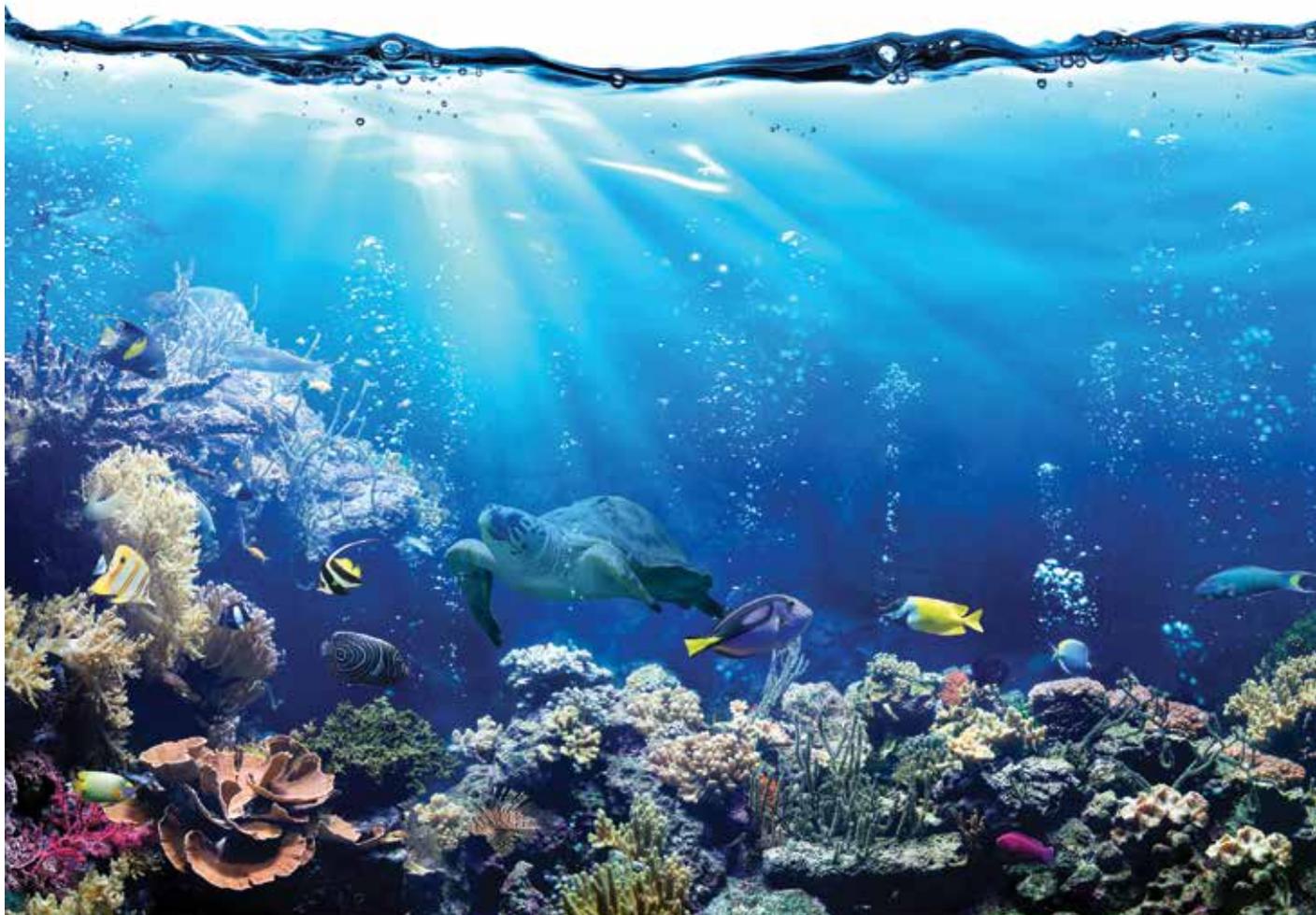


Saving the Great Barrier Reef



Edited by Justin Healey

ISSUES
IN SOCIETY

Saving the Great Barrier Reef

Volume | 436

ISSUES
IN SOCIETY

Edited by Justin Healey

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INTRODUCTION

Saving the Great Barrier Reef is Volume 436 in the 'Issues in Society' series of educational resource books. The aim of this series is to offer current, diverse information about important issues in our world, from an Australian perspective.

KEY ISSUES IN THIS TOPIC

As the largest coral reef system on the globe and home to 1,500 species of fish and other diverse marine life, Australia's Great Barrier Reef is unquestionably one of the great wonders of the natural world.

Unfortunately, it is also in grave danger of dying. Recent annual back-to-back coral bleaching events have drastically accelerated the existing damage to the Great Barrier Reef and its rich biodiversity. The reef is under threat from numerous pressures, both natural and man-made. These threats include over-fishing, coastal development, agriculture, mining, tourism and the ravaging ecological impacts of climate change.

How is Australia sustainably managing the reef and the land-based and sea life it supports? What conservation threats are being effectively addressed – is it too late to save the Great Barrier Reef?

SOURCES OF INFORMATION

Titles in the 'Issues in Society' series are individual resource books which provide an overview on a specific subject comprised of facts and opinions.

The information in this resource book is not from any single author, publication or organisation. The unique value of the 'Issues in Society' series lies in its diversity of content and perspectives.

The content comes from a wide variety of sources and includes:

- Newspaper reports and opinion pieces
- Website fact sheets
- Magazine and journal articles
- Statistics and surveys
- Government reports
- Literature from special interest groups

CRITICAL EVALUATION

As the information reproduced in this book is from a number of different sources, readers should always be aware of the origin of the text and whether or not the source is likely to be expressing a particular bias or agenda.

It is hoped that, as you read about the many aspects of the issues explored in this book, you will critically evaluate the information presented. In some cases, it is important that you decide whether you are being presented with facts or opinions. Does the writer give a biased or an unbiased report? If an opinion is being expressed, do you agree with the writer?

EXPLORING ISSUES

The 'Exploring issues' section at the back of this book features a range of ready-to-use worksheets relating to the articles and issues raised in this book. The activities and exercises in these worksheets are suitable for use by students at middle secondary school level and beyond.

FURTHER RESEARCH

This title offers a useful starting point for those who need convenient access to information about the issues involved. However, it is only a starting point. The 'Web links' section at the back of this book contains a list of useful websites which you can access for more reading on the topic.

GREAT BARRIER REEF

A FACT SHEET OVERVIEW COURTESY OF THE AUSTRALIAN GOVERNMENT

The Great Barrier Reef is the only living organic collective visible from Earth's orbit. The Great Barrier Reef, off the east coast of Australia, is one of the wonders of the natural world – it is the world's largest coral reef ecosystem. It was declared a World Heritage Area in 1981 and added to the National Heritage List in 2007.

The reef is scattered with beautiful islands and idyllic coral cays and covers more than 300,000 square kilometres. The Great Barrier Reef system consists of more than 3,000 reefs which range in size from 1 hectare to over 10,000 hectares in area. Dunk Island is one of more than 600 islands of the Great Barrier Reef.

Human activity in the reef areas has led to increased pollutants and the reef has suffered damage. Protecting the Reef is the responsibility of the Marine Park Authority. In 2003, the previous Australian Government and Queensland Governments, in partnership with a wide range of industry and community groups,

developed the Reef Water Quality Protection Reef Plan (the Reef Plan) as a combined effort to protect the reef.

Of particular concern is wetlands – which have decreased by over 50 per cent since European settlement. The Great Barrier Reef Coastal Wetlands Protection Program is developing measures for the long-term conservation and management of priority wetlands.

The Great Barrier Reef, off the east coast of Australia, is one of the wonders of the natural world – it is the world's largest coral reef ecosystem.

THE CORAL

Corals make up the various reefs and cays. These are the basis for the great variety of sea and animal life in the reef. Coral consists of individual coral polyps – tiny live creatures which join together to form colonies. Each polyp lives inside a shell of aragonite, a type of



calcium carbonate which is the hard shell we recognise as coral. The polyps join together to create forests of coloured coral in interesting fan, antler, brain and plate shapes.

The ideal environment for coral is shallow warm water where there is a lot of water movement, plenty of light, where the water is salty and low in nutrients. There are many different types of coral, some are slow growing and live to be hundreds of years old, others are faster growing. The colours of coral are created by algae. Only live coral is coloured. Dead coral is white.

One of the greatest dangers to the habitat is the crown-of-thorns starfish. Since the 1960s the crown-of-thorns has been destroying the corals which make up the reef. Crown-of-thorns outbreaks go through a series of stages which can take from 1 to 15 years. The impact of a crown-of-thorns infestation on sea and bird life can be significant as the corals die.

Another scourge of the reef is bleaching, where corals have died in large numbers. This phenomenon is not exclusive to Queensland's Great Barrier Reef, but has been observed on reefs throughout the world. It is thought the bleaching has been caused by rises in water temperature related to the El Niño effect, although the evidence is not conclusive.

The coral has, over the years, brought many ships to grief including Captain James Cook's ship *Endeavour*. One of the most famous wrecks is that of the HMS *Pandora*, which foundered in 1791. The Queensland Museum has been leading archaeological digs to the *Pandora* since 1983 and its most recent was completed in February 1999. There are 30 shipwreck sites known in the marine park.

THE HABITAT

The World Heritage Area hosts many habitats or native environments where animals and plants naturally live. Different degrees of protection are provided for different habitats in the World Heritage Area. One of the main aims of the Reef Plan is to maintain biodiversity within the larger ecosystem of the reef as well as different habitats to help sustain the biodiversity of species and population levels.

The reef is scattered with beautiful islands and idyllic coral cays and covers more than 300,000km². The Great Barrier Reef system consists of more than 3,000 reefs which range in size from 1 hectare to over 10,000 hectares in area.

The Great Barrier Reef area abounds with wildlife, including dugong and green turtles, varieties of dolphins and whales, more than 1,500 species of fish, 4,000 types of mollusc and more than 200 species of bird life.

However, in 2006 it was reported that over the last 40 years, 'numbers of nesting loggerhead turtles have declined by between 50 per cent and 80 per cent'; and

'estimates of dugong populations ... indicate that they are currently only about 3 per cent of what they were in the early 1960s'.

Since 2004, rezoning different areas of the reef was introduced to try and recognise important habitats as well as identify different species of fish as key targets of protection.

Human activity in the reef areas has led to increased pollutants and the reef has suffered damage.

TOURISM

More than two million people visit the reef each year generating more than \$AU2 billion in tourism dollars, making tourism a major earner for the north-eastern Australian economy. Tourists are carried to the reef system by more than 500 commercial vessels, and tourism is permitted through nearly all the park.

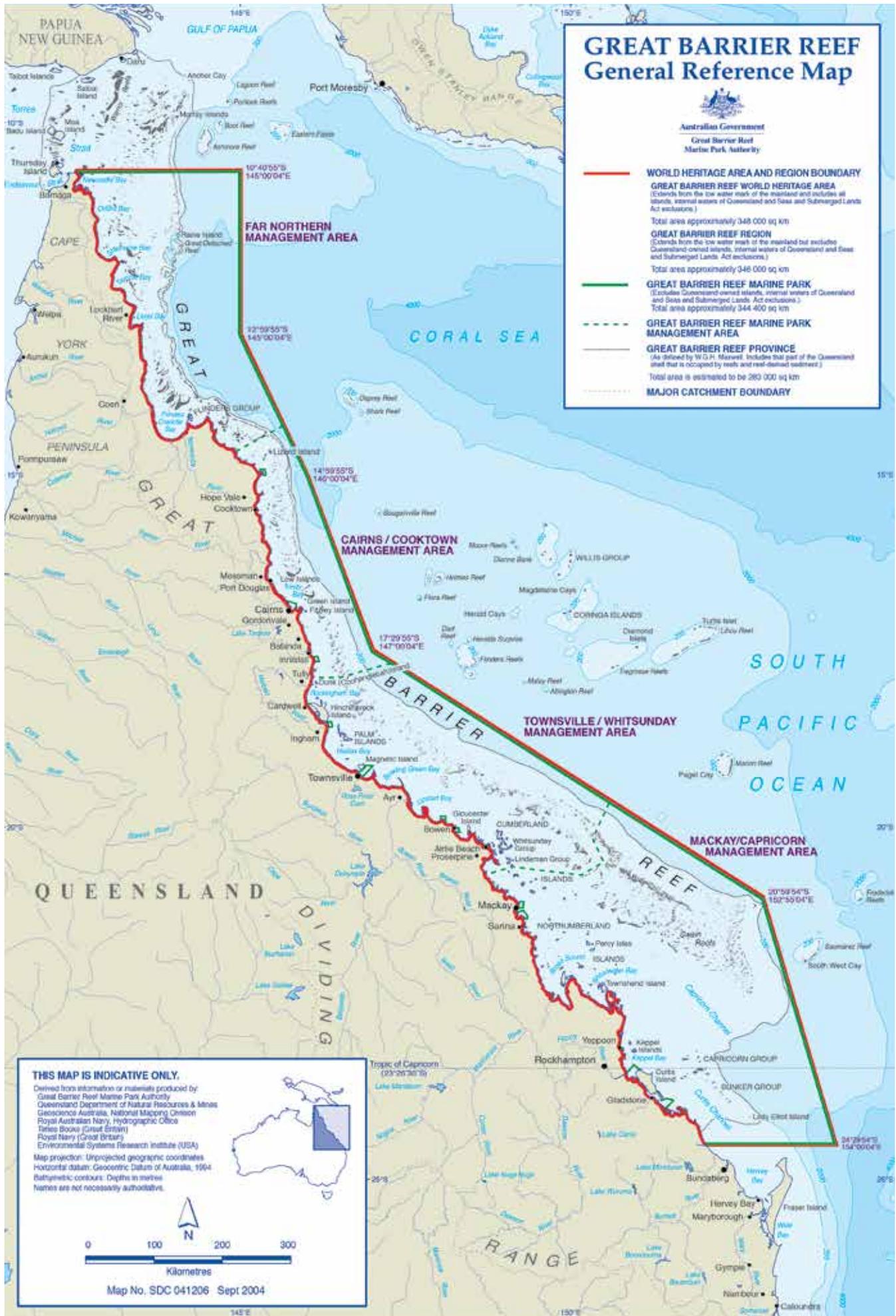
Most of the reef is part of the Great Barrier Reef Marine Park and various parts of it are protected in certain ways. For example, fishing is restricted in some areas and particular animals – like whales, dolphins, green turtles and dugong – are protected.

