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AUSTRALIA'S GREAT BARRIER REEF – PROTECTION, THREATS, VALUE AND TOURISM USE

Bruce Prideaux and Anja Pabel

Introduction

The Great Barrier Reef (GBR) has a long history of attracting travellers but a much shorter history as a mass tourism destination. The following passage written by Dr A Rattray Royal Navy in 1869 provides an insight into how early travellers to the GBR described what they experienced:

When opportunity offers, a trip by boat to the outer edge of the reef well repays the trouble. Mollusca, crustaceans, and especially fishes, team, whose splendid colouring, intensified by the tropical sun and beautiful transparent waters, rivals that of the ledges and grottoes of many-hued coral amidst which they sport, forming a fairy-like scene, surpassing all that the imagination can conceive.

A more contemporary view drawn from Trip Advisors' Viator tour booking site for the GBR (<https://www.viator.com/Cairns-and-the-Tropical-North-attractions/Great-Barrier-Reef/d754-a1443>) paints a somewhat grimmer picture:

Encompassing roughly 3,000 individual reefs and dotted with almost 900 islands and coral cays (small sandy isles), Australia's Great Barrier Reef is one of the world's most unforgettable natural treasures. Snorkelers and certified divers often place the reef at the top of their bucket lists due to the unparalleled array of marine life in its underwater world, ranging from thousands of different varieties of fish, birds, and clams to hundreds of types of birds, seaweed, and turtles. *And with experts expecting much of this diversity to dwindle in the next decade, there's never been a better reason to plan a visit to this natural wonder* (italics inserted by author).

Reports about global scale coral bleaching over the period 2014–2017 highlight the vulnerability of many coral reef destinations to climate change in both the short and long term. In Australia, the gravity of the situation is summed up in a report (Great Barrier Reef Marine Park Authority [GBRMPA], 2017a) on the impact of the 2016 coral bleaching event on the GBR which stated that “bleaching events are expected to increase in frequency and severity as a result of climate change” (p. 25). This observation raises concern about the long-term sustainability of coral reefs as a major destination pull factor in regions where coral reefs constitute an important part of destination image. The preceding warning from Trip Advisor's Viator booking site about the future of the reef should generate considerable concern in destinations that rely on the GBR as one of their main destination pull factors. This chapter focuses on Australia's GBR and examines how the coral reef system is protected, the threats it faces and the importance of this system to the tourism industry it supports.

The GBR is widely regarded as one of Australia's best known tourism icons and is almost always included in international marketing campaigns undertaken by government funded tourism promotion bodies as well as the private sector. As a result of this marketing effort, about 10% of international visitors find their way to the GBR, making it one of the most important non-metropolitan tourism attractions in the nation. In 2016, 2.4 million domestic and international tourists visited the GBR (GBRMPA, 2017b). From a tourism dispersal perspective, the GBR plays a major role in attracting visitors to regional destinations. However, the GBR faces a number of problems that may affect its ongoing capacity to attract tourists to regional Queensland. These problems include climate change (see Chapter 6 in this volume for a discussion of the impact of coral bleaching on tourism destinations), declining water quality, coral diseases, coastal development, crown-of-thorns starfish (COTS) infestations and natural events such as cyclones. This chapter includes a brief discussion on key biophysical characteristics of the GBR, how it is protected and the threats that it faces from both natural and anthropogenic causes.

Figure 4.1 illustrates the matrix of boundaries that are used to describe the Great Barrier Reef Marine Park (GBRMP) and its marine subregions, and the mainland Natural Resource Management (NRM) regions that are discussed in this chapter. The GBRMP has four management areas, as illustrated in Figure 4.1. The adjacent coast region is divided into six NRM catchment regions (Burdekin, Burnett–Mary, Cape York, Fitzroy, Mackay–Whitsunday and Wet Tropics). The major coral reef destinations in the GBR and catchment region are Port Douglas, Cairns and the Whitsundays. The remaining towns and cities have limited involvement in coral reef tourism but many offer a large range of non-coral reef tourism related activities.

Biophysical characteristics

The GBR is the world's largest coral reef system, extending over 2,300 kilometres from north to south and includes a small area that extends beyond Australian territorial waters into Papua New Guinea. Most of the GBR is located within the

