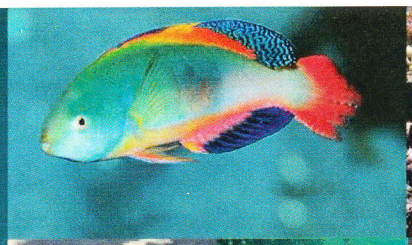
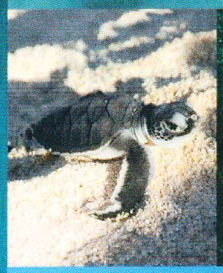
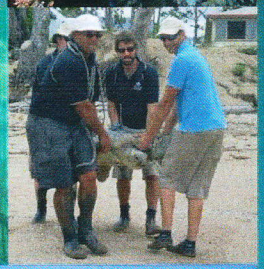
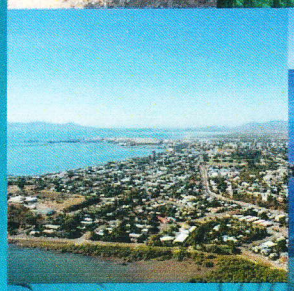
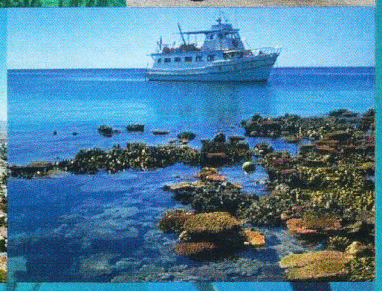
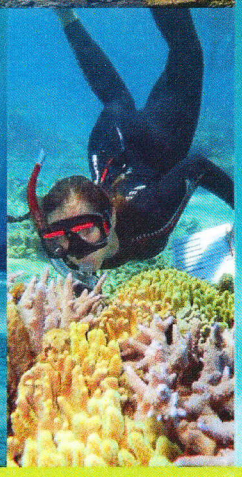




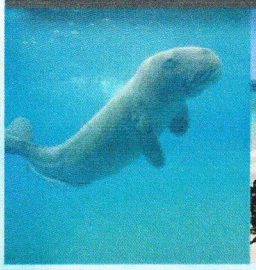
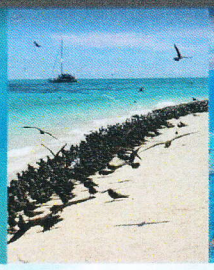



Australian Government

Great Barrier Reef Marine Park Authority

GREAT BARRIER REEF REGION STRATEGIC ASSESSMENT

Strategic Assessment Report


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. 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]

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 5.2 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.[6] 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. Although change in ecosystem state is likely to be a gradual process, there is evidence to suggest that the reduced resilience of ecosystems increases their vulnerability to catastrophic events. For example, a severe cyclone may push a coral reef towards a tipping point, beyond which it is unable to rebound.

Potential climate change effects for species groups and habitats have been considered in *Climate change and the Great Barrier Reef: a vulnerability assessment*[7] and in many recent scientific studies.[8,9,10] 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*'.[11]

The projected vulnerability of a number of the Region's habitats and species presented in Figure 5.2 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.[12,13,14,15] 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.[8,14,16]

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.[17] 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.[8,17,18]

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,[19] 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.[20]
- **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.[1,21] 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.[7,22]

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.[23]

It is likely fishing activities will be highly sensitive to climate change, including projected changes in fish abundance, survivorship[24,25,26], size and distribution, disruptions to shallow water nurseries and loss of coral reef habitats, as well as changes in cyclone and storm activity[7,27,28].

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.[27]

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.[29] 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[30] has been published, and key stakeholders have been engaged in a climate change adaptation planning process.[31]

An examination of the extreme weather events in the summer of 2010–2011 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.[32] It was also responsible for 11 port closures.[33] Many resorts, jetties and marinas were damaged, along with more than 4000 houses.[33]

Two Reef-dependent industries were particularly affected by that season's cyclones and floods.[34] 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[28] 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.[34]

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.[35]

