How the Great Barrier Reef and its industries can adapt to climate change: some scenarios

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Executive summary

In this report we draw four alternative future scenarios – snapshots of possible futures – which are designed to help the communities, businesses and industries involved in Australia’s Great Barrier Reef to understand and discuss how climate change may affect the Reef and those who depend on it.

These scenarios are created by combining best-case/worst-case climate outlooks, with best-case/worst-case adaptation on the part of both humans and the environment. These are not forecasts of what will happen: rather they allow us to explore what might happen if we act more or less effectively in response to moderate or more extreme climate change. This, in turn, will help us to envision and design a safer, more prosperous and more sustainable future, both for the Reef and for ourselves.

Briefly the four main scenarios for 2050 are:

Paradise perturbed – climate change is minimised but adaptation is limited. Coral communities shift to massive and encrusting species. Existing mangrove habitat is eroded and new habitat struggles to establish further south. Due to habitat changes, marine biodiversity declines slightly. Fish, like coral trout, move south and to deeper waters. The numbers of other fish species, like barramundi, also vary with changing rainfall patterns. The fishing and tourism industries try to maintain the status quo of the early 21st century. As such, fishing and tourism are profitable but the sustainability of the Reef declines.

Reef relief – climate change is minimised and adaptation is ideal. Coral communities still include the more heat sensitive bushy, staghorn, and table corals. Existing mangrove habitat is eroded but new habitat establishes itself further south. Marine biodiversity is maintained. Fish, like coral trout, move south and to deeper waters. The abundance of other fish species, like barramundi, also varies with changing rainfall. The fishing and tourism industries anticipate changes and pursue well-planned adaptation. Both industries remain profitable, recreational fishers continue to enjoy fishing, and the Reef’s sustainability improves.

Coastal calamity – climate change is not minimised and adaptation is limited. Corals are lost and reefs become dominated by seaweeds. Existing mangrove habitat is heavily eroded and new habitat fails to establish further south. Reef-dependent species are affected and marine biodiversity declines significantly. Fish, like coral trout, move south and to deeper waters and their numbers also decline. The abundance of other fish species, like barramundi, varies considerably with changing rainfall patterns. The fishing and tourism industries are forced to react to the rate and degree of change and the adaptation strategies they follow are not well thought out. As a consequence many businesses fail and the health of the Reef is compromised.

Volatile waters – climate change is not minimised but human adaptation is ideal. Reefs are in a state of flux, shifting between coral and seaweeds. Existing mangrove habitat is heavily eroded but some new habitat establishes itself further south. Reef-dependent species are affected and marine biodiversity declines periodically. Fish, like coral trout, move south and to deeper waters but abundance also declines. The number of other fish species, like barramundi, varies considerably with changing rainfall. The fishing and tourism industries anticipate changes and pursue a wide range of well-planned adaptation strategies. The businesses that do adapt with forethought are the ones that survive. Climate conditions continue to challenge the sustainability of the Reef.

The report explores in detail the implications of these four scenarios for the tourism and fishing (professional and recreational) sectors. Encouragingly, we found that many of the current activities occurring in the Great Barrier Reef’s fishing and tourism industries in many ways, but for a variety of reasons, reflect what we refer to in the scenarios as ‘ideal adaptation’ actions.

We developed these scenarios as tools to help focus public and industry discussion on potential GBR futures, under different levels of risk. They can be used for many other purposes, from planning a business to developing new industries. Feel free to use, adapt, and amend the scenarios to help in planning how you will adapt to the changes we are all likely to face as the world’s climate alters.
1. Introduction

We present four alternative future scenarios or storylines. These explore the different things that people involved in Australia’s Great Barrier Reef and its fishing and tourism industries might do to adapt to the altered conditions under climate change. Their purpose is to generate discussion around alternative futures and the options available to individuals, businesses, industries and government for looking after the Reef and continuing to benefit from it long into the future.

We explain how we developed these scenarios, the assumptions we made in doing so, and then we present the four alternative storylines for the future of the Reef and its industries.

2. Scenario development

Scenarios are “plausible descriptions of how the future may develop”. They do not predict the future but instead outline different choices and possible outcomes from them. Scenarios have been developed to understand what future carbon emissions might mean for our climate. They have been used to think about how environmental change or degradation might impact our lives and our wellbeing in the future. They have also been created to explore how global and/or local action or inaction might affect important natural icons in Australia, such as the Great Barrier Reef.

In this research, we explore two different climate change possibilities and their impacts on the Reef and its fishing and tourism industries. We then look at two different adaptation strategies and what might result from them. We use these scenarios to help us understand whether adaptation in the environment and in our lives and industries can reduce our vulnerability to climate change risk.

Adaptation is how we react to a real or perceived disturbance, in this case climate change. It means finding ways to reduce negative impacts and take advantage of new opportunities as they emerge.

Ecological adaptation means changes that occur naturally in fish, corals and other marine plants and animals, triggered by an external change such as climate.

Social adaptation means individuals, businesses, industries, cities or whole societies making changes in what they do and how they work and live, in order to better cope with external changes, like the climate.

Sometimes we might follow a particular adaptation strategy that we think is useful, but which in fact does not help us to reduce negative impacts or improve our lives. We want to identify and avoid these kinds of ‘limited’ adaptation strategies. Instead, we want to follow adaptation strategies that our experiences so far suggest are actually effective and will continue to be in the future. These kinds of strategies are referred to here as ‘ideal’ adaptation.

Over 50 people, from scientists to government to fishing and tourism operators and their representatives, helped us at different stages to develop and test the scenarios. First, we used the scientific literature to identify two future climate change trends for the Reef. We selected a best-case and a worst-case option for 2050, mainly based on the Great Barrier Reef Marine Park Authority’s vulnerability assessment (Figure 1). We then contacted climate change scientists from all over Australia to ask them to provide alternative storylines on what might happen when the climate changes and we adapt well (ideal adaptation) or poorly (limited adaptation). Finally, we asked people, businesses, and industries whether the scenarios that we had developed were plausible for their region and what their experiences said about the kinds of adaptation that worked well or not.

In short we compare four different situations (Figure 1). In one pair of scenarios (1a and 1b), air temperatures rise by less than 1.5°C by 2050 compared with 1990 levels and other conditions change as outlined in Figure 1. In this situation, people, businesses and industries may adapt well (ideal adaptation, 1b) or not - selecting strategies that they think work, but which real experiences suggest don’t necessarily reduce our vulnerability to risk (limited adaptation, 1a). In the other pair of scenarios (2a and 2b), air temperatures rise by more than 2.5°C above 1990 levels, with other conditions changing too. Again, in this situation, we may adapt well (2b), thereby minimising negative impacts as much as possible, or we may adapt poorly (2a), exacerbating the consequences for our lives and industries.
3. Broad assumptions

The scientists who helped us develop the initial scenarios identified some broad assumptions associated with different adaptation strategies and outcomes for the Reef and its fishing and tourism industries. These are shown in Table 1.

In the best-case climate scenario we assume that effective climate mitigation (meaning a global reduction of carbon emissions) has occurred. This will mean increases in fuel prices due to green taxes, such as the carbon tax. In the worst-case climate scenario we suggest that climate mitigation has not occurred. In this case, fuel prices also rise as oil supplies dwindle.