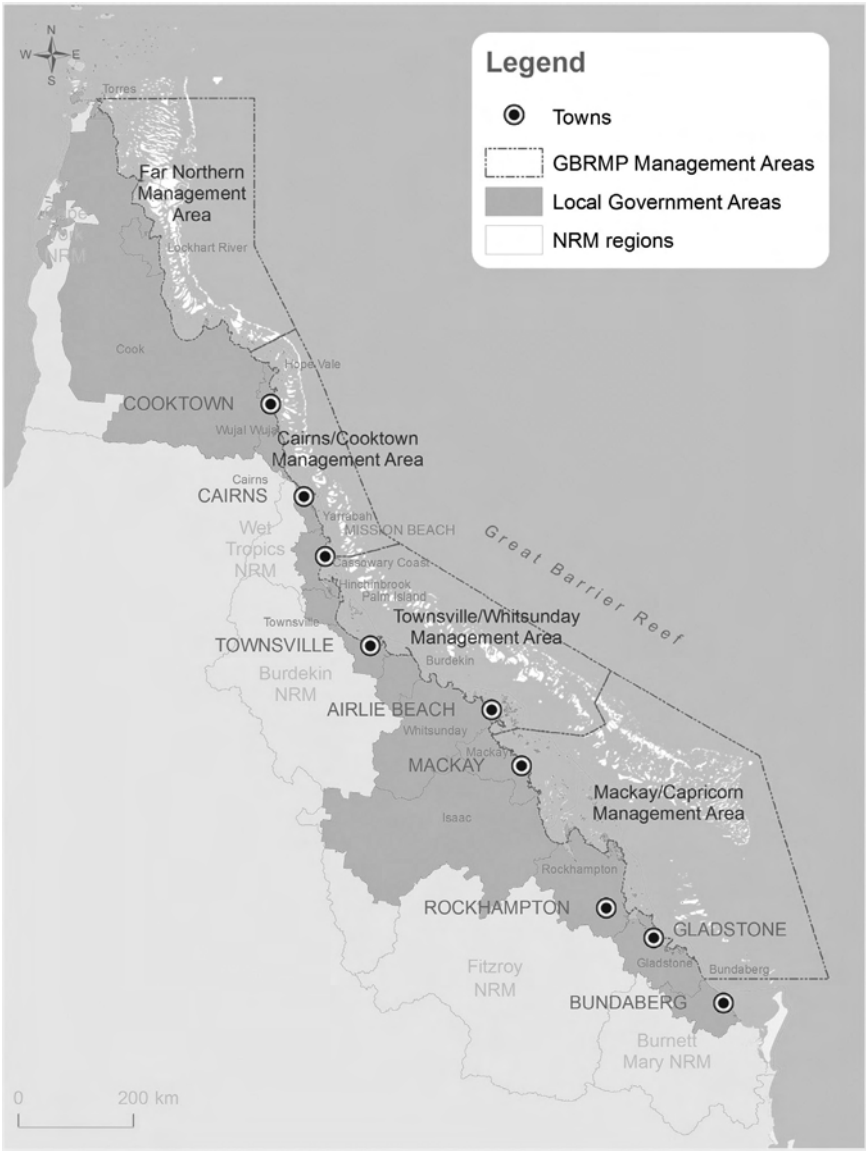


FIGURE 4.1 Great Barrier Reef Marine Park sections and NRM regions

Source: Marshall et al. (2014).

boundaries of the GBRMP, which is managed by the GBRMPA. Coral comprises about 7% of the GBRMP's total area, with the remainder comprised of the continental slope, seagrass beds, mangrove forests, inter-reefal areas and the GBR lagoon. The GBR includes over 2,900 individual reefs, 600 continental

islands, 300 coral cays and about 150 inshore mangrove islands covering an area of approximately 344,400 square kilometres (GBRMPA, 2018a).

The geological history of the eastern Australian seaboard indicates that after the separation of Australia from Gondwanaland, eastern Australia experienced a period of tectonic uplift and associated volcanic activity that culminated in the creation of the Coral Sea Basin (Queensland Museum, 2013). As the Australian continent drifted north driven by plate tectonics, the area where the GBR is now located drifted north into the warmer oceans of the tropics creating the conditions that led to the formation of the region's first coral reef systems. The extent of the reef system waxed and waned as the earth's climate has oscillated between glacial periods, rising and falling sea levels, the impact of erosion of the Great Dividing Range and Australia's continued drift northwards. Over the last 500,000 years there have been 17 cycles of sea level oscillations and sea levels have been closest to current levels five times during this period, the last being about 120,000 years ago (Queensland Museum, 2013).

Between 20,000 and 6,000 years ago the sea level rose by 120 metres, submerging extensive areas of the adjacent coastal plain and creating a large number of continental islands, the best examples of which are Hinchinbrook Island and the islands of the Whitsundays. Other submerged areas provided platforms for cays and individual reefs. The age of the reef in its current form is estimated to be about 6,000 to 8,000 years old, paralleling the end of post-glacial ocean level rises (Queensland Museum, 2013). In the most recent period of reef development, coral reefs built on limestone platforms that were part of earlier coral reef systems (Hopley et al., 2007) and created the GBR lagoon that lies between the inner and outer reef systems. The outer reef lies on the edge of the continental shelf while the inner lagoon has much shallower waters that support high levels of marine biodiversity.