Tourism may also have a negative impact, with fragile corals broken by reef walking, dropped anchors or by boats dropping fuel and other sorts of pollution. Even the number of people in the water with the associated run-off of sweat and suntan lotions may well have a negative impact on the fragile reef environment.

Before visiting the Great Barrier Reef Marine Park, it is important you study the zoning map for the area you are visiting to be sure of the activities that you can do and where you can do them.

The Marine Park Authority also recognises the need to protect the cultural and heritage values held by traditional owners. Since 2004, indigenous traditional owners and government agencies are working together in relation to the traditional use of marine resources.

Australian Government. *Great Barrier Reef* (Last updated 16 March 2016). Retrieved from www.australia.gov.au on 4 December 2017.



ABOUT THE GREAT BARRIER REEF

SOME REEF FACTS FROM THE QUEENSLAND GOVERNMENT

World Heritage listed in 1981, the Great Barrier Reef is the world's largest and most complex reef system and one of Australia's most treasured natural wonders. Roughly the same size as Japan or Germany (344,400 square kilometres or 70 million football fields), it is home to a breathtaking array of life including a number of rare and threatened species as well as:

- 1,625 types of fish
- 600 types of coral
- 100 species of jellyfish
- 3,000 varieties of molluscs
- 30 species of whales and dolphins
- 133 varieties of sharks and rays
- And much more.

The Great Barrier Reef stretches more than 2,300 kilometres along Queensland's coastline and is made up of around 3,000 individual coral reefs.

It is of special significance to Aboriginal and Torres Strait people with a number of cultural sites on many of its islands. It also supports around 69,000 jobs and contributes approximately \$5.7 billion to the Australian and Queensland economies.

UNESCO World Heritage listing

The World Heritage Committee meets each year to consider the state of conservation of World Heritage properties. In July 2015, the committee met and unanimously agreed not to place the Great Barrier Reef on the World Heritage 'in danger' list.

The decision recognised the significant work by the Australian and Queensland governments, in partnerships with scientists, Traditional Owners, community and industry to further protect and manage the Great Barrier Reef with the development of the Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan).

In December 2016, Australia provided UNESCO's World Heritage Centre with an update on the progress with actions under the Reef 2050 Plan.

Managing the World Heritage Area

The Great Barrier Reef's World Heritage Area lies within one of the best managed marine parks in the world, the Great Barrier Reef Marine Park.

The Great Barrier Reef Marine Park Authority manages the park with support from Queensland Parks and Wildlife Service marine park rangers through a joint field management program and through laws and zoning plans.

The field management program includes monitoring patrols, compliance work, maintenance of camping grounds and moorings, monitoring of nesting and breeding sites and pest and fire control on the reef's

national park islands.

Tourism, fishing, recreation, traditional use, research, defence, shipping and ports are all carefully managed through zoning plans that define what activities can occur in what locations to minimise environmental impact and conserve the majestic marine environment.

In the catchments adjacent to the reef, the Queensland Government works with farmers, industry and other groups to ensure everyone plays their part in improving the quality of water flowing to the reef through the Queensland Reef Water Quality Program.

Threats

The Great Barrier Reef has lost almost half its coral cover since 1985 and is under pressure from:

- Climate change
- Poor water quality from land-based run-off
- Impacts from coastal development
- Illegal fishing.

Reef health (coral, seagrass and marine life) has been declining due to poor water quality and the cumulative impacts of climate change, including warmer weather leading to coral bleaching and increased severe weather events, such as cyclones.

Reef health (coral, seagrass and marine life) has been declining due to poor water quality and the cumulative impacts of climate change, including warmer weather leading to coral bleaching and increased severe weather events, such as cyclones.

In the summer of 2015-16, the Great Barrier Reef experienced its worst mass coral bleaching event on record. Bleaching occurs when corals are stressed, in this case from overheating.

Excess nutrients, fine sediments and pesticides from agricultural run-off and other industries pose the biggest risk to reef water quality. Sediment smothers corals and reduces the amount of light reaching seagrasses and other plants, affecting their growth and survival as well as the survival of the marine animals that depend on them for food and shelter. Excess nutrients may be linked to outbreaks of the coral eating crown-of-thorns starfish.

© The State of Queensland 2017.

Queensland Government. *About the Great Barrier Reef* (Last updated 11 January 2017). Retrieved from www.qld.gov.au on 4 December 2017.

Complex and interconnected
A great barrier reef
86% of Australia's sea product of 85 World Heritage areas

Part of our identity
A great barrier reef
86% of Australia's sea product of 85 World Heritage areas

Sea country of Traditional Owners
New Year's Eve fireworks, Crown of Thorns, Enclosed connections, Caring and nature management

Rich heritage
Managed through partnerships
First investigation and conservation
Research and monitoring
Stewardship and best practice

Internationally significant
Valued and visited by people from all over the world

A precious part of our lives
Home to 44% of Australia and 16% of local community's recreation
30.4 billion visitors in 2011-12
1.3 million visits to the Reef for community tourism operations 2011-2012
7000 tonnes of international commercial fisheries catch (2012)

LARGE
Covers 346,000 km²
- 70 million football fields

World Heritage
Outstanding universal value because of its natural, scientific, educational, aesthetic, historic, cultural, and natural beauty and integrity as a system

DIVERSE
Many 1000s of different plants and animals

Resilient but under pressure
Marine Park and Great Barrier Reef Marine Park Authority established
World Heritage Area
Marine Park progressively declared
Marine Park progressively declared
Marine Park progressively declared

PROTECTED
Almost all of the Great Barrier Reef ecosystem is now included within the Great Barrier Reef Marine Park

Timeline:
1975 1980 1985 1990 1995 2000

Australian Government
Great Barrier Reef Marine Park Authority

THE REMARKABLE Great Barrier Reef

Stretching 2300 km along Australia's coast, the Great Barrier Reef is a national and global treasure. It is managed as a Commonwealth Marine Park by the Great Barrier Reef Marine Park Authority working in partnership with the Queensland Government.

www.gbrmpa.gov.au

[f](https://www.facebook.com/GreatBarrierReefMarinePark) GreatBarrierReefMarinePark

[@gbrmarinepark](https://twitter.com/gbrmarinepark)

[YouTube](https://www.youtube.com/user/TheGBRMPA) TheGBRMPA

Source: Great Barrier Reef Outlook Report 2011

Great Barrier Reef Marine Park Authority. *The remarkable Great Barrier Reef*. Retrieved from www.gbrmpa.gov.au on 4 December 2017.

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ANIMALS ON THE GREAT BARRIER REEF

The Great Barrier Reef is a refuge for many species of conservation concern, according to this fact sheet from the [Great Barrier Reef Marine Park Authority](#)

More than just fish and coral

The Great Barrier Reef is home to a stunning array of animals, from microscopic plankton to whales weighing more than 100 tonnes.

More than just fish and coral, the reef supports:

- 1,625 species of fish, including 1,400 coral reef species
- More than 3,000 species of molluscs (shells)
- 630 species of echinoderm (starfish, sea urchins)
- 14 breeding species of sea snakes
- 215 species of birds, including 22 species of seabirds and 32 species of shorebirds
- Six of the world's seven species of marine turtle
- 30 species of whales and dolphins
- One of the world's most important dugong populations
- 133 species of sharks and rays
- ... and much more

The different types of animals found along the reef help make it one of the richest and most

complex natural systems on Earth. While there is a lot known about some animals that make the Reef home, vast amounts of information and species are yet to be discovered.

The Great Barrier Reef Biodiversity Strategy

Great Barrier Reef animals form just one part of the ecosystem's immense biodiversity. We work to protect and conserve all elements of biodiversity, as outlined in our Biodiversity Conservation Strategy.

While there is a lot known about some animals that make the reef home, vast amounts of information and species are yet to be discovered.

Species of conservation concern

The Great Barrier Reef is a refuge for many species of conservation concern. We work to protect marine animal species that are threatened, iconic or at risk.

By working closely with the

state and federal governments and the community, threats to species can be identified and appropriate management actions can occur.

Protected species are those that are protected by law and need special management (*see the snapshot table on the next page*).

Still more species make the Great Barrier Reef home and these include:

- **Bryzoans:** around 950 species of tiny animals that form coral-like colonies and are often confused with corals
- **Worms:** about 500 species have been recorded along the Great Barrier Reef
- **Marine insects and spiders:** likely to be greater than five species of marine spider and more than 20 species of marine insects
- **Plankton:** a major food source for a number of species
- **Ascidians/tunicates:** sometimes called sea squirts, this group of around 720 species provide another splash of colour to the Great Barrier Reef.



SNAPSHOT OF REEF ANIMALS

| | |
|---|---|
| Marine mammals (whales, dolphins, dugong, seals) | More than 30 species of marine mammals are found along the Great Barrier Reef. Bottlenose dolphins, humpback and dwarf minke whales are frequently seen while other species such as Bryde's whales are seldom seen or perhaps seldom recognised. The Great Barrier Reef is an important habitat for dugong. |
| Birds, seabirds and shorebirds | Islands and cays along the Great Barrier Reef support breeding populations of 22 seabird species. Areas of international significance for migratory and resident species of shorebirds are found on, or adjacent, to the Great Barrier Reef. |
| Marine turtles | Six of the world's seven species of marine turtle occur on the Great Barrier Reef with globally significant nesting areas for four of these found in the region. All six species are classified as threatened as a result of pressures both from within the Great Barrier Reef region and elsewhere. |
| Crocodile | The estuarine crocodile can be found in most coastal waters and around many of the islands and cays of the Great Barrier Reef. |
| Sea snakes | Sitting in a global hotspot of sea snake diversity, the Great Barrier Reef is home to 14 different species of sea snake. This high number of different species is largely due to the marine park's variety of suitable habitat. |
| Sharks and rays | 133 species are found along the Great Barrier Reef and range from small, cryptic species such as the epaulette shark to large, migratory species such as the whale shark. |
| Fishes | Around 1,625 of bony fish species including important commercial species such as coral trout. |
| Echinoderms | About 630 species recorded along the Great Barrier Reef, with starfish perhaps being the most well known. |
| Crustaceans | Around 1,300 species, including a number that are commercially important (for example, some species of crabs and prawns). |
| Molluscs | More than 3,000 species known from the Great Barrier Reef. This group includes clams, oysters, squid, octopus, cuttlefish, nautilus, nudibranchs, chitons and snails. |
| Hard corals | The signature group of the Great Barrier Reef with more than 450 species known. |
| Sea anemones | Around 40 species recorded along the Great Barrier Reef. |
| Soft corals and sea pens | At least 150 species known from the Great Barrier Reef. With their swaying bodies and jelly-like feel, soft corals bodies are made up of a large number of polyps connected by fleshy tissue. |
| Jellyfish | More than 100 species recorded along the Great Barrier Reef, including blue bottles and box jellyfish. Large adult jellyfish are often accompanied by small fish which hide amongst their tentacles for protection. |
| Sponges | Often colourful and common reef animals. Around 30 per cent of Australia's sponge species are found in the Great Barrier Reef. |

© Commonwealth of Australia.