In the best-case adaptation scenarios (ideal adaptation) we then assume that the costs of adapting are distributed over time. Adaptation savings and investment funds are established to support well-planned adaptation. We assume in this situation, that our society looks to the future intelligently and plans for it. Also, industry, society and government work together to achieve the best outcomes.

In contrast, in the worst-case adaptation scenarios we assume that adaptation is more expensive because adaptation is less about prevention and more about reacting to impacts, such as through emergency response and rebuilding. We also assume that adaptation is not supported by tailored adaptation funds. In these scenarios, Australians remain focused on the past and are resistant to change. Because of this, individuals, industry and government do not work well together to achieve better outcomes.
<table>
<thead>
<tr>
<th>Broader context</th>
<th>Best case climate scenario for 2050</th>
<th>Worst-case climate scenario for 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs of mitigation (i.e. reduction in carbon emissions) are spread over 40 years. Climate stabilises by 2050.</td>
<td>Costs of mitigation are spread over 40 years. Climate stabilises by 2050.</td>
<td>No investment in mitigation. Global climate change continues.</td>
</tr>
<tr>
<td>Fuel prices rise due to green taxes.</td>
<td>Fuel prices rise due to green taxes.</td>
<td>Fuel prices rise in line with peak oil.</td>
</tr>
<tr>
<td>Benefits derived from the green economy go to individuals and corporations and are not channelled into adaptation funds.</td>
<td>Benefits derived from the green economy are channelled into adaptation funds.</td>
<td>Benefits derived from economic growth are channelled into adaptation funds.</td>
</tr>
<tr>
<td>Adaptation costs are concentrated in reactive adaptation strategies.</td>
<td>Adaptation costs are spread over 40 years through planned adaptation.</td>
<td>Adaptation costs are concentrated in reactive adaptation strategies.</td>
</tr>
<tr>
<td>Backward-looking</td>
<td>Future-looking. Life back in the 1990s is considered the most desirable.</td>
<td>Backward-looking</td>
</tr>
<tr>
<td>Values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individually and businesses perceive they have limited personal responsibility to plan and adapt.</td>
<td>Individuals and businesses perceive they have limited personal responsibility to plan and adapt.</td>
<td>Individuals and businesses perceive they are best placed to adapt.</td>
</tr>
<tr>
<td>Climate change is not a major concern.</td>
<td>Climate change is used as an opportunity to improve.</td>
<td>Climate change can no longer be ignored and forces us to react.</td>
</tr>
<tr>
<td>Climate induced changes to ecosystems are unexpected and seen as a threat.</td>
<td>Climate induced changes to ecosystems are expected and seen as an opportunity.</td>
<td>Climate induced changes to ecosystems are unexpected and seen as a threat.</td>
</tr>
<tr>
<td>Governance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management strategies do not help people to adapt. People are encouraged to specialise and regulation is high.</td>
<td>Management strategies help people to adapt. People are encouraged to take responsibility, spread risk, and continually learn.</td>
<td>Management strategies do not help people to adapt. People are encouraged to specialise and regulation is high.</td>
</tr>
<tr>
<td>There is little coordination among government, industries and communities.</td>
<td>There is extensive coordination among government, industries and communities.</td>
<td>There is little coordination among government, industries and communities.</td>
</tr>
<tr>
<td>Politics are directed at appeasing powerful constituents.</td>
<td>Politics are directed at reducing inequality between constituents.</td>
<td>Politics are directed at appeasing powerful constituents.</td>
</tr>
</tbody>
</table>
4. Four alternative scenarios for the future of the Reef and its industries: summaries

1a Paradise perturbed: It is 2050. Climate change is minimised but adaptation on the part of society is limited. Climate change has affected the natural environment and human communities along the Great Barrier Reef in subtle ways. The impacts on the Reef are felt in different places at different times. The consequences for industry are therefore similar to other pressures they experience, such as cost or market price changes. However, the environment itself is unable to adapt to this change and the actions taken by people living in the region do little to reduce the negative impacts or exploit the opportunities that arise from climate change. For example, the consequences of climate variability in the catchment area are exacerbated by failure to change land use practices, which means that water quality on the reef has not improved. The reef remains in a coral-dominated state but coral cover declines and its species composition shifts. Coastal habitat is eroded and tries to shift shore-ward and southward but new habitat struggles to establish because of coastal development and the barriers created to protect coastal infrastructure. Overall habitat cover declines slightly as a result. In turn, these habitat changes affect dependent species such as reef fish, turtles, and sea-birds, and marine biodiversity declines slightly. Direct climate change impacts on fish include shifts in distribution southward and into deeper waters. In this scenario, climate change does not trigger major re-organisation and adaptation within the fishing and tourism industries. Instead these industries deal with climate risks and the effects of mitigation policy by trying to keep doing what they did in the early 21st century. Climate change stabilises beyond 2050.

*Figure 2: Paradise perturbed - climate change is minimised but adaptation is limited. Coral composition shifts to massive and encrusting species. Existing mangrove habitat is eroded and new habitat struggles to establish further south. Many fish species, like coral trout, move south and to deeper waters. The abundance of some fish species, like barramundi, also varies with changing rainfall patterns. The fishing and tourism industries try to maintain the status quo of the early 21st century. Artwork by Pinillos, 2011.*
1b Reef relief: By 2050 climate change is minimised by early human action and adaptation has been highly effective. Climate change has affected the natural environment and human communities along the Great Barrier Reef in subtle ways. The impacts on the Reef are usually felt in different places at different times. The consequences for industry are therefore similar to other pressures they experience, such as cost or market price changes. The environment itself is somewhat able to adapt and the actions taken by businesses, industries and communities effectively reduce the negative impacts of climate change and capture the opportunities that arise from it. For instance, climate variability in the catchment area prompts changes in land use practices, leading to stable or improved water quality on the Reef. The Reef remains coral-dominated, with high coral cover and enduring communities of heat-sensitive corals. Shifts in coastal habitat shore-ward and southward are also facilitated by well-planned coastal development and rehabilitation programmes, and overall habitat cover is maintained. Dependent species such as reef fish, turtles and sea-birds adapt to habitat changes and marine biodiversity is maintained. Direct climate change impacts on fish include shifts in distribution southward and into deeper waters. Climate change triggers re-organisation and successful adaptation within the fishing and tourism industries. The new visions and strategies of these industries effectively offset the impacts from climate change and climate mitigation. Climate change stabilises beyond 2050.

Figure 3: Reef relief - climate change is minimised and adaptation is ideal. Coral communities still include the more heat sensitive bushy, staghorn, and table corals. Existing mangrove habitat is eroded but new habitat establishes itself further south. Many fish species, like coral trout, move south and to deeper waters. The abundance of some fish species, like barramundi, also varies with changing rainfall. The fishing and tourism industries anticipate changes and pursue well-planned adaptation. Artwork by Pinillos, 2011.
**2a Coastal calamity:** In this scenario, by 2050, climate change has brought 2.5 degrees of warming and there has been little or no adaptation on the part of humans. This has dramatically affected both the natural environment and human communities along the Great Barrier Reef. The effects on the Reef are widespread and usually felt in many places at the same time. The consequences for industry are therefore greater and last longer than other pressures they normally experience, such as cost or market price changes. The environment itself is unable to cope with this change and the actions taken by people living in the region fail to reduce the negative impacts or exploit the opportunities that arise from climate change. The consequences of climate variability in the catchment are exacerbated by failure to change land use practices. Water quality on the reef declines significantly due to increased catchment runoff.