The northern section of the GBR features numerous deltaic and ribbon reefs that are generally located quite close to the coast. There are no atolls in this part of the reef system. The southern part of the GBR has a large number of continental islands such as those found in the Whitsundays with many of the islands surrounded by fringing reefs. Other types of reef systems found on the GBR include crescentic reefs, which are quite common in the northern end of the GBR marine park, and plana reefs found in the northern section near Cape York Peninsula, Cairns and Princess Charlotte Bay.

The GBR supports a wide diversity of terrestrial and marine habitats containing many endemic, vulnerable or endangered species (Queensland Museum, 2013). While corals and marine animals are the most commonly recognised GBR species, the reef system also supports a wide range of terrestrial flora and fauna, including mangrove forests, seagrass meadows and rainforests as well as a range of small marsupials, birds and crocodiles. Ongoing research continues to locate and name new species of corals, fish and even a new species of dolphin (Australian snubfin dolphin first described in 2005) hence the following discussion often uses terms such as "estimated" or "about" to describe the number of species.

The system has the world's richest diversity of coral species, including an estimated 600 species of soft and hard corals (GBRMPA, 2018a). Most corals in the inner reef spawn during the week after the first full moon in October triggered by rising sea temperatures as the region moves into summer. Corals in the outer reef have a different pattern of spawning, which usually occurs in late November or early December. The GBR also has an estimated 3,000 varieties of molluscs ranging from giant clams to nudibranchs (a soft-bodied marine gastropod that often exhibits an extraordinary variety of colours and shapes), 500 species of worms, 100 species of jelly fish (GBRMPA, 2018a) and 330 species of ascidians (sea squirts, a sac like invertebrate filter feeder). Other marine creatures that demonstrate the diversity of the GBR include about 500 species of bryozoans (an invertebrate filter feeder typically up to 0.5 millimetres in length) and 630 species of echinoderms (star fish and sea urchins) (GBRMPA, 2018b).

Marine animals are also abundant in the GBR and include six of the world's seven known species of sea turtles, 30 species of whales, dugongs, dolphins and porpoises, 133 varieties of sharks and rays and 14 breeding species of sea snakes (GBRMPA, 2018b). From a tourism perspective, whales and dolphins, sharks and rays, marine turtles and large fish are the most popular of the GBR's marine animals (Farr et al., 2014). Whales, including the humpback and dwarf minke, migrate to the warmer winter waters of the GBR to give birth before returning to the Antarctic during the summer. The reef is an important site for turtle hatcheries, with a number of turtle hatcheries such as Mon Repos being popular with tourists. Turtle species include the green sea turtle, hawksbill turtle, the Olive Ridley turtle, loggerhead turtle, leatherback sea turtle and the flatback turtle. Although protected in the GBRMP, many of these turtle species travel widely throughout the Pacific and Indian Oceans and many are in decline because of hunting, ocean pollution and commercial harvesting. The Olive Ridley turtle is an example of a turtle species in decline because of disturbances to its traditional hatchery areas and commercial harvesting. The Olive Ridley is classified as threatened by the International Union for Conservation of Nature [IUCN] (2012).

Fish life is particularly abundant with over 1,624 recorded species, including 1,400 reef species found in the GBR system (GBRMPA, 2018b). Several of these species, including clown fish and sharks, have attained iconic status as a result of featuring in Hollywood movies such as *Finding Nemo*. Other marine animals present in the GBR region include about 125 species of stingrays, sharks and skates (Queensland Museum, 2013).

The region also features large seagrass meadows, fringing mangrove forests and salt marshes. These areas are important hatcheries for many species of fish. The region's seagrass meadows sustain large but possibly declining populations of dugongs. Coastal development, particularly in areas not protected by the GBR marine park or terrestrial parks, has reduced the size of the region's mangrove forests while run-off from rivers and in some areas dredging for shipping channels has adversely affected many seagrass meadows. The region's mangrove forests also provide habits for saltwater crocodiles.

A wide variety of birds, both endemic and migrating, have been observed in the GBR region, including 215 species that visit to nest or roost on the islands (GBRMPA, 2018b). The GBRMP also supports a wide range of plant life on the region's islands. Of the region's approximately 2,000 known species of vascular plants, the most diverse are found in the tropical forests of the Whitsunday Islands (Turner & Batianoff, 2007).

Protection

The ecological significance of the GBR is recognised by the Australian Federal Government through the Great Barrier Reef Marine Park Act 1975. The Act also established the GBRMPA to manage the GBRMP. In the four decades since the gazetting of the Great Barrier Reef Marine Park Act 1975, enormous resources have been allocated by both the Federal and Queensland state governments for the management and protection of the GBR. In 1981, the GBR was proclaimed as a World Heritage Site, an action that firmly established the GBR as a world scale tourism attraction. The proclamation of World Heritage Area status also alerted government to the need to invest in the science needed to understand the complexities of the GBR ecosystem.