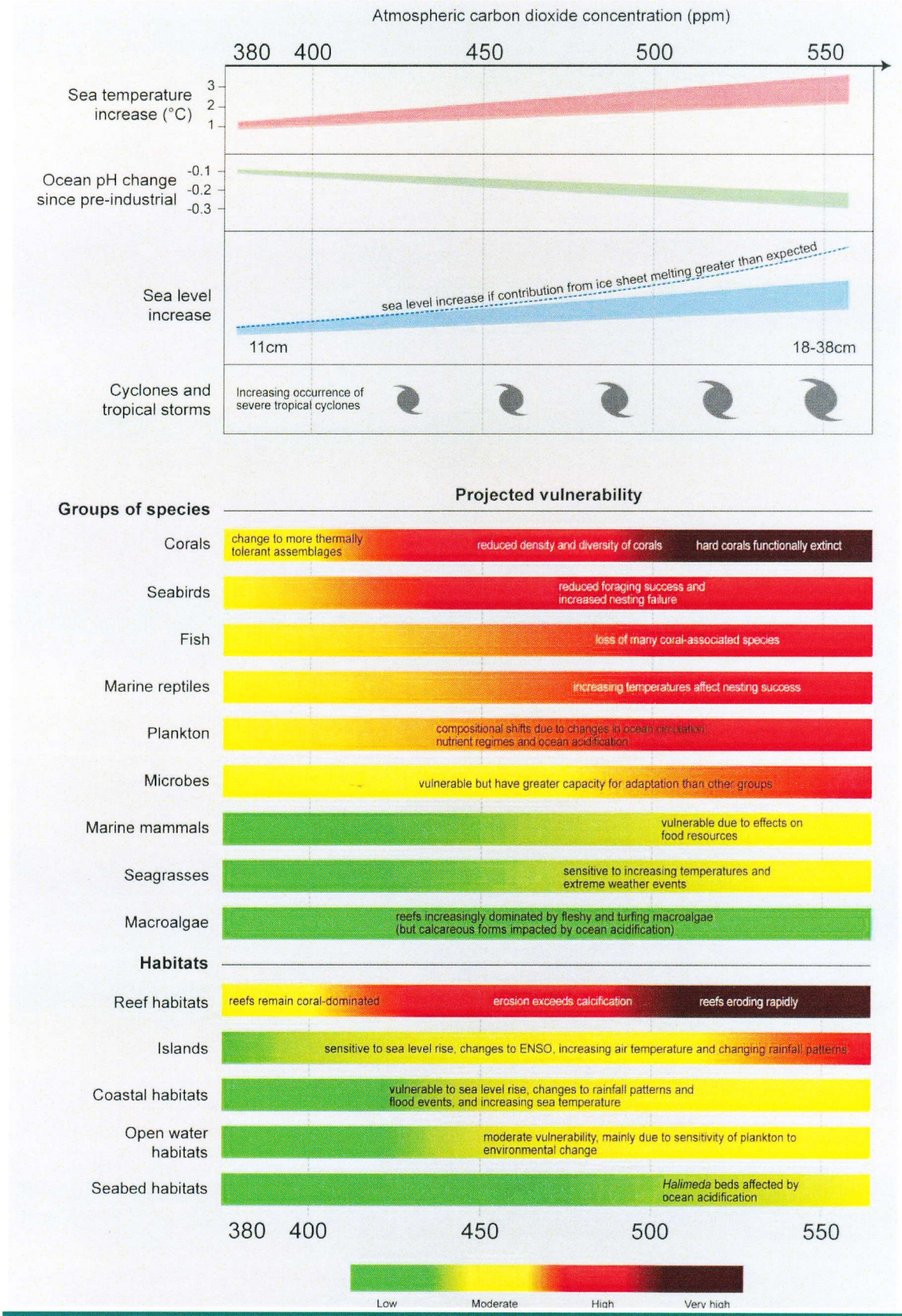


Figure 5.2 Projected trends in climate change variables and the Region's biodiversity values

The average monthly global carbon dioxide concentration reached 396 parts per million (ppm) in March 2013.[36] A concentration of 550 ppm carbon dioxide is predicted to be reached by about 2100.[3,19] Concentrations could potentially exceed this value, resulting in even more serious effects on the Region's ecosystem. In certain scenarios, tipping points for ecosystems can occur suddenly in response to a severe disturbance, hence causing a rapid change.

The science of carbon dioxide concentrations and coral reefs

The pre-industrial concentration of atmospheric carbon dioxide was approximately 280 parts per million.[37] Since then, the concentration of atmospheric carbon dioxide has been increasing, and reached 396 parts per million in March 2013.[19]

Figure 5.3 shows atmospheric concentrations since 1958, 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.[38] Bleaching began on most reefs worldwide when carbon dioxide concentrations reached approximately 340 parts per million.[38]

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.[4,38]

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.

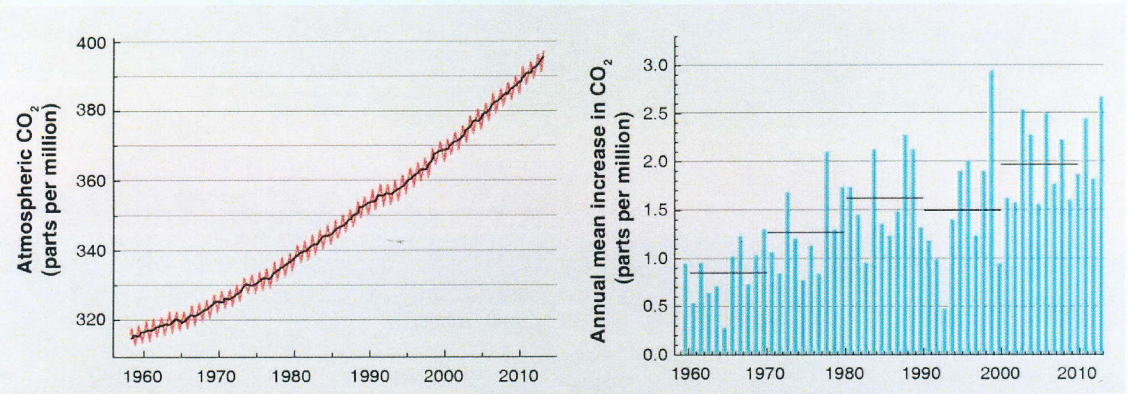


Figure 5.3 Mean atmospheric concentrations and the annual mean increase of carbon dioxide, 1958–2013

The data was collected from Mauna Loa, Hawaii. This is 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[39])

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*[40] 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

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.