Great Barrier Reef Marine Park Authority. *Animals*. Retrieved from www.gbrmpa.gov.au on 4 December 2017.

BIODIVERSITY OF THE GREAT BARRIER REEF

There are a lot of animals living on the Great Barrier Reef – and they've all got their own job to do, write [Professor David Bellwood](#) and [Dr Jennie Mallela](#)

Essentials

- The Great Barrier Reef is the largest living structure on Earth.
- It provides habitat for nearly 9,000 species of marine life – and that's just the (relatively) easy to count ones!
- The reef's rich biodiversity helps it to maintain a stable and healthy coral reef system.
- Another way to look at biodiversity is from the perspective of the 'jobs' that organisms do within the system.
- High biodiversity in terms of numbers of species does not necessarily ensure high resilience or robustness.

The enormous coral reef that graces the waters of eastern Queensland extends for 2,300 kilometres, is the planet's largest living structure, and can be seen from space. Its 2,500 individual reefs and 900 islands extend from the northern tip of Queensland down to south of Gladstone, and its ecosystems range from shallow near-shore environments to deep waters 250 kilometres offshore. It is the largest coral reef ecosystem on our planet and home to not just corals, but countless other marine life. It's our Great Barrier Reef.

HOW THE REEF FORMED

Coral reefs form under a rather specific set of circumstances – the temperature, water chemistry and water depth have to be just right. Although deep water corals do exist, the majority of reef builders like to be in shallow waters, where sufficient sunlight can penetrate to fuel the photosynthesis of the algae that lives alongside the coral animals and provides them with essential food. As sea level rises and slowly floods coastal plains, coral reefs will follow.

A reef's beginnings occur when coral larvae floating around in the ocean attach themselves to a solid

substrate, such as a rock, or older coral skeleton. The coral animals build their skeleton, which is made from calcium carbonate (CaCO_3), pulling the calcium (Ca) and carbonate (CO_3) from the seawater. Over time, the skeletons of dead corals and shells become cemented together to form massive deposits of the rock limestone.

There are three types of coral reef structure: *fringing reefs*, which form close to shore, *barrier reefs*, which are more substantial, stronger reef structures, located further offshore, and *atolls*, which are essentially fringing reefs that formed around an island and remained as a ring of coral after the island became submerged.

As its name implies, the Great Barrier Reef is a barrier reef. Its strong limestone structures, formed by the cemented skeletons of corals and other reef carbonates, protect much of the Queensland coastline.

In geological terms, the Great Barrier Reef is pretty young. At the end of the most recent ice age, sea level on the coast of Queensland was around 120 metres lower than today. As it rose, reef systems started to develop, most likely forming fringing reefs along the coastline. These became submerged as the sea continued to rise, and the modern reef as we know it started growing somewhere between 6,000 and 9,000 years ago, when sea level stabilised close to today's level. Over these few thousand years, it's grown and developed into one of the world's most diverse ecosystems.

BIODIVERSITY OF THE REEF

A simple way to look at an ecosystem's biodiversity is to look at the number and variety of different species that it supports – known as species diversity. Other measures of biodiversity include genetic diversity (the variety of a specific organism's genes), and ecosystem diversity (the number of different ecosystems found within a particular area).

Using species diversity, it is certainly justified to describe the Great Barrier Reef as one of the most diverse habitats on the planet. Close to 9,000 species of marine life call it home, and this doesn't include any of the huge number of microbes, plankton and fungi that also live there. And although the modern reef system is only around 6,000 to 9,000 years old, many of the creatures that call it home have existed for millions of years.

A DIFFERENT PERSPECTIVE ON BIODIVERSITY

Another way to look at the diversity of the Great Barrier Reef is to examine all the organisms and animals that live there as if they were machines all working together in an integrated system. So, instead of looking at a fish and seeing a pretty bright orange guy, called Nemo, we would look at him as a machine that performs a job. Figuring out exactly how that machine works helps





us understand what job he does, and how important both the job and machine are to the reef ecosystem as a whole. This is known as functional diversity.

It is one of the most diverse habitats on the planet. Close to 9,000 species of marine life call it home, and this doesn't include any of the huge number of microbes, plankton and fungi that also live there.

Using this approach to look at fish fossils provides insights into the sorts of roles fish played in the reef systems in the past, and how those jobs might have changed (or not!) over time. This is known as functional evolution and it's a very useful tool for understanding reef evolution, adaptation and potential vulnerability.

For example, fish jawbones have changed a lot over the past 100 million years. Once upon a time, fish were limited to catching their prey by simply grabbing at prey

as it swam past them. Over time, some fish's bones have evolved into structures that let the fish jaw protrude out from its head by up to 8 centimetres. This means the fish are now able to snap up their prey, turning them into more efficient feeders that can catch smaller prey.

And, at the same time as fish have evolved these longer jawbones, the prey animals have also evolved: they have become smaller. On the reef today, the average size of a crustacean is less than 1 millimetre. They're harder to catch and they can hide more easily.

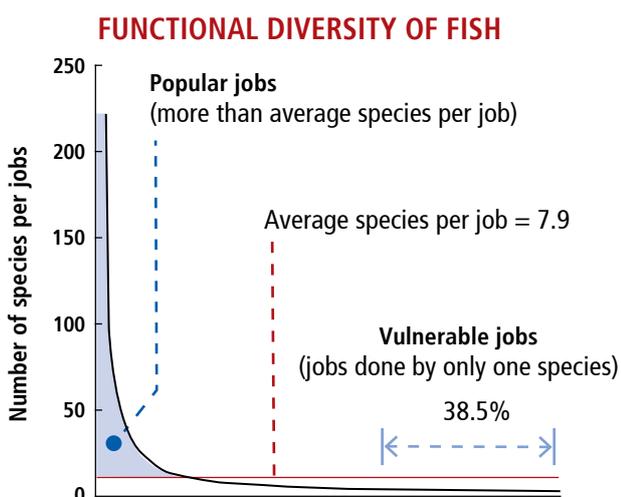
Another change has been seen in the sort of teeth fish have. Prior to 25 million years ago, fish teeth ranged from long and pointy, designed to puncture and tear, to short and round, designed to scrape and grind. Fish that lived on the reef ate crustaceans, and the crustaceans fed on the detritus found on the surface of the reef – fine dust-like particles high in nutrients. The development of long teeth shaped a bit like toothbrushes meant that fish can feed directly on the nutrient-rich detritus on the reef, and leave the crustaceans alone. This change in feeding dynamics would have had an impact upon the entire reef system and played a role in the development of modern reefs.

A JOB FOR EVERYONE, AND EVERYONE DOING THEIR JOB

Looking at things from this functional approach also enables us to ask some important questions about biodiversity – sure we've got lots of species here on the Great Barrier Reef, but is that really important? Does having so many different species actually offer a meaningful benefit to the reef system as a whole? Maybe it's okay if we lose one or two species, surely another species can just take over their job?

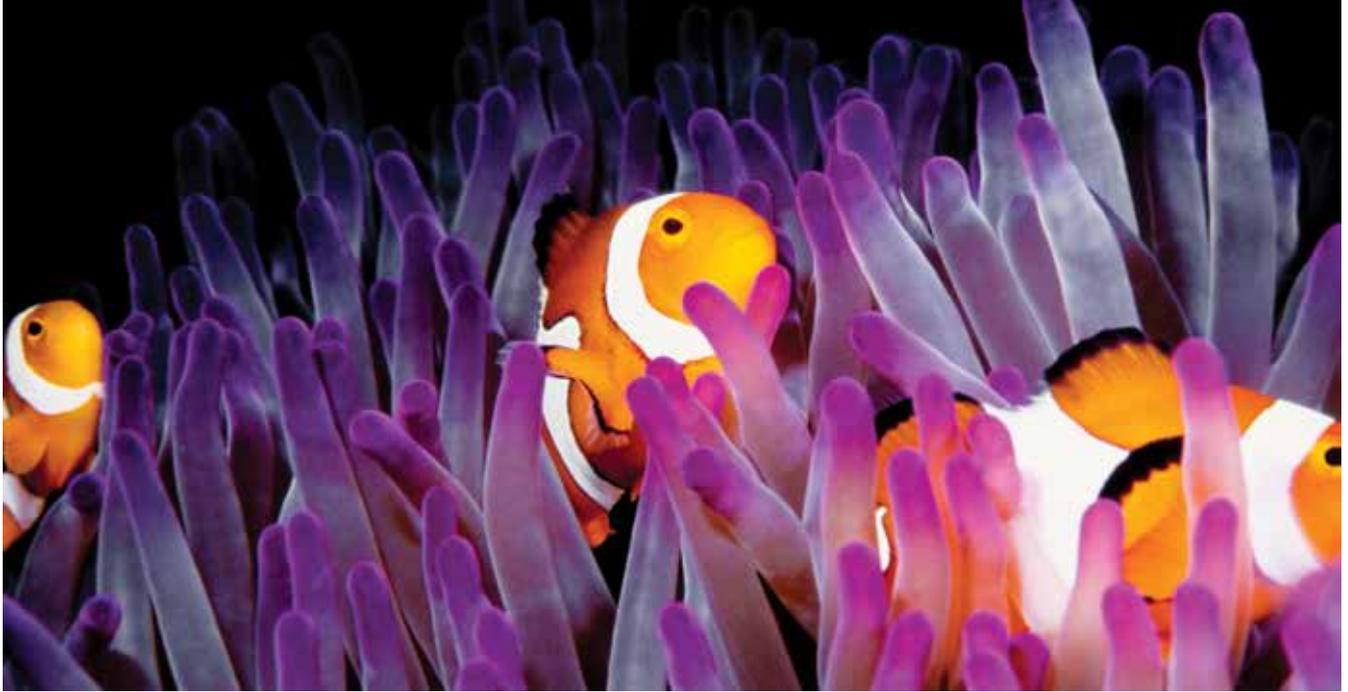
Research done on the Great Barrier Reef says ... a little bit of yes and quite a lot of no. There is a very small subset of jobs that are extremely popular – there are lots of species all doing the same job, so yes, if one of those species disappears, the job will still get done. Eating plankton is one of these jobs of choice.

Probably the most important job is providing the actual 'bricks and mortar' of the reef structure. The



This graph shows the functional diversity of fish communities in the Indo-Pacific region, which includes the Great Barrier Reef. While there are some jobs that are performed by lots of fish, the steep downward slop of the curve indicates that most jobs are done by only a few species, and nearly 40 per cent of jobs are done by only one species.

Adapted from Mouillot et al. (2014) *PNAS* 111:38, 13757-13762.



'bricks' are formed by the reef-building scleractinian corals and there are various encrusting organisms (e.g. bryozoans, coralline algae, bivalves) that make up the 'mortar'. There are several different species of scleractinian corals, and lots of different encrusting organisms, but the role they collectively perform is crucial.

More alarmingly, of the numerous roles performed by reef fish, nearly 40 per cent are performed by a single species. If these specialists disappear, there's no one waiting in the wings to step in and do their job. High biodiversity clearly does not necessarily ensure high resilience or robustness.

Giant hump-headed parrotfish (*Bolbometopon muricatum*), for example, are integral to a healthy reef system. Parrotfish eat more than 5 tonnes of coral reef material a year, around half of which is live corals. In a healthy system, parrotfish help keep the coral growth in check, with coral growth rates roughly balancing the amount of coral eaten by the parrotfish.

Parrotfish also eat a lot of macroalgae, which is also important within the reef system. In over-fished or nutrient-enriched reefs, macroalgae can out-compete the corals. So, without parrotfish, coral growth and reef structure could change dramatically.

Another example is the role played by the giant moray eel (*Gymnothorax javanicus*). The eel only eats at night. This means it preys on fish and other animals that are also active at night. These species escape being eaten by predators that operate in the daytime, and so the eel is potentially important in keeping these species in check.

Another specialised predator is the giant triton (*Charonia tritonis*). This snail is one of the very few animals that can eat the extremely voracious, coral-eating crown-of-thorns starfish (*Acanthaster planci*). Although they generally would only eat one starfish a week, their very presence helps to disperse groups of crown-of-thorns starfish, weakening their ability to breed and multiply on the reef.

The surgeonfish is another important reef-dweller. Like the parrotfish, it is essential in the process of sediment removal. A study looking at surgeonfish (*Ctenochaetus striatus*) on the Lizard Island reef, in the northern end of the Great Barrier Reef, found these fish ate somewhere between 8 and 66 grams of sediment per fish per day. They generally get rid of their stomach contents in a different location to their eating grounds, and around one third of the sediment they eat is deposited off the reef, in deep water. This process helps maintain the reef, and possibly specific algal habitats in particular, which are a valuable food source for herbivore fish.

It's clear that it's an amazingly intricate and dynamic system. It's also fragile. The specialised nature of many of the jobs carried out by the different species on the reef mean that we cannot take the reef's resilience for granted.

Whether looking at the sheer numbers of species of marine life, or the range of tasks and jobs they carry out on the Great Barrier Reef, it's clear that it's an amazingly intricate and dynamic system. It's also fragile. The specialised nature of many of the jobs carried out by the different species on the reef mean that we cannot take the reef's resilience for granted.

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Retrieved from www.science.org.au on 4 December 2017.

At what price? The economic, social and icon value of the Great Barrier Reef

EXECUTIVE SUMMARY FROM A REPORT BY DELOITTE ACCESS ECONOMICS

The Great Barrier Reef has a economic, social and icon asset value of \$56 billion. It supports 64,000 jobs and contributes \$6.4 billion to the Australian economy.

The Great Barrier Reef is the largest living structure on Earth. It is as big in size as Japan, and bigger than the United Kingdom, Switzerland and the Netherlands put together. Spanning 2,300 kilometres, the Great Barrier Reef can even be seen from space. The hundreds of thousands of marine and coral species that make up its rich tapestry of biodiversity make it one of the most unique and complex ecosystems in the world.

But it is more than a coral reef. The Great Barrier Reef is in Australia's cultural DNA. It is integral to the identity of Australia's Traditional Owners. What's more, its status as one the seven natural wonders of the world makes it an international asset. In many ways, it hardly seems necessary to quantify its value. The value of the Great Barrier Reef is priceless and we know that there is no replacement.

However, identifying, measuring and reporting on the economic and social value of the environment elevates its significance in decision making. Valuing nature in monetary terms can effectively inform policy settings and help industry, government, the scientific community and the wider public understand the contribution of the environment, or in this case the Great Barrier Reef, to the economy and society.

At a time when the global natural environment is under threat from the pressures of humankind, particularly climate change, it has never been more important to understand the economic and social value of the natural environment.

The Great Barrier Reef is incredibly rich, diverse – and under threat. The tight and unforgiving deadline the Great Barrier Reef is up against necessitates an understanding of its true value to know what kind of policy action is required in response.

This report assesses the economic, social, icon and brand value of the Great Barrier Reef. Its purpose is to gauge the Great Barrier Reef's value to Australians and understand how the international community values it. This research synthesises the results from a range of publicly available data sources, a new survey of over 1,500 Australians and residents from 10 countries world-wide, fresh insights from stakeholder consultations and the efforts of previous research. The sample was representative and the size statistically significant.

The report estimates the Great Barrier Reef's:

- Contribution to the Australian economy in 2015-16 through industry value added and employment,
- Economic, social and icon value,

- Significance to Aboriginal and Torres Strait Islander Traditional Owners,
- And brand value to Australia and the international community.

The first way of valuing the reef is through its annual contribution to the Australian economy in terms of value added (Gross Domestic Product) and employment. Our research has shown the Great Barrier Reef contributed \$6.4 billion in value added and over 64,000 jobs to the Australian economy in 2015-16 (direct and indirect). Most of these jobs came from tourism activities generated by the Great Barrier Reef, but there were also important economic contributions from fishing, recreational and scientific activities.

The annual employment supported by the Great Barrier Reef is more than most of Australia's major banks, and many corporates including the likes of Qantas and Deloitte Australia. Considering this, the reef is critical to supporting economic activity and jobs in Australia. The livelihoods and businesses it supports across Australia far exceeds the numbers supported by many industries we would consider too big to fail.

Another way of valuing the reef is its economic, social and icon asset value. This figure captures the broader aspects of why we value the reef, and cannot be added to the annual economic contribution figure.

More than the jobs it supports and the value it adds

More than the jobs it supports and the value it adds to the economy each year, the Great Barrier Reef is valued at \$56 billion as an Australian economic, social and iconic asset.



LET'S PUT IT IN PERSPECTIVE

The Great Barrier Reef supports 39,000 direct jobs in Australia

- **Telstra 33,000 jobs**
- **QLD international education sector 19,000 jobs**
- **Kmart Australia Ltd 30,000 jobs**
- **Australian oil and gas extraction jobs 19,000 jobs**
- **National Australia Bank 34,000 jobs**
- **Qantas Group 26,000 jobs**

to the economy each year, the Great Barrier Reef is valued at \$56 billion as an Australian economic, social and iconic asset.

That's more than 12 Sydney Opera Houses, or the cost of building Australia's new submarines. It's even more than 4 times the length of the Great Wall of China in \$100 notes.

This is Australia's reef. This is our natural asset. If we split the \$56 billion asset value down into its parts:

- Australians who have visited the reef as tourists – on their honeymoon, on a family holiday, on a bucket-list trip – derive \$29 billion in value
- Australians that have not yet visited the reef – but value knowing that it exists – derive \$24 billion in value
- And the lucky Australians that are recreational users of the reef – going to the beach, taking the boat out, diving on the weekends – derive \$3 billion in value.

The above figures are estimates based on reasonable assumptions about the length of analysis and the 'discount rate' – how much we value the reef in the future. Varying these produces a range of \$37 billion to \$77 billion. The estimates do not include quantified estimates of the value Traditional Owners place on the reef. Another approach that analyses how the reef is natural capital that provides ecosystem services is also explored qualitatively in this report.

So why do people value the Great Barrier Reef? What makes it worth \$56 billion? Australians and the international community value the Great Barrier Reef for a range of reasons. Some reasons are more concrete such as their belief in its importance for tourism, while some are more abstract such as their belief that Australia would just not be 'the same' without it.

Australians want their children and future generations to be able to visit the Great Barrier Reef and enjoy it. From a global perspective, the Great Barrier Reef's importance to the planet and to biodiversity is paramount. By every measure, the Great Barrier Reef is seen as the natural asset contributing most powerfully to Australia's global brand. In our research, the Great Barrier Reef left other Australian land-based natural assets far behind in terms of visitor preference, reputation and experience.

Why is this? Of the almost 1,000 respondents who named the Great Barrier Reef as Australia's most iconic natural asset, their justification includes: they consider it to be one of the most beautiful places in Australia;

it's the most famous UNESCO natural site in Australia, and it is one of the seven natural wonders of the world.

Two-thirds of Australian and international respondents were prepared to pay to protect the Great Barrier Reef. Of these respondents:

- 61% alluded to its importance to the planet
- 59% felt future generations should be able to visit it
- 59% cited its importance to biodiversity
- 52% felt it was morally and ethically right to pay for its protection.

On one level, all of these figures seem enormous, but when you reflect on it, it's also clear how inadequate financial measures are for something as important to the planet as the Great Barrier Reef.

The Great Barrier Reef is an immense and unique ecosystem that holds a significant value to humans and other interlinked systems. In this sense, the reef performs important environmental and ecological functions. These functions, if quantified, would show that the Great Barrier Reef is worth much more than the 64,000 jobs annually and \$56 billion asset value reported here.

This isn't the first report to consider the importance of the Great Barrier Reef – some of the significant examples include Costanza et al. (2014) analysis of reefs globally, Windle and Rolfe's (2005a) application of choice modelling, Oxford Economics (2009), Stoeckl et al (2011) comprehensive account of literature and Deloitte Access Economics' various contribution analyses.

There have also been decades of effort to protect the reef. The Commonwealth and Queensland Governments have implemented various policies to mitigate the impacts of local threats and build resilience against other pressures. The Great Barrier Reef 2050 Long-term Sustainability Plan was established in 2015 for greater co-ordination between stakeholders to protect the future health of the reef. In addition, significant government funding is committed each year to the research effort of understanding – and protecting – the complex nature of the reef.

While efforts to date have been substantial, the significance of the Great Barrier Reef's contribution to the Australian economy, to Australian jobs and its remarkable asset value strongly indicates the reef should be given even greater priority by all citizens, businesses and levels of government.

There is an opportunity – and a need – now more than ever for action on a universal level.

But more than just getting the policy settings right and investing wisely, understanding the true value of the Great Barrier Reef shows us what is at stake. And when called on, it is this knowledge that allows us to make it clear that the Great Barrier Reef's protection is not only an Australian priority, or an international one – it is a human one.

Deloitte Access Economics (3 July 2017). *At what price? The economic, social and icon value of the Great Barrier Reef*, Executive summary, pp. 5-8. Retrieved from www2.deloitte.com on 4 December 2017.

WHAT'S THE ECONOMIC VALUE OF THE GREAT BARRIER REEF? IT'S PRICELESS

HOW DO YOU VALUE THE GREAT BARRIER REEF, ASKS NEIL PERRY

Deloitte Access Economics has valued the Great Barrier Reef at A\$56 billion, with an economic contribution of A\$6.4 billion per year. Yet this figure grossly underestimates the value of the reef, as it mainly focuses on tourism and the reef's role as an Australian icon.

When you include aspects of the reef that the report excludes, such as the ecosystem services provided by coral reefs, you find that the reef is priceless.

Putting a price on the Great Barrier Reef buys into the notion that a cost-benefit analysis is the right way to make decisions on policies and projects that may affect the reef. For example, the environmental cost of the extension to the Abbot Point coal terminal can be compared to any economic benefits.

But as the reef is both priceless

and irreplaceable, this is the wrong approach. Instead, the precautionary principle should be used to make decisions regarding the reef. Policies and projects that may damage the reef cannot go ahead.

How do you value the Great Barrier Reef?

The Deloitte report uses what's known as a "contingent valuation" approach. This is a survey-based methodology, and is commonly used to measure the value of non-market environmental assets such as endangered species and national parks – as well as to calculate the impact of events such as oil spills.

In valuing the reef, surveys were used to elicit people's willingness to pay for it, such as through a tax or levy. This was found to be A\$67.60 per person per year. The report also uses the travel-cost method, which estimates willingness to pay for the Great Barrier Reef, based on the time and money that people spend to visit it. Again, this is commonly used in environmental economics to value national parks and the recreational value of local lakes.

Of course, all methods of valuing environmental assets have limitations. For example, it is difficult to make sure that respondents are stating realistic amounts in their willingness to pay. Respondents may

The precautionary principle should be used to make decisions regarding the reef. Policies and projects that may damage the reef cannot go ahead.



act strategically if they think they really will be slugged with a Great Barrier Reef levy. They may conflate this environmental issue with all environmental issues.

But more importantly, the methodology in the report leaves out the most important non-market value that the reef provides, which are called ecosystem services. For example, coral reefs provide storm protection and erosion protection, and they are the nurseries for 25% of all marine animals which themselves have commercial and existence value.

The Deloitte report even cites (but does not reference) a 2014 study that values the ecosystem services provided by coral reefs at US\$352,249 per hectare per year. The Great Barrier Reef Marine Park covers 35 million hectares with 2,900 individual reefs of varying sizes. This means the ecosystem services it provides are worth trillions of dollars per year.

That is, it is essentially priceless.

The problem with putting a value on the Reef

Valuing the environment at all is contentious in economics. Valuation is performed so that all impacts from, say, a new development, can be expressed in a common metric – in this case dollars. This allows a cost-benefit analysis to be performed.

But putting a price on the Great Barrier Reef hides the fact that it is irreplaceable, and as such its value is not commensurate with the values of other assets. For instance, using Deloitte's figure, *The Australian* newspaper compared the reef to the value of 12 Sydney Opera Houses. But while they are both icons, the Opera House can be rebuilt. The Great Barrier Reef cannot. Any loss is irreversible.

When environmental assets are irreplaceable and their loss irreversible, a more appropriate decision-making framework is the Precautionary Principle.

The Precautionary Principle suggests that when there is uncertainty

regarding the impacts of a new development on an environmental asset, decision makers should be cautious and minimise the maximum loss. For example, if it is even remotely possible that the extension to the Abbot Point coal terminal could lead to massive destruction of the reef, then precaution suggests that it shouldn't go ahead.

Assigning a value to the reef might still be appropriate under the Precautionary Principle, to estimate the maximum loss. But it would require the pricing of all values and especially ecosystem services.

While the Precautionary Principle has been much maligned due to its perceived bias against development, it is a key element of the definition of Ecologically Sustainable Development in Australia's *Environment Protection and Biodiversity Conservation Act 1999*.

For a priceless asset like the Great Barrier Reef, it is perhaps better to leave it as "priceless" and to act accordingly. After all, if the Precautionary Principle is ever going to be used when assessing Ecologically Sustainable Development, in contrast with cost-benefit analysis and valuations, it is surely for our main environmental icon.

Ultimately, the protection and prioritisation of the Great Barrier Reef is a political issue that requires political will, and not one that can be solved by pricing and economics.

DISCLOSURE STATEMENT

Neil Perry does not work for, consult, own shares in or receive funding from any company or organisation that would benefit from this article, and has disclosed no relevant affiliations beyond his academic appointment.

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THE CONVERSATION

Perry, N (29 June 2017). *What's the economic value of the Great Barrier Reef? It's priceless.*

Retrieved from <http://theconversation.com> on 4 December 2017.

Ultimately, the protection and prioritisation of the Great Barrier Reef is a political issue that requires political will, and not one that can be solved by pricing and economics.



CORAL BLEACHING

A fact sheet from the [Great Barrier Reef Marine Park Authority](#)

WHAT IS CORAL BLEACHING?

Bleaching is a sign that corals are under stress. Corals are able to cope in a limited range of environmental conditions but when these limits are exceeded (e.g. temperature), they experience stress.

Most corals have microscopic marine algae (called zooxanthellae) living inside their tissue. These photosynthetic organisms give corals much of their colour and also provide up to 90 per cent of the energy corals need to grow and reproduce.

When corals are under stress, this symbiotic relationship breaks down, and corals expel the zooxanthellae and begin to starve.

As zooxanthellae leave the corals, the corals become paler and increasingly transparent. However, corals also contain fluorescent proteins (green, yellow, red and cyan) that may help minimise damage from ultraviolet light.

When corals lose their zooxanthellae (bleach), these fluorescent proteins become more visible and the coral can display striking fluorescent hues of pink, yellow or blue. Not all of these fluorescent proteins are visible in daylight though, so corals can also look completely white.

WHAT CAUSES CORAL BLEACHING?

The most common cause of coral bleaching is sustained heat stress, which is occurring more frequently as our climate changes and oceans become warmer.

Other stressors that cause bleaching include freshwater inundation (which results in low salinity), poor water quality from sediment or pollutant run-off, and ocean acidification.

Bleaching can occur whenever sea surface temperatures exceed the long-term average. Severity of bleaching will vary depending on how warm the water becomes (measured as how many degrees Celsius above the long-term average) and how long it remains warm (days to weeks). Importantly, if heat stress is severe enough, corals can die without ever bleaching.

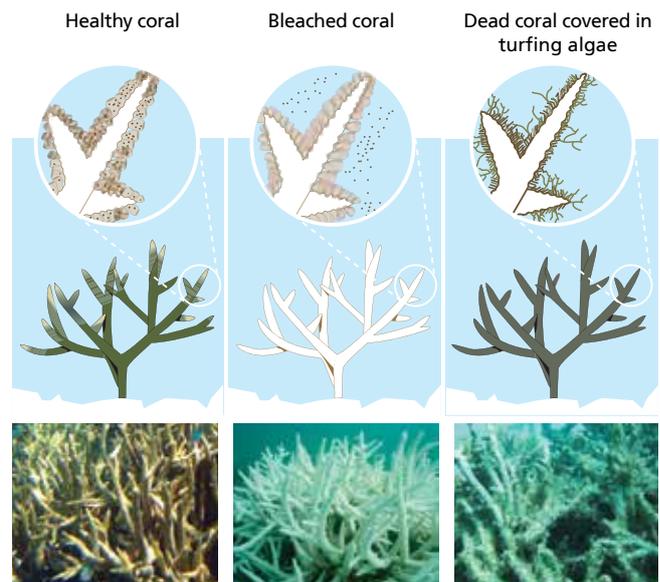
Shallow areas experiencing high temperatures and high exposure to sunlight are most at risk.

DO CORALS DIE FROM CORAL BLEACHING?

Bleaching does not automatically mean affected corals will die. If conditions return to normal, corals can slowly repopulate their tissues with zooxanthellae and recover.

During their recovery, however, they are likely to experience reduced growth and reproduction, and are more susceptible to disease.

If the stress is severe or prolonged, such as increased temperatures for several weeks, bleached corals can die. Coral reefs that have high rates of coral death from



bleaching can take many years or decades to recover.

If not kept in check by herbivorous fish, algae can soon overgrow dead corals leaving no suitable place for new corals to colonise. If recovery is impeded in this way, we might see coral – dominated reefs changing to algae – dominated reefs, causing changes in the species of fish and other animals living on the reef.

WHAT IS THE CURRENT BLEACHING SITUATION ON THE REEF?

In 2016, the Great Barrier Reef suffered the worst ever bleaching event due to record-breaking summer sea surface temperatures. This was due in part to a strong El Niño combined with the ongoing effect of climate change. An estimated 22 per cent of coral on the Great Barrier Reef died as a result of bleaching, mainly from reefs in the northern section.

Bleaching is a sign that corals are under stress. Corals are able to cope in a limited range of environmental conditions but when these limits are exceeded (e.g. temperature), they experience stress.

In 2017, the Great Barrier Reef, along with other reefs around the world, suffered a second consecutive year of mass coral bleaching, driven predominantly by ocean warming due to climate change. The effects of this event are being monitored and will continue to unfold for several months.

WHEN ELSE HAS MASS CORAL BLEACHING OCCURRED ON THE GREAT BARRIER REEF?

In 1998, the first global mass bleaching event occurred due to record breaking sea surface temperatures. Reefs



around the world lost up to 90 per cent of their coral cover. Approximately 50 per cent of the reef was affected by bleaching.

Mass bleaching also occurred on the reef in 2002, with 60 per cent of reefs affected. This was the largest coral bleaching event on the reef on record prior to 2016.

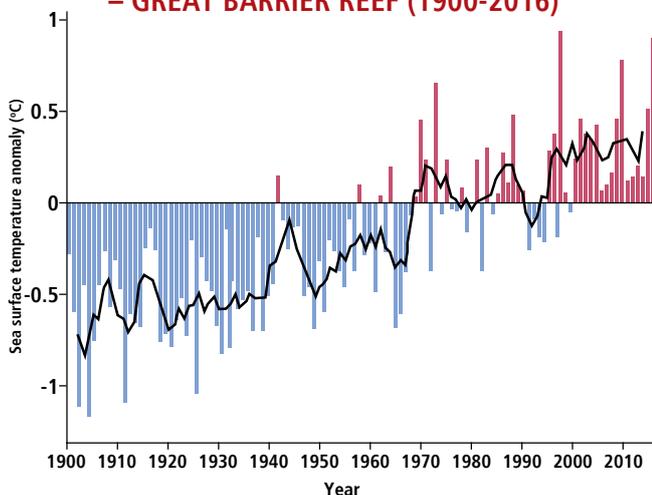
In both the 1998 and 2002 events, the vast majority of corals on the reef survived, as sea temperatures came back down again in time for them to recover. About five per cent of the Great Barrier Reef's coral reefs experienced high coral die-off in both these events.

WHAT IS HAPPENING TO AVERAGE SEA SURFACE TEMPERATURES?

Climate change is responsible for increasing temperatures on land and sea. The average sea surface temperature in the Great Barrier Reef has risen substantially over the past century.

Since instrumental records began, most of the

ANNUAL SEA SURFACE TEMPERATURE ANOMALY – GREAT BARRIER REEF (1900-2016)



5-year averages shown by black curve. Based on a 30-year climatology (1961-1990).

Source: Bureau of Meteorology 2017.

warmest years have been in the past two decades. This is due to an increase in carbon dioxide in the atmosphere, which produces a greenhouse effect, trapping heat within our atmosphere. The frequency and severity of coral bleaching is projected to increase as global temperatures rise.

HOW DOES THE GREAT BARRIER REEF MARINE PARK AUTHORITY RESPOND TO CORAL BLEACHING?

The Great Barrier Reef Marine Park Authority (the Authority) has a Coral Bleaching Risk and Impact Assessment Plan in place. The Authority and the Bureau of Meteorology work closely with the National Oceanic and Atmospheric Administration (NOAA) to monitor, model, forecast and risk assess coral bleaching conditions each year.

If mass coral bleaching occurs, the Authority works with Queensland Parks and Wildlife Service and key science and industry partners to evaluate the extent and impacts of the event, and looks to promote recovery through targeted actions that reduce pressures on the ecosystem.

Depending on the severity of the bleaching, pressures may need to be alleviated at a local, regional or reef-wide level.

The most common cause of coral bleaching is sustained heat stress, which is occurring more frequently as our climate changes and oceans become warmer.

Compliance with reef-wide zoning, including a network of highly protected no-take areas, is important to the reef's resilience. A dedicated control program is also underway to protect coral cover from an outbreak of the coral-eating crown-of-thorns starfish.

Through the Australian and Queensland governments' Reef 2050 Long-term Sustainability Plan, significant investment is being made to improve water quality, in addition to work that has been taking place since 2003 to reduce nutrients, pesticides and sediments in farm run-off. Research shows improving water quality would support recovery of coral reefs.

Actions contained in the plan are also designed to improve the overall health of the reef, which will build its resilience to impacts such as climate change.

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Great Barrier Reef Marine Park Authority. *Coral Bleaching* fact sheet (Information current as at 5 May 2017). Retrieved from www.gbrmpa.gov.au on 4 December 2017.

BACK-TO-BACK BLEACHING HAS NOW HIT TWO-THIRDS OF THE GREAT BARRIER REEF

This year's bleaching has mainly affected the Great Barrier Reef's central region, report [Terry Hughes](#) and [James Kerry](#)

Corals on the Great Barrier Reef have bleached again in 2017 as a result of extreme summer temperatures. It's the fourth such event and the second in as many years, following earlier mass bleachings in 1998, 2002 and 2016.

The consecutive bleaching in 2016 and 2017 is concerning for two reasons. First, the 12-month gap between the two events is far too short for any meaningful recovery on reefs that were affected in 2016.

Second, last year's bleaching was most severe in the northern section of the reef, from the Torres Strait to Port Douglas, whereas this year the most intense bleaching has occurred further south, between Cooktown and Townsville. The combined footprint of this unprecedented back-to-back bleaching now stretches along two-thirds of the length of the Great Barrier Reef.

Last year, after the peak temperatures in March, 67% of the corals died along a 700km northern section of the reef – the single greatest loss of corals ever recorded on the reef.

Further offshore and to the south, most of the

bleached corals regained their colour after the 2016 bleaching, and survived. The patchiness of the bleaching means that there are still sections of the Great Barrier Reef that remain in good condition.

It is still too early to tell how many corals will survive or die over the next few months in the central section as a result of this year's bleaching.

FOUR MAJOR EVENTS

Each of the four bleaching events has a distinctive geographic pattern that can be explained by where the water was hottest for sustained periods during each summer.

For example, the southern Great Barrier Reef escaped bleaching in both 2016 and 2017 because the summer sea temperatures there remained close to normal. Similarly, the earlier mass bleaching events in 1998 and 2002 were relatively moderate, because the elevated water temperatures experienced then were lower than those in 2017 and especially 2016.

The marine heatwaves in 1998 and 2016 coincided with El Niño periods, but this was not the case in



2002 or this year, when water temperatures were also abnormally high. Increasingly around the tropics, we are seeing more and more bleaching events, regardless of the timing relative to the El Niño-La Niña cycle. This reflects the growing impact of global warming on these events.

The local weather also plays an important role in determining where and when bleaching occurs. For example, in 2016, ex-Tropical Cyclone Winston came from Fiji to Australia at the end of February as a rain depression, and cooled the southern region of the Great Barrier Reef, saving it from bleaching.

If the world continues its business-as-usual greenhouse emissions for several more decades, it will almost certainly spell the end of the Great Barrier Reef as we now know it.

This year, the category 4 Tropical Cyclone Debbie tracked across the reef in late March, close to the southern boundary of the latest bleaching.

But TC Debbie was too far south to prevent the bleaching that was already under way in the reef's central and northern sections. Instead of helping to ameliorate the bleaching, this powerful cyclone has added to the pressures on some southern reefs by smashing corals and exacerbating coastal run-off.

PROSPECTS FOR THE FUTURE

The fallout from this and last year's events will continue to unfold in the coming months and years. It takes several months for severely bleached corals to regain their colour, or to die. On some reefs in the Great Barrier Reef's central region, underwater surveys in 2017 are already documenting substantial loss of corals.

The recovery times for northern and now central reefs that have lost many corals will be at least 10-15 years, assuming that conditions remain favourable for corals during that period.

We have a narrowing window of opportunity to tackle global warming, and no time to lose in moving to zero net carbon emissions. We have already seen four major bleaching events on the Great Barrier Reef with just 1° of global average warming.

The goals enshrined in the Paris climate agreement, which aims to hold global warming well below 2° and as close as possible to 1.5°, will not be sufficient to restore the Great Barrier Reef to its former glory. But they should at least ensure that we continue to have a functioning coral reef system.

In contrast, if the world continues its business-as-usual greenhouse emissions for several more decades, it will almost certainly spell the end of the Great Barrier Reef as we now know it.

DISCLOSURE STATEMENT

Terry Hughes receives competitive research funding from the Australian Research Council, and provides regular advice to both the Commonwealth and Queensland governments. James Kerry does not work for, consult, own shares in or receive funding from any company or organisation that would benefit from this article, and has disclosed no relevant affiliations beyond their academic appointment.

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THE CONVERSATION

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The Great Barrier Reef isn't listed as 'in danger' – but it's still in big trouble

The Great Barrier Reef is reeling under a combination of bleaching, over-fishing and land clearing, write [James Watson](#) and [Martine Maron](#)

In a somewhat surprising decision, UNESCO ruled this week that the Great Barrier Reef – one of the Earth's great natural wonders – should not be listed as 'World Heritage in Danger'.

The World Heritage Committee praised the Reef 2050 Long-Term Sustainability Plan, and the federal minister for the environment, Josh Frydenberg, has called the outcome “a big win for Australia and a big win for the Turnbull government”.

But that doesn't mean the reef is out of danger. Afforded World Heritage recognition in 1981, the reef has been on the warning list for nearly three years. It's not entirely evident why UNESCO decided not to list the reef as 'in danger' at this year's meeting, given the many ongoing threats to its health.

However, the World Heritage Committee has made it clear they remain concerned about the future of this remarkable world heritage site.

The reef is still in deep trouble

UNESCO's draft decision (the adopted version is not yet released) cites significant and ongoing threats to the reef, and emphasises that much more work is needed to get the health of the reef back on track. Australia must provide a progress report on the reef in two years' time – and they want to see our efforts to protect the reef accelerate.

Right now, unprecedented coral bleaching in consecutive years has damaged two-thirds of Australia's Great Barrier Reef. This bleaching, or loss of algae, affects a 1,500km stretch of the reef. The latest damage is concentrated in the middle section, whereas last year's bleaching hit mainly the north.

Pollution, overfishing and sedimentation are exacerbating the damage. Land clearing in Queensland has accelerated rapidly in the past few years, with about 1 million hectares of native vegetation being cleared in the past five years. That's an area the size of the Brisbane Cricket Ground being cleared every three minutes.

About 40% of this vegetation clearing is in catchments that drain to the Great Barrier Reef. Land clearing contributes to gully and streambank erosion. This erosion means that soil (and whatever chemical residues are in it) washes into waterways and flows into reef lagoon, reducing water quality and affecting the health of corals and seagrass.

Land clearing also directly contributes to climate change, which is the single biggest threat to the reef. The recent surge in land clearing in Queensland alone poses a threat to Australia's ability to meet its 2030 emissions reduction target. Yet attempts by the Queensland Government to control excessive

THE 'IN DANGER' LIST

- The World Heritage Committee gets information about the state of significant sites like the Great Barrier Reef.
- The WHC decides what makes the 'in danger' list on the basis of threats to the future of the site.
- A threat can either be imminent or potential danger.
- When a site is declared as 'in danger' the WHC can allocate funds to help.
- The 'in danger' status also highlights the threats to the world, thereby encouraging donor agencies to help.
- However, being 'in danger' is also a first step in the potential removal of a site from the World Heritage List.

land clearing have failed – a concern highlighted by UNESCO in the draft decision.

A time for action, not celebration

The reef remains on UNESCO's watch list. Just last month the World Heritage Committee released a report concluding that progress towards achieving water quality targets had been slow, and that it does not expect the immediate water quality targets to be met.

The draft decision still expressed UNESCO's “serious concern” and “strongly encouraged” Australia to “accelerate efforts to ensure meeting the intermediate and long-term targets of the plan, which are essential to the overall resilience of the property, in particular regarding water quality”.

Unprecedented coral bleaching in consecutive years has damaged two-thirds of Australia's Great Barrier Reef ... Pollution, overfishing and sedimentation are exacerbating the damage ... Land clearing in Queensland has accelerated rapidly in the past few years.

This means reducing run-off of sediment, nutrients and pollutants from our towns and farmlands. Improving water quality can help recovery of corals, even if it doesn't prevent mortality during extreme heatwaves.

The Great Barrier Reef is the most biodiverse of all the World Heritage sites, and of “enormous scientific and intrinsic importance” according to the United Nations. A recent report by Deloitte put its value at A\$56bn. It contributes an estimated A\$6.4bn annually to Australia's economy and supports 64,000 jobs.

Excessive land clearing in Queensland, which looks like being a core issue in the next State election, has been



Brisbane residents march in protest for the health of the Great Barrier Reef, 21 September 2014.

successfully curbed in the past, and it could be again.

But the reef cannot exist in the long term without international efforts to curb global warming. To address climate change and reduce emissions, we need to act both nationally and globally. Local action on water quality (the focus of the Reef 2050 Plan) does not prevent bleaching, or “buy time” to delay action on emissions.

Regardless of lists and labels, the evidence is clear. The Great Barrier Reef is dying before our eyes. Unless we do more, and fast, we risk losing it forever.

We need adequate funding for achieving the Reef 2050 Plan targets for improved water quality, and a plan to reach zero net carbon emissions. Without that action, an “in danger” listing seems inevitable in 2020. But regardless of lists and labels, the evidence is clear. The Great Barrier Reef is dying before our eyes. Unless we do more, and fast, we risk losing it forever.

DISCLOSURE STATEMENT

James Watson receives funding from the Australian Research Council and the National Environmental Science Programme. He is the global Director of the Science and Research Initiative at the Wildlife Conservation Society and President of the Society for Conservation Biology. Martine Maron receives funding from the Australian Research Council, the National Environmental Science Programme, the Science for Nature and People Partnership, and the NSW Office of Environment and Heritage. She is a Director of BirdLife Australia and a Governor of WWF Australia.

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THE CONVERSATION

Watson, J and Maron, M (7 July 2017). *The Great Barrier Reef isn't listed as 'in danger' – but it's still in big trouble*. Retrieved from <http://theconversation.com> on 4 December 2017.

GREAT BARRIER REEF: WORLD HERITAGE OUTLOOK



Conservation Outlook summary information from the International Union for Conservation of Nature

The Great Barrier Reef is a site of remarkable variety and beauty on the north-east coast of Australia. It contains the world's largest collection of coral reefs, with 400 types of coral, 1,500 species of fish and 4,000 types of mollusc. It also holds great scientific interest as the habitat of species such as the dugong ('sea cow') and the large green turtle, which are threatened with extinction.

SIGNIFICANT CONCERN

The Great Barrier Reef, one of the earliest properties to be inscribed as World Heritage, is a global icon. Unfortunately, a number of values for which the property was inscribed are declining, with a further dramatic decline occurring during the 2016 and 2017 coral bleaching events.

Some of the activities causing a threat to the values of the property can be influenced by the management authorities, such as fishing and coastal development. Other pressures on the property cannot be addressed at the site level, such as climate change, which arguably poses the greatest threat to the values of the property.

While individual decisions and management approaches appear in themselves adequate, the cumulative impacts of many decisions, on top of the legacy impacts and impending impacts of climate change, are unclear. Although the property's protection and management capacity is often cited as being among the best in the world, there is a real concern that many of the values may continue to decline.

The Reef 2050 Long-Term Sustainability Plan for the property should help direct many conservation and land management actions with the aim of ensuring that the best possible scenarios are in place for the long-term conservation of the property's iconic values. However, its implementation still needs to be evaluated. A comprehensive review of the performance in meeting the targets established under the LTSP will be undertaken by the World Heritage Committee at its 44th session in 2020.

CURRENT STATE AND TREND OF VALUES

High concern Trend: **Deteriorating**

The Great Barrier Reef is a very large property containing a large number of World Heritage values. Since inscription in 1981, and despite good management and protection, many iconic species and habitats have declined. While there have been positive trends, such as improved water quality and the increase in Humpback Whale numbers, coral bleaching continues to be a significant threat to the values of the property. The 2016-2017 back-to-back coral bleaching events have been unprecedented in severity and impacts.

OVERALL THREATS

Very high threat

Climate change poses the most important threat to the long-term conservation of the property. Significantly the 2016 and 2017 bleaching events have seriously affected the outstanding universal value (OUV) of the property and climate change continues to impact the resilience of the property. Poor water quality from catchment run-off, impacts from coastal development, illegal and unsustainable fishing and crown-of-thorns starfish also continue to be major threats to the long-term conservation of the property. Poor water quality is an extremely important threat to the property, influencing in-shore regions of the reef in particular.

Despite good management and significant resources in place to deal with these challenges, the level of threats to the site's values remains very high. These major threats are only some of the 41 threats impacting the GBR that are listed in the *2014 Outlook Report* (GBRMPA 2014a, p.256). Two further issues of real concern are the cumulative, long-term impacts of all these threats.

OVERALL PROTECTION AND MANAGEMENT

Effective

The enormous size of the property and surrounding developmental pressures means that there will always be protection and management challenges. The management authority (the Great Barrier Reef Marine Park Authority, or GBRMPA) has often been cited as a leader in protected area management and protection, and the *EPBC Act* used as exemplary legislation for World Heritage.

However, there remain strategic issues concerning climate change and sustainable development that continue to be of significant challenge and threat to the property. Although the management authority has taken extensive and innovative measures in order to protect the property, until the status of values is shown to be maintained, concerns remain and overall the threats to the values of the property remain significant and the status of the values for which the property was inscribed continue to deteriorate. The adoption of the Reef 2050 LTSP has been recognised as a significant step in providing an overarching framework for the management of the property and addressing the multiple threats it is facing; however, progress towards achieving some of the targets has been slow so far.

International Union for Conservation of Nature (IUCN). Great Barrier Reef, *Conservation Outlook Assessment Summary*, 2017 (Finalised 8 November 2017). Retrieved from www.worldheritageoutlook.iucn.org on 4 December 2017.

Great Barrier Reef needs far more help than Australia claims in its latest report to UNESCO

THE GREAT BARRIER REEF'S MAJOR THREAT IS CLIMATE CHANGE,
CAUTION JOHN C DAY, ALANA GRECH AND JON BRODIE

At first glance, the progress reports on the Great Barrier Reef released last week by the Australian and Queensland governments might seem impressive. The update on the Reef 2050 Plan suggests that 135 of the plan's 151 actions are either complete or on track.

The Australian government's apparent intention in releasing five recent reports is to reassure UNESCO that the Great Barrier Reef should not be listed as 'World Heritage in Danger' (as the World Heritage Committee has previously threatened). Sadly, behind the verbosity and colour of these reports, there is disappointingly little evidence of progress in the key areas needed to make a significant difference to a World Heritage Area that is in crisis.

Poor baseline

The government framework for protecting and managing the Reef from 2015 to 2050, the Reef 2050 Plan, has been widely criticised as failing to provide a sound basis for the necessary long-term protection of the reef.

As well as providing a shaky basis to build effective actions, the Reef 2050 Plan has few measurable or realistic targets. It is therefore not easy to report on the actual progress.

Several of the actions that will have the greatest impacts on the overall health of the reef are shown in the progress reports as "not yet due". In some cases, such as climate change, the Reef 2050 Plan is silent, instead simply referencing Australia's national efforts on climate change.

Instead, the plan is to "[improve] the reef's resilience to climate change by reducing local pressures". Besides addressing water quality, there are many things that should also be considered but they involve making some really hard decisions,

such as choosing between coal and coral.

Progress versus reality

The overview of progress claims that 135 of the 151 actions in the Reef 2050 Plan are either completed (dark green) or are on track for their expected milestones (light green), as shown – *in the next article*.

The reality, however, is that many of the 103 of the actions described as "on track/underway" have not progressed as initially proposed when the Reef 2050 Plan was submitted to UNESCO, and that the definition of "underway" is far too loose to be meaningful.

Our rapid assessment of the status of actions indicates that the level of progress reported for at least 32 of these 151 actions (around 21%) has been overstated. The following are just some examples (*see table next page*).

The unfortunate truth is that neither UNESCO nor the IUCN has the time or resources to conduct their own comprehensive assessment of the Great Barrier Reef. They rely heavily on these reports when deliberating on what to recommend to the World Heritage Committee, including whether the reef should be placed on the World Heritage 'In danger' list.

Our rapid assessment indicates there are real concerns with relying on the government to self-report accurately. It would appear the only way that UNESCO will receive an accurate update is if that assessment is done independently of government. Fortunately, UNESCO and IUCN do consider other evidence.

It is also concerning that the members of the government's Independent Expert Panel and the Reef 2050 Advisory Committee were not involved in making the final assessments for the 2016 update report.

Despite pronouncements that the Great Barrier Reef remains healthy, the evidence of the 2015 *Water Quality Report Card*, along with numerous expert opinions (for example, Jon Brodie on water quality; Terry Hughes on coral health; the Queensland government on scallops; and the Marine Park Authority on inshore dolphins) shows that the real situation is not as rosy as UNESCO and the Australian public are being told.

Some real progress, but not enough

It is important to recognise some progress is being made – but sadly too little and not enough to reverse the declining trend for many of the values for which the reef was listed as World Heritage.

We should also question some of the priorities in the Reef 2050 Plan given the widely acknowledged critical issues (*see page 252 in the government's 2014 Outlook Report*). Adopting best practice for water quality from point sources such as sewage discharge (action WQA11 under the plan) and protecting habitat for coastal dolphins (BA12) should be immediately addressed.

Whether we have the money to do what's necessary is another question. The government's pledge to spend A\$2 billion over 10 years is the current collective yearly spending (A\$200 million) of four federal agencies, six state agencies and several major research programs, extrapolated over the coming decade.

While the level of funding is significant compared with many other World Heritage areas, the amount and priorities must be questioned, given that many of the reef's values are continuing to decline.

So far most funding has been spent on addressing water quality, and while this has achieved some positive results, it has not managed to stop the deteriorating trends.

| ACTION | REPORTED STATUS | PROGRESS | ACTUAL STATUS |
|---|---|--|--------------------------------------|
| CBA13: Support long-term social and economic monitoring. | On track | Inadequate funding allocated to monitor progress for 4 of the 7 themes in the Reef 2050 Plan. | Limited progress |
| EBA12: Adopt a fisheries resource allocation policy which maximises the value of sustainable fisheries. | On track | While some reforms under the <i>Fisheries Act</i> were progressed in mid-2016, this policy has yet to be finalised. | Delayed |
| EBA15: Release an action plan for charter fishing. | On track | A discussion paper was due by September 2016, but has still to be released. | Delayed |
| EHA17: Finalise a classification of the GBR Marine ecosystems. | Completed/ in place | This classification was completed in 2003 well before the Reef 2050 Plan was even requested. | n.a. |
| EHA19: Develop guidelines for the assessment of cumulative impacts. | On track | A specific recommendation of the 2014 Strategic Assessment was that guidelines be made available within a year, but the guidelines have yet to be released. | Delayed |
| EHA5: Develop, implement and coordinate a protocol and knowledge management system for recording, storing, protecting and sharing traditional knowledge. | On track | A specific recommendation of the 2014 Strategic Assessment, this protocol has yet to be developed. | Limited progress |
| WQA2: Continued improvement in water quality. | On track | The 2015 Report Card shows far more needs to be done to achieve the targets. Current progress is rated 'poor' in the Card. | Limited progress |
| WQA3 – 6: Four actions related to WQA2 to actually improve water quality. | All reported as 'On track/ underway' | Given actual water quality improvement in the 2015 Report Card is rated as generally 'poor' the best that can be said is that these actions are 'underway', but definitely NOT 'on track'. | Underway but limited progress |

Some progress is being made – but sadly too little and not enough to reverse the declining trend for many of the values for which the reef was listed as World Heritage.

As Jon Brodie recently wrote on *The Conversation*:

The best estimate is that meeting water quality targets by 2025 will cost A\$8.2 billion ... If we assume that ... A\$4 billion is needed over the next five years, the amounts mentioned in the progress report (perhaps A\$500-600 million at most) are ... totally inadequate.

More action needed

The reef is unquestionably of global significance. Given its sheer size and location, no other World Heritage Area on the planet includes such biodiversity.

The worst-known bleaching event in the Great Barrier Reef demonstrates the limitations of the Reef 2050 Plan, which is silent on the impact of greenhouse emissions from Queensland's coal mines and the effects of climate change more generally.

Governments have an obligation

to protect all the reef's values for future generations. To do this they must recognise growing global moves to address climate change, and the widespread national and international expectations that more needs to be done to protect the reef.

Australia is a relatively rich country and has the technical capability to address the issues. This provides an opportunity to show some global leadership for managing such a significant part of the world's heritage.

Listing the reef as World Heritage 'In danger' won't in itself fix the problems – but it will certainly focus the spotlight on the issues.

As the World Heritage Committee prepares for its next meeting in July 2017, and considers once again whether to officially list the reef as in danger, it will need to study all the evidence, not just the government's reports.

Certainly the true picture is more complicated and dire than the most recent government reports imply.

DISCLOSURE STATEMENT

Alana Grech receives funding from the Australian Research Council. Jon Brodie is a partner in the environmental consulting partnership C20. Jon C. Day does not work for, consult, own shares in or receive funding from any company or organisation that would benefit from this article, and has disclosed no relevant affiliations beyond his academic appointment.

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THE CONVERSATION

Day, JC, Grech, A and Brodie, J (6 December 2016). *Great Barrier Reef needs far more help than Australia claims in its latest report to UNESCO*. Retrieved from <http://theconversation.com> on 4 December 2017.

REEF PLAN – UPDATE ON PROGRESS

A summary update on the progress of the Reef 2050 plan since its inception, from the [Department of the Environment and Energy](#)

Status of reef 2050 actions

Australia is implementing the 151 actions outlined in the Reef 2050 Plan. These actions relate to the first five years of the 35-year plan. Each action has been assigned a lead reporting agency along with partner agencies that will help in its implementation. Progress on implementing actions is communicated by the lead reporting agencies regularly through a traffic light reporting system.

The first Reef 2050 Plan Annual Report was released in October 2016 and can be found at: www.environment.gov.au/reef2050-progress.

The Annual Report documented the status of actions at July 2016. The status of actions below is an update to the Annual Report, representing progress from the inception of the Plan until early November 2016.

The actions prioritised under the themes of water quality and ecosystem health are among the most consequential for the future of the reef and these actions are on track, with the exception of the ecosystem health action to strengthen Queensland's vegetation management legislation.

Status of investment

\$1.28 billion will be directly invested in specific Reef 2050 actions over the next five years. This is part of our commitment to invest \$2 billion over the next decade. This includes \$716.6 million from the Australian Government, \$409.1 million from the Queensland Government and \$161.2 million from other sources. The majority of investment is directed to the water quality and ecosystem health themes.

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Department of the Environment and Energy (1 December 2016). *Reef 2050 Plan – Update on Progress*, 1. Summary of Reef 2050 Plan Inception, pp. 6-7. Retrieved from www.environment.gov.au on December 2017.

| | |
|-----|--|
| 32 | are completed or in place (implementation is fully completed OR initial implementation has been completed, but part of the action is ongoing) |
| 103 | are on track/underway (implementation is meeting expected milestones and progress is being made) |
| 3 | are delayed/limited progress (major implementation milestones have been delayed by less than 6 months, or only superficial progress has been made) |
| 1 | are significant delays or no progress (major implementation milestones have been delayed for longer than six months or no progress has been made) |
| 12 | are not yet due (implementation is not yet due to commence) |

Figure 1: Summary of progress in implementing the Plan's 151 actions

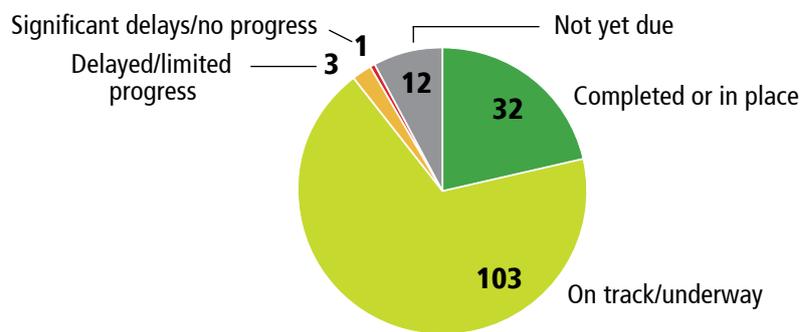
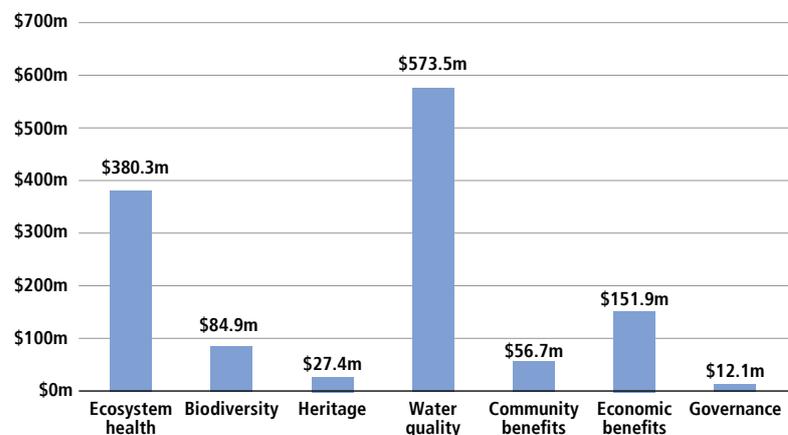


Figure 2: Shows the \$1.28 billion in funding by Reef 2050 theme



THE STATE OF THE GREAT BARRIER REEF

A FACT SHEET UPDATE FROM THE AUSTRALIAN INSTITUTE OF MARINE SCIENCE

What do we know? What don't we know?

The past year has been a period of intense local, national and international discussion about the future of the Great Barrier Reef, culminating in the launch of the Reef 2050 Long-Term Sustainability Plan (Reef 2050) in March, 2015.

These conversations about the reef were informed by years of research by the Australian Institute of Marine Science (AIMS) and our partners. AIMS is Australia's national tropical marine research agency. This document summarises much of the information that we and others have gathered that have helped governments, industry and the wider community make informed decisions about the management of the Great Barrier Reef including:

- How has the reef changed? AIMS scientists have been directly monitoring the state of the reef for more than 30 years; we also have a range of tools to look further back in time. Dozens of scientific reports clearly show that the reef has been in serious decline. This is most clearly demonstrated by the loss of half the coral cover since 1985.
- What is causing those changes? There are many factors at work and it varies – from north to south, from outer reef to inner reef. Storms, increasing ocean temperature and acidity, crown-of-thorns starfish (COTS), water quality and other factors all play a role. We don't have the complete story yet. Some impacts are well understood, others, like dredging, are not. We're working to fill the knowledge gaps.
- How will the reef continue to change in response to continuing climate change and other pressures? What will the cumulative impact be? Is the reef losing its capacity for repair? And can we help the reef remain resilient and adapt to change? These questions require us to answer fundamental questions about coral biology which we're doing through a series of studies in our SeaSim aquaria, in the field, and by combining this knowledge into models that predict the future state of the reef based on credible scenarios.

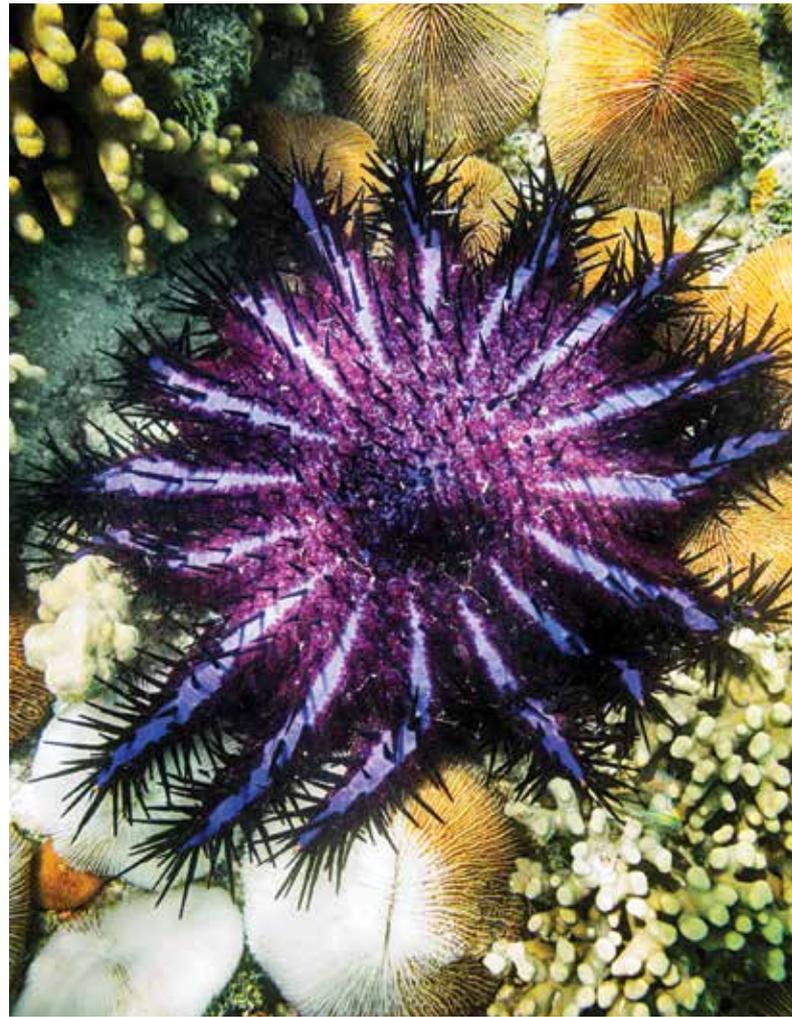
These are all complex questions and there are many gaps in our knowledge. So what do we know?

WE KNOW

The Great Barrier Reef has lost half its coral cover since 1985

We know this from direct monitoring, involving 2,258 reef surveys covering 214 reefs over a 27-year sampling period. These studies were undertaken as part of the AIMS Long Term Monitoring Program for the GBR

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Can corals or reef ecosystems adapt to warmer oceans? How will the bacteria and algae associated with coral cope? Can we help coral ecosystems adapt to change? These questions are the subject of a series of long-term experiments and field studies ...

– the most comprehensive monitoring program of any reef system in the world.

In 2012, AIMS published a paper that summarised the major trends in reef condition over the 27 years to 2012 and reported that the reef had lost half its coral cover over this time. Subsequent studies have affirmed these trends. Some reefs are doing better, some are doing worse, and coral reefs go through cycles of disturbance and recovery. But the general trend over the past three decades shows that coral cover, the number of juvenile corals, and other important processes for coral reefs such as calcification, have been decreasing. For example, the rate of growth of *Porites* coral (measured by calcification) declined by 11 per cent between 1990 and 2005.

The recent decline in coral calcification is unprecedented in at least the past 400 years

We know this from studies of long coral core records. Coral growth can be measured by coral calcification – the speed at which their calcium carbonate skeleton is deposited. Sustained calcification is essential for coral recovery, and for repair to the reef after physical erosion (such as from storms) and biological erosion. The recent slowing of coral growth rates on the reef between 1990 and 2005 has also been reported for several other reef locations around the world. The observed decline in calcification in the field is likely to be due to warming seas. Laboratory experiments indicate that future declines in calcification will be driven by ocean warming and acidification.

Storms, spikes in sea temperature and crown-of-thorns starfish outbreaks are the major direct contributors to the decline in coral cover

The known causes of the observed decline in coral cover since 1985 were storm damage (48%), crown-of-thorns starfish (42%), and bleaching (10%) from extended periods of increased sea temperature. The reef has been impacted by an unusually high number of severe storms over the past decade. The impact of crown-of-thorns begs the question: what causes these starfish outbreaks?

Water quality is the number one suspect for crown-of-thorns starfish outbreaks

We don't know precisely what causes the periodic crown-of-thorns outbreaks but water quality is the



number one suspect and, in particular, the availability of more nutrients that increase the amount of plankton for the larvae of crown-of-thorns starfish to feed on. This means that river floods and associated sediment and nutrient run-off are strongly implicated.

A new outbreak of crown-of-thorns is developing now (mid-2015). The reefs between Cairns and Cooktown are currently carrying more than five million adult crown-of-thorns starfish. About 500,000 starfish have been killed by divers and this activity is protecting individual reefs. However, we also need a more systemic approach for long-term protection of the whole of the Great Barrier Reef from crown-of-thorns outbreaks. Ideally this would involve identifying and controlling the conditions that lead to outbreaks, and developing effective means for early detection and control.

Flood events are more frequent, more extreme, and they're impacting on the mid-shelf reefs

The frequency of large river floods affecting the central Great Barrier Reef (GBR) has increased since the late 19th century. High flow events are now occurring on average every six years (1948-2011), compared with every 20 years in the period 1748-1847. Three of the most extreme flood events have occurred within the past 40 years (1974, 1991, and 2011). Extreme flood events are also resulting in more frequent freshwater impacts on mid-shelf reefs. We know this from measurements of luminescent records of flood events contained in long cores taken from the skeletons of large massive corals.

Rising carbon dioxide levels will be bad for coral but good for seagrass

Rising carbon dioxide in the atmosphere will lead to ocean acidification and other changes in the seawater chemistry. Such acidification can reduce coral calcification and growth, and lead to a decline in coral diversity. Fish behaviour is also impacted by ocean acidification, increasing the risk of mortality in some species.

Ocean acidification may also encourage the growth of seaweeds, which compete for space with corals. The growth of seagrasses also benefits from ocean acidification. We know this from studies of naturally occurring carbon dioxide seeps in Papua New Guinea.

The Great Barrier Reef can recover – given time and a reduction in the cumulative impacts of cyclones, acidification, crown-of-thorns, hotter oceans, etc

In the absence of tropical cyclones, crown-of-thorns starfish, and bleaching, the coral cover on the reef could recover on average by nearly three per cent a year, so coral cover would come back if the reef was given enough time between disturbances. However, rates of recovery depend in part on the type of coral present. For example, reefs with tabulate (plate-forming) *Acropora* corals recover faster from storm damage than massive corals. But they're also more vulnerable to damage.

The recovery potential of the reef in the future will

also depend on how sensitive coral growth (calcification) will be to future acidification of the oceans, continued warming, and to future extreme thermal stress events causing bleaching.

Inner reefs have shown some recovery, perhaps due to low rainfall and recovery following the devastation caused by Tropical Cyclone Yasi

Recent AIMS surveys indicate that over the past two years, coral decline on the inner reef has paused but its condition is still 'poor'. In a parallel study, James Cook University researchers found that inshore seagrass has started to recover. These results may indicate that land management changes are working, or it may reflect the recent low rainfall years reducing the amount of run-off of freshwater, sediments and nutrients to the reef, and/or recovery from Tropical Cyclone Yasi which destroyed many seagrass beds.

WE DON'T KNOW ENOUGH YET

We need to know more about the potential impact of dredging and other coastal development

Historically the focus on monitoring on the reef was on the mid- and outer-reef systems so we know less about changes on the inner-reefs and their causes.

The recently published *Dredging Synthesis Report* identified "significant areas of insufficient knowledge" including sediment dynamics, monitoring, and sensitivity of coral and seagrass to increased sediment exposure. AIMS is working to fill these knowledge gaps with field studies, analysis of water quality data from past dredging projects, and experiments in its SeaSim aquaria. The aim is to enhance capacity within government and the private sector to predict and manage the environmental impacts of dredging, and to facilitate more informed environmental decision-making.

We need to know more about what happens when everything comes together

Coral on the reef faces multiple challenges. What happens when higher temperatures combine with higher acidity and changing water quality? Are existing pollutants more or less dangerous at higher temperatures? What about sediments, storms and other factors working together? And what will be the impact of these changes on fish?

These questions are being tackled by combining field data with experiments in SeaSIM, the AIMS research aquaria. SeaSIM can produce controlled combinations of warming oceans, sediment, pollutants, acidity, water flow and other factors, giving scientists unprecedented ability to simulate real-world environmental conditions.

We don't know how adaptable reef life will be to cumulative impacts

Can corals or reef ecosystems adapt to warmer oceans? How will the bacteria and algae associated with coral cope? Can we help coral ecosystems adapt to change?



These questions are the subject of a series of long-term experiments and field studies exploring such issues as:

- Finding and breeding heat-tolerant corals that might be suitable for reef rehabilitation
- Identifying reefs with heat-tolerant coral communities and protecting them so that they naturally repopulate other reefs.

THE STATE OF THE GREAT BARRIER REEF – KEY PAPERS

The following are just a few of the scientific studies on the state of the Great Barrier Reef by AIMS and other researchers.

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community responses to declining water quality: Whitsunday Islands, Great Barrier Reef, Australia. *Coral Reefs* 33:923-938.

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MANAGING AND PROTECTING THE GREAT BARRIER REEF

The Department of the Environment and Energy explains what Australia is doing to manage the Great Barrier Reef

We all have a common goal – protecting and managing the Great Barrier Reef for current and future generations. The Australian and Queensland governments are jointly investing approximately \$200 million annually in the reef's health.

- Great Barrier Reef Marine Park Authority
www.gbrmpa.gov.au
- Great Barrier Reef – Queensland Government
www.qld.gov.au/environment/coasts-waterways/marine-parks/gbrc

What Australia is doing to manage the Great Barrier Reef

Australia is working to make sure the Great Barrier Reef remains one of the best managed World Heritage sites in the world.

- More about what Australia is doing to manage the Great Barrier Reef:
www.environment.gov.au/marine/gbr/publications/what-australia-is-doing

Reef 2050 Long-Term Sustainability Plan

The Reef 2050 Long-Term Sustainability Plan is the overarching framework for protecting and managing the Great Barrier Reef from 2015 to 2050.

The plan is a key component of the Australian Government's response to the recommendations of the UNESCO World Heritage Committee. The committee regularly reviews the state of conservation of all properties inscribed on the World Heritage List.

- More about the Reef 2050 Plan:
www.environment.gov.au/marine/gbr/long-term-sustainability-plan

Reef Trust

The Reef Trust will combine both Australian Government and private funds to focus on improving coastal habitat and water quality throughout the Great Barrier Reef and adjacent catchments.

The Australian Government is committing \$225 million to the Reef Trust to address key threats to the reef.

- More about the Reef Trust:
www.environment.gov.au/marine/gbr/reef-trust

Great Barrier Reef Gully and Streambank Joint Program

The Australian and Queensland governments in 2016 announced the Great Barrier Reef Gully and Streambank Joint Program. This program will focus on remediating gully and streambank erosion to significantly reduce the amount of sediment entering the reef. The program will be guided by the Sediment Working Group, who will provide technical, policy and strategic input into how best to tackle gully and streambank remediation to maximise the on ground actions.

Sediment run-off is one of the biggest pressures on the Great Barrier Reef with gully and streambank erosion contributing significantly to sediment entering the reef. The Australian and Queensland governments, in partnership with the private sector, conservation groups, research institutions, regional natural resource management bodies and industry groups are investing more than \$45 million over six years through the Great Barrier Reef Gully and Streambank Joint Program to tackle sediment run-off by fixing gullies and streambanks in high erosion areas of the reef catchments.

Read the fact sheet to find out more about the joint program and how sediment affects the Great Barrier Reef:

- Great Barrier Reef Gully and Streambank Joint Program – fact sheet:
www.environment.gov.au/marine/gbr/publications/gbr-gully-streambank

Run-off reduction and control of crown-of-thorns starfish

Through the Reef Trust, funding will be provided to farmers and land managers to assist them to implement techniques to reduce run-off to the Great Barrier Reef catchment that contribute to crown-of-thorns starfish outbreaks.

Additional actions are also planned to control crown-of-thorns starfish outbreaks and reduce the incidence of new outbreaks through partnerships between managing agencies and marine tourism operators. These will build on existing direct control activities being undertaken as part of the Australian Government Reef Program.

Dugong and Turtle Protection Plan

To enhance the protection of our iconic marine turtles and dugong in Far North Queensland and the Torres Strait, the Australian Government has committed \$5.3 million over three years for delivery of a Dugong and Turtle Protection Plan under the Reef 2050 Plan and Reef Trust. The plan addresses threatening processes that impact on the long-term recovery and survival of these protected migratory species.

- National Dugong and Turtle Protection Plan www.environment.gov.au/marine/publications/national-dugong-and-turtle-protection-plan-2014-2017

Draft Reef 2050 Water Quality Improvement Plan

The Australian and Queensland governments have released the draft Reef 2050 Water Quality Improvement Plan 2017-2022 for consultation.

The Plan (formerly the Reef Water Quality Protection Plan) has been renamed to reflect the direct alignment with the Reef 2050 Plan.

The Great Barrier Reef is under pressure from many factors – one of which is the poor quality of water running into it from adjacent catchments. The renewed five-year plan details how industry, government and the community will continue to work together to improve the quality of water flowing to the Great Barrier Reef.

The desired outcome of the plan is that reef water quality supports the