The role of the GBRMPA is to manage the park. The Authority has developed a range of policy instruments and agreements to manage the park, including zoning plans, plans of management for specific areas of the GBRMP, agreements with Traditional Owners, partnerships, education, and issue of use permits for commercial tourism operators, compliance and monitoring. Funding for the GBRMPA is provided by the Australian Federal government and through a management charge levied on tourists who visit the GBR on commercial tourism vessels.

Every five years the GBRMPA publishes an outlook report which discusses a range of GBR related issues, including threats. The *2014 Outlook Report* (GBRMPA, 2014) nominated climate change, land-based run-off, coastal land-use change and residual impacts of commercial fishing as the most significant threats that will affect the future vitality of the GBR. Concerns identified in the *2014 Outlook Report* were subsequently addressed by the *Great Barrier Reef Water Quality Protection Plan (Reef 2050 Plan)* (Commonwealth of Australia, 2015), which also responded to concerns raised by the World Heritage committee about the long-term sustainability of the GBRs Outstanding Universal Values.

The *Great Barrier Reef Water Quality Protection Plan* (Commonwealth of Australia, 2015) generally referred to as the Reef 2050 plan was a major policy initiative designed to halt and then reverse the decline in the quality of the water entering the reef. Actions outlined include reducing nitrogen, pesticide and sediment loads. Other actions include building resilience and funding additional research. In the first decade of the plan, total spending is estimated to be AU\$2 billion. The plan was supported by a commitment from the Queensland state government and the Australian Federal government to invest AU\$375 million over five years to improve water quality. The overall aim of the plan was to ensure

“that by 2020 the quality of the water entering the reef from adjacent catchments has no detrimental impacts on the health and resilience of the Great Barrier Reef” (Commonwealth of Australia, 2015). The need for plans of this type are important to halt the continued decline of the GBR, which the *Great Barrier Reef Water Quality Protection Plan* acknowledged has resulted in a 50% reduction in coral cover over the 30 years to 2013.

Examples of other policies adopted by the GBRMPA include the *Biodiversity Conservation Strategy 2013* (GBRMPA, 2013) and the *Great Barrier Reef Climate Change and Adaption Strategy and Action Plan 2012–2017* (GBRMPA, 2012). The *Biodiversity Conservation Strategy 2013* was developed in response to threats posed to the GBR and concerns about declining biodiversity. The aim of the strategy is to provide a framework for biodiversity protection, conservation and management within the GBR. A key part of the plan is vulnerability assessments of at risk habitats including mangroves, seagrass meadows and the reef lagoon floor.

The *Great Barrier Reef Climate Change and Adaption Strategy and Action Plan 2012–2017* (GBRMPA, 2012) builds on earlier climate change action plans and outlines a series of initiatives to improve the resilience of the GBR. Actions supported as part of this plan include supporting GBR reliant industries to implement adaption strategies, funding research aimed at supporting effective management decisions in relation to climate change and, more generally, supporting the need for climate change adaptation.

The marine park is divided into a range of use zones, each of which have a specific set of rules governing permitted and prohibited activities. The zoning plan was introduced in 2004 and was based on four management areas (see Figure 4.1). The zoning plan also specified permitted activities in each zone. A key aim of the zoning plan was to protect the GBRs biodiversity. The zones are largely self-explanatory: general use, habitat protection, conservation park, marine national park, preservation, scientific research, buffer and Commonwealth Islands (Queensland Museum, 2013). An important aspect of the zoning plan is that it assists with regulation of activities such as fishing and shipping and prevents conflicting use. The zoning scheme has enabled the GBRs 30 protected reef bioregions and 40 protected non-reef bioregions to be protected under the Representative Areas Program that ensures that at least 20% (and often more) of each habitat is represented within a highly protected zone.

Human use

Traditional indigenous use of the GBR included a range of activities such as fishing, hunting, quarrying of stone, cultural activities and religious ceremonies. The Queensland Museum (2013) reported that Aboriginal people used watercrafts to voyage around their “sea country” at least 9,000 years ago. In the north, archaeological evidence (Queensland Museum, 2013) indicates that Torres Strait Islanders were also making extensive use of watercrafts to travel throughout the Torres Straits region. Chapter 16 provides a detailed discussion of indigenous use of coral reefs.

In the nineteenth century, European settlers moved into the region displacing many of the Aboriginal people living in the area at that time. The first wave of European settlers were mainly interested in developing natural resource-based export industries and included farmers, pastoralists, miners and timber cutters. These settlers were supported by coastal settlements that acted as ports for the exports generated by agriculture, timber and mining. Extractive industries continue to be an important part of the economies of these coastal settlements. During the latter decades of the twentieth century tourism emerged as a major industry in many of the GBR NRM catchment regions, aided by advances in transport technology including rail, roads and commercial aviation. Easy access to the GBR from Cairns, Port Douglas and the Whitsundays encouraged the tourism industry in those communities to develop a very reef focused tourism offer. In the southern section of the GBR NRM catchment region, the tourism industry has primarily focused on terrestrial tourism experiences. Other industries in the GBR hinterland that can impact on the reef include extensive coastal farming and grazing as well as large scale mining. Exports of farm output, as well as coal, occur through a large number of ports located in the GBR lagoon.

Threats

Although regarded as one of the world's most pristine reef systems, there is evidence that the GBR has been in decline for many decades (Daley et al., 2008). As Daley et al. (2008) note, there was little systematic scientific study of the reef prior to 1970 when systematic scientific monitoring began. Prior to that, the GBR had been affected by a number of activities, although the extent of impacts is difficult to gauge as available evidence is in qualitative rather than quantitative form. Factors leading to the post-European settlement decline of the GBR were identified by Daley et al. (2008) and others as coral mining, coral and shell collection, guano and phosphate mining, the introduction of exotic species and commercial harvesting of fish, turtles, bêche-de-mer and dugongs, coastal urban development, recreational fishing, sewerage discharge, run-off from farming, dredging and reclamation of wetlands and mangrove forests. Daley et al. (2008) make the point that reconstruction of ecological changes prior to the commencement of systematic scientific monitoring indicates that the GBR was already in decline as early as 1900. Pandolfi et al. (2003) noted that on a global scale most reefs were substantially degraded before 1900 through over-fishing and land-derived pollution. Pandolfi et al. (2003, p. 957) also observed that "maintenance of the status quo within partially protected areas such as the Great Barrier Reef is at best a weak goal for management, which should strive instead for restoring reefs that are clearly far from pristine." Considering the current level of decline and the future impact of even more extensive bleaching, Pandolfi et al. (2003) call seems a target that is becoming more difficult to achieve as each year passes.

As the following discussion highlights, many of the factors that have contributed to post-1970s coral decline continue to pose problems despite the best efforts of the

GBRMPA and the state and national governments. Climate change is of particular concern because of the impacts that will be generated by rising water temperature, sea level rise, coral bleaching and ocean acidification. Collectively, these impacts will continue to reduce biodiversity and cause significant change in the structure of reef ecosystems.

Threats to the GBR can be classed as anthropogenic and natural. Anthropogenic threats can be classed as localised or global, while natural threats can be grouped into biological and weather related. The creation of the GBRMPA has played a major role in reducing a wide range of non-nature based threats to the GBR, such as coral mining, over-fishing, oil drilling and coastal development including wet-land conversion and more recently agricultural run-off. Dealing with the impacts of climate change is more problematic because of the global nature of the threat and the need for mitigation on a global scale. In its response to climate change, the GBRMPA has implemented a number of strategies that have focused on adaptation. More recently, a number of non-governmental organisations (NGOs) and research organisations have begun looking at the potential for coral regeneration. Compared to other coral reef systems, including the Maldives and Thailand (see Chapter 10 in this volume), programmes supporting reef regeneration are in an early stage of development but may provide a useful method of regenerating damaged coral reefs in areas of high tourism use.

Natural threats to the GBR include a range of climatic factors such as wind storms and discharge from flooded coastal river systems. Wind storms such Tropical Cyclone Debbie, which struck the Whitsundays region in March 2017, may cause extensive damage to coral reef systems by increasing water turbidity and sediment load and through the pounding action of the large waves generated by cyclonic systems. Many of the Whitsunday's inner coral reefs were covered with a fine layer of silt which led to significant coral death. Coral disease can also have a significant impact on the health of reefs as can the presence of COTS. Although described as part of the normal cycle of life in coral reef ecosystems, the magnitude of many of these threats is increased by climate change. Wind storms, for example, are predicted to increase in intensity in coming decades (IPCC, 2014) as are the number and intensity of El Niño events.

Coral bleaching

The first major bleaching event in the GBR occurred in 1998, followed by a second event in 2002. More recently, the GBR suffered two consultative years of bleaching in 2016 and 2017. These bleaching events were part of a much larger global scale bleaching event that occurred over the period 2014–2017 (Eakin et al., 2016). During the 2016 event, average ocean temperatures rose 1.35°C above the average of ocean temperatures between 1951 and 1980 (Hoegh-Guldberg & Ridgway, 2016). As Figure 4.2 illustrates, the most severe bleaching during 2016 occurred in reefs north of Cairns. During the 2017, the area of bleaching extended to the vicinity of Townsville but did not affect reefs further south.

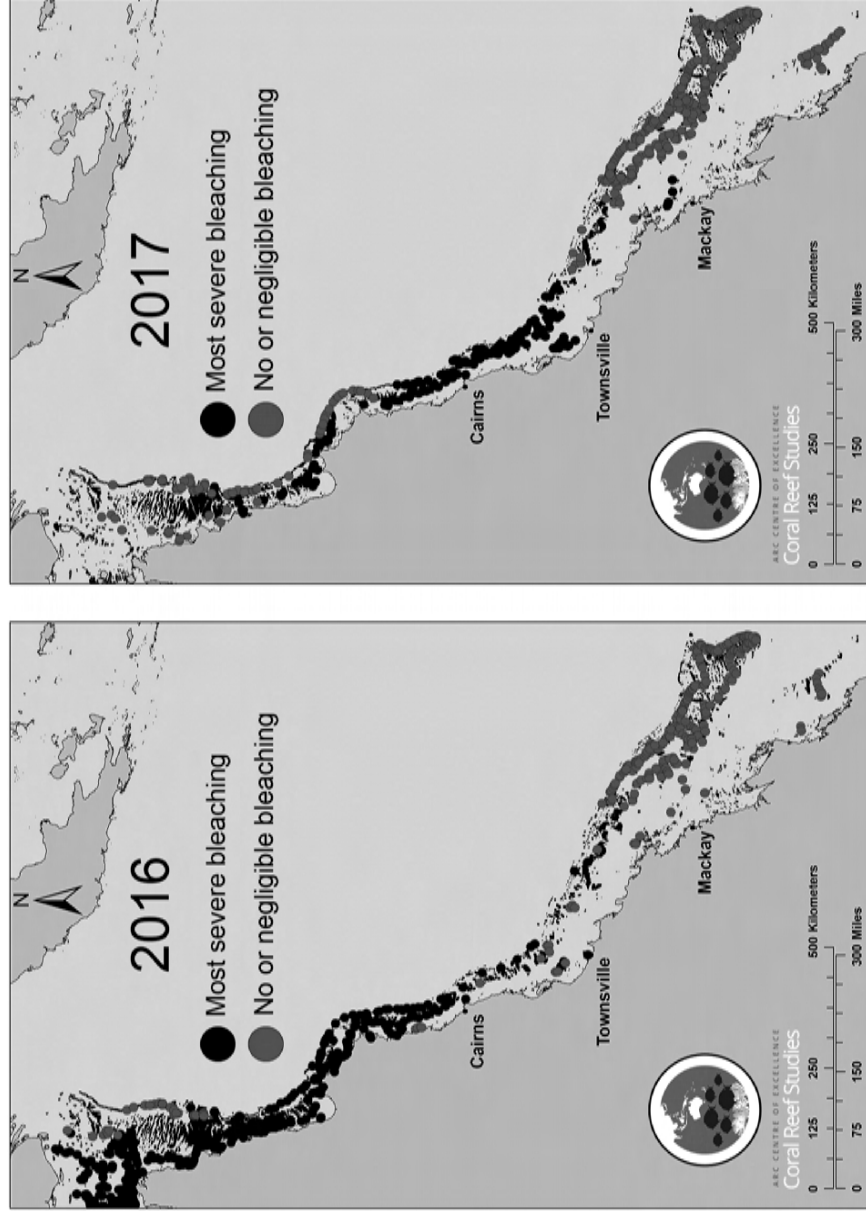


FIGURE 4.2 Coral bleaching of the Great Barrier Reef in 2016 and 2017

Source: ARC Centre of Excellence for Coral Reef Studies (2017).

Declining water quality

The GBRMPA has identified land-based run-off as one of the most significant threats to the long-term health and resilience of the GBR. Thirty-five major river catchments drain into the GBR and in periods of high rainfall these river systems may deposit significant sediment load into the reef lagoon. Intensive farming in these regions also adds to the volume of sediment, nutrients and pesticides carried by these systems. To address the problems the *Great Barrier Reef Water Quality Protection Plan* (GBRMPA, 2013) was implemented as a long-term strategy to improve water quality through measures that include encouraging agricultural industries to reduce their use of fertilisers and pesticides. Considerable effort has also been given to improving the quality of sewerage disposal into the GBR lagoon.

Coastal development

Land uses in the GBR catchment region, which include agriculture, mining, port construction and associated dredging, urban and industrial development and aquaculture, can have a significant effect on the health of the GBR. More than 80% of the GBR catchment supports some form of agriculture ranging from sugar cane production to pastoralism and small crops. Mining is also an important economic activity in the area from Mackay to Gladstone with some of the world's largest coal mines located in this region. Since 1981 about 8 square kilometres of land has been reclaimed from the GBRMP for port development.

Coral disease

A number of coral diseases, including White Syndromes, Brown Band and Black Band Disease, have been recorded on the GBR. Between 1995 and 2009, coral diseases are estimated to have been responsible for up to 6.5% of coral death recorded on the GBR. Corals that have survived coral bleaching remain stressed for some time and have a lower resilience to coral diseases. Although coral diseases are a normal part of reef ecosystems there is evidence that anthropogenic activity such as poor water quality can increase the susceptibility of coral to disease (GBRMPA, 2018c).

Crown-of-thorns starfish

COTS are found in reefs throughout the Indo-Pacific region and in normal circumstances assist slower growing corals to form colonies by feeding on faster growing staghorn and plate corals. However, outbreaks of COTS can cause significant damage to coral reefs. Surveys by the Australian Institute of Marine Science (De'ath et al., 2012) found that in the 30 year period to mid-2010s coral cover has declined by about 50%, with COTS responsible for half of this loss. Outbreaks of COTS occurs about every 17 years, with the last outbreak commencing in 2010 and

was still underway when this chapter was written in 2018. One method to contain COTS, and operated by the Association of Marine Park Tourism Operators (AMPTO), uses teams of divers to kill COTS. Given the volume of coral cover that has been lost through COTS in the last 30 years it is difficult to understand why substantially more resources have not been allocated to COTS control programmes. As De'ath et al. (2012, p. 17995) state, "reducing COTS populations, by improving water quality and developing alternative control measures, could prevent further coral decline and improve the outlook for the Great Barrier Reef".

Tourism

Tourism has emerged as a major industry in the GBR region and the GBR is widely promoted as a unique attraction by Tourism Australia and Tourism and Events Queensland, as well as by regional tourism organisations such as Tropical Tourism North Queensland based in Cairns and Tourism Whitsunday located in the Whitsundays. Most coral reef focused activity is located in Port Douglas, Cairns and the Whitsundays. In 2015–2016, 17.8 million people visited the GBR and its catchment region staying for 43.2 million visitor nights (Australian Bureau of Statistics [ABS], 2017). About 2.4 million visits were made to the GBR on commercial tourism vessels during this period (GBRMPA, 2017b). The number of tourists visiting the GBR region compared to the number of tourists visiting the GBR is relatively small. This poses an interesting question for destinations such as Port Douglas, Cairns and the Whitsundays – are tourists visiting the GBR and taking the opportunity to engage in other tourism activities after their visit to the GBR, or are tourists visiting these destinations and while there taking the opportunity to visit the GBR?

Tourism activity in the GBR includes both land and water-based activities. The type of water-based activities varies between destinations but usually includes day and overnight tours that offer opportunities for swimming, snorkelling, scuba diving and coral reef viewing via glass-bottom boats and semi-submersible coral viewing vessels. A number of tourism operators use moored platforms located on popular reefs as the focus of their reef experience (see Figure 4.3). Glass-bottom boats and semi-submersibles operate from these platforms which also serve as a base for swimming, snorkelling and scuba diving. Other operators moor their boats adjacent to coral reefs, with customers able to participate in snorkelling and other activities from the boat. The other main form of water-based activity is sailing, which includes day and overnight options. Sailing includes both crewed expedition boats and bare boat charters where tourist hire and crew sailing boats. The majority of operators are located in the Whitsundays.

The strong supervision exercised by the GBRMPA over all groups that use the GBR, including tourists, has ensured that damage from commercial tourism operations has been minimised. However, snorkelling and diving can cause damage through touching coral. The use of sun cream also continues to be a problem.



FIGURE 4.3 Reef pontoon on the Great Barrier Reef

Source: Photo courtesy of Bruce Prideaux.

In recent years, ocean cruising has emerged as a popular and fast growing form of tourism in the GBR region and is supported by state and local tourism authorities. However, further expansion of cruising will require significant dredging, with associated risks in the areas where dredging occurs. This appears to be at odds with efforts to improve the quality of the GBR. Land-based activities are mainly focused on beach activities including sunbathing, swimming and snorkelling and visits to islands that feature fringing reefs.

A recent report by the ABS (2017) estimated the total economic contribution of tourism in the GBR and its catchment to the Australian economy in 2015–2016 was AU\$7.976 billion and that tourism accounted for 8.2% of total employment in the GBR and catchment region. Direct tourism employment was estimated to be 46,000 persons in 2015–2016. In the Cairns region, tourism expenditure was estimated to be AU\$3.2 billion (ABS, 2017).

Apart from economic value, other values that can be placed on natural systems such as the GBR include social and iconic values. A report by Deloitte Access Economics ([DAE], 2017) calculated that GBR's asset value was AU\$56 billion based on its social, economic and iconic values, including the value of the reef to tourists who had visited the GBR (AU\$29 billion), Australians who had yet to visit the GBR (AU\$24 billion) and recreational users (AU\$3 billion).

Given that tourism accounts for 8.2% of total employment in the GBR and its catchments, it is apparent that any threats to the quality of the reef experience are likely to have an adverse impact on destinations such as Port Douglas, Cairns and the Whitsundays. Much of the current research into the impact of climate change on the GBR has focused on biological impacts and has given relatively little attention to investigating how a decline in the quality of the GBR experience will affect coastal communities. From a tourism perspective, this is a significant gap which has only just begun to be addressed. Research into community resilience by Prideaux et al. (2018) found Cairns residents were well informed about the causes of coral bleaching, concerned about the future impacts of coral bleaching and supported efforts to protect the GBR. Two-thirds of respondents thought that coral bleaching will affect them on a personal level. The research also found that most respondents did not believe that their employment will be affected by future decline of the GBR.

Extensive media coverage of the 2016 and 2017 coral bleaching events alerted both domestic and international tourists, and the travel trade in general, to the bleaching event and raised fears that the GBR was either in terminal decline or had suffered extensive damage. Media coverage began with a report posted by the ARC Centre of Excellence Coral Reef Studies that stated that 93% of the GBR had suffered bleaching based on an aerial survey of 911 of the GBR's 2,700 reefs (ARC, 2017). The release was quickly reworked into media stories such as that posted by Smail (2016) which stated that "Only 7% of the Great Barrier Reef has avoided coral bleaching." The event was given extensive coverage by the print and electronic media as well as social media. The impression that the entire GBR rather than one-third of the reef had suffered bleaching was never corrected by the media nor did affected destinations mount an effective crisis management strategy to counter that view. The result of what can only be described as "sloppy" and factually incorrect media that was not effectively challenged led to the type of report found on the Viator website and reported earlier in this chapter. Surprisingly, Viator's websites for the Florida Keys, Maldives and Koh Tao (Thailand) do not contain similar warnings, despite these destinations having low coral cover (see Chapters 8 and 10 in this volume). There are a number of clear messages emulating for this event. Any communications from research institutions should be factual and based on peer reviewed research, not findings that are open to interpretation and lacking rigour. Destinations also need to be prepared for media sensationalism and be able to rapidly deploy crisis recovery strategies to deal with the crisis in an honest, timely and factual manner.

Discussion and conclusion

The GBR exhibits the greatest biodiversity of any coral reef system and is claimed to be the most well managed coral reef system in the world. Although both state and national governments have allocated substantial financial resources to the protection and management of the GBR, it continues to show signs of ongoing decline

through problems with water quality, the effects of climate change and COTS. While significant funds have been allocated to monitoring, science-based research and management, very little funding has been allocated to active control measures such as the AMPTO-managed COTS eradication programme. Regeneration projects which have enjoyed varying degrees of success elsewhere are just beginning to be considered by the GBRMPA. Only a very small percentage of research funds have been allocated to investigate how threats to the GBR may impact the tourism industry and coral reef dependent tourism destinations. The ABS (2017) and DAE (2017) reports are only the latest of a large number of reports that have confirmed the importance of the GBR in terms of jobs and income for the regional economy.

The overwhelming majority of research into the GBR has taken a reef centric science view and largely neglected the impact on the GBR on human populations. This situation has arisen because of the science capture of research programmes and funding schemes and the seeming inability of governments to recognise the needs of human communities in the GBR catchment. Funding further scientific study of the GBR's decline, but also neglecting to study how the decline is caused by and will impact on human communities, seems counterproductive at best and verging on stupidity at worst.

It is apparent from the discussion in this chapter that tourism is a significant industry in the GBR region and that a range of threats to the GBR may have serious spill over effects on local communities, particularly if the quality of coral cover and the tourism experiences associated with the ability to view live and healthy coral is diminished. Chapter 6 discusses in greater detail how coral bleaching poses a significant threat to the major coral reef destinations of Port Douglas, Cairns and the Whitsundays. The potential for further coral bleaching is concerning and suggests that these destinations need to commence studies into alternative tourism experiences.

This chapter has also touched on the problems caused by COTS and the first experiments in coral reef regeneration. Combined, these two initiatives have the potential to increase the resilience of the GBR and enhance the long-term economic sustainability to coral reef tourism in the GBR region. The GBRMPA has been slow to react in both areas and, as a consequence, has lost valuable time discharging its responsibilities to protect the GBR. Ultimately, however, the fate of the GBR and all other coral reef systems rests on the ability of the global community to come together and implement meaningful programmes to reduce global warming and hold global temperature increase to under 2°C. The withdrawal of the US from the 2015 Paris Climate Change Accord is a stark reminder of how difficult this will be to achieve in a time frame that will prevent significant damage to coral reef ecosystems.

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