensland Government recommended improvements
REC29: Adopt regionally-based cooperative approaches to protect inshore biodiversity hotspots — supporting local actions and encouraging cooperation	
REC30: Improve alignment and coordination of strategic research priorities and strengthen partnerships between the Authority and research institutions to facilitate the delivery of critical research needs	**REC17:** Work with partners to identify critical research needs to inform management and support the long term sustainability plan for the Great Barrier Reef World Heritage Area
Monitoring and evaluation	
REC31: Implement an integrated monitoring, reporting and adaptive management program for the Great Barrier Reef World Heritage Area, including more explicit reporting on the condition and trend of matters of national environmental significance	**REC19:** Work with the Great Barrier Reef Marine Park Authority to look for opportunities to integrate existing monitoring programs and focus on reporting against consistent outcomes **REC20:** More explicitly report on the condition and trend of matters of national environmental signifcance
REC32: Maintain and improve monitoring, investigation and data management relating to critical species and habitats	
REC33: Support implementation of a long-term social and economic monitoring program to improve understanding of changing use, investment and values	
Governance	
REC34: Contribute to the development of improved governance arrangements for the management and coordination of development activities that affect the Great Barrier Reef	**REC 21:** Consider improved governance arrangements for the management and coordination of coastal development issues in the Great Barrier Reef coastal zone, using the Reef Plan governance framework as a benchmark
Adapting to climate change	
REC35: Communicate the implications of climate change impacts for the Great Barrier Reef and the critical need to halt increasing concentrations of global greenhouse gases and restore them to levels that will support growth, recruitment and recovery processes of the Great Barrier Reef ecosystem	
REC36: Ensure the impacts of climate change and extreme weather are appropriately considered in the Authority's management decisions	
REC37: Encourage reduction of greenhouse gas emissions in the Great Barrier Reef Region in partnership with industry and communities	
REC38: Support initiatives to build the capacity of management agencies and Reef users to adapt and respond to climate change and extreme weather events	



Chapter 13

Adaptive management

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Cover page image: Releasing a turtle rehabilitated at Reef HQ Turtle Hospital.

Extract from Great Barrier Reef Region Strategic Assessment terms of reference

6.2 Principles of ecologically sustainable development

Describe how the principles of ecologically sustainable development have been applied in the proposed Program. The principles of ecologically sustainable development as described in section 3A of the Environment Protection and Biodiversity Conservation Act 1999 are:

a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations

b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation

c) the principle of intergenerational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations

d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making

e) improved valuation, pricing and incentive mechanisms should be promoted.

6.3 Adaptive management

a) identify the key adaptive management measures in the proposed Program that address uncertainties and risks inherent in the decision making process

b) describe how the adaptive management measures will be implemented to ensure the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, are effectively protected and managed over the life of the Program.

6.4 Monitoring and reporting

a) describe the monitoring, review and public reporting process that will be used to examine whether the Program adequately protects and manages the relevant matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area, and the framework for measuring success

b) describe the processes for adapting the Program in response to new information

c) nominate the parties responsible for undertaking the monitoring, review and reporting and for implementing any actions arising.

6.5 Review, modification or abandonment

a) identify and analyse likely circumstances and procedures that may result in the review, modification or abandonment of the Program. This is to include a discussion of how any commitments under the Program would continue to be met under these situations.

13 Adaptive management

Based on the recommendations set out in Chapter 12, the Great Barrier Reef Marine Park Authority (the Authority) has developed a Program Report — a companion volume to this report — which sets out its future management program.

The purpose of this chapter is to: demonstrate how the principles of ecologically sustainable development have been applied in the development of the Authority's management program; describe the key adaptive management measures, including those to address uncertainties and risk in decision making; outline monitoring and reporting processes; and consider review, modification and abandonment of the program.

13.1 Summary of the Program Report

The Program Report provides the overarching strategic direction for the Authority's management of matters of national environmental significance in the Great Barrier Reef Region (the Region).

The Authority's vision for the Great Barrier Reef is: *A healthy Great Barrier Reef for future generations.*

To make the vision a reality, the Authority will focus its management on achieving four goals:

- protecting and restoring of the Reef's ecosystem health and biodiversity
- safeguarding the Reef's heritage values
- maintaining sustainable multiple use and community benefits derived from the environment
- reducing cumulative impacts.

The Authority's program is made up of the three elements: foundational management, proposals to strengthen management actions and future commitments. These are supported by regular reporting and strong governance arrangements. The life of the program is 25 years.

13.1.1 Foundational management

Into the future, the Authority will continue to employ its strong foundational management arrangements to protect matters of national environmental significance, including its biodiversity and heritage values, and provide for ecologically sustainable use. The foundational arrangements are built around three program areas:

- **Environmental regulation** — recognising the Authority is the primary environmental regulator for protection of the Great Barrier Reef. The Authority's current environmental regulation arrangements, including its direct field management activities, provide a strong foundation for its future management program. In partnership with other relevant government agencies, the Authority will continue to fulfil its statutory obligations set out in the *Great Barrier Reef Marine Park Act 1975* (the Act), adapting as required to address emerging risks and changing circumstances. The principle regulatory tools employed by the Authority will continue to be the Zoning Plan, plans of management, permits, Traditional Owner agreements, field management, compliance, site infrastructure, fees and charges and policy.
- **Engagement** — focusing on enhancing protection measures within the Region and influencing drivers and activities which affect the Region but fall outside of the Authority's jurisdictional control. Recognising that protection of the Great Barrier Reef requires local, national and international effort, the Authority will continue to work with Traditional Owners, the community, business, industry, local government, plus Australian and Queensland government agencies to influence best practice and find pragmatic solutions to secure the future health of the Reef. The Authority will continue to undertake engagement through partnerships, providing advice, education and community awareness, stewardship and best practice, and consultation.
- **Knowledge, innovation and integration** — accessing and capturing the best available science, as well as drawing on traditional ecological knowledge and information from the wider community. The Authority recognises that a comprehensive and up-to-date understanding of the Great Barrier Reef, its values, the processes that support it and the impacts that are affecting it is fundamental to managing the Region. Such knowledge and understanding is improved through the activities of a wide range of research providers, as well as commercial companies, consultants, stakeholders, Traditional Owners and community members. The Authority will continue to implement existing knowledge, innovation and integration actions, including identifying values, research and monitoring, reporting and building corporate knowledge.

13.1.2 Strengthening management

As part of its adaptive management approach, the Authority will strengthen management in key areas, based on the findings of the strategic assessment. As well as specific improvements to strengthen its foundational management, the Authority will deliver a suite of new initiatives to enhance protection and reduce impacts on values relevant to matters of national environmental significance, namely:

- adopting an **management framework based on outcomes** for the condition of values and targets to guide decision making and actions required to maintain and restore the condition of values

- **strengthening standards and identifying critical thresholds** to protect ecosystem health and ensure activities within and adjacent to the Region do not result in unacceptable impacts on matters of national environmental significance
- implementing a **cumulative impact assessment policy** to provide a transparent, consistent and systematic approach to the management of cumulative impacts and associated risk from activities within and adjacent to the Region
- implementing a **net benefit policy** to guide actions required to restore ecosystem health, improve the condition of values and manage financial contributions to that recovery
- supporting a **Reef recovery program** which applies the measures above and cooperative management approaches, with a focus on restoring sites of high environmental value
- implementing a Reef-wide **integrated monitoring and reporting program** which directly links to the outcomes-based management framework and underpin the Authority's adaptive management approach.

13.1.3 Forward commitments

The Authority has identified a program of forward commitments to improve integration of management arrangements across jurisdictions and inform adaptive management approaches across the life of the program. In particular, the Authority will contribute to the development of a long-term sustainability plan for the Great Barrier Reef World Heritage Area, drawing on the outcomes of the strategic assessments for both the Region and the adjacent coastal zone. The plan will provide an overarching framework to guide protection and management of the Great Barrier Reef World Heritage Area's outstanding universal value and support ecologically sustainable development and use. It will build on the Australian and Queensland government's strong foundation of management measures to protect the Great Barrier Reef.

13.2 Applying the principles of ecologically sustainable development

The principles of ecologically sustainable development as described in section 3A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are:

a) Decision-making processes should effectively integrate both long-term and short-term environmental, economic, social and equitable considerations.
b) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
c) The principle of intergenerational equity — that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
d) The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.
e) Improved valuation, pricing and incentive mechanisms should be promoted.

It is a requirement of the Great Barrier Reef Marine Park Act that, in managing the Marine Park and performing its other functions, the Authority has regard to and seeks to act in a way that is consistent with the principles of ecologically sustainable use. These principles are defined in the Act and closely match the above principles of ecologically sustainable development. The Authority is bound by the requirements of the Act and will therefore continue to apply these principles to its protection and management of the environment, biodiversity and heritage values of the Region.

The ways in which the principles of ecologically sustainable development will continue to be applied in the Authority's management program are summarised in Table 13.1.

Table 13.1 Applying the principles of ecologically sustainable development

Principles of ecologically sustainable development	Application in the Authority's management program
a) Decision-making processes should effectively integrate long-term and short-term economic, environmental, social and equitable considerations.	• Section 7(3) of the Act requires the Authority to perform its functions consistent with the principles of ecologically sustainable use. This includes consideration of these principles in the preparation of zoning plans, plans of management and permit decision making. • The potential impacts on the environment and on social, cultural and heritage values must be considered in all permit decisions. • The effects on public appreciation, understanding and enjoyment of the Marine Park, as well as impacts on other activities may be considered in permit decisions. • The Authority's environmental impact management policy requires consideration of impacts on environmental, economic and social values. • Decision making is informed by the best available information, and where appropriate, stakeholders are engaged and public comment is sought (for example during major permit assessments). • There is explicit recognition of the importance of the Great Barrier Reef to its Traditional Owners and their cultural heritage. They are increasingly engaged in its management. • The community benefits derived from the environment are explicitly recognised in the Program Report and, increasingly, the outcomes of integrated monitoring and modelling will be available for consideration in decision making, providing guidance on socio-economic benefits and impacts and likely future trends. • Biodiversity, heritage values and community benefits derived from the environment are the foundations of the Authority's strategic planning. • Minimum standards for public consultation are identified under the Act and in the Authority's policies to guide those involved in the Authority's decision-making processes. • A cumulative impact assessment policy will incorporate this principle.
b) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.	• Section 7(3) of the Act requires the Authority to perform its functions consistent with the objects of the Act and the principles of ecologically sustainable use. This includes consideration of these principles in the preparation of zoning plans, plans of management and permit decision making. • Consideration of permit applications is based on the best available science. • Where there is scientific uncertainty, the Authority seeks to harness expert opinion, plus knowledge held by Traditional Owners and stakeholders, including through its advisory committees and through seeking public comment. • Risks and threats to the Great Barrier Reef are identified and assessed in the Great Barrier Reef Outlook Report, which is updated every five years. • Increasingly, outcomes of integrated monitoring and modelling will be available for consideration in decision making, providing guidance on likely future trends. • A cumulative impact assessment policy will incorporate this principle and increase the rigour of environmental assessment processes.
c) The principle of intergenerational equity — that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	• Section 7(3) of the Act requires the Authority to perform its functions consistent with the principles of ecologically sustainable use. This includes consideration of these principles in the preparation of zoning plans, plans of management and permit decision making. • The Authority recognises the overall condition of the Great Barrier Reef has declined. Future management is focused on minimising further impacts and enhancing and restoring the values of most concern.

Principles of ecologically sustainable development	Application in the Authority's management program
	• A policy on delivering net benefits, including offsets, will contribute to the maintenance and enhancement of the health, diversity and productivity of the environment for future generations. • Programs and actions are implemented to address remaining risks identified in the Outlook Report and improve the future outlook for the Reef. • Regional and local actions facilitated by the Authority, including Traditional Use of Marine Resources Agreements and the Reef Guardian program, are an important element in enhancing health, diversity and productivity and often involve activities that engage a range of generations. • Increasingly, the outcomes of integrated monitoring and modelling will be available for consideration in decision making, providing guidance on community benefits and likely future trends, and evaluating the delivery of net benefits. • A cumulative impact assessment policy will incorporate this principle. • An outcomes-based management approach and a net benefit policy will improve actions to maintain and enhance the condition of the Region's values for future generations.
d) The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.	• The main object of the Act includes providing for the long-term protection and conservation of the environment, biodiversity and heritage of the Great Barrier Reef Region. This is the basis for the Authority's management arrangements. • Zoning arrangements, which include about one-third of the Marine Park in no-take zones, are a vital component in conserving biological diversity and ecological integrity. Connectivity and protecting a representative area of all bioregions were key considerations in designating no-take zones. • A range of policies, including the *Great Barrier Reef Biodiversity Conservation Strategy* guides the Authority's management relevant to the conservation of biological diversity. Additionally, the *Great Barrier Reef Climate Adaptation Strategy and Action Plan* assists the Authority to address the challenges of climate change in relation to biological diversity. • The potential impacts on the environment, including its biodiversity, and the objects of the zone where an activity will occur are required to be considered in all permit decisions. • Any relevant recovery, conservation threat abatement plans or approved conservation advice under the EPBC Act may be considered in permit decisions. • A cumulative impact assessment policy and a net benefit policy will incorporate this principle.
e) Improved valuation, pricing and incentive mechanisms should be promoted.	• Socio-economic monitoring will be included in long-term core monitoring for the Region. • The Authority's management is informed by economic valuations of Reef-dependent activities. • Tourism operators are recognised and rewarded for being certified as meeting best practice standards, including with longer-term permits. • There is public recognition of participants in the Reef Guardian program and of Traditional Use of Marine Resources Agreements. • Cost recovery principles are applied in the Authority's management arrangements. • A framework will be developed to guide implementation of investments for net conservation benefits designed to increase the resilience of the Great Barrier Reef Region. • A cumulative impact assessment policy will incorporate this principle.

13.3 Adaptive management

13.3.1 Addressing risk

The Authority adopts a risk-based approach in its management and decision making. The strategic assessment identifies existing and emerging impacts that are predicted to present the highest risks to the values relevant to matters of national environmental significance. The Authority's future management program is clearly focused on the highest risk impacts, without ignoring medium and lower risks that are already mitigated.

Section 54(3)(d) of the Act requires 'an assessment of the risks to the ecosystem' within the Region be included in each Outlook Report. This legislative requirement means the assessment of current impacts and future risks will be regularly updated. The risk assessment presented in the first Outlook Report in 2009 was undertaken using the Australian Standard for Risk Assessment and has subsequently been a principal guide for the Authority in determining management priorities. The Authority also applies the standard in its environmental assessment and management and its permitting processes.

One key component of managing risks is having access to the most up-to-date information. It is anticipated the proposed integrated monitoring program (Section 13.4) will substantially improve the knowledge base available to the Authority. Recognising the significance of the Great Barrier Reef to local communities and the nation, and the community benefits derived from the environment, the proposed monitoring program has an expanded focus to better include information on social, cultural and economic values. The Authority also intends to expand the sources of information it uses in making decisions, so that traditional ecological knowledge and information held by the broader community are better considered. A commitment to the development of a heritage database, including a protocol to manage culturally sensitive information, will further improve consideration of cultural, social and economic values relevant to matters of national environmental significance.

Ongoing improvements in linkages with information providers and advances in information technology are likely to continue to greatly improve the ways in which the Authority and its management partners provide, access and integrate information used to address risk.

This strategic assessment has clearly demonstrated that impacts — whether the result of human activities or natural forces — do not operate in isolation or on a single value or in a specific area. It also shows consideration of cumulative impacts is one of the weakest aspects of the Authority's current management arrangements. A commitment in the Authority's management program is to integrate risk management and the consideration of cumulative impacts into regulatory frameworks through development of a cumulative impact policy.

13.3.2 Addressing uncertainty

Inherently, there is a large amount of uncertainty surrounding protection and management of the Great Barrier Reef — an enormous, complex marine protected area which is managed for multiple use.