Over much of the reef, coral is replaced by seaweeds. Coastal habitat also declines significantly as existing habitat is eroded and new habitat fails to establish due to coastal development and coastal protection policies. Habitat loss greatly affects dependent species such as reef fish, turtles, sea-birds with only some weed-eating fish benefiting from increased seaweed growth. Overall, marine biodiversity declines significantly. Direct climate change impacts on fish include changes in numbers and shifts in distribution southward and into deeper waters. Nevertheless, climate change does not trigger re-organisation for effective adaptation within the fishing and tourism industries, which try to offset impacts from climate change and peak oil by pursuing strategies to maintain the status quo of the early 21st century. Climate change continues to accelerate beyond 2050.

*Figure 4: Coastal calamity - climate change is not minimised and adaptation is limited.* Corals are lost and reefs become dominated by seaweeds. Existing mangrove habitat is heavily eroded and new habitat fails to establish further south. Many fish species, like coral trout, move south and to deeper waters and their numbers also decline due to changes in reef habitat. The abundance of other fish species, like barramundi, varies with changing rainfall patterns. The fishing and tourism industries are forced to react to the rate and degree of change, for example by increasing fishing effort through the use of motherships or developing alternative tourism activities. Artwork by Pinillos, 2011.
2b Volatile waters: Climate change is not minimised by 2050 but human adaptation has been highly effective. Climate change has had dramatic impacts on the natural environment and human communities along the Great Barrier Reef. Impacts are widespread, so usually felt in many places at the same time. The consequences for industry are therefore greater and last longer than other pressures they experience, such as cost or market price changes. The environment itself is somewhat able to adapt and the actions taken by businesses, industries and communities minimise, to the extent possible, the negative impacts and exploit the limited opportunities created by climate change. Impacts from greater variability in climate in the catchment lead to changes in land use practices. Water quality on the reef therefore varies with extreme climate events. The reef is constantly changing, shifting between coral and seaweed cover. Shifts in coastal habitat shoreward and southward are facilitated by well-planned coastal development and rehabilitation programmes, but overall habitat cover declines as temperatures rise quickly and weather events become more acute. Rapid habitat changes affect dependent species such as reef fish, turtles and sea-birds and marine biodiversity experiences significant declines periodically. Direct climate change impacts on fish include changes in numbers and shifts in distribution southward and into deeper waters. Climate change causes people and industries to adapt more effectively. This limits negative impacts from climate change and peak oil. Climate change continues beyond 2050.

Figure 5: Volatile waters - climate change is not minimised but human adaptation is ideal. Reefs are in a state of flux, shifting between coral and seaweeds. Existing mangrove habitat is heavily eroded but some new habitat establishes itself further south. Many fish species, like coral trout, move south and to deeper waters but their abundance also declines due to changes in reef habitat. The number of other fish species like barramundi, vary with changing weather patterns, such as rainfall. The fishing and tourism industries anticipate changes well and pursue planned adaptation, such as developing co-operative networks in the fishing industry or developing and effectively marketing alternative activities in the tourism industry. Artwork by Pinillos, 2011.
5. Ecological impacts and environmental governance

In this section, we look at how potential responses by government, communities, and industries under the two climate change trends might affect the Reef itself. The scenario storylines bring together information on reefs, coastal habitats, and associated species. The tables summarise information on reef habitats (Table 2), coastal habitats represented by mangroves (Table 3), and land use in the catchment as a driver of water quality on the Reef (Table 4).

1a Paradise perturbed: Climate change alters the distribution, composition and overall cover of reef and coastal habitat. Reefs are more frequently exposed to sharp temperature shifts, freshwater runoff from the land, storm damage, disease, and predation - but impacts tend to be localised. The heat-sensitive corals are the ones most prone to die off. However there are still some places, or habitats, where they are protected and can survive and it is possible for affected corals to recover. This process is hindered by ocean acidification (caused by carbon dioxide from the atmosphere dissolving in seawater), which slows coral growth. Coastal habitats are exposed to sea level rise and more intense storm surges which interfere with the recovery of existing habitat. Marine and coastal habitats try to adapt by shifting shore-ward, upstream, and southward. However coastal development and land use along the Great Barrier Reef have continued unabated throughout the 21st century. Coastal communities and local government build higher and higher sea walls to protect property and people against sea level rise. This reduces opportunities for mangroves and beaches to establish in the southern parts of the Reef. Reef management consists mainly of bandaid measures such as shading and coral transplantation, and only manages to help a few individual reefs. The Reef remains in a coral-dominated state, but coral cover declines to below 20% and species composition shifts to more heat-resistant species - the iconic branching corals are replaced by massive and encrusting corals. Coastal mangrove and other habitat cover declines, for example, 5% of the beach nesting grounds of northern Green turtles is lost. The abundance of marine species dependent on reef and coastal habitat, therefore, declines. While other species fill the gaps, biodiversity, as the total number of species on the Reef declines slightly.

1b Reef relief: The impacts of climate change alter the distribution, composition and overall cover of reef and coastal habitat. Reefs are more frequently exposed to sharp temperature changes, freshwater runoff from the land, storm damage, disease, and predation, but impacts are localised. Reef species manage to cope somewhat and coral death is lower than expected, even in heat-sensitive corals. There are many places where coral reef species can survive and recovery is rapid, although it is hindered by ocean acidification, which slows coral growth. Coastal habitats are exposed to sea level rise and more intense storm surges which interfere with the recovery of existing habitat. Marine and coastal habitats try to adapt by shifting shore-ward, upstream, and southward. Thanks to effective action by people with a stake in the region, coastal development and land use have been well managed throughout the 21st century. Coastal communities and local government have worked together to pull back in a planned way in response to sea level rise, building protection only for vital coastal infrastructure. This creates opportunities for mangroves and beaches to move into new habitats particularly in the southern Reef. Good reef management anticipates climate change. Adaptation strategies involve integrated management of the catchment, reef and its fisheries; rehabilitation of coastal habitat; and rapid responses to bleaching events, cyclones, disease outbreaks and predation of corals by crown-of-thorns starfish. Technical solutions, such as reef shading and coral transplantation are used in addition to protect vital coral refuges. The reef remains in a coral-dominated state with above 30-40% coral cover made up of heat-sensitive (bushy, staghorn and table corals) and more heat-resistant (massive and encrusting corals) species. Coastal habitat shifts but overall cover is maintained at 2010 levels. For example, while 5% of the nesting grounds of northern Green turtles are lost, new sites are established and protected to enable breeding turtles to relocate. Marine animals adapt to the changes in reef and coastal habitat and both reef function and overall biodiversity are maintained, though the composition and distribution of marine environments have changed.