The Authority will continue to employ a range of tools to provide certainty with regard to where activities may occur and under what conditions they may proceed. These tools are outlined in Section 4, Foundational management, in the Program Report and include zoning plans, plans of management, permits, policies and guidelines. The resulting level of certainty provided for different activities in the Region was presented previously in Chapter 8 of this report. Where uncertainty exists, the Authority adopts a risk-based approach and applies the principles of ecologically sustainable use to its decision making. The use of these tools, approaches and principles is embedded in the Authority's governing legislation (the Act) and reflected in its policies. The Authority also deals with uncertainty by, where feasible, maintaining flexibility in its management approach, so that changing circumstances can be considered and reflected in management arrangements.

Uncertainty is also addressed by always seeking to improve the knowledge base available for decision making (see Section 5.3.3 of the Program Report). The Authority will continue to be actively involved in determining research and monitoring priorities for the Region and maintaining strong connections with the research community (including those undertaking voluntary monitoring) so that emerging information can be understood and applied to management. The Authority will also seek to improve the ways that it is informed by knowledge and understanding held by the Great Barrier Reef's Traditional Owners, stakeholders and the community (see Section 5.3.3 of the Program Report). This knowledge will continue to be acquired through ongoing liaison, specific workshops and the Authority's Reef Advisory Committees and Local Marine Advisory Committees.

For key matters that affect the Region, the Authority takes a leading role in improving understanding and defining the priorities for management action. For example, in the case of reducing impacts on the Region's values arising from clearing and modifying coastal habitats, the Authority:

- improved technical understanding of the role that coastal habitats play in providing ecosystem services to the Reef ecosystem, culminating in the report *Informing the outlook for Great Barrier Reef coastal ecosystems*[1]
- is defining priorities for action by undertaking basin assessments to identify the coastal basins that remain intact and those that are slightly to moderately affected by human activity.

These bodies of work will guide the Authority's partnership activities with local and state government agencies, natural resource management bodies, Reef Guardian participants and local communities to actively manage and restore the functioning of coastal ecosystems critical to the health of the Great Barrier Reef.

In its future management, the Authority will adopt the systematic approach used in this report to the identification of the values relevant to matters of national environmental significance, and the drivers, activities and impacts affecting them (see Appendices 3 and 4 of the Program Report). It will also adopt a systematic approach to considering the cumulative effect of impacts on values (see Section 5.2.4 of the Program Report). This will include using models (qualitative or quantitative) to examine the relationships between multiple drivers, activities and impacts, for example those that can affect key habitats such as coral reefs and seagrass meadows. Such tools can help the Authority deal with uncertainty by allowing consideration of multiple alternate models in situations where the cause-and-effect relationships between values and impacts are uncertain or contentious. They can also help tackle a key source of uncertainty — the cumulative effect of impacts. It is intended that ongoing use of modelling in the Authority's decision-making processes will be formalised through the policy on cumulative impact assessment (see Section 5.2.4 of the Program Report).

13.3.3 Implementing adaptive management to protect and manage matters of national environmental significance

Through the ongoing foundational activities and the future improvements identified in the Program Report and the vital contributions of its partners, the Authority anticipates declines in key components of the Region's ecosystem can be halted and reversed and the desired outcomes achieved for values relevant to matters of national environmental significance. It is recognised that this will require a sustained and ongoing commitment of resources, and that such improvements in environmental condition may take decades to achieve.

Adaptive management has played a central role in the understanding and management of impacts in the Region in the last decade.[2,3,4,5,6,7,8,9] The Authority recognises that to achieve the desired outcomes for a system as dynamic and complex as the Great Barrier Reef Region, an ongoing adaptive approach will be required.

The Authority will continue to adopt a comprehensive and coordinated approach to its management of impacts on matters of national environmental significance, operating at a number of levels (Figure 13.1):

- influencing drivers and activities
- mitigating (reducing) impacts and pressures
- restoring, maintaining and enhancing the state or condition of the environment
- promoting appreciation of the community benefits derived from the environment.

Management responses directed towards drivers and activities are often the most effective as they act on the source of impacts and enable them to be avoided. Management actions that directly address impacts or pressures focus on reducing or mitigating the magnitude of the impact and are fundamental to allowing use to occur within ecologically sustainable limits. Management actions that work directly to improve the condition of the environment once the impact has occurred are generally least effective and often most costly. Lastly, interventions which target community benefits are focused on promoting understanding and awareness of the benefits derived from the Region (for example, enjoyment and income) or of the World Heritage Area (for example, outstanding universal value).

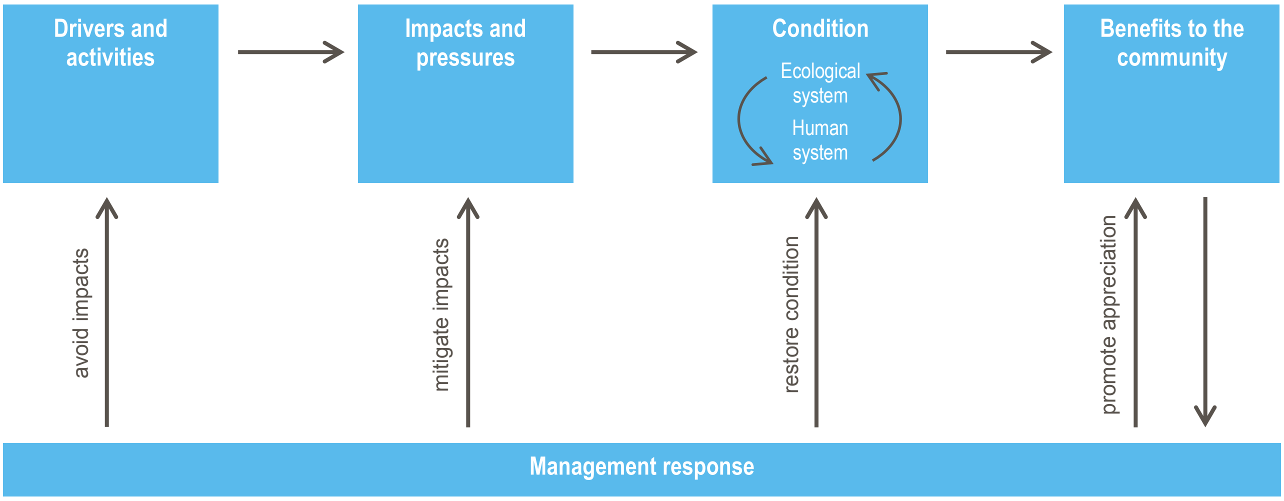

Figure 13.1 Pathways of management intervention

Adaptive management that responds to changing circumstances requires an up-to-date and comprehensive understanding of the status and trend of values relevant to matters of national environmental significance, the impacts that may be affecting them and the benefits being derived from the environment. One of the Authority's new initiatives is an integrated monitoring program to standardise and integrate ecological, social and economic monitoring for the Great Barrier Reef as part of an adaptive management cycle (see Section 13.4).

The Authority will continue to use its five-yearly preparation of the statutory Great Barrier Reef Outlook Report to examine the current status, future risks and likely outlook for the Region. The outcomes of each report will inform the Authority's future priorities and be the principle guide to adaptive management. Importantly, the 'management effectiveness' section will identify management topics that require improvement, and the 'outlook' section of each report will inform adaptive management by integrating current knowledge and modelling to produce a predicted future condition of the values relevant to matters of national environmental significance.

Annual strategic planning, taking into account emerging information and monitoring results, will inform finer-scale adjustments to management arrangements.

The Authority will also continue to review and update its science information needs every five years as part of the Outlook Report cycle.

The Authority will systematically and regularly monitor and evaluate its performance towards achieving the Program's desired outcomes. Evaluating performance will allow the Authority to learn from its successes, improve continually as an organisation, adapt its management arrangements and better deliver on its vision and goal. By structuring its future management program around outcomes, rather than outputs, the Authority will have the flexibility to adapt its management and the programs and projects it undertakes while staying true to its vision and goals.

13.4 Monitoring and reporting

13.4.1 Monitoring

Monitoring provides information to track the condition and trend of the Region's values, as well as the status of the impacts and activities affecting those values. It allows early detection of trends and the assessment of future risks, as well as playing a fundamental role in evaluating management effectiveness. It is also critical to informing the development, refinement and application of maps and models that help managers understand trends and patterns in the Region. Monitoring data are used to meet statutory reporting requirements such as the Authority's five-yearly Outlook Report and its annual report, as well as other reporting obligations including communicating the outcomes of *Reef Water Quality Protection Plan* actions.

The integrated monitoring program, outlined in Section 5.2.7 of the Program Report, will establish the monitoring, review and public reporting process to be employed by the Authority. Once implemented, the program will provide important information for management, support the Authority's outcome-based management approach and be a vital component of the Authority's adaptive management of the Region.

The integrated monitoring program identifies three types of monitoring required for management:

- long-term core monitoring programs — to assess the condition and trend of the Region's values and broadscale impacts, such as water quality, over many years
- short to medium-term, issue-specific monitoring — to examine the condition of, extent of impact on and recovery rate of species, habitats or community benefits
- compliance monitoring — to target the impacts of a development action (for example, construction of a marina or a dredging program) in accordance with conditions specified in a permit, licence or approval.

The program will improve the integration and coordination of existing monitoring programs through the development and implementation of standardised protocols for information collection, collation and data sharing. It will improve the scalability of data (from point source or local, to regional and Reef-wide scales) and synthesis of information from different sources. This will provide a more comprehensive and systematic understanding of the condition of values and scale of impacts.

It is proposed that the effectiveness of the integrated monitoring program will be reviewed in the same way as other management arrangements — every five years through the Outlook reporting process.

13.4.2 Review and public reporting

Research and monitoring as well as community-derived data is captured, synthesised and presented every five years through preparation of the Outlook Report. The report is a statutory reporting responsibility for the Authority, providing a regular and reliable assessment of the Great Barrier Reef and its management. The outcomes of the integrated monitoring program will be synthesised and comprehensively reported in future Outlook Reports. In this way, the Outlook Report will be the primary reporting mechanism of the integrated monitoring program.

There are good examples of monitoring programs already tightly integrated into adaptive management, such as the marine monitoring program which operates under Reef Plan, and the monitoring of the effectiveness of the Zoning Plan. These programs are reported more regularly than the Outlook Report cycle and, because they are linked to specific management objectives, feed directly into assessments of management effectiveness. However, for many monitoring programs, linkages to management effectiveness are not as explicit. Through the integrated monitoring program, links to management will be made clearer and the causal relationships between drivers, pressures, impacts and condition will be better understood. Data from monitoring programs will be able to be synthesised with other data and readily incorporated into adaptive management processes.

13.4.3 Adapting to new information

Research is fundamental to interpreting monitoring data and understanding the effects of impacts on values. In addition, research analysis of existing datasets to uncover patterns and relationships and develop unifying concepts such as on ecosystem health, resilience and sustainability, substantially contribute to adaptive management. Synthesising data and other information is also vital to informing ecological and social risk assessments and developing standards and guidelines for the management of impacts.

Information from research and monitoring will be critical to implementing and adapting the new initiatives outlined in the Program Report — for example, the development of thresholds for ecosystem health (Section 5.2.3 in the Program Report), and targets for management action (Section 6.2.2 of the Program Report). Research will also be needed to conceptualise and, in some cases, model how a system works and how the elements interact and respond to changing pressures.

Traditional ecological knowledge and local community knowledge shared with the Authority by Traditional Owners, stakeholders and members of the community play a central role in informing its adaptive management and decision making. Combined with scientific information, such knowledge informs development of management strategies and policies and, where feasible, will continue to be used to monitor and assess the effectiveness of management arrangements (see Sections 4.3 and 5.2.7 of the Program Report). Furthermore, the integration traditional and community knowledge with scientific knowledge can extend the time perspective of scientific knowledge and highlight potential subject areas for future studies.[10]

13.4.4 Parties responsible for monitoring, review and reporting

The Authority will be the lead coordination agency responsible for the implementation of the integrated monitoring program.

Monitoring activities to inform adaptive management will be conducted by:

- research institutions and government agencies (as identified above) where monitoring is carried out by scientists, technicians and field staff
- Reef-based industries where monitoring may be a voluntary contribution to management, undertaken to meet a permit condition, or a compulsory reporting obligation
- members of the community, typically on a voluntary basis and associated with a recognised community monitoring program
- Traditional Owners of the Great Barrier Reef who are actively involved in monitoring and protecting the health and biodiversity of their sea country. This monitoring provides a valuable link between traditional ecological knowledge and modern science. Examples include training in scientific and wildlife monitoring as part of a two-way information exchange between Traditional Owners, scientists and management agencies.

While the Authority will be responsible for ensuring it continues to meet its statutory monitoring and reporting functions, a whole of government approach, across all levels of government, such as that described in the integrated monitoring program is required to coordinate and integrate monitoring and reporting functions across the Great Barrier Reef and its catchments.

13.5 Review, modification or abandonment of the Program

The terms of reference for this strategic assessment require that the Authority 'identify and analyse likely circumstances and procedures that may result in the review, modification or abandonment of the Program. This is to include a discussion of how any commitments under the Program would continue to be met under these situations'.

Under the Great Barrier Reef Marine Park Act, the Authority has an ongoing responsibility to protect and manage the Great Barrier Reef. Over the life of the proposed Program and beyond, the Authority will continue to aim for best practice management of the Region, adapting to changing conditions and government priorities as required. The Authority will continue the adaptive management approach outlined above to fulfil its responsibilities and respond to change.

It is anticipated the outcomes-based management framework, described in the accompanying Program Report, will provide sufficient flexibility to deal with changing circumstances over the next 25 years and allow for modification as required.

By virtue of the provisions of the Act, the Authority has a clear and continuing responsibility to protect the Great Barrier Reef for future generations.

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Appendix 1

Agreement with the then Minister for Sustainability, Environment, Water, Population and Communities

ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Part 10 Strategic Assessments

Section 146 Agreement

Strategic assessment of the impacts of actions on the values of the Great Barrier Reef World Heritage Area, other relevant matters of national environmental significance, and the management arrangements to deal with such impacts under the jurisdiction of the Great Barrier Reef Marine Park Authority

between

THE MINISTER FOR SUSTAINABILITY, ENVIRONMENT, WATER, POPULATION AND COMMUNITIES ON BEHALF OF THE COMMONWEALTH GOVERNMENT

and

THE GREAT BARRIER REEF MARINE PARK AUTHORITY

CONTENTS

1 PARTIES

The Parties to this agreement are:

The Minister for Sustainability, Environment, Water, Population and Communities on behalf of the Commonwealth Government

and

The Great Barrier Reef Marine Park Authority.

2 DEFINITIONS

2.1 Unless stated otherwise in this Agreement, the definitions, meanings and terms in the *Environment Protection and Biodiversity Conservation Act 1999* apply to this Agreement and its attachments.

2.2 In this Agreement:

agreement means this strategic assessment agreement entered into between the Minister for Sustainability, Environment, Water, Population and Communities and the Great Barrier Reef Marine Park Authority on the date the last Party executes this agreement.

day means a business day as measured in Canberra, Australian Capital Territory.

Department means the Australian Government department administering the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

endorsement criteria means the endorsement criteria detailed in Attachment C of this Agreement.

EPBC Act means the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

GBRMP means the Great Barrier Reef Marine Park as established by the *Great Barrier Reef Marine Park Act 1975* (Cth).

GBRMPA means the Great Barrier Reef Marine Park Authority as established by the *Great Barrier Reef Marine Park Act 1975* (Cth).

GBRMP Act means the *Great Barrier Reef Marine Park Act 1975* (Cth).

GBRMPA management arrangements means those management arrangements under the jurisdiction of GBRMPA, and may include partnership and collaborative arrangements with other Commonwealth and Queensland Government agencies and partnerships with stakeholders and members of the Great Barrier Reef coastal community. These management arrangements include, but are not limited to, those described in Attachment B.

GBRWHA means the Great Barrier Reef World Heritage Area and is the same as the area described in Schedule 1 to the GBRMP Act.

Great Barrier Reef Region has the same meaning as described in the GBRMP Act.

Minister means the Minister responsible for administering the EPBC Act or the Minister's authorised delegate.

MNES means matters of national environmental significance protected under Part 3 of the EPBC Act.

Queensland strategic assessment is defined in clause 3.5 of this Agreement.

Parties mean the Minister and the GBRMPA together, each a ***Party***.

Program is the 'policy, plan or program' (section 146 of the EPBC Act) of the GBRMPA management arrangements that will apply to those parts of the strategic assessment area as described in the Program Report and for which endorsement by the Minister is sought.

Program Report means a report prepared specifically for this strategic assessment that describes the Program.

strategic assessment means the strategic assessment to which this Agreement relates, namely the strategic assessment of the impacts, including cumulative impacts, of actions on the environmental values of the strategic assessment area, relevant MNES and the GBRMPA management arrangements to deal with such impacts.

strategic assessment area is the Great Barrier Reef Region (map at Attachment A) and areas outside the Great Barrier Reef Region, to the extent that actions in those areas may affect the Great Barrier Reef Region.

Strategic Assessment Report means the report prepared in accordance with the Terms of Reference assessing the likely impacts, including cumulative impacts, on MNES from implementing the Program.

Supplementary Report means the report submitted to the Department following public exhibition of the draft Strategic Assessment Report which addresses and responds to public comments including revisions to the Strategic Assessment Report.

Terms of Reference means the terms of reference for the preparation of the Strategic Assessment Report.

Work Plan means a plan jointly developed by the Parties for undertaking the strategic assessment, documenting a common understanding about what strategic assessment tasks will be completed by whom, by when, and what resources are required for those tasks, amongst other things.

3 PREAMBLE

3.1 Australia's Great Barrier Reef is the largest coral reef ecosystem on earth. In 1975 the Great Barrier Reef Region was established and today provides for the long term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region.

3.2 The Great Barrier Reef Region extends more than 2,300 km along the Queensland coastline and covers 346,000 square kilometres. In 1981 the area was listed as a World Heritage property for its outstanding universal value and in 2007 it was listed as a National Heritage property.

3.3 Both the Australian and Queensland Governments have legislative responsibilities within the GBRWHA. The *Great Barrier Reef Intergovernmental Agreement 2009* sets out the joint management arrangements between the two governments to ensure an integrated and collaborative approach to the management of the marine and land environments within and adjacent to the GBRWHA.

3.4 The strategic assessment will examine the impacts, including cumulative impacts, of actions on the GBRWHA, other relevant MNES, and the GBRMPA management arrangements to deal with such impacts.

3.5 The strategic assessment will complement the Queensland Government's strategic assessment of the impacts of actions on the values of the GBRWHA under the Queensland coastal management, planning and development framework (the Queensland strategic assessment). The GBRMPA strategic assessment combined with the Queensland strategic assessment will form a comprehensive strategic assessment of the entire GBRWHA property and its values and the adjacent coastal zone.

3.6 The Parties agree that the GBRWHA and the adjacent coastal zone contain MNES that are highly inter-related. The Parties commit to:
(a) undertaking a strategic assessment of the impacts, including cumulative impacts, of actions on all MNES under the jurisdiction of GBRMPA, other than nuclear actions.
(b) developing a Work Plan for the strategic assessment describing governance arrangements, key milestones and deliverables, public exhibition requirements, communication and data sharing agreements and other responsibilities of the Parties to ensure timely completion of the strategic assessment.
(c) working collaboratively with the Queensland Government on the complementary Queensland strategic assessment.

3.7 The strategic assessment does not affect the application of the EPBC Act or GBRMP Act in the strategic assessment area in relation to actions or activities already approved or for which approval has been sought through the assessment and approval process
(a) established under Parts 7, 8 and 9 of the EPBC Act; or
(b) established under Part 2A of the *Great Barrier Reef Marine Park Regulations 1983* (Cth).

4 BACKGROUND

4.1 Subsection 146(1) of the EPBC Act allows the Minister to agree in writing with a person responsible for the adoption or implementation of a policy, plan or program to assess the impacts of actions taken under that policy, plan or program on MNES.

4.2 This Agreement is intended to be an agreement for the purposes of subsection 146(1) of the EPBC Act to assess the impacts of actions taken under the Program.

4.3 A draft Strategic Assessment Report and draft Program Report will be made available for public comment for a minimum of at least 28 days. Following the public comment period, a Supplementary Report (addressing public comments) and a revised Program Report will be submitted to the Minister. After considering these, the Minister may decide to endorse the Program if satisfied that the reports adequately address the impacts and endorsement criteria to which this Agreement relates and that recommended modifications (if any) to the Program made by the Minister, or modifications having the same effect, have been made.

4.4 The Parties acknowledge that the endorsement of the Program itself does not constitute any approval for the taking of actions under Part 10 of the EPBC Act.

4.5 If the Minister endorses the Program, the Minister may then approve the taking of an action, or a class of actions, in accordance with the Program and the EPBC Act. The effect of this approval decision is that any actions or class of actions approved under section 146B would not need further approval by the Minister under the EPBC Act if taken in accordance with the endorsed Program.

4.6 The Parties acknowledge that, where proponents propose to take an action in accordance with the Program that is not the subject of an approval under section 146B, they are able to seek approval for that action through the assessment and approval process established under Parts 7, 8 and 9 of the EPBC Act. Paragraphs 87(3)(b) and 136(2)(e) of the EPBC Act provide that the strategic assessment report for a policy, plan or program must be taken into account in deciding the level of assessment and approval for actions that are referred under the EPBC Act.

5 TERMS OF REFERENCE FOR THE STRATEGIC ASSESSMENT REPORT

5.1 The Parties will prepare draft Terms of Reference for the strategic assessment report that include the following (at a minimum):
- Purpose and description of the Program;
- Description of the area in which the Program will be implemented;
- MNES affected by the Program;
- Identification and analysis of the potential impacts, including cumulative impacts, on MNES;
- Consideration of existing pressures on MNES;
- Measures to enhance the existing environment, including management of existing threats;

- Measures to avoid, mitigate and offset likely impacts, including impacts of cumulative impacts, on MNES;
- Consideration of ecologically sustainable development principles;
- Adaptive management and risk management;Auditing and reporting requirements; and
- Review, modification and abandonment of the Program.

5.2 The GBRMPA will seek public comment on the draft Terms of Reference. The GBRMPA will provide the draft Terms of Reference for public comment by notice consistent with arrangements for other major environmental impact assessment projects, including:
(a) posting on the GBRMPA's website;
(b) publishing in newspapers circulating in Queensland; and
(c) circulation to key stakeholder groups agreed between the Department and the GBRMPA.

5.3 The notice must state:
(a) that the draft Terms of Reference are available for public comment;
(b) how copies may be obtained;
(c) the contact details for obtaining further information; and
(d) that public comments are invited for a period of at least 28 days as specified by the Minister.

5.4 Following the public comment period for the draft Terms of Reference in accordance with clause 5.3(d), the GBRMPA will submit to the Minister:
(a) proposed Terms of Reference;
(b) public responses relating to the draft Terms of Reference; and
(c) a report on how the public responses have been taken into account.

5.5 Following receipt of the proposed Terms of Reference, the Minister will notify the GBRMPA that the proposed Terms of Reference:
(a) are approved, or
(b) are not approved, in which case the Minister will notify the GBRMPA of any concerns and invite the GBRMPA to provide revised Terms of Reference which take those concerns into account.

5.6 Within 15 working days of receipt of the revised Terms of Reference from the GBRMPA in accordance with clause 5.5(b), the Minister will either:
(a) notify the GBRMPA of the Minister's approval of the revised Terms of Reference; or
(b) provide approved Terms of Reference that meet the Minister's requirements.

6 PREPARATION OF THE STRATEGIC ASSESSMENT REPORT AND PROGRAM REPORT

6.1 The GBRMPA will prepare a Strategic Assessment Report and Program Report in accordance with this Agreement and the Terms of Reference approved in accordance with clause 5.5(a) or clause 5.6.

6.2 The GBRMPA will provide a draft Strategic Assessment Report and draft Program Report to the Minister for comment prior to finalising the documents for public comment.

6.3 The GBRMPA must release the draft Strategic Assessment Report and draft Program Report for public comment by notice consistent with arrangements for other major environmental impact assessment projects, including:
(a) posting on the GBRMPA's website;
(b) publishing in newspapers circulating in Queensland; and
(c) circulation to key stakeholder groups agreed between the Department and the GBRMPA.

6.4 The notice must state:
(a) that the draft Strategic Assessment Report and draft Program Report are available for public comment;
(b) how copies may be obtained;
(c) provide contact details for obtaining further information; and
(d) that public comments are invited on the draft reports for a period of at least 28 days as specified by the Minister.

6.5 The GBRMPA will:
(a) prepare a Supplementary Report and revise the Program Report, taking into account any public comments received in accordance with clause 6.4(d);
(b) provide drafts of these reports to the Minister for comment prior to their finalisation; and
(c) incorporate any recommendations by the Minister.

6.6 The Department agrees to assist the GBRMPA in ensuring that the reports adequately address the requirements for strategic assessments described in Part 10 of the EPBC Act and to provide comments in a timely manner.

7 ENDORSEMENT OF THE PROGRAM

7.1 The GBRMPA will submit to the Minister:
(a) the Strategic Assessment Report (which was exhibited for public comment);
(b) the Supplementary Report (explaining how relevant public responses have been taken into account and addressed in the impact assessment and revised Program);
(c) the Program Report (incorporating any revisions in light of public comments);
(d) public comments received during the consultation relating to the Strategic Assessment Report and Program Report;
(e) any other documents required to support the GBRMPA's submission.

7.2 If the Minister is not satisfied that the reports adequately address the impacts of actions on MNES in the strategic assessment area, or that the Program does not provide for adequate protection of MNES, then:
(a) the Minister can make recommendations to amend the Program;
(b) the GBRMPA may seek clarification from the Minister on the recommendations;
(c) the GBRMPA will then submit to the Minister for consideration the revised Program, and a summary of how the Minister's recommendations were given effect;

(d) the Minister will consider the revised Program, and any supporting material provided, and may accept it as the final Program; and

(e) the Minister may request further modifications if still not satisfied that the Program provides for adequate protection of MNES.

7.3 The Minister may endorse the Program if satisfied that the reports submitted under clause 7.1 adequately address the impacts to which this Agreement relates, and that any recommended modifications to the Program (clause 7.2) or modifications having the same effect have been made. In considering whether to endorse the Program the Minister will also consider the endorsement criteria at Attachment C.

8 APPROVAL OF ACTIONS UNDER THE PROGRAM

8.1 The Minister may approve, or approve with conditions, the taking of an action or class of actions in accordance with the endorsed Program under Section 146B of the EPBC Act. In doing so, the Minister must act in accordance with sections 146F-M of the EPBC Act. This includes considering MNES in the area affected by the Program and economic and social matters.

8.2 The Minister will seek comment from other Australian Government Ministers with administrative responsibilities relating to the actions before approving the taking of an action, or class of actions, pursuant to section 146C of the EPBC Act.

8.3 Both Parties will make publicly available electronically through their websites the endorsed Program (including the Program Report), the Strategic Assessment Report, the Supplementary Report and any approval decision and conditions.

8.4 Approvals for actions or classes of actions may occur progressively after endorsement of the Program.

9 VARIATION, CONFLICT RESOLUTION AND TERMINATION

9.1 This Agreement may only be varied by written agreement (including electronic communications) between the Parties and in accordance with the EPBC Act.

9.2 Where there is a dispute between the Parties to this Agreement on a particular matter, the Parties will consult in the spirit of mutual cooperation in relation to that matter and will use their best endeavours to negotiate a mutually acceptable resolution.

9.3 Either party may at any time terminate this Agreement by written correspondence to the other Party.

9.4 The Parties do not intend this Agreement to create contractual or other legal obligations, or that a breach of the Agreement will give rise to any cause of action, or right to take legal proceedings.

9.5 To avoid any doubt, nothing in clause 9.4 is intended to override the provisions of the EPBC Act.

SIGNED BY:

Tony Burke

16.2.12

The Hon. Tony Burke MP
Minister for Sustainability, Environment, Water, Population and Communities

Dated

Reichelt

Dr Russell Reichelt
Chairpersan, Great Barrier Reef Marine Park Authority

Dated 6/1/2012

Attachment A

STRATEGIC ASSESSMENT AREA

The strategic assessment area is the Great Barrier Reef Region (refer Figure 1) and areas outside the Great Barrier Reef Region, to the extent that actions in those areas may affect the Great Barrier Reef Region.

Figure 1: Great Barrier Reef Region

Attachment B

GBRMPA MANAGEMENT ARRANGEMENTS

Management of the GBRWHA relies upon a number of Commonwealth and Queensland **agencies** using a combination of management **tools** (including zoning plans, plans of management, permits, species recovery plans, the Reef Water Quality Protection Plan and shipping management arrangements), along with various management **approaches** (including education, planning, environmental impact assessment, monitoring, stewardship, enforcement) to regulate access, and to control and/or mitigate impacts associated with **activities** (such as tourism, fisheries, shipping) or address **pressures** (including climate change or declining water quality).

For the purpose of this strategic assessment, ***GBRMPA's management arrangements*** mean those management arrangements under the jurisdiction of GBRMPA. They include, but are not limited to, the following:

- Statutory instruments, including regulations, zoning plans, plans of management and permits;
- Non-statutory mechanisms including policies, position statements and guidelines;
- Partnership and collaborative arrangements with other Commonwealth and Queensland Government agencies;
- Partnerships with Traditional Owners in the management of marine resources;
- Partnership and stewardship programs, including education programs and engagement with local governments, communities, Indigenous persons and industry; and
- Research and monitoring programs.

Attachment C

ENDORSEMENT CRITERIA FOR STRATEGIC ASSESSMENT

When deciding whether to endorse the Program, the Minister must be satisfied that the Strategic Assessment Report adequately addresses the impacts to which this Agreement relates, and that any recommendations by the Minister to modify the Program have been responded to appropriately.

In determining whether or not to endorse the Program, the Minister will have regard to the extent to which the Program meets the objects of the EPBC Act. In particular, that it:

- protects the environment, especially those aspects of the environment that are MNES;
- promotes ecologically sustainable development through the conservation and ecologically sustainable use of natural resources;
- promotes the conservation of biodiversity;
- provides for the protection and conservation of heritage;
- promotes a cooperative approach to the protection and management of the environment; and
- assists in the co-operative implementation of Australia's international environmental responsibilities.

Without limiting the matters the Minister may consider when making the decision to endorse the Program, the Minister will consider the manner in which the Program:

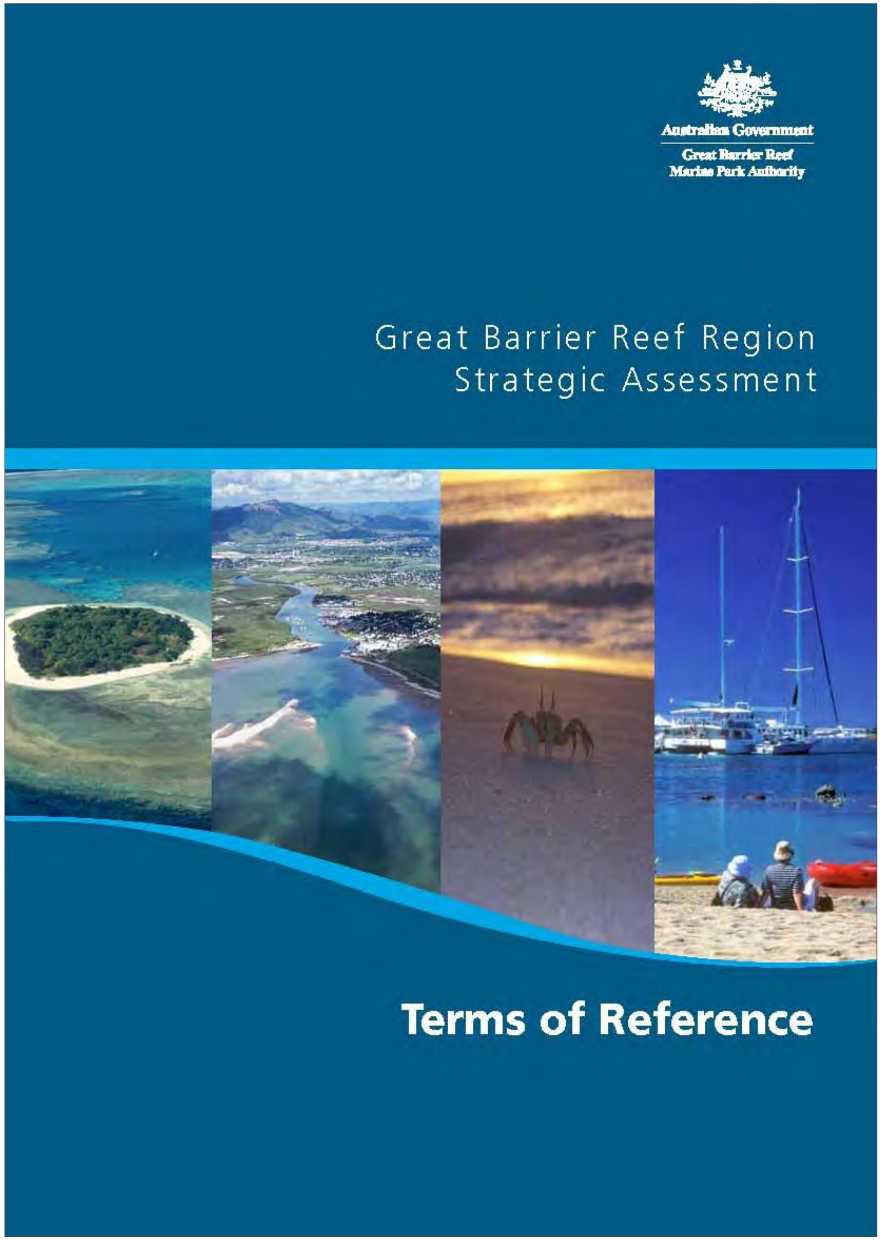
- identifies direct, indirect and cumulative impacts on MNES;
- avoids impacts on MNES;
- mitigates the impacts on MNES;
- offsets the impacts on MNES;
- contributes to the enhancement of the existing environment and management of existing threats; and
- demonstrates adaption to reasonable climate change scenarios.

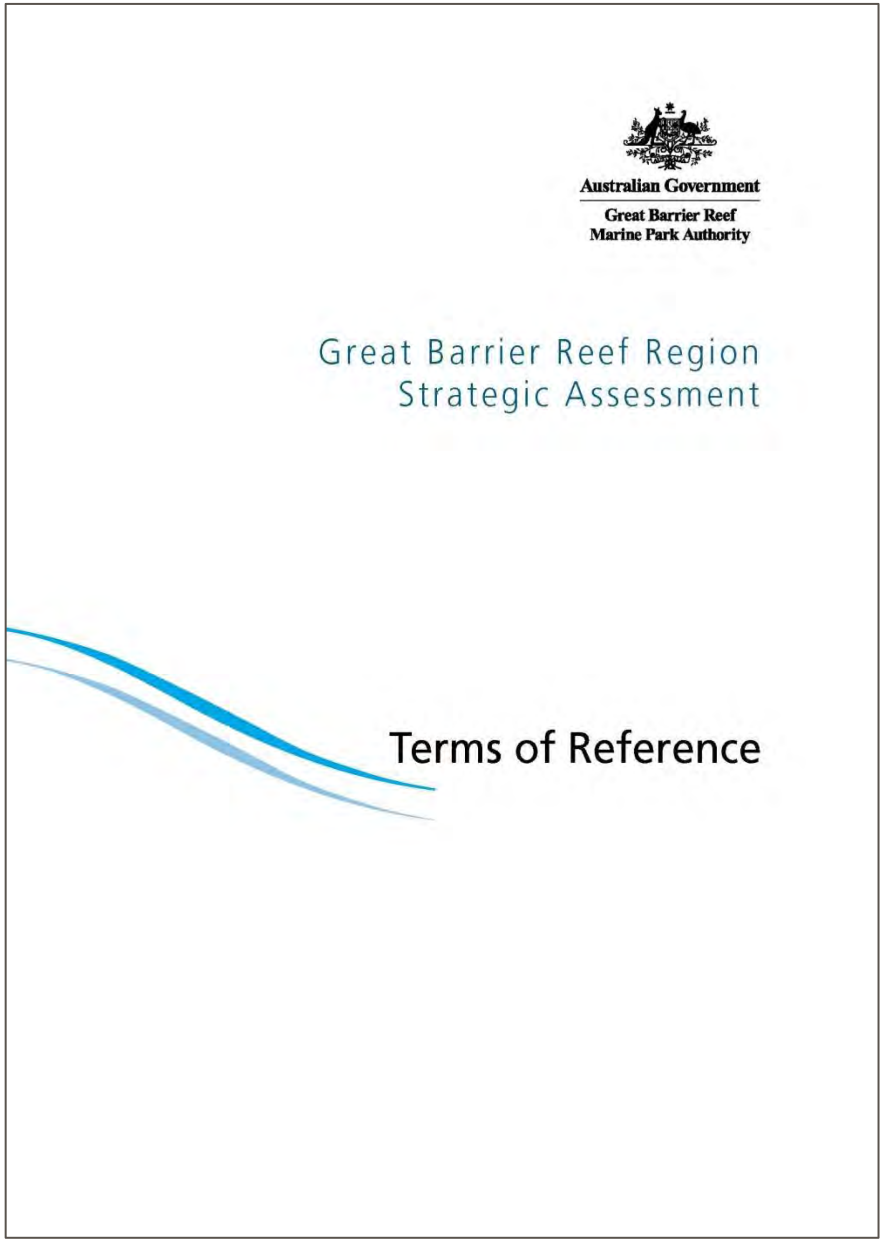
Commitments in the Program must be adequately resourced throughout its life. The Program must demonstrate an effective system of adaptive management that addresses uncertainty and contingency management as well as procedures for monitoring, independent auditing and public reporting on implementation.

The Program must address all of the above matters for it to be considered for endorsement by the Minister in accordance with the EPBC Act.

Appendix 2

Great Barrier Reef Region Strategic Assessment Terms of Reference


Australian Government
Great Barrier Reef
Marine Park Authority
Great Barrier Reef Region
Strategic Assessment
Terms of Reference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INTRODUCTION

Background

The Australian and Queensland governments are working together to undertake a comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone. The comprehensive strategic assessment will help identify, plan for and manage existing and emerging risks so that the unique values of the Great Barrier Reef are protected and managed.

There are two components to the comprehensive strategic assessment - a marine component and a coastal component. The Great Barrier Reef Marine Park Authority (the Authority) will lead the marine component involving a strategic assessment of the Great Barrier Reef Region (the Strategic Assessment). The Queensland Government will lead the coastal component involving a strategic assessment of the Great Barrier Reef Coastal Zone.

Purpose

The purpose of these Terms of Reference is to set out the requirements for the Authority in preparing the Strategic Assessment Report for the Great Barrier Reef Region Strategic Assessment.

The Strategic Assessment will assess the likely impacts of actions on relevant matters of national environmental significance as defined in the *Environment Protection and Biodiversity Conservation Act 1999*, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, and the Authority's management arrangements to deal with such impacts.

Map 1: Great Barrier Reef Region

Scope

The scope of the Strategic Assessment is defined by both geographic area and the management arrangements within the Authority's jurisdiction.

The area to be considered by the Authority in its Strategic Assessment is the Great Barrier Reef Region, as defined in the *Great Barrier Reef Marine Park Act 1975*, and areas outside that Region to the extent that actions in those areas may affect that Region (the Strategic Assessment area). The Great Barrier Reef Region covers an area from the tip of Cape York in the north to past Lady Elliot Island in the south, with mean low water as its western boundary and extending eastwards a distance of between 70 and 250 km (Map 1).

All management arrangements under the jurisdiction of the Authority will be considered together with partnerships and collaborative arrangements with other Queensland and Australian government agencies and partnerships with stakeholders and members of the Great Barrier Reef coastal community.

The Authority and the Queensland Government will work closely together on those aspects of the two strategic assessments where they have joint management responsibilities, for example shipping, water quality and island management.

Due to the size and complexity of the Great Barrier Reef, the Authority's Strategic Assessment will include both a broad examination of the Great Barrier Reef Region and more focussed studies of specific locations and issues.

Context

The Australian and Queensland governments share responsibility for managing the Great Barrier Reef. The adaptive, ecosystem-based management approach for the Great Barrier Reef is constantly reviewed and updated in response to new and emerging issues.

In 2009, the Great Barrier Reef Outlook Report identified that the Great Barrier Reef ecosystem is at a crossroad and decisions made now are likely to determine its long-term future. Climate change, declining water quality from catchment runoff, coastal development and remaining impacts from fishing were identified as the biggest risks to the future of the Reef. Since this 2009 report, some of the identified risks to the Reef have increased. These include increases in shipping activity as a result of port expansions; population growth as a result of expanding urban and industrial activities along the Great Barrier Reef coast; intensification and changes in land use within the Great Barrier Reef catchment; and extreme weather events including flooding and cyclones.

The comprehensive strategic assessment is part of the Australian and Queensland governments' adaptive approach to managing the Great Barrier Reef. Once complete the comprehensive strategic assessment will strengthen the protection of the Great Barrier Reef and guide its management by providing greater certainty on where sustainable uses can occur, the type of activities that will be allowed and the conditions under which activities may proceed.

The comprehensive strategic assessment is being carried out under Part 10 of the *Environment Protection and Biodiversity Conservation Act 1999*. Agreements between the Minister for Sustainability, Environment, Water, Population and Communities (the Minister) and both the Authority and the Queensland Government to undertake the complementary strategic assessments are available at: http://www.environment.gov.au/epbc/notices/assessments/great-barrier-reef.html

The comprehensive strategic assessment also forms part of the Australian Government's response to the World Heritage Committee's concerns regarding the impacts of development on the Great Barrier Reef World Heritage Area.

Great Barrier Reef and Coastal Zone values

In accordance with the *Environment Protection and Biodiversity Conservation Act 1999*, the assessment will address impacts on **matters of national environmental significance** as defined in that Act, including world heritage properties, national heritage properties, nationally threatened species and ecological communities, nationally listed migratory species, wetlands of international importance, Commonwealth marine areas and the Great Barrier Reef Marine Park. The Strategic Assessment will describe the extent to which these matters apply to the Great Barrier Reef Region, the values which underpin these matters and ecosystem processes critical to their functioning.

As part of the strategic assessment, there will also be explicit consideration of matters relating to the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

Outstanding Universal Value is a concept central to world heritage properties. It relates to the exceptional qualities of global significance that make an area worthy of special protection. The Great Barrier Reef was listed as a world heritage property in 1981 on the basis that it met all four of the natural criteria which contribute to its Outstanding Universal Value. These criteria relate to the property's biodiversity, its significant ongoing biological and geological processes, its superlative natural phenomena and exceptional natural beauty, and its evolutionary history. Outstanding Universal Value also includes the concept of 'integrity' which is a measure of wholeness or intactness of the property's natural heritage and its attributes.

Reports to be prepared

The Great Barrier Reef Region Strategic Assessment will deliver two reports:

- **Program Report** containing a detailed description of the Authority's management arrangements, including future commitments, to protect and manage matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.
- **Strategic Assessment Report** prepared in accordance with these Terms of Reference.

The Great Barrier Reef Coastal Zone component of the comprehensive strategic assessment will be made up of two similar reports, as shown in Figure 1. Where there are joint management responsibilities these aspects will be addressed in both the Authority's and Queensland Government's reports.

Figure 1: Reports of the *Comprehensive Strategic Assessment for the Great Barrier Reef World Heritage Area and Adjacent Coastal Zone*

Drafts of the Program Report and the Strategic Assessment Report will be released together for public comment prior to their finalisation and submission to the Minister for Sustainability, Environment, Water, Population and Communities.

Timeframes

It is anticipated that a draft Strategic Assessment Report and Program Report for the Great Barrier Reef Region Strategic Assessment will be made available for public comment early to mid 2013.

It is intended that the comprehensive strategic assessment for the Great Barrier Reef World Heritage Area and adjacent coastal zone will be finalised by mid to late 2013.

Prior to finalisation of the comprehensive strategic assessment, the Australian and Queensland governments will continue to apply high environmental standards when considering development proposals that may affect the Great Barrier Reef World Heritage Area.

The life of the Program described in the Program Report will be 25 years, during which time there will be monitoring, evaluation and periodic review of the Program.

Development of the Terms of Reference

To ensure a consistent approach to developing the two strategic assessments, the Terms of Reference have been developed in close cooperation with the Queensland Government and the Australian Government's Department of Sustainability, Environment, Water, Population and Communities.

Draft Terms of Reference were made available for public comment between 18 February and 30 April 2012. A report on submissions received and how public comments were considered in finalising the Terms of Reference is available on the Authority's website at www.gbrmpa.gov.au.

Strategic Assessment process

In preparing the Strategic Assessment, the Authority will:

- Work in close consultation and collaboration with the Queensland Government, the Australian Government's Department of Sustainability, Environment, Water, Population and Communities and other relevant Australian Government agencies.
- Engage stakeholders and the community throughout the Strategic Assessment process using the Authority's network of advisory committees together with regional and issue-based meetings.
- Communicate with the wider community throughout the Strategic Assessment process using the Authority's website, fact sheets, media releases, advertisements and newsletters.
- Use methods consistent with, and build upon approaches employed in the Great Barrier Reef Outlook Report 2009, where relevant.
- Engage independent expertise to assess the effectiveness of the Authority's Program and commission a peer review of the Strategic Assessment Report.
- Use the best available information to undertake the Strategic Assessment, including scientific data, expert opinion, and Traditional Owner and community knowledge.

Use of the term 'Program'

The word 'Program' is used throughout the Terms of Reference. In simple terms it means those management arrangements ('policy, plan or program') under the jurisdiction of the Authority. Management arrangements include, but are not limited to, those described in section 4.1.2 of the Terms of Reference.

TERMS OF REFERENCE

In preparing the Great Barrier Reef Region Strategic Assessment Report, the Authority must comply with the requirements set out below.

1. Purpose and Description of the Program

1.1 Provide an overview of the current Program. For the purposes of the Strategic Assessment the life of the Program is 25 years. The overview is to include a description of:

a) The purpose of the Program, including Program objectives.

b) The area to which the Program applies (the Strategic Assessment area).

c) Legislation, plans, policies and other mechanisms that make up the Program, including Program commitments.

d) Relevant activities within the scope of the Program.

e) International, national, state and regional context (environmental, social, cultural and economic) in which the Program operates, including activities outside the Strategic Assessment area that may influence the Program.

f) Relevant national, state, regional and local planning or management frameworks that affect the Program and contribute to protection and management the matters of national environmental significance.

g) Identification of how long the Program will be in effect and the process for review of the Program, including adaptive management.

h) Identification of the relevant authorities responsible for the implementation of the Program.

2. Matters of National Environmental Significance

2.1 Description of matters of national environmental significance

2.1.1 Describe the extent to which the following relevant matters of national environmental significance, as defined in the *Environment Protection and Biodiversity Conservation Act 1999* apply to the Strategic Assessment area.

a) world heritage properties, including consideration of the Outstanding Universal Value of the Great Barrier Reef World Heritage Area

b) national heritage places

c) wetlands of international importance

d) listed threatened species and ecological communities

e) listed migratory species

f) Commonwealth marine areas

g) the Great Barrier Reef Marine Park.

The description must:

h) Identify key terrestrial, coastal and marine environmental, biodiversity and heritage values and/or attributes which underpin the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

i) Describe ecosystem processes considered critical to the functioning of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

j) Provide sufficient information to allow an understanding the connectivity between the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

2.2 Condition and trend of matters of national environmental significance

a) Describe the current condition and trend of key indicators of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

b) For world heritage values, benchmark the current condition of key indicators of Outstanding Universal Value against the retrospective statement of Outstanding Universal Value which describes the state of the Great Barrier Reef World Heritage Area at the time of listing in 1981.

c) Identify key information gaps and processes to address critical information needs.

3. Assessment of Impacts on Matters of National Environmental Significance

3.1 Actual and potential impacts

a) Describe the environmental, social, cultural and economic drivers affecting the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

b) Describe and analyse the actual and potential impacts on the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, in the Strategic Assessment area, including:

i. impacts from past, present and future activities

ii. direct, indirect, consequential and cumulative impacts

iii. the likely impacts of climate change.

c) Describe the spatial and temporal scale at which impacts and their effects on the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, are occurring or are likely to occur.

d) Identify key information gaps and processes to address critical information needs.

4. Measures to Address Impacts

4.1 Current Program

4.1.1 Describe and assess the effectiveness of the Program to:

a) Identify the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, and determine their current condition and trend, including spatial and non-spatial approaches.

b) Identify and analyse direct, indirect, consequential and cumulative impacts, including the methods used to determine these types of impacts.

c) Consider environmental, social, cultural and economic issues.

d) Avoid, mitigate, offset and adaptively manage impacts.

e) Address uncertainty and risk.

f) Provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be unacceptable.

g) Halt and reverse any declines and enhance the condition of the relevant matters of national environmental significance, including mechanisms to deliver a 'net benefit' to the condition of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area,

h) Adapt to reasonable climate change scenarios.

i) Integrate with related local, Queensland and Australian government programs to protect and manage the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

j) Meet Australia's international responsibilities in relation to the environment and protection of world heritage.

k) Monitor, evaluate and report on the:

i. Condition and trends of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

ii. Impacts of activities, including the setting of targets to benchmark management performance.

4.1.2 In assessing the effectiveness of the Program, consideration must be given to:

a) Statutory instruments, including regulations, zoning plans, plans of management and permits.

b) Non-statutory mechanisms including policies, position statements and guidelines.

c) Partnership and collaborative arrangements with Queensland and other Australian government agencies.

d) Partnerships with Traditional Owners in the management of marine resources.

e) Partnership and stewardship programs, including education programs and engagement, with local governments, communities, Indigenous persons, business and industry.

f) Research and monitoring programs.

g) Compliance and enforcement programs.

h) Resourcing of the Program.

4.2 Demonstration cases

4.2.1 Develop demonstration cases to assess in finer detail the effectiveness of the Program to protect and manage the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, and to guide improvements to the Program.

4.2.2 Demonstration cases are to be chosen by the Australian and Queensland governments. Criteria that will be used to guide this selection process include, but are not limited to:

a) Where multiple impacts are acting or predicted to act upon a region, locality or value.

b) To examine a specific management approach or method to identify a set of values/attributes or to assess a range of impacts/pressures.

c) To demonstrate connectivity across coastal and marine systems.

d) To demonstrate the integration of environmental, social, cultural and economic benefits in decision-making.

e) To improve understanding of factors affecting Great Barrier Reef ecosystem resilience.

f) Where lessons or outcomes could transfer to other areas.

g) Opportunities to build capacity for future management.

h) To examine the effectiveness of management across local, Queensland and Australian government jurisdictions.

5. Projected Condition of Matters of National Environmental Significance

5.1 Describe the projected condition of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, based on an evaluation of their:

a) Current status and trends.

b) Actual and potential impacts.

c) The effectiveness of the Program to protect the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, and manage impacts.

d) An understanding of ecosystem resilience.

e) An assessment of overall risks to the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

6. Proposed Program

6.1 Recommendations for changes to the Program

6.1.1 Recommend changes to the current Program to improve its effectiveness to deliver its objectives, including outcomes that protect the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area. Recommendations for improvements should specifically address the matters listed in section 4.1.1.

6.1.2 Consistent with section 6.1.1 above, recommend improvements to related local, state and national government programs.

6.2 Principles of Ecologically Sustainable Development

Describe how the principles of ecologically sustainable development have been applied in the proposed Program. The principles of ecologically sustainable development as described in section 3A of the *Environment Protection and Biodiversity Conservation Act 1999* are:

a) Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

b) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

c) The principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

d) The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.

e) Improved valuation, pricing and incentive mechanisms should be promoted.

6.3 Adaptive management

a) Identify the key adaptive management measures in the proposed Program that address uncertainties and risks inherent in the decision making process.

b) Describe how the adaptive management measures will be implemented to ensure the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, are effectively protected and managed over the life of the Program.

6.4 Monitoring and reporting

a) Describe the monitoring, review and public reporting process that will be used to examine whether the Program adequately protects and manages the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, and the framework for measuring success.

b) Describe the processes for adapting the Program in response to new information.

c) Nominate the parties responsible for undertaking the monitoring, review and reporting and for implementing any actions arising.

6.5 Review, modification or abandonment

a) Identify and analyse likely circumstances and procedures that may result in the review, modification or abandonment of the Program. This is to include a discussion of how any commitments under the Program would continue to be met under these situations.

7. Strategic Assessment Process

7.1 Collaboration with the Queensland Government and other Australian Government agencies

a) Undertake the Strategic Assessment in consultation and collaboration with the Queensland Government, the Australian Government's Department of Sustainability, Environment, Water, Population and Communities and other relevant Australian Government agencies.

7.2 Community engagement

a) Document how the community and stakeholders were engaged in the Strategic Assessment process and how views and comments were taken into account in the preparation of the Strategic Assessment Report and the Program Report.

b) Along with the draft Program Report, make the draft Strategic Assessment Report available for public comment for a period of no less than 28 days.

c) Provide the Minister with a report on the public submissions received on the draft Reports, together with proposed final drafts of the Strategic Assessment Report and Program Report, incorporating any revisions made in response to public comments.

7.3 Independent review

a) Engage independent expertise to undertake an assessment of the effectiveness of the current Program to protect and manage the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

b) Arrange for the content of the draft Strategic Assessment Report to be peer reviewed by at least three appropriately qualified persons.

c) Provide the Minister with the independent assessment of management effectiveness, the peer review comments and a report identifying how the findings of the independent assessment and peer review have been considered in the Strategic Assessment Report and the Program Report.

7.4 Information and assessments

a) Use the best available information to undertake the Strategic Assessment, including scientific data, expert opinion, and Traditional Owner and community knowledge.

b) Document the methods used to undertake the Strategic Assessment.

c) For information used in the Strategic Assessment, indicate where possible

i. the source of the information

ii. how recent the information is

iii. the reliability and limitations of the assessment

8. Endorsement Criteria

Describe how the Strategic Assessment Report meets the Endorsement Criteria set out below:

Endorsement Criteria

When deciding whether to endorse the Program, the Minister must be satisfied that the *Strategic Assessment Report* adequately addresses the impacts to which this Agreement relates, and that any recommendations by the Minister to modify the Program have been responded to appropriately.

In determining whether or not to endorse the Program, the Minister will have regard to the extent to which the Program meets the objects of the *Environment Protection and Biodiversity Conservation Act 1999*. In particular, that it:

a) Protects the environment, especially those aspects of the environment that are matters of national environmental significance.

b) Promotes ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.

c) Promotes the conservation of biodiversity.

d) Provides for the protection and conservation of heritage.

e) Promotes a cooperative approach to the protection and management of the environment.

f) Assists in the co-operative implementation of Australia's international environmental responsibilities.

g) Recognises the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity.

h) Promotes the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in co-operation with, with the owners of the knowledge.

Without limiting the matters the Minister may consider when making the decision to endorse the Program, the Minister will consider the manner in which the Program:

i) Identifies direct, indirect and cumulative impacts on matters of national environmental significance.

j) Avoids impacts on matters of national environmental significance.

k) Mitigates the impacts on matters of national environmental significance.

l) Offsets the impacts on matters of national environmental significance.

m) Contributes to the enhancement of the existing environment and management of existing threats.

n) Demonstrates adaption to reasonable climate change scenarios.

Commitments in the Program must be adequately resourced throughout its life. The Program must demonstrate an effective system of adaptive management that addresses uncertainty and contingency management as well as procedures for monitoring, independent auditing and public reporting on implementation.

The Program must address all of the above matters for it to be considered for endorsement by the Minister in accordance with the *Environment Protection and Biodiversity Conservation Act 1999*.

END

Appendix 3

Statement of Outstanding Universal Value

Great Barrier Reef – Property ID 154

United Nations Educational, Scientific and Cultural Organization

World Heritage in Australia

STATEMENT OF OUTSTANDING UNIVERSAL VALUE

GREAT BARRIER REEF - PROPERTY ID 154

Brief synthesis: As the world's most extensive coral reef ecosystem, the Great Barrier Reef is a globally outstanding and significant entity. Practically the entire ecosystem was inscribed as World Heritage in 1981, covering an area of 348,000 square kilometres and extending across a contiguous latitudinal range of 14° (10°S to 24°S). The Great Barrier Reef (hereafter referred to as GBR) includes extensive cross-shelf diversity, stretching from the low water mark along the mainland coast up to 250 kilometres offshore. This wide depth range includes vast shallow inshore areas, mid-shelf and outer reefs, and beyond the continental shelf to oceanic waters over 2,000 metres deep.

Within the GBR there are some 2,500 individual reefs of varying sizes and shapes, and over 900 islands, ranging from small sandy cays and larger vegetated cays, to large rugged continental islands rising, in one instance, over 1,100 metres above sea level. Collectively these landscapes and seascapes provide some of the most spectacular maritime scenery in the world.

The latitudinal and cross-shelf diversity, combined with diversity through the depths of the water column, encompasses a globally unique array of ecological communities, habitats and species. This diversity of species and habitats, and their interconnectivity, make the GBR one of the richest and most complex natural ecosystems on earth. There are over 1,500 species of fish, about 400 species of coral, 4,000 species of mollusk, and some 240 species of birds, plus a great diversity of sponges, anemones, marine worms, crustaceans, and other species. No other World Heritage property contains such biodiversity. This diversity, especially the endemic species, means the GBR is of enormous scientific and intrinsic importance, and it also contains a significant number of threatened species. At time of inscription, the IUCN evaluation stated "... if only one coral reef site in the world were to be chosen for the World Heritage List, the Great Barrier Reef is the site to be chosen".

Natural beauty and phenomena (Criterion iii now Criterion VII): The GBR is of superlative natural beauty above and below the water, and provides some of the most spectacular scenery on earth. It is one of a few living structures visible from space, appearing as a complex string of reefal structures along Australia's northeast coast.

From the air, the vast mosaic patterns of reefs, islands and coral cays produce an unparalleled aerial panorama of seascapes comprising diverse shapes and sizes. The Whitsunday Islands provide a magnificent vista of green vegetated islands and spectacular sandy beaches spread over azure waters. This contrasts with the vast mangrove forests in Hinchinbrook Channel, and the rugged vegetated mountains and lush rainforest gullies that are periodically cloud-covered on Hinchinbrook Island.

On many of the cays there are spectacular and globally important breeding colonies of seabirds and marine turtles, and Raine Island is the world's largest green turtle breeding area. On some continental islands, large aggregations of over-wintering butterflies periodically occur.

Beneath the ocean surface, there is an abundance and diversity of shapes, sizes and colours; for example, spectacular coral assemblages of hard and soft corals, and thousands of species of reef fish provide a myriad of brilliant colours, shapes and sizes. The internationally renowned Cod Hole near Lizard Island is one of many significant tourist attractions. Other superlative natural phenomena include the annual coral spawning, migrating whales, nesting turtles, and significant spawning aggregations of many fish species.

Major stages of the Earth's evolutionary history (Criterion i now Criterion VIII): The GBR, extending 2,000 kilometres along Queensland's coast, is a globally outstanding example of an ecosystem that has evolved over millennia. The area has been exposed and flooded by at least four glacial and interglacial cycles, and over the past 15,000 years reefs have grown on the continental shelf.

During glacial periods, sea levels dropped, exposing the reefs as flat-topped hills of eroded limestone. Large rivers meandered between these hills and the coastline extended further east. During interglacial periods, rising sea levels caused the formation of continental islands, coral cays and new phases of coral growth. This environmental history can be seen in cores of old massive corals.

Today the GBR forms the world's largest coral reef ecosystem, ranging from inshore fringing reefs to mid-shelf reefs, and exposed outer reefs, including examples of all stages of reef development. The processes of geological and geomorphological evolution are well represented, linking continental islands, coral cays and reefs. The varied seascapes and landscapes that occur today have been moulded by changing climates and sea levels, and the erosive power of wind and water, over long time periods.

One-third of the GBR lies beyond the seaward edge of the shallower reefs; this area comprises continental slope and deep oceanic waters and abyssal plains.

Ecological and biological processes (Criterion ii now Criterion IX): The globally significant diversity of reef and island morphologies reflects ongoing geomorphic, oceanographic and environmental processes. The complex cross-shelf, longshore and vertical connectivity is influenced by dynamic oceanic currents and ongoing ecological processes such as upwellings, larval dispersal and migration.

Ongoing erosion and accretion of coral reefs, sand banks and coral cays combine with similar processes along the coast and around continental islands. Extensive beds of *Halimeda* algae represent active calcification and accretion over thousands of years.

Biologically the unique diversity of the GBR reflects the maturity of an ecosystem that has evolved over millennia; evidence exists for the evolution of hard corals and other fauna. Globally significant marine faunal groups include over 4,000 species of molluscs, over 1,500 species of fish, plus a great diversity of sponges, anemones, marine worms, crustaceans, and many others. The establishment of vegetation on the cays and continental islands exemplifies the important role of birds, such as the Pied Imperial Pigeon, in processes such as seed dispersal and plant colonisation.

Human interaction with the natural environment is illustrated by strong ongoing links between Aboriginal and Torres Strait Islanders and their sea-country, and includes numerous shell deposits (middens) and fish traps, plus the application of story places and marine totems.

Habitats for conservation of biodiversity (Criterion iv now Criterion X): The enormous size and diversity of the GBR means it is one of the richest and most complex natural ecosystems on earth, and one of the most significant for biodiversity conservation. The amazing diversity supports tens of thousands of marine and terrestrial species, many of which are of global conservation significance.

As the world's most complex expanse of coral reefs, the reefs contain some 400 species of corals in 60 genera. There are also large ecologically important inter-reefal areas. The shallower marine areas support half the world's diversity of mangroves and many seagrass species. The waters also provide major feeding grounds for one of the world's largest populations of the threatened dugong. At least 30 species of whales and dolphins occur here, and it is a significant area for humpback whale calving.

Six of the world's seven species of marine turtle occur in the GBR. As well as the world's largest green turtle breeding site at Raine Island, the GBR also includes many regionally important marine turtle rookeries.

Some 242 species of birds have been recorded in the GBR. Twenty-two seabird species breed on cays and some continental islands, and some of these breeding sites are globally significant; other seabird species also utilize the area. The continental islands support thousands of plant species, while the coral cays also have their own distinct flora and fauna.

Integrity: The ecological integrity of the GBR is enhanced by the unparalleled size and current good state of conservation across the property. At the time of inscription it was felt that to include virtually the entire Great Barrier Reef within the property was the only way to ensure the integrity of the coral reef ecosystems in all their diversity.

A number of natural pressures occur, including cyclones, crown-of-thorns starfish outbreaks, and sudden large influxes of freshwater from extreme weather events. As well there is a range of human uses such as tourism, shipping and coastal developments including ports. There are also some disturbances facing the GBR that are legacies of past actions prior to the inscription of the property on the World Heritage list.

At the scale of the GBR ecosystem, most habitats or species groups have the capacity to recover from disturbance or withstand ongoing pressures. The property is largely intact and includes the fullest possible representation of marine ecological, physical and chemical processes from the coast to the deep abyssal waters enabling the key interdependent elements to exist in their natural relationships.

Some of the key ecological, physical and chemical processes that are essential for the long-term conservation of the marine and island ecosystems and their associated biodiversity occur outside the boundaries of the property and thus effective conservation programs are essential across the adjoining catchments, marine and coastal zones.

Protection and management requirements: The GBR covers approximately 348,000 square kilometres. Most of the property lies within the GBR Marine Park: at 344,400 square kilometres, this Federal Marine Park comprises approximately 99% of the property. The GBR Marine Park's legal jurisdiction ends at low water mark along the mainland (with the exception of port areas) and around islands (with the exception of 70 Commonwealth managed islands which are part of the Marine Park). In addition the GBR also includes over 900 islands within the jurisdiction of Queensland, about half of which are declared as 'national parks', and the internal waters of Queensland that occur within the World Heritage boundary (including a number of long-established port areas).

The World Heritage property is and has always been managed as a multiple-use area. Uses include a range of commercial and recreational activities. The management of such a large and iconic world heritage property is made more complex due to the overlapping State and Federal jurisdictions. The Great Barrier Reef Marine Park Authority, an independent Australian Government agency, is responsible for protection and management of the GBR Marine Park. The Great Barrier Reef Marine Park Act 1975 was amended in 2007 and 2008, and now provides for "the long term protection and conservation of the Great Barrier Reef Region" with specific mention of meeting "... Australia's responsibilities under the World Heritage Convention."

Queensland is responsible for management of the Great Barrier Reef Coast Marine Park, established under the Marine Parks Act 2004 (Qld). This is contiguous with the GBR Marine Park and covers the area between low and high water marks and many of the waters within the jurisdictional limits of Queensland. Queensland is also responsible for management of most of the islands.

The overlapping jurisdictional arrangements mean that the importance of complementary legislation and complementary management of islands and the surrounding waters is well recognised by both governments. Strong cooperative partnerships and formal agreements exist between the Australian Government and the Queensland Government. In addition, strong relationships have been built between governments and commercial and recreational industries, research institutions and universities. Collectively this provides a comprehensive management influence over a much wider context than just the marine areas and islands.

Development and land use activities in coastal and water catchments adjacent to the property also have a fundamental and critical influence on the values within the property. The Queensland Government is responsible for natural resource management and land use planning for the islands, coast and hinterland adjacent to the GBR. Other Queensland and Federal legislation also protects the property's Outstanding Universal Value addressing such matters as water quality, shipping management, sea dumping, fisheries management and environmental protection.

The Federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) provides an overarching mechanism for protecting the World Heritage values from inappropriate development, including actions taken inside or outside which could impact on its heritage values. This requires any development proposals to undergo rigorous environmental impact assessment processes, often including public consultation, after which the Federal Minister may decide, to approve, reject or approve under conditions designed to mitigate any significant impacts. A recent amendment to the EPBC Act makes the GBR Marine Park an additional 'trigger' for a matter of National Environmental Significance which provides additional protection for the values within the GBR.

The GBR Marine Park and the adjoining GBR Coast Marine Park are zoned to allow for a wide range of reasonable uses while ensuring overall protection, with conservation being the primary aim. The zoning spectrum provides for increasing levels of protection for the 'core conservation areas' which comprise the 115,000 square kilometres of 'no-take' and 'no-entry' zones within the GBR.

While the Zoning Plan is the 'cornerstone' of management and provides a spatial basis for determining where many activities can occur, zoning is only one of many spatial management tools

and policies applied to collectively protect the GBR. Some activities are better managed using other spatial and temporal management tools like Plans of Management, Special Management Areas, Agreements with Traditional Owners and permits (often tied to specific zones or smaller areas within zones, but providing a detailed level of management not possible by zoning alone). These statutory instruments also protect the Outstanding Universal Value of the property.

Many Aboriginal and Torres Strait Island peoples undertake traditional use of marine resource activities to provide traditional food, practice their living maritime culture, and to educate younger generations about traditional and cultural rules and protocols. In the GBR these activities are managed under both Federal and Queensland legislation and policies including Traditional Use of Marine Resource Agreements (TUMRAs) and Indigenous Land Use Agreements (ILUAs). These currently cover some 30 per cent of the GBR inshore area, and support Traditional Owners to maintain cultural connections with their sea country.

Similarly non-statutory tools like site management and Industry Codes of Practice contribute to the protection of World Heritage values. Some spatial management tools are not permanently in place nor appear as part of the zoning, yet achieve effective protection for elements of biodiversity (e.g. the temporal closures that are legislated across the GBR prohibit all reef fishing during specific moon phases when reef fish are spawning).

Other key initiatives providing increased protection for the GBR include the comprehensive Great Barrier Reef Outlook Report, (and its resulting 5-yearly reporting process); the Reef Water Quality Protection Plan; the GBR Climate Change Action Plan; and the Reef Guardians Stewardship Programs which involve building relationships and working closely with those who use and rely on the GBR or its catchment for their recreation or their business.

The 2009 Outlook Report identified the long-term challenges facing the GBR; these are dominated by climate change over the next few decades. The extent and persistence of damage to the GBR ecosystem will depend to a large degree on the amount of change in the world's climate and on the resilience of the GBR ecosystem to such change. This report also identified continued declining water quality from land-based sources, loss of coastal habitats from coastal development, and some impacts from fishing, illegal fishing and poaching as the other priority issues requiring management attention for the long-term protection of the GBR.

Emerging issues since the 2009 Outlook Report include proposed port expansions, increases in shipping activity, coastal development and intensification and changes in land use within the GBR catchment; population growth; the impacts from marine debris; illegal activities; and extreme weather events including floods and cyclones.

Further building the resilience of the GBR by improving water quality, reducing the loss of coastal habitats and increasing knowledge about fishing and its effects and encouraging modified practices, will give the GBR its best chance of adapting to and recovering from the threats ahead, including the impacts of a changing climate.

Appendix 4

Assessment of Management Effectiveness Terms of Reference

TERMS OF REFERENCE

ASSESSMENT OF MANAGEMENT EFFECTIVENESS BY INDEPENDENT EXPERTS FOR THE GREAT BARRIER REEF WORLD HERITAGE AREA STRATEGIC ASSESSMENT

1. BACKGROUND

The Australian and Queensland governments are working together to undertake a comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone. The comprehensive strategic assessment will help identify, plan for and manage existing and emerging risks so that the unique values of the Great Barrier Reef are protected and managed.

There are two components to the comprehensive strategic assessment - a marine component and a coastal component. The Great Barrier Reef Marine Park Authority (the Authority) will lead the marine component involving a strategic assessment of the Great Barrier Reef Region (the Strategic Assessment). The Queensland Government will lead the coastal component involving a strategic assessment of the Great Barrier Reef Coastal Zone.

2. PURPOSE

The Strategic Assessment Terms of Reference (SA TOR) sets out the requirements for the Authority in preparing the Strategic Assessment Report and Program Report for the marine component. The GBRMPA Strategic Assessment's key objectives are:

i. **Identifying and describing values to be protected.** The first step in the assessment is to identify values that underpin matters of national environmental significance in the Great Barrier Reef Region. Values will be described and information gaps identified.

ii. **Identifying and analysing threats and pressures to the values.** Threats and pressures impacting on values identified above will be described. It is important to understand how different threats and pressures impact on values in order to assess the effectiveness of management. Pressures may include climate change, extreme weather, and coastal development.

iii. **Assessing management effectiveness**. The assessment will examine how the Authority's management arrangements protect values. It will look at how impacts are avoided, mitigated, offset and/or adaptively managed across the life of the activity. It will look monitoring, compliance and stewardship programs in addition to environmental impact assessment and planning tools. It is proposed that particular cases be used as examples to examine management effectiveness, such as looking closely at management of a particular region or species.

iv. **Recommending changes to management arrangements**. Recommendations for changes to management arrangements will be made based on the above assessment.

The Strategic Assessment requires the management effectiveness of the current Program to be described and assessed (sections 4.1.1 - 4.1.2 of the SA TOR). The purpose of the present Terms of Reference (TOR) is to set out the requirements for the independent review of management effectiveness of the Authority's current Program[1] against the SA TOR to help inform what improvements to management arrangements are needed for the Program Report.

[1] The word 'Program' is used throughout the Terms of Reference. In simple terms it means those management arrangements ('policy, plan or program') under the jurisdiction of the Authority. Management arrangements include, but are not limited to, those described in section 4.1.2 of the GBRWHA Terms of Reference.

3. SCOPE

The strategic assessment area relevant to this TOR is the Great Barrier Reef Region which includes the Great Barrier Reef Marine Park (including 70 Commonwealth Islands) and the 13 Ports in 12 exclusion areas. It does not include Internal Waters of Queensland or the 980 Queensland Islands within the Great Barrier Reef World Heritage Area. However, the management Program of the Great Barrier Reef Marine Park Authority applies to the Great Barrier Reef Marine Park and to matters that relate to the Marine Park, namely:

- the use or management of an area which would or might affect the Marine Park; and
- the use of a place outside the Marine Park for a purpose relating to the Marine Park.

Therefore, the management arrangements of the Authority directly address activities that occur in the Marine Park itself and seek to influence activities outside the Marine Park that are affecting or may affect the Marine Park. In addition, under Section 66(2)(e) of the Regulations, the Authority may regulate or prohibit acts, whether in the Marine Park or elsewhere, that may pollute water in a manner harmful to animals and plants in the Marine Park.

Therefore the scope of this independent assessment should primarily concentrate on management activities within the Authority's jurisdiction within the Great Barrier Reef Region, joint management arrangements with Queensland (e.g. joint Marine Park permitting and joint compliance and enforcement through the Field Management Program) where they exist, and any activities that occur outside the Great Barrier Reef Region that are affecting or may affect the Marine Park.

A key component of the Strategic Assessment is stakeholder engagement. An Engagement Strategy has been developed (Attachment B) and should be taken into consideration when determining approaches for stakeholder engagement as part of the independent review of management effectiveness.

4. CONTEXT

The TOR for the review must be considered in the context of:

i. background information provided above

ii. the approved Great Barrier Reef Region Strategic Assessment Terms of Reference (Attachment A)

iii. the methodology used to assess management effectiveness as part of the Outlook Report 2009 (refer Hockings and Gilligan (2009)[2])

iv. the Strategic Assessment – Great Barrier Reef Stakeholder Engagement Plan (Attachment B)

v. timeframes for delivery of the Strategic Assessment and Program report.

5. PROJECT DETAILS

5.1 Project Title

"Great Barrier Reef Region Strategic Assessment - Independent Review of Management Effectiveness"

5.2 Duration of Project

Start Date: "Insert the Project Start Date"

End Date: 31 May 2013

[2] Hockings, M. & Gilligan, B. 2009 Assessment of management effectiveness for the 2009 Great Barrier Reef Outlook Report: report to the Great Barrier Reef Marine Park Authority. Great Barrier Reef Marine Park Authority, Townsville, Australia.

5.3 Proposed Audience

The primary audience for the Management Effectiveness Report is the Government (both Commonwealth and State), the Australian community and the international community (e.g. The World Heritage Committee).

6. PROJECT OUTCOMES

6.1 Provide a comprehensive independent review of the effectiveness of the Authority's current Program to:

a) Identify the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, and determine their current condition and trend, including spatial and non-spatial approaches.

b) Identify and analyse direct, indirect, consequential and cumulative impacts on relevant matters of national environmental significance, including the methods used to determine these types of impacts.

c) Consider environmental, social, cultural and economic issues in its decision-making processes.

d) Avoid, mitigate, offset and adaptively manage impacts from activities.

e) Address uncertainty and risk.

f) Provide certainty regarding where uses may occur, the type of activities allowed, conditions under which activities may proceed and circumstances where impacts are likely to be unacceptable.

g) Halt and reverse any declines and enhance the condition of the relevant matters of national environmental significance, including mechanisms to deliver a 'net benefit' to the condition of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

h) Adapt to reasonable climate change scenarios.

i) Integrate with related local, Queensland and Australian government programs to protect and manage the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area.

j) Meet Australia's international responsibilities in relation to the environment and protection of world heritage.

k) Monitor, evaluate and report on the:

i. Condition and trends of the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area

ii. Impacts of activities, including the setting of targets to benchmark management.

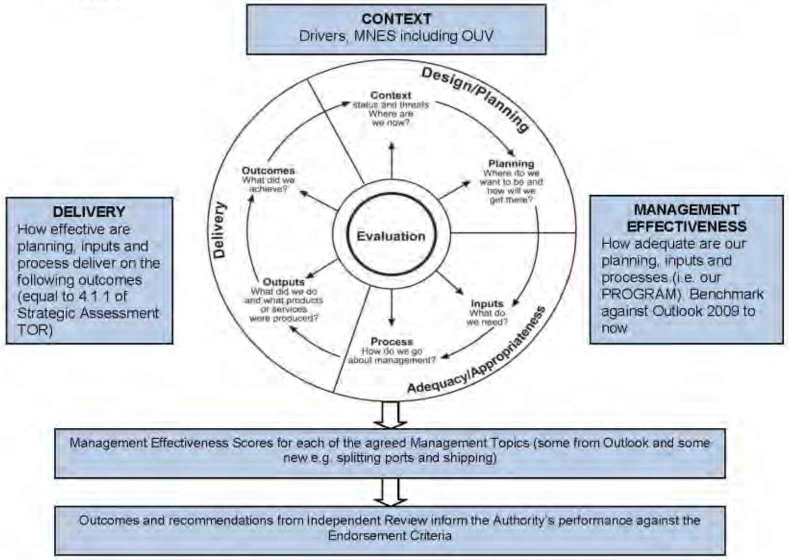
l) Assess in finer detail the effectiveness of the Program to protect and manage the relevant matters of national environmental significance, including the Outstanding Universal Value of the Great Barrier Reef World Heritage Area, and to guide improvements to the Program, in up to 10 Demonstration Cases.

6.2 In assessing the effectiveness of the Authority's Program, consideration must be given to:

a) Statutory instruments, including regulations, zoning plans, plans of management and permits.
b) Non-statutory mechanisms including policies, position statements and guidelines.

c) Partnership and collaborative arrangements with Queensland and other Australian government agencies.
d) Partnerships with Traditional Owners in the management of marine resources.
e) Partnership and stewardship programs, including education programs and engagement, with local governments, communities, Indigenous persons, business and industry.
f) Research and monitoring programs.
g) Compliance and enforcement programs.
h) Resourcing of the Program.

6.1 The independent review should follow the established framework for evaluating management effectiveness as specified in the Great Barrier Reef Outlook Report 2009. Each of the items listed in 6.1. are Desired Outcomes. The framework should consider how effective the Authority's Program is at achieving these desired outcomes in accordance with the framework below.



6.2 The independent review of management effectiveness must include engagement with relevant stakeholders to determine their views on management effectiveness of the current Program (listed in item 2.3 (b) of this TOR). Delivery mechanisms are to be determined by consultants. At a minimum, an online survey of relevant stakeholder's views on the effectiveness of the current management arrangements must be undertaken. The GBRMPA will provide a list of stakeholders and their contact details to the independent reviewer.

6.3 The review must provide findings on the following (as a minimum):

i. activities that are considered effectively managed

ii. gaps and deficiencies in management arrangements

iii. possible additional, improved or alternative arrangements that may be effective in achieving the objectives of the Strategic Assessment TOR.

7. PROVISION OF ASSESSMENT SERVICES

The service to be provided comprises a written report delivered as a consensus view of the Independent Experts, addressing the Project Outcomes and in accordance with the timeframes outlined in the Project Deliverables (see 8 below),

8. PROJECT DELIVERABLES (generally, to be finalized in contracts)

Appointment of Independent Reviewers	September 2012
Assessment methodology and stakeholder engagement strategy finalised	September 2012
Stakeholder Engagement Completed	October 2012
Draft Assessment Report delivered	December 2012
Final Assessment Report delivered	February 2013

Appendix 5

Traditional Owner and Stakeholder Engagement – Report on Workshops and Surveys

Australian Government
Great Barrier Reef
Marine Park Authority

Great Barrier Reef Region
Strategic Assessment

Great Barrier Reef Region
Strategic Assessment
Traditional Owner and Stakeholder Engagement – Report on Workshops and Surveys

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Background

The Australian and Queensland governments are working together to undertake a comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and the adjacent coastal zone. The goal is to create an agreed, long-term plan for sustainable development within the Great Barrier Reef Region that provides greater certainty for industry and decision making in the area, while ensuring the values of the World Heritage Area are protected into the future. The strategic assessment's key objectives are:

- **Identifying and describing values to be protected:** Values that underpin matters of national environmental significance in the Great Barrier Reef Region are identified and described, and information gaps are identified.
- **Identifying and analysing impacts on values:** It is important to understand how different activities impact on values in order to assess the effectiveness of management.
- **Assessing management effectiveness:** This relates to how management arrangements protect values by looking at how impacts are avoided, mitigated, offset and/or adaptively managed across the life of an activity. It assesses monitoring, compliance and stewardship programs as well as environmental impact assessment and planning tools.
- **Recommending changes to management arrangements:** Recommendations for changes to management arrangements will be made based on the above assessment.

The terms of reference for the strategic assessment state that in the preparation of the assessment, the Great Barrier Reef Marine Park Authority (the Authority) will:

> *Engage stakeholders and the community throughout the strategic assessment process using the Authority's network of advisory committees together with regional and issue-based meetings* and *use the best available information to undertake the strategic assessment, including scientific data, expert opinion, and Traditional Owner and community knowledge.*

This report provides an overview of the stakeholder and community engagement undertaken and the general outcomes, including how feedback has been incorporated into the strategic assessment. It does not include the public submissions for the draft terms of reference in May 2012, which is covered by a separate report. The outcomes of the public submissions for the Draft Strategic Assessment Report will also be covered by a separate report.

Approach to Stakeholder Engagement

Following the release of the strategic assessment's terms of reference in August 2012, a stakeholder engagement plan was developed to provide a structured approach for stakeholder and community input during development of the assessment. The approach is anchored in the following principle:

> *To work directly with the public throughout the process to ensure that public issues and concerns are consistently understood, considered and included as appropriate.*

Objectives

The stakeholder engagement plan's objectives highlight the value of incorporating stakeholder knowledge and perspectives from the beginning of the strategic assessment and throughout the process:

- to improve decision making by gathering a range of information, views and experiences from stakeholders as part of the strategic assessment process
- to provide a transparent framework for the development of a common understanding of the broad range of issues and to foster informed and engaged stakeholders and communities as part of the process
- to seek feedback from stakeholders on the potential impact of different approaches, acknowledging that there may not be consensus
- to provide a mechanism to better understand implementation issues that may need to be considered.

Staged engagement

The stakeholder engagement plan used the key requirements in the terms of reference to construct a two-stage process for seeking stakeholder input:

- Stage one to understand stakeholders' values of the Great Barrier Reef Region and the pressures and potential impacts on those values
- Stage two to investigate stakeholders' views of current management effectiveness and their aspirations for future management actions.

The components of the staged process (Figure 1) are outlined in further detail below. A list of background documents relating to the staged engagement process can be found at Appendix 1.

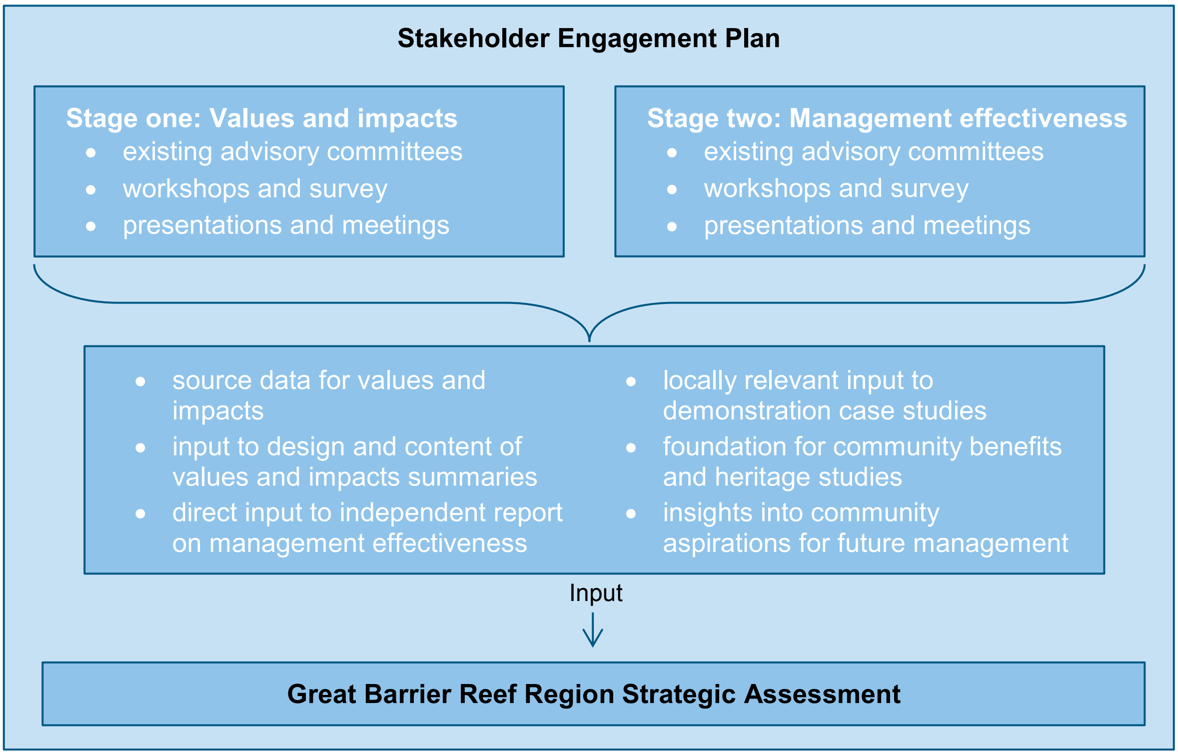

Figure 1 Stakeholder and community engagement process

Using existing advisory groups

The stakeholder engagement plan established a framework for targeted stakeholder engagement to ensure community views were captured, while meeting the timelines of the strategic assessment process. A key element was the use of existing expert and community advisory groups.

Reef Advisory Committees:

> The Authority's Reef Advisory Committees are competency-based committees comprising a cross-section of stakeholder interests with relevant expertise and experience. The four Reef Advisory Committees are: Indigenous, Catchment and Coastal, Tourism and Recreation and Ecosystem.
>
> The Reef Advisory Committees provided advice on the engagement process for the strategic assessment, have been kept informed on the progress of the strategic assessment, and have provided ongoing advice in areas relevant to their expertise.

Local Marine Advisory Committees:

> Local Marine Advisory Committees are voluntary, community-based committees established by the Authority to provide advice on management issues. There are 12 committees which cover the Great Barrier Reef Region: Cape York; Douglas; Cairns; Cassowary Coast; Hinchinbrook; Townsville; Bowen–Burdekin; Whitsundays; Mackay; Capricorn Coast; Gladstone and Burnett.
>
> The committees played an integral role in all stages of the stakeholder engagement process. The Local Marine Advisory Committee Chairs' meeting in October 2012, which was attended by two representatives from each region, provided feedback on proposed approaches as well as being a source of critical input for the strategic assessment.

Workshops and surveys

Opportunities were provided for further stakeholder input through a series of purpose-designed workshops and follow-up surveys. The aim of the workshops and surveys was to ensure a spectrum of stakeholder views was gathered which were representative of the wider community's views and opinions.

Individuals were invited to participate in the process through the Authority's stakeholder and community networks. This targeted consultation achieved representation from a diverse range of interests including Traditional Owners; local government; ports, shipping and related development sectors; mining and resource sectors; research organisations; tourism industry; commercial fishers; recreational users including fishers; natural resource managers; farmers; conservation groups and the broader community.

Stakeholder presentations and meetings

Authority staff undertook a significant number of presentations and discussions with stakeholders including sectoral interests and other government agencies.

Stage one: Values and impacts

The terms of reference (section 2.1) requires the strategic assessment to identify and describe the values that underpin matters of national environmental significance. These wide-ranging ecological, social, cultural and economic values may differ between industries, communities and individuals. Capturing these differences and mapping and describing values was an essential step early in the strategic assessment. Discussions with stakeholders were critical in order to understand the many different ways people interact with and benefit from the Great Barrier Reef. These ‘community benefits’ had not previously been comprehensively studied and recorded.

The terms of reference (section 3.1) also requires the assessment to describe and analyse the actual and potential impacts on those values. Stakeholder involvement is fundamental to understanding the potential impacts on their social, cultural and economic values.

Stage one workshops

A series of workshops were held to gather stakeholders’ views about values and impacts. A total of 290 people attended the workshops between August and October 2012:

- Three purpose-designed stakeholder workshops were held in Townsville, Cairns and Rockhampton in August 2012.
- The same process was used in 12 mini-workshops at the regular Local Marine Advisory Committee meetings in September 2012.
- Input from Traditional Owners was gathered at two specific workshops in Cairns and Rockhampton in September 2012.

The workshops consisted of overview presentations about the strategic assessment and opportunities for stakeholders to provide input through roundtable discussions. Participants from diverse backgrounds were seated at tables, together with Authority facilitators promoting the discussions, which led to a broad range of thinking and a shared awareness among participants of the complexity of the issues and wide range of community views.

Participants were asked three prescribed questions to obtain responses that would inform the strategic assessment:

- What are the natural elements of the Great Barrier Reef which are important to you, and why are they important?
- Based on the natural elements you identified, what are the factors that might impact on these?
- What are some of the key elements you would like to see in the Great Barrier Reef in 25 years?

This last aspirational question related to a requirement in the terms of reference (section 1.1) for an overview of management for the next 25 years. Participants were provided with a copy of the vision statement from the *25-year Strategic Plan for the Great Barrier Reef World Heritage Area* developed in 1994. They were asked if the statement was still relevant today, and were invited to reword it or write their own vision statement.

When thinking about values, participants were asked to consider the categories of social, economic, Indigenous cultural, heritage and aesthetic values. Participants were also asked to assess the condition and trends of these values, and to identify impacts on them. Their views were captured on individual sheets and collective butchers paper. The information was later entered into electronic databases which grouped the different responses into broad categories.

Stage one workshop analysis

A report on each of the stakeholder workshops described and compared responses to the three questions. The reports highlighted some notable differences in the findings from each workshop. For example, people from far north Queensland (that is, around Hinchinbrook and further north) saw connectivity, integrity and health of the whole Great Barrier Reef ecosystem as being essential to maintain into the future. While several individuals participating in the other workshops also saw these as very important, people living further south tended to focus more on impacts at specific sites, especially where human activity was obviously affecting the natural, social, heritage and cultural values of the site. Consistent values to emerge from all of the five large workshops are presented in Table 1.

Factors impacting on values that were mentioned consistently across all workshops were:

- coastal development including urban sprawl and increased industrialisation of the coast
- port development and associated increase in shipping
- mining
- climate change
- extreme weather events
- overfishing
- declining water quality.

Key elements that workshop participants would like to see in the Great Barrier Reef in 25 years fell into nine broad categories:

- healthy Reef
- protection
- sustainable use
- effective Reef management
- regulated coastal development
- stewardship
- communication and education
- research and monitoring
- consultation and engagement.

Table 1 Important natural elements and values consistently mentioned in workshops

Reef attribute	Reef elements	Values mentioned consistently in workshops
Specific sites/ habitats	Islands, beaches and coastlines; estuaries, deep water, bays, inlets and coral reefs	**Social:** supports recreation, for example walking, camping, snorkelling, diving, fishing, wildlife watching, relaxing, spending time with family and friends, education, health, lifestyle, stewardship **Aesthetic:** reefs and islands can be seen from space, place of natural wonder, spectacular pristine beauty, awesome, spiritual, majestic and calming, looked upon with pride, unique habitats **Natural:** obligation to have it there for our children **Cultural:** significance for Traditional Owners, for example locations of fish traps, sites for traditional use of marine resources and ceremonies; other cultural heritage values, for example locations of ship wrecks, lighthouses, sites of Cook's landings **Economic:** supports commercial fishing, shipping (deep water), tourism and recreation
	Wetlands	**Natural:** important breeding and feeding grounds for a variety of fish species, migratory birds and other animals **Cultural:** Indigenous medicine and food sources **Social:** supports recreation, for example wildlife watching, education **Economic:** supports commercial fishing and tourism
	Seagrass meadows	**Natural:** important breeding and feeding grounds for a variety of fish species, turtles, dugong and other animals **Social:** supports recreation, for example snorkelling, stewardship, education **Cultural:** supports dugong and turtle populations **Economic:** supports commercial fishing and tourism
Biodiversity	Fishes, coral, dolphins, crocodiles, birds, whales, dugong, sharks, rays, sea snakes, turtles	**Economic:** supports commercial fishing and tourism **Social:** supports recreation, for example snorkelling, diving, wildlife watching, education **Cultural:** supports traditional hunting of some species **Natural:** having such a large protected area for species to move through without risk **Aesthetic:** 'wow' factor
Processes	Connectivity	**Natural**: linking biophysical processes, supporting biodiversity **Cultural:** connection of people to land and sea through stories, also in terms of the way people moved from inland areas to the sea seasonally in search of food. Connectivity occurs from west to east (i.e. catchment to sea) and from north to south through travel/trade routes.
	Integrity	**Natural:** linking biophysical processes, supporting biodiversity **Cultural:** maintaining sites for traditional use of marine resources, ceremonies and stories
	Spawning (Coral/fish)	**Economic:** supports commercial fishing and tourism **Natural:** contributes to biodiversity
	Water quality	**Social:** supports human health; recreation, for example swimming, snorkelling, diving **Economic:** supports commercial fishing and tourism **Aesthetic:** water clarity; colour of water

Traditional Owner workshops

Aboriginal and Torres Strait Islander people are the Traditional Owners of the Great Barrier Reef Region. Today, there are approximately 70 Traditional Owner clan groups whose customary estates include sea country within the Great Barrier Reef Marine Park. Traditional Owners have a unique knowledge and understanding of many coastal, island and marine environments adjacent to and within the Marine Park.

Traditional Owners took a holistic approach to the questions about values and impacts, considering all elements of the land, sea and people together. A major issue for consideration mentioned by the Cairns workshop participants was the connectivity between Traditional Owners and sea country, and between land and sea. A major issue for consideration mentioned by the Rockhampton workshop participants was the capacity for Traditional Owners of the area to share traditional ecological knowledge and pass it on to the next generation.

Key impacts on values identified by Traditional Owners include:

- lack of recognition and support for Traditional Owners
- dispossession from country/ loss of access to traditional grounds
- loss of language and cultural knowledge leading to loss of cultural practices and management
- (lack of) capacity of Aboriginal rangers to enforce infringements
- unauthorised entry to sites of cultural significance
- coastal development
- vandalism — damage and graffiti
- marine debris and litter
- ships and boats cutting across storylines
- overfishing
- water quality
- extreme weather events
- lack of cultural knowledge-sharing between agencies (for example sacred sites).

Follow-up surveys

Workshop participants were invited to answer a short online survey to gain a deeper understanding about what is important to them and why. The survey was sent to people who had attended one of the workshops. Of the 290 workshop participants, 135 people (47 per cent) responded to the survey. Results give an indication of the relative importance that this group of people place on Great Barrier Reef values, threats and their aspirations.

The respondents were asked to rate different elements where *1 = not important* and *5 = extremely important.* Ecosystem health, coral reefs and the integrity of the whole Great Barrier Reef received the highest scores (see Figure 2). The most commonly chosen reason (that is, value) for why respondents considered elements to be important was *natural beauty*, followed closely by *scientific*; then *understanding and appreciation; health; and recreation and enjoyment.* Values were equally weighted and respondents could choose as many values as they wished for each element. So although *natural beauty* and *scientific* were the most commonly selected values, it does not necessarily mean that respondents thought they were the most important value. Rather, it means that many of the respondents attributed natural beauty and scientific values to most elements on the list.

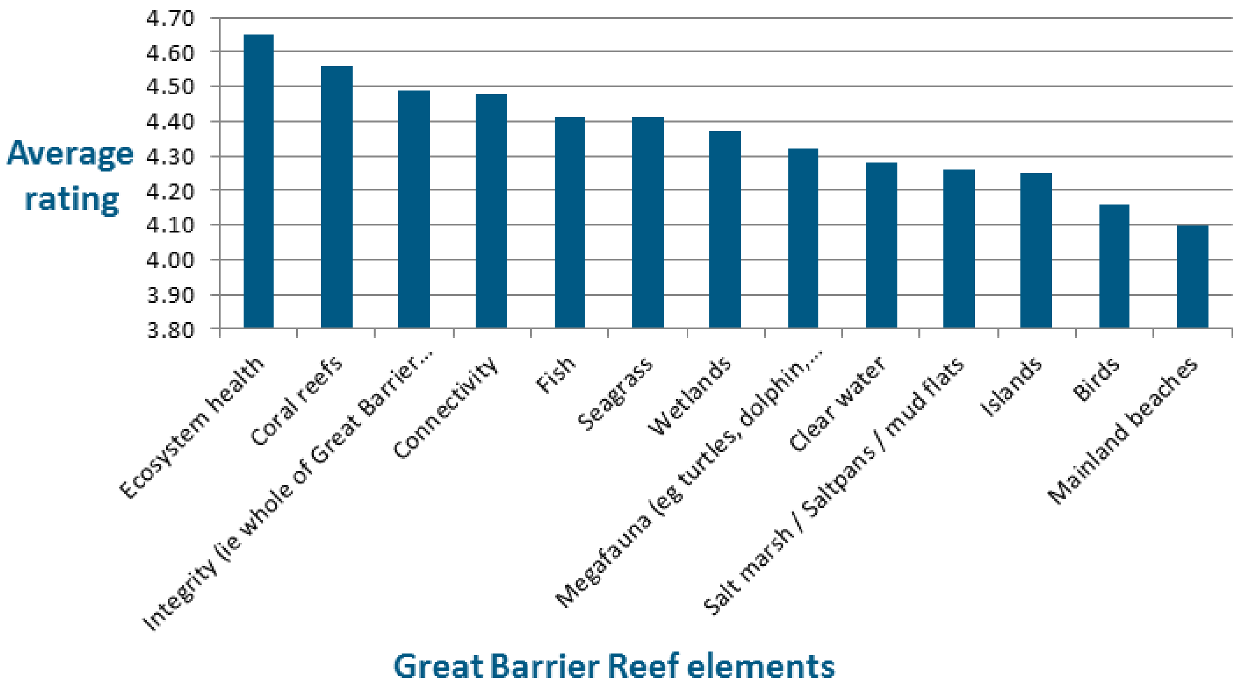

Figure 2 Importance of Great Barrier Reef elements according to survey respondents

Respondents were asked to rate a list of possible threats to the Great Barrier Reef. A total of 118 out of 135 people responded to this question (see Table 2). Water quality, climate change and extreme weather were seen as the most serious threats.

Fourteen respondents thought one key threat not listed was *urban and coastal development*. It was not included as a specific item because it is a multi-faceted factor which includes a range of human activities and associated infrastructure already listed (that is, shipping, ports, agriculture, aquaculture, fishing, recreation and tourism). Twelve respondents thought another threat related to management effectiveness including the adequacy of legislation, zoning and enforcement.

The most important 25-year aspiration for the Great Barrier Reef was *ecosystem health/biodiversity protection* as identified by 40 per cent of respondents. More than two-thirds of respondents rated it as their first or second most important aspiration. The other aspiration most commonly identified was *preservation for future generations*.

Table 2 Survey respondents rank top three threats to the Great Barrier Reef

Great Barrier Reef threats	Threat rating (number of responses) 1 = highest threat 3= third highest threat			Response rate (out of a total of 118)
	1	2	3	
Water quality	27	33	16	76 (64%)
Climate change	40	17	11	68 (58%)
Extreme weather (for example cyclones)	14	9	14	37 (31%)
Crown-of-thorns starfish	8	14	16	38 (32%)
Ports	8	15	19	42 (36%)
Shipping	7	8	17	32 (27%)
Agriculture	4	10	10	24 (20%)
Illegal fishing or poaching	3	5	5	13 (11%)
Commercial fishing	1	5	6	12 (10%)
Recreational fishing	2	0	2	4 (3%)
Aquaculture	1	0	1	2 (2%)
Tourism	1	2	1	4 (3%)
Recreation (excluding fishing)	2	0	0	2 (2%)

Stage one outcomes

The values and impacts information collected from the stakeholder workshops and surveys informed a number of different components of the strategic assessment process:

- The information provided valuable source data which was incorporated into the identification and analysis of values and impacts.
- The information provided valuable insights into community benefits — a requirement for strategic assessment which had not been previously comprehensively studied.
- The workshops and surveys developed a common understanding among stakeholders of the key issues, and ensured the Authority understood issues from the viewpoints of the wider community.
- The information established a base from which to move forward in assessing management effectiveness and potential management arrangements that may be required to address some of the major risks.
- The results were provided to external consultants undertaking independent studies as part of the strategic assessment, including management effectiveness and aesthetic values studies.
- The insights gained will also inform the development of the Outlook Report 2014 and a proposed update of the Authority's Heritage Strategy.

Stage two: Management effectiveness

The strategic assessment is being undertaken to evaluate and improve (where necessary) the effectiveness of the Authority's current management arrangements. To ensure an impartial and objective approach, three independent reviewers were engaged to independently assess the Authority's management effectiveness. Gathering the views of stakeholders was an important part of the reviewers' brief as it recognised that stakeholders have valuable knowledge and practical experience of the management issues and the tools used by the Authority.

Testing the methodology

The reviewers undertook an assessment based on the International Union for Conservation of Nature (IUCN) framework for assessing management effectiveness, also used for the *Great Barrier Reef Outlook Report 2009*. This methodology was presented at the annual meeting of Local Marine Advisory Committee Chairs in Townsville in October 2012. The presentation included an explanation of the approach and described the opportunity for stakeholders to submit their views through an online survey. Committee Chairs piloted the survey and contributed to its final design. Survey respondents could choose from a list of management issues and indicate the Authority's strengths and weaknesses in management of that issue, and then rate the effectiveness of each management tool on a four-point scale (effective, mostly effective, partially effective, not effective). They could also indicate if they had no opinion or believed the tool was not applicable to that issue.

The representatives formed discussion groups to test the survey instrument. Each table examined three of the following management topics, looking at strengths, weaknesses and rating management effectiveness:

- Biodiversity protection
- Climate change and extreme weather
- Coastal ecosystems
- Community benefits
- Defence activities
- Commercial fishing
- Recreational fishing
- Indigenous heritage
- Non-Indigenous heritage
- Marine-based tourism
- Ports
- Shipping
- Recreation (non-extractive)
- Research activities
- Water quality.

The tools assessed were:

- Act and Regulations
- Zoning Plan
- plans of management
- permits (including environmental impact assessment)
- Traditional Use of Marine Resources Agreements
- compliance (formal and informal)
- policy documents
- site infrastructure
- partnerships
- education and community awareness
- stewardship and best practice
- research and monitoring.

The contributions of Local Marine Advisory Committee representatives were recorded and their comments were used to improve the survey's content and presentation.

The external consultants distributed the survey electronically to members of Local Marine Advisory Committees, Reef Advisory Committees and interested participants of the regional workshops. Participants without access to the internet were contacted and invited to undertake the survey over the phone or in writing. Face-to-face interviews were undertaken with Traditional Owners to ensure their views were documented.

Survey results

A total of 95 people made 172 assessments of the 15 management topics. For some management topics, the number of people responding was quite low, making statistical analysis difficult. For instance, the management topics of non-Indigenous heritage, defence activities and climate change and extreme weather each received less than 10 assessments. Respondents may not have had an opinion on the topic or may have been unsure of the relevant management tools and arrangements. However, some general patterns of effectiveness were evident for most of the tools.

Surveys results show a perceived lack of effectiveness for most of the management tools, and the independent reviewers recommended the Authority investigate these views with its existing advisory committees. Only the Zoning Plan was considered to be effective or mostly effective by more than half of the respondents. Compliance and policy documents were considered to be the least effective tools, with fewer than one in three respondents considering them to be effective. Problems with compliance and enforcement of Regulations were also commonly cited as problematic in the qualitative comments of respondents. The other commonly cited issue limiting the effectiveness of management tools was the Authority's limited jurisdictional responsibility. Respondents thought many issues fell partly or largely under the responsibility of state and local governments, with a perceived lack of commitment at those levels to the protection of the Great Barrier Reef.

Traditional Owners expressed wide-ranging views, including the desire for the development of stronger partnerships and greater involvement in decision making and management. The need for education and communication with the wider community was also raised.

Demonstration case studies

Demonstration case studies were developed as part of the strategic assessment to provide more detailed snapshots of management effectiveness and provide recommendations on possible improvements.

The Local Marine Advisory Committee Chairs' meeting provided an opportunity for stakeholder input across a number of demonstration case studies, in particular the regionally-specific studies. Authority staff gave a presentation on the demonstration case studies at the meeting and explained the interactions of drivers, activities, values and management. For the purposes of the feedback sessions, representatives were grouped in regionally-specific tables together with Authority staff who facilitated and recorded dialogue. Committee representatives were requested to:

- provide advice on where management topics were of concern locally
- provide advice on how management arrangements could be improved locally
- exchange ideas on a range of proposed approaches to overcome challenges.

Tables were assigned four key management topics relevant to their region. Participants were asked to focus their discussion on these management topics, especially from a socio-economic perspective, and to address two key questions:

- What are the three or four key local pressures in your area and where are they occurring? Are there any other issues in your area and where are they happening?
- For the three or four key local pressures identified, what management arrangements are working in your area and what are not? Moving forward — what arrangements are needed? If there are no problems, is this because management arrangements are working or is it just luck?

At the end of the session, each group presented feedback which was tape-recorded and transcribed. The participants contributed detailed local knowledge including conflicts of use, new pressures and insights into management undertaken by other government agencies. Issues raised included the impacts from a growing number of fly-in fly-out miners who are moving to regional centres and becoming new recreational users on the Reef.

Stage two workshops

Stakeholders and community members who participated in the workshops held between August and October 2012 were invited to reconvene to provide further advice on elements of the strategic assessment. The workshops would also provide an opportunity to update participants on the progress of the strategic assessment.

The objectives of the stage two workshops were:

- to test key findings to date and gain insights on issues of community concern
- to identify any discrepancies between expert opinion and on-ground community knowledge which may require further review
- to ensure the final reports are accessible and easy to understand for stakeholders and the wider community.

A total of 105 stakeholders attended workshops in Cairns, Townsville and Rockhampton in December 2012. The workshops included representatives of Traditional Owner groups, with strong attendances in Cairns and Rockhampton in particular.

The workshops began with presentations by Authority staff who provided updates on the progress of the strategic assessment, including outcomes of the previous workshops and other stakeholder engagement which had been undertaken. The workshop broke into roundtable discussions and feedback sessions which were facilitated and recorded by Authority staff.

Participants were asked for input on three key components:

- the condition and trends for values of the Great Barrier Reef
- management effectiveness of the Authority
- future management actions to protect the Great Barrier Reef.

Condition and trends

The first feedback session focused on condition and trends. Authority staff explained the processes, data collection and mapping which had been undertaken to evaluate values and impacts. A list of 85 elements, including habitats, species, ecosystem processes, heritage and community benefits, had been developed, including using the information gathered in previous expert and stakeholder workshops. Each element had been graded in terms of its condition and trend, based on literature reviews, expert opinion and community knowledge.

Participants were asked to comment on the condition and trend in terms of:

- whether the approach was easy to understand
- whether the format was easy to understand
- their views on the gradings
- suggestions for improvements.

The information provided at the workshops had been summarised in a series of tables and for many participants it represented a large amount of information to absorb and evaluate in a short period of time. The following issues were consistently raised about the format and approach:

- improve and simplify the presentation of information
- clearly explain the methodology and categories
- make the grading parameters more consistent
- ensure the final reports can be used as management tools (for example, for Indigenous rangers).

Participants provided wide-ranging comments about the content of the tables, with many common concerns:

- the geographic scale is too broad to provide meaningful results of condition and trend
- highlight hotspots to avoid people assuming whole regions are in poor condition
- general summaries may be sensationalised by the media
- ensure transparency in the process used for scoring grades
- if confidence in the data is low, don't grade the element's condition and trend
- the positive trend of the community benefits was questioned.

Management effectiveness

External consultants led the second component of the workshop, where they provided participants with their preliminary assessment of the Authority's management effectiveness and asked for feedback. Each table was provided with up to three management topics which had been graded from 'ineffective' to 'very effective'. Participants were asked to re-evaluate the grades to provide a sense of whether the community agreed with the outcomes.

Participants generally supported the grades, however discussions consistently returned to the difficulty of grading the Authority on management topics which were outside its jurisdiction. Workshop participants raised the issue of confusing federal, state and local government jurisdictions as a barrier to effective management, and the need to overcome these differences in order to effectively manage the Great Barrier Reef.

Traditional Owners at the Cairns workshop raised concerns that the management tools focused on the restriction of take of turtle and dugong rather than high-level, cooperative management approaches which could be achieved through mechanisms such as Indigenous Land Use Agreements. Traditional Owners at the Rockhampton workshop said management should be more holistic and consider the connections of land and water, and that the impacts of development should be controlled.

Future management actions

The final session provided participants with an opportunity to consider the status and trends of values and current management practices, and to recommend future management actions which would help to protect those values. The responses were wide-ranging and showed the wealth of knowledge and insights of stakeholders and the community.

Many of the recommendations reflected earlier comments about management effectiveness:

- a whole of government approach to strategically plan for development, rather than react to proposals

- a tri-lateral agreement between all levels of government
- a seamless regulatory framework which recognises land and sea connections
- stronger partnerships and greater involvement in decision making and management by Traditional Owners
- streamlined application processes and quicker responses by the Authority
- increased compliance efforts
- continued focus on education and stewardship.

Stage two outcomes

The management effectiveness information collected during stage two from the Local Marine Advisory Committee Chair's meeting, demonstration cases, surveys and workshops fed directly into the strategic assessment report:

- stakeholder feedback informed and improved the design and presentation of the values and trends information, and led to a re-evaluation of some of the grades
- the survey results generally confirmed the independent consultants' findings on the Authority's management effectiveness and provided insights into management gaps and overlaps
- the workshops also provided an opportunity to update stakeholders on the progress of the assessment, including how their previous input had informed the process
- the workshops also gave insights into the community's aspirations for the future of the Reef and its management.

Summary

The stakeholder and community engagement undertaken during the strategic assessment provided the Authority with an opportunity to better understand how people value the Great Barrier Reef and their views on threats to those values. It provided valuable insights into how the community views management of the Great Barrier Reef, and how management could be improved.

One of the key successes has been involving stakeholders from the beginning of the process. They were invited to join the Authority in an inclusive process of learning more about the values, pressures and management issues facing the Great Barrier Reef Region. Their views were treated with respect and in return they shared a wealth of local information and knowledge for the strategic assessment.

The timeframes for such a complex and substantial assessment were tight, with less than four months to undertake consultation. Stakeholders were often inundated with multiple requests for information and feedback which had to be accommodated around their everyday work and life commitments. The Authority wishes to acknowledge the considerable contributions made by stakeholders and community members. Those contributions have enriched the process and significantly improved the outcome of the strategic assessment.

Appendix 1: Background documents

Figure 3 Background documents used in the preparation of the Stakeholder Engagement Report

Great Barrier Reef Region Strategic Assessment: Stakeholder engagement plan (GBRMPA, 2012)

Great Barrier Reef Region Strategic Assessment: Stakeholder and Community Workshops - Townsville workshop and outcomes (GBRMPA, 2012)

Great Barrier Reef Region Strategic Assessment: Stakeholder and Community Workshops - Cairns Traditional Owner workshop outcomes (GBRMPA, 2012)

Great Barrier Reef Region Strategic Assessment: Stakeholder and Community Workshops - Cairns workshop outcomes (GBRMPA, 2012)

Great Barrier Reef Region Strategic Assessment: Stakeholder and Community Workshops - Rockhampton Traditional Owner workshop outcomes (GBRMPA, 2012)

Great Barrier Reef Region Strategic Assessment: Stakeholder and Community Workshops - Rockhampton workshop a outcomes (GBRMPA, 2012)

Great Barrier Reef Region Strategic Assessment: Local Marine Advisory Committee outcomes (GBRMPA, 2012)

Stage one:
Values and impacts

Great Barrier Reef Region Strategic Assessment: Stakeholder and community workshops: General workshop report (GBRMPA, 2012)

Local Marine Advisory Committee Chairs' Meeting October 2012 – Meeting Notes (GBRMPA, 2012)

Input into demonstration case studies and management effectiveness assessment

Assessment of management effectiveness for the Strategic Assessment of the Great Barrier Reef Region (Hockings, Gilligan and Leverington, 2012)

Stage two:
Management effectiveness

Great Barrier Reef Region Strategic Assessment: Stakeholder and community workshops: General workshop report addendum: December 2012 Workshops (GBRMPA, 2012)

Great Barrier Reef Region Strategic Assessment

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