2a Coastal calamity: The cumulative impacts of climate change massively alter the distribution, composition and overall cover of reef and coastal...
Reefs are much more frequently exposed to sharp temperature shifts, freshwater runoff, storm damage, disease, and predation. Impacts are widespread and extend to lower depths. Both heat-sensitive and heat-resistant corals die off. Places where corals are protected are few and far between. The rapid succession of impacts combined with ocean acidification, which slows coral growth and undermines coral structure, mean it is quite hard for coral reefs to recover. Populations of crown-of-thorns starfish and other reef-eaters expand periodically. Coastal habitats are exposed to high sea level rise, more intense storm surges, and more variable rainfall. These limit the recovery of existing habitat. Marine and coastal habitats try to adapt by shifting shore-ward, up-stream, and south-ward. Coastal development and land use along the Great Barrier Reef continue unabated throughout the 21st century. Coastal communities and local government have staged a planned retreat from rising sea levels, building sea walls to protect strategic coastal infrastructure only. This creates opportunities for new natural habitats, particularly for mangroves, to re-establish mainly in the southern Reef. However, the rate of climate change inhibits this to some extent. Reef managers anticipate climate change well. Their responses include integrated catchment, reef and fisheries management; rehabilitation of coastal habitat; and rapid responses to bleaching events, cyclones, disease outbreaks and coral predation by COTS. Technical solutions are used to protect vital places where corals can hang on; provide artificial habitat; and breed and store endangered species. Geo-engineering technologies, such as surface treatments that reflect heat from large areas are also employed in an attempt to limit future impacts. In spite of this, the reef moves into a state of flux, with corals and seaweeds competing for reef space, each sometimes gaining, sometimes losing ground. Coral composition shifts to heat-resistant massive and encrusting corals. Coastal habitat shifts, but declines overall. For example, 20-30% of the nesting grounds of northern Green turtles are lost. The abundance of marine species dependent on reef and coastal habitat declines significantly. Shoreline erosion increases. The essential functions of the Reef are lost, along with the benefits they provide to humans, and marine biodiversity declines significantly.

2b Volatile waters: Climate change impacts significantly alter the distribution, composition and overall cover of reef and coastal habitat. Reefs are much more frequently exposed to sharp temperature shifts, freshwater run-off, storm damage, disease, and predation. Impacts are widespread and extend to lower depths. However reef species manage to cope somewhat and coral death is lower than expected among heat-resistant corals. Some refuges where corals are protected remain, particularly on outer and mid-shelf reefs.
Government and industry perspectives on environmental change and management

The people who took part in our workshops supplied examples from across the Great Barrier Reef region and southern Queensland which suggest that some of the impacts outlined in these four scenarios are plausible. These related to changes caused by climate and other types of driver. For instance, they reported shifts in coral species composition between branching and massive coral species in Moreton Bay and the Great Sandy Marine Park in response to pulses of freshwater and sediment run-off from the land. Earlier flood events apparently caused branching corals to be replaced by massive corals - but the more recent construction of the Wivenhoe dam reduced flood runoff and prompted a shift back towards branching species.

Other examples of change appear to contradict some of our assumptions about adaptation in the natural environment. For instance, the southern Reef may experience more rapid temperature increases due to changes in the East Australian Current and more frequent flooding events. Moreton Bay and the Great Sandy Marine Park were said to bleach before areas of the Great Barrier Reef in the 1998 and 2002 widespread coral bleaching events. This suggests it may be hard for corals, in particular, to migrate southwards to escape warmer waters. In general, participants felt there was a high level of uncertainty about impacts on the Reef related to climate change and tend to believe that its size and geographical spread will absorb most of the impacts, keeping them local and varied.

Participants in our workshops also discussed their experiences of management and adaptation activities and how they might influence the outcomes for Reef habitats. In particular, they regarded choices around coastal development and land use in the catchment as vital to the sustainability or degradation of coral and coastal habitats, independent of climate change. Climate change provides a great opportunity to benefit the Reef and its industries where it prompts us to reconsider how we value and manage the catchment and coastline. The government and industry representatives suggested that if management and adaptation activities were really effective (ideal adaptation), and mangrove habitat was protected and rehabilitated around the Trinity Inlet, Hinchinbrook Channel and the Fitzroy River, for instance, the outlook for the Reef’s ecosystems and industries could be improved in spite of climate change. However, these opportunities and any potential benefits to Reef industries may require significant changes in industries such as sugarcane, cattle and real estate development. And it was recognised that the economic drivers of current coastal development and land use in the region are extremely powerful and deeply embedded in Australian culture and businesses.

More conventional reef and fisheries management were also discussed. Participants argued for a more flexible approach to implementing marine protected areas that can respond to i) environmental change triggered by climate change, such as shifting habitats, and ii) the changing vulnerabilities of the Reef’s industries. In some cases, the latter is already beginning to happen: for example, fishing and tourism operators have been given access to alternative sites in cases where their usual grounds are impacted by floods or cyclones. Nevertheless, participants suggested that more flexibility is needed. At the same time, industry can promote flexibility within its own operators in response to climate events. For instance, there are examples in the aquarium fishery of fishers not catching key fish species that play an essential role in the reef ecosystem for a period of time after a bleaching event, so that these fish can help the reef recover.

In general, the people we spoke to in our workshops and interviews support an approach to management similar to that outlined in the scenarios under ideal adaptation. This involves: i) integrated catchment, fisheries, and reef management, ii) rehabilitation of coastal habitat, and iii) flexible management or protected areas that anticipates and responds rapidly to bleaching events, cyclones, disease outbreaks and predation.

“\What I’m hearing is that there are a whole range of other things - catchment management, coastal development, industrialisation - that go to making a sustainable fishery. So to make those green zones, bag limits, and seasonal closures most effective, we need to get the catchment management and coastal development right.\\”

Government representative
25 March 2011.
**Table 2: Summary of climate change impacts, adaptation, and outcomes for coral reef habitats in the Great Barrier Reef region.**

<table>
<thead>
<tr>
<th>Reefs</th>
<th>1. Best-case climate scenario for 2050</th>
<th>2. Worst-case climate scenario for 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. Limited adaptation</td>
<td>b. Ideal adaptation</td>
</tr>
<tr>
<td><strong>Exposure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature spikes are experienced at least once per decade.</td>
<td>Mid-shelf corals hit by freshwater runoff more than once a century.</td>
</tr>
<tr>
<td></td>
<td>Cyclone damage increases moderately.</td>
<td>Disease and Crown-of-Thorn Starfish (COTS) outbreaks are more frequent.</td>
</tr>
<tr>
<td></td>
<td>Ocean acidification slows coral growth. Impacts are localised. Up to 40% of corals are affected.</td>
<td></td>
</tr>
<tr>
<td><strong>Ecological adaptation</strong></td>
<td>No capacity for ecological adaptation.</td>
<td>Some capacity for ecological adaptation.</td>
</tr>
<tr>
<td><strong>Social adaptation</strong></td>
<td>Reef management does not anticipate climate change.</td>
<td>Reef management anticipates climate change.</td>
</tr>
</tbody>
</table>
Table 3: Summary of climate change impacts, adaptation, and outcomes for coastal habitat in the Great Barrier Reef region.

<table>
<thead>
<tr>
<th>Coastal habitat</th>
<th>1. Best-case climate scenario for 2050</th>
<th>2. Worst-case climate scenario for 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>a. Limited adaptation</td>
<td>b. Ideal adaptation</td>
</tr>
<tr>
<td></td>
<td>Erosion of existing habitat (e.g. mangrove). Extensive damage to existing habitat in storms events.</td>
<td>Extensive erosion of existing habitat (e.g. mangrove). Extensive damage to existing habitat in storm events. Decline in habitat cover exacerbated by variable rainfall (floods and drought).</td>
</tr>
<tr>
<td>Ecological adaptation</td>
<td>No capacity for ecological adaptation.</td>
<td>Some capacity for ecological adaptation.</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Little recovery of existing habitat. Shore-ward or upstream migration (10-100m). Southward migration.</td>
<td>Moderate recovery from cyclones but little recovery of existing habitats from chronic erosion. Shore-ward or upstream migration (10-100m). Southward migration.</td>
</tr>
<tr>
<td>Social adaptation</td>
<td>Coastal development does not anticipate climate change. Coastal protection and habitat eradication of newly established habitat pursued.</td>
<td>Coastal development anticipates climate change. Coastal retreat and habitat rehabilitation actions taken.</td>
</tr>
<tr>
<td>Outcome</td>
<td>Few new areas of habitat are established upstream or south. Mangrove, seagrass and inter-tidal habitat declines significantly. Habitat declines affect large sea animals (e.g. 5% decrease in nGBR Green Turtle nesting grounds). Habitat declines affect sea-bird populations (e.g. sporadic nesting failures).</td>
<td>New areas of habitat are established further upstream and further south. Mangrove, seagrass and inter-tidal habitat cover is maintained. Habitat shifts affect larger sea animals (e.g. 5% decrease in nGBR Green Turtle nesting grounds), but new sites are established. Habitat shifts affect sea-bird populations (e.g. sporadic nesting failures).</td>
</tr>
</tbody>
</table>
### Table 4: Summary of climate change impacts, adaptation, and outcomes for the Great Barrier Reef catchment.

<table>
<thead>
<tr>
<th>GBR Catchment</th>
<th>1. Best-case climate scenario for 2050</th>
<th>2. Worst-case climate scenario for 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. Limited adaptation</td>
<td>b. Ideal adaptation</td>
</tr>
<tr>
<td><strong>Exposure</strong></td>
<td>Greater year-to-year variation.</td>
<td>Intermittent cyclone damage.</td>
</tr>
<tr>
<td></td>
<td>Impacts are experienced in patches along the GBR.</td>
<td>Heat stress on crops, plants, animals and water.</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>Reduced land availability and thereby productivity.</td>
<td>Reduced land availability and thereby productivity.</td>
</tr>
<tr>
<td><strong>Adaptation</strong></td>
<td>Management of the catchment does not anticipate climate change.</td>
<td>Management of the catchment anticipates climate change.</td>
</tr>
<tr>
<td><strong>Outcome</strong></td>
<td>Some farmers go out of business. In general, variability is buffered by government subsidies. Land degradation, erosion and run-off increase.</td>
<td>Farmers diversify livelihoods and overall profits are maintained. Decisions are made about what a more desirable industry looks like. Land degradation, erosion and run-off are minimised</td>
</tr>
</tbody>
</table>
6. Impacts and adaptation in the fishing industry

Here, we extend the four scenarios to describe potential impacts on fish and the commercial and recreational fishing industries resulting from interactions between the two climate change trends and industry adaptation responses under both limited and ideal situations. Table 5 summarises the information.

1a Paradise perturbed: Climate change affects the distribution and abundance of fish. The impacts on reef habitats reduce the abundance of some fish, like butterflyfish that depend heavily on corals. Higher temperatures, which may benefit some pelagic species, cause many species, such as coral trout, to shift southward and into deeper waters. Sea level rise also floods low-lying fishing port facilities and changes land values. These changes are gradual and are in line with changes that fishers already adapt to day-to-day and year-to-year. As a result, fisheries management and the organisation of the fishing industries remain largely unchanged. Adaptation among both commercial and recreational fishers is ad hoc. Fishers respond to changes in availability of target fish species, including opportunities to exploit stock increases, by increasing fishing effort, travelling further south and offshore, and using less selective fishing methods to diversify the catch. Much of the flooded coastal infrastructure is abandoned and replaced elsewhere. The commercial fishing sector remains profitable for many, though some operators exit. Recreational fishers continue to enjoy the cultural services of the Reef. However, the overall sustainability of the Reef fisheries declines and conflict between managers, commercial fishers, and recreational fishers decreases. Adapting to climate change has also raised the capacity of people in the fishing industries to adapt to other drivers of change such as market prices, technology and fuel costs.

2a Coastal calamity: The distribution and abundance of fish stocks are heavily influenced by climate change. In particular, effects on marine and coastal habitat in turn affect many target reef species of the fisheries, from butterflyfish to coral trout, leading to decreased fish abundance and stock availability. In contrast, changes from coral- to weed-dominated reefs lead to growth in herbivore numbers. Increasing temperatures, which may benefit some pelagic species, cause most species, again like coral trout, to shift southward and into deeper waters. New fish appear in Australian waters from more northern fisheries, for instance black bass. Bigger fluctuations in rainfall cause rainfall-dependent species such as barramundi, whiting and prawns to vary in number. The impacts of ocean acidification remain uncertain but may compound declines in fisheries productivity. Sea level rise floods a lot of low-lying fishing port facilities and leads to changes in land values. These changes exceed the degree of variability that fishers typically adapt to on a day-to-day, year-to-year basis and are more permanent. Nevertheless, fisheries management remains largely unchanged. The majority of the commercial fishing industry is absorbed by large international companies. Adaptation in both the commercial and recreational sectors is ad hoc. Fishers respond to declines in fish stock availability or opportunities to exploit stock increases by
increasing fishing effort, travelling further south and offshore, and diversifying the catch. The commercial sector, in particular, organises around off-shore ports or motherships to reduce travel time at sea while increasing effort. Much of the flooded coastal infrastructure is abandoned and replaced elsewhere. The commercial fishing sector is no longer profitable and many operators exit the fishery. The international conglomerates survive through a series of take-overs of quota and assets. Some recreational fishers continue to fish but receive far less enjoyment from the cultural services of the Reef, most choose to fish elsewhere. The sustainability of the Reef fisheries declines and conflict between managers, commercial fishers, and recreational fishers increases dramatically. Lifestyle values associated with fishing are lost.

2b Volatile waters: Climate change dramatically alters the distribution and abundance of fish. Changes to habitat have considerable effects on many reef species targeted by fishers, leading to decreased abundance and stock availability. In contrast, periodic changes from coral to weed-dominated reefs lead to growth in herbivore numbers. Further, rising temperatures, which may benefit some pelagic species, cause most species, such as coral trout, to shift southward and into deeper waters. Consequently, new species like black bass move into Australian waters from more northern fisheries. Bigger fluctuations in rainfall cause rainfall-dependent species such as barramundi, whiting and prawns to vary in abundance. The impacts of ocean acidification remain uncertain but may compound declines in fisheries productivity. Sea level rise leads to extensive flooding of low-lying fishing port facilities and changes in coastal land values. These changes exceed the level of change that fishers typically adapt to day-to-day, year-to-year and are more permanent. Fishers and fisheries managers anticipate climate change. The commercial fishing industry organises around co-operatives and recreational fishers link up with these co-operatives. Both the commercial and recreational sectors adapt strategically by improving marine and fisheries stewardship through integrated catchment, fisheries and reef management, improving business planning and forecasting, permanently reducing effort, migrating to different coastal ports and Australian fisheries to relieve stress on vulnerable species or impacted sites, diversifying product, income and activities, and developing comprehensive emergency plans. Fisheries infrastructure is gradually retrofitted or relocated in response to sea-level rise. The commercial fishing sector becomes less profitable and many operators exit voluntarily: however it remains viable for the individual businesses that adapt. Recreational fishers continue to fish but combine fishing with other leisure activities in order to maintain enjoyment from the varied cultural services of the Reef. Sustaining the Reef’s fisheries remains an ongoing challenge but collaboration between managers, commercial fishers and recreational fishers is strengthened by the common problem. Adapting to climate change has also increased the capacity of people and industry to adapt to other non-climate drivers of change, which continue to be significant to Queensland’s fishing industries.

Government and industry perspectives on adaptation in the fishing industry

The Great Barrier Reef’s fishing industry is very diverse. It has several commercial fisheries that are organised and managed differently, as well as a large and dispersed recreational fishery. The fact that these sectors are exposed to numerous climate and other disturbances provides them with extensive experience of adaptation. Activities include broad approaches such as business planning and improved stewardship to maintain the long term sustainability of the Reef on which they depend.

Commercial fishing industries are usually made up of entrepreneurs driven primarily by profit, and other fishers who identify more closely with the way of life. Typically, the entrepreneurs are more innovative, adept at business planning and able to adapt. Lifestyle fishers are often less profitable, more vulnerable to disturbance events and least able to adapt. The viability of the fishing industries as a whole relies on adaptation across all operators.

Government and industry peak bodies are focused on providing information, technical assistance, and sometimes financial support to enable fishers to fish smarter in times of change. This includes furnishing operators with enhanced business skills, such as improved forecasting, financial management, marketing and networking. As well as helping businesses and the industry as a whole to diversify, manage effort, be mobile, and use green technologies to reduce costs and maintain
or increase market share and product price. In turn, it is recognised that business viability, market position and the capacity to adapt are all enhanced by improved stewardship – which is the proven ability to implement sustainable practices.

Workshop participants related a range of experiences that illustrate the scope for particular adaptation actions to reduce the vulnerability of the Reef and fishers to risk. For example, at the industry level, trends towards amalgamation in the commercial fisheries sectors in Australia into fewer, large companies is on the whole seen to compromise the capacity of individual boat owner/operators to adapt. These conglomerates are also considered to possess fewer stewardship values than independent owner/operators. Alternatively, organisation into co-operative structures, industry associations and networks is expected to spread innovation and facilitate effective adaptation. Although importantly, a range of organisational and business models are needed to accommodate for changing circumstances, preferences, and capabilities.

Another important adaptation option that we discussed is the removal of fishing effort or capacity. Buy-back schemes were attempted as part of the 2004 Representative Areas Programme and have been trialled in other fisheries since then. Approaches vary from full government funding, to government loans to industry, to industry co-operative buy-backs. Experience suggests that not all attempts minimise environmental impact and mitigate the negative impacts on fishers. Further, buy-backs tend to occur under a sustainability banner. Where an industry sector might use effort reduction to improve profitability for the remaining operators under climate or other risks, government support is perceived to be lacking.

Finally, workshop participants discussed the considerable progress that has been made in terms of stewardship and sustainability in the fishing industry and the potential of industry and individuals to leverage a market advantage through green, organic and buy-local marketing. Stewardship and green marketing are seen as essential to counter the declining profitability of the fishing industries as prices stagnate or decline and costs, especially fuel, increase. Ever-improving relationships between industry, government and scientists are credited with advancing this and a number of other important management and adaptation objectives in the past five years or so.

“What we’re finding is that with all the government agencies that we used to consider as enemies, we’ve said ‘No, let’s embrace the knowledge. Let’s work together’ and it’s been very effective for our industry. We’ve found that the information that we’ve received and the change of attitudes has been very, very good.”

Commercial fishing industry representative
01 April 2011.

Representatives of the recreational sector also note that organising into associations and networks can enhance the legitimacy and stewardship potential of the sector, and contribute to its ability to withstand change. Encouragingly, the economic value of the industry is increasingly recognised, i.e. in the Northern Territory, and new opportunities are emerging for partnerships between recreational fishers and the tackle and tourism industries. The industry continues to struggle with membership and representation of fishers, but it is now more frequently included in fishing industry and government negotiations on policy and management. Climate risk is not a focal concern for many recreational fishers. Instead, adapting to other legislation that might result from climate mitigation and adaptation policy is seen as a challenge and potential source of conflict.

“We can adapt to climate change but it’s going to be increasingly difficult for us to adapt to some of the other changes that are forced on us.”

Recreational fishing sector representative
01 April 2011.

At the same time, the climate change debate is perceived to have brought people together and to have built partnerships and trust within and between industries.

In practice, fisheries management and adaptation are situated somewhere between the ideal and limited adaptation scenarios, but continue to progress towards the kinds of strategies that are expected to reduce the vulnerability of fish, fishers and the fishing industries to climate risk and to create opportunities for the future.
### Table 5: Summary of climate change impacts, adaptation, and outcomes for the Great Barrier Reef fishing industry

<table>
<thead>
<tr>
<th>Fisheries</th>
<th>1. Best-case climate scenario for 2050</th>
<th>2. Worst-case climate scenario for 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. Limited adaptation</td>
<td>b. Ideal adaptation</td>
</tr>
<tr>
<td><strong>Direct impacts</strong></td>
<td>Shifts in fish distribution (southward and deeper) increased abundance of some fish (e.g. red-throat emperor, pelagics). Sea level rise (13m of flooding on gentle slopes).</td>
<td>Shifts in fish distribution (southward and deeper) increased variability in abundance of rainfall-dependent fish (e.g. barramundi, whiting, prawns). Increased abundance of some fish (e.g. herbivores, red-throat emperor, pelagics). New species appear (e.g. black bass). Sea level rise (68m of flooding on gentle slopes).</td>
</tr>
<tr>
<td><strong>Indirect impacts from habitat change and land use</strong></td>
<td>Abundance of coral dependent species (e.g. Coral trout) declines. Mangrove, seagrass and inter-tidal habitat declines. Land degradation, erosion and run-off increase. Land values change as beach-front properties lose value.</td>
<td>Abundance of coral dependent species (e.g. Coral trout) declines significantly. Mangrove, seagrass and inter-tidal habitat disappears in many areas. Land degradation, erosion and run-off increase significantly. Land values change over a large area.</td>
</tr>
<tr>
<td><strong>Social adaptation</strong></td>
<td>Industry organisation unchanged. Stewardship constant. Increases in fishing effort (e.g. new gear). Reactive diversification. Reactive mobility. Structural defence and abandonment of infrastructure.</td>
<td>Industry amalgamates into big international companies. Recreational fishers compete with large corporations. Stewardship declines. Increased effort (e.g. motherships). Reactive diversification. Reactive mobility. Structural defence and abandonment of infrastructure.</td>
</tr>
</tbody>
</table>
7. Impacts and adaptation in the tourism industry

In this section we further develop our scenarios to describe potential impacts on the tourism industry resulting from interactions between the two climate change trends and industry adaptation responses under a limited and an ideal situation. Table 6 summarises the information.

1a Paradise perturbed: The direct and indirect impacts of climate change cause a series of changes to the aesthetics and appeal of the Reef with implications for the tourism industry. The quality, composition and distribution of important reef assets, including corals, beaches and iconic species are affected although effects are spread out. Changes to rainfall patterns and the increasing intensity of cyclones lead to a more volatile climate in the region. Sea level rise floods low-lying tourism infrastructure and changes land values. Nevertheless, other non-climate drivers such as green taxes on international travel have a greater impact on tourism. Consequently, tourism management and the organisation of the industry remain largely unchanged. Adaptation by the industry responds to changes in the Reef and its biodiversity by increasing effort for instance by creating coral farms and fish zoos, concentrating effort on remaining coral refuges, travelling further south and offshore, and diversifying into other water activities. Much of the inundated coastal infrastructure is abandoned and replaced elsewhere. The tourism sector remains profitable for many, though some operators exit. However, the overall sustainability of the Reef declines and conflict between managers, tourism operators, and fishers increases slightly. Non-climate drivers of change continue to be of greater importance to people working in the tourism industry.

1b Reef relief: Climate change causes a series of changes to the aesthetics and appeal of the Reef and affects the tourism industry. The quality, composition and distribution of important reef assets, including corals, beaches and iconic species are affected although effects are spread out and fairly small. Changes to rainfall patterns and increasing intensity of cyclones lead to a more volatile climate in the region. Sea level rise floods low-lying tourism infrastructure and changes land values. Other non-climate drivers such as green taxes on international travel have a greater impact on tourism. The organisation of the tourism industry remains unchanged, but tourism operators and managers anticipate climate change. Industry adaptation is strategic, responding to subtle changes in the Reef by increasing marine stewardship, improving business planning and forecasting, reducing effort, dispersing effort by co-ordinating operators, migrating or moving operators to other locations to relieve stress on vulnerable species or impacted sites, and diversifying into new activities, markets and sources of income. Tourism infrastructure is gradually retrofitted or relocated in response to sea-level rise. The tourism sector remains profitable. Sustainability of the Reef is achieved and conflict between managers, tourism operators, and fishers reduces. Adapting to climate change has furnished the tourism operators and managers with capacity to adapt to other non-climate drivers of change, which continue to be significant for the industry.

2a Coastal calamity: The many impacts of climate change cause a series of substantial changes to the aesthetics and appeal of the Reef with major impacts on the tourism industry. The quality, composition and distribution of important reef assets, including corals, beaches and iconic species are affected and the consequences are widely felt. Changes to rainfall patterns and increased intensity of cyclones lead to a much more volatile climate in the region. Sea level rise floods low-lying tourism infrastructure and changes land values. The impacts on tourism are exacerbated by other non-climate drivers such as oil scarcity and rising fuel prices, and strict immigration policy. The tourism industry amalgamates into large international companies. Industry adaptation is ad hoc. Businesses respond to changes in the Reef and its biodiversity by increasing effort through aggressive marketing, relocating operators south, and expanding into other water and land-based activities including reef museums. Much of the flooded coastal infrastructure is abandoned and replaced elsewhere. The reef-based tourism sector is no longer profitable for many and large numbers of operators exit the industry. The international conglomerates survive through a series of takeovers. Overall sustainability of the Reef declines and conflict between managers, tourism operators, and fishers increases dramatically. Lifestyle values associated with the reef-based tourism sector are lost.
2b Volatile waters: The aesthetics and appeal of the Reef and associated tourism are affected by climate change. The quality, composition and distribution of important reef assets, including corals, beaches and iconic species are affected and the consequences are widely felt. Changes to rainfall patterns and increased intensity of cyclones lead to a much more volatile climate in the region. Sea level rise floods low-lying tourism infrastructure and changes land values. Climate change impacts on tourism are exacerbated by other non-climate drivers such as oil scarcity and rising fuel prices, and strict immigration policy. The tourism industry organises around co-operatives and adaptation is strategic. It involves increasing marine stewardship, improving business planning and forecasting, tactically reducing the numbers of operators, dispersing effort by co-ordinating operators, migrating or moving operators to other locations to relieve stress on vulnerable species or impacted sites, diversifying activities, branding, market and income, and developing comprehensive emergency planning. Tourism infrastructure is gradually retrofitted or relocated in response to sea-level rise. The reef-based tourism sector is less profitable and many operators exit voluntarily. The industry remains viable for those who remain and adapt. The sustainability of the Reef is an ongoing challenge but collaboration between managers, tourism operators, and fishers is strengthened by the common problem. Adapting to climate change has furnished tourism operators with the capacity to adapt to other non-climate drivers of change, which continue to be significant for the tourism industry.

Government and industry perspectives on adaptation in the tourism industry
The tourism industry is exposed to both climate and non-climate risks and opportunities from which insights can be drawn about adaptation. Management and adaptation in the tourism sector are integrated, and emphasis is placed on business viability and industry reputation, which enable businesses to cope with and adapt to change.

At the regional scale, tourism-dependent communities are found to be highly vulnerable to fluctuations in international trends and drivers. Cairns, for instance, is said to have experienced the Global Financial Crisis in a completely different way to the rest of Australia because of its high dependence on international tourism, the compounding impacts of the 2010/2011 Queensland floods and cyclones, and the Japanese earthquake. Broader development policy to diversify the economic basis of tourism hubs is therefore important for adaptation and the long-term viability of communities impacted by downturns in the tourism market.

At the industry level, workshop participants suggested that an important response is to ensure that customer expectations change along with changes to the Reef and that the comparative advantage of the Reef is recognised. It was noted that the Great Barrier Reef is one of the best-managed reefs in the world and is likely to weather the impacts of climate change well relative to other reef-based tourist destinations.

“I’m buoyed by the fact that the reef isn’t going to disappear [related to stakeholder perceptions that impacts will be localised and dispersed along the vast reef], but it’s going to change. So, as long as we don’t over promise, as long we’re honest about what people are going to see, they will still get a better experience than if they were diving off the Florida Keys or Thailand.”

Tourism industry representative
25 March 2011.

Management and adaptation in the tourism industry involves diversifying the market to include more domestic inter-state and intra-state tourism, promoting the green credentials of the marine park and World Heritage Area, developing new tourist attractions such as identifying the eight most iconic and rare marine species, and providing up-to-date and rare information to the media about the real extent of damage to the Reef and its tourism infrastructure following events such as the Queensland floods and Cyclone Yasi.

Tourism management and adaptation also tries to enhance the business skills of individual enterprises, including improved forecasting, financial management, marketing and networking, and to provide information to operators about how to diversify and use green technologies. Managing effort or the number of operators within the industry is not viewed as a promising adaptation strategy at the industry or enterprise level. However, managing human resources, through sharing of staff or combining tours is
emerging as a smart response to unusual, temporary events.

In general, there is a high turn-over of businesses and it is difficult to guarantee return on investment in the tourism industry. For many operators, the capital investment needed and the risk involved in pursuing particular adaptation activities, such as adopting green technologies, are often too much. Only a small number of innovators manage this risk and successfully leverage financial and technical support through their networks, which may include links to government and peak industry bodies. For these operators, adopting new technologies improves both the stewardship credentials and profitability of their businesses. On the other hand, there are also examples of tourism property developers, who are unwilling to invest in adaptation strategies for the greater good of the industry, and are driven by short timeframes for return on investment. Nevertheless, on the whole, workshop participants argued that stewardship values across the industry are stronger than 20 years ago.

“I would say that most people on the reef, in tourism, actually understand the asset, and I wouldn’t have said that 20 years ago. They understand that they need to protect the asset that they are working on, so that’s great, that’s a huge leap forward.”

Tourism industry representative
25 March 2011.

Much of the progress in stewardship and green market positioning is attributed to improved relationships between industry, government and scientists. It was also noted that the management and adaptation planning of the Australian and Queensland tourism sectors, in terms of building safety, environmental regulation, and emergency planning is very strong. This affords the industry a potentially powerful market advantage but makes it difficult to compete with less well-regulated destinations on price.

In practice, tourism management and adaptation appear to favour certain adaptation strategies over others, namely business planning and diversification over mobility and effort management. Recent experiences of multiple disturbance events suggest that while temporary, unexpected threats can be easily absorbed and adapted to, prolonged exposure to economic and climate risk remains a real challenge for the industry.
### Table 6: Summary of climate change impacts, adaptation, and outcomes for the Great Barrier Reef tourism industry

<table>
<thead>
<tr>
<th>Tourism</th>
<th>1. Best-case climate scenario for 2050</th>
<th>2. Worst-case climate scenario for 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. Limited adaptation</td>
<td>b. Ideal adaptation</td>
</tr>
<tr>
<td><strong>Direct impacts</strong></td>
<td>Change or damage is localised. The region experiences a more volatile climate. Sea level rises and claims 13m of shoreline.</td>
<td>Damage is extensive. The region experiences a much more volatile climate. Sea level rises and claims 68m of shoreline. The coastline erodes and some beaches are lost. Chronic impacts include salt water intrusion and pollution of ground water.</td>
</tr>
<tr>
<td><strong>Indirect impacts from habitat change and land use</strong></td>
<td>The reef remains in a coral-dominated state. Coral composition shifts to massive and encrusting corals. Coral-dependent species decline. Mangrove, seagrass and inter-tidal habitat declines slightly. Some iconic species are affected (e.g. turtles, seabirds). Marine biodiversity declines slightly. Land values change as beach-front properties lose value.</td>
<td>The reef shifts to a state dominated by seaweed. Coral-dependent species decline considerably. Mangrove, seagrass and inter-tidal habitat disappears in many areas. Some iconic species are heavily affected (e.g. turtles, seabirds). Marine biodiversity declines significantly. Land values change over a large area.</td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
<td>Industry organisation is unchanged. Increased stewardship. (regulated development, habitat restoration) Improved business planning &amp; forecasting (price increases &amp; consumer campaigning) Reduced effort (reduced operating days) Effort is dispersed. Reactive diversification. Pre-planned mobility. Retrofitting of infrastructure &amp; planned retreat.</td>
<td>Industry remains profitable. Sustainability achieved. Lifestyle values retained.</td>
</tr>
</tbody>
</table>
8. In sum: reflections on climate change

Representatives of Reef industries suggested in our workshops and interviews that while changes to climate are not necessarily disputed, the rate of climate change and its likely consequences remain debated. As such, some participants voiced concern about the general trend among the scientific and management community to represent climate change trends and impacts as overly negative.

We have made every effort to provide a fair and varied overview of potential impacts and outcomes. Our scenarios assume that climate change is happening but explore both a best-case and worst-case situation. Change will occur even under a best-case climate scenario, regardless of individual beliefs on who or what is causing the climate to change. While some new opportunities may emerge, it is likely that climate change will bring added risk to the natural environment and to Reef industries. How well we manage this risk will determine overall outcomes. Our research suggests that opportunities are more likely to come from successful adaptation than from climate change impacts directly.

Under a best-case climate scenario where industries and individuals adapt poorly, reef and coastal habitats change in quality, composition and distribution; habitat-associated species and biodiversity decline; and fish experience mixed impacts. These trends are not unlike current patterns of habitat and biodiversity loss. We do not suggest in the scenarios that these changes are unacceptable. Further, while we aim to contrast effective and ineffective adaptation, we do not suggest that the latter reflects the current state of play. Indeed, many of the management and adaptation strategies proposed under ideal adaptation are already happening or are in development within the Great Barrier Reef region. There is every possibility that continued progress in management and adaptation will be able to minimise, and even halt, many of the declining trends in habitat cover and biodiversity, despite climate change.

However, under the worst-case climate change scenario the impacts imposed by climate change on the natural environment and on industries are considerable. Again, how well we adapt will determine the outcomes we achieve. If a worst-case climate scenario is combined with a limited adaptation response, negative outcomes for both ecosystems and industries are likely. However, if progress in management and adaptation within the region continues, adaptation will play an integral part in reducing negative impacts even under the worst-case climate change scenario. Nevertheless, the pressure on ecosystems and industries would remain high.

These scenarios do not represent a pessimistic outlook for the Great Barrier Reef. They try to capture a range of possible climate risks and impacts, and to show what can happen with various types of adaptation by humans. This is based on the premise that social adaptation - how well we respond - will determine what ultimately happens to us.

The government and industry representatives also emphasised that climate change adaptation is viewed as an integral part of overall enterprise and ecosystem management, not as a separate agenda. There is some concern among people who work in the region that the political interest in climate change and the financing attached to it could detract from the fundamentals of coastal and marine resilience such as biodiversity, sustainability, water quality, and coastal development. To this end, it is important to integrate climate change into existing policy and programmes not vice versa.

Finally, the research revealed many cases of successful adaptation to all sorts of new risks and opportunities and the lessons learned from these experiences are just as relevant and useful to climate contexts as they are to non-climate ones.

We developed the scenarios as a tool to help focus broad discussion on potential futures under different levels of risk. We used them to identify which adaptation strategies are and are not likely to reduce vulnerability to climate risk in the long term, but they can be used, in part or in full, for many other of purposes. Please feel free to use, adapt, and amend the scenarios to help in your ongoing adaptation research and planning, if you find them useful.
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The contents of this brief remain the sole responsibility of the authors.

Reference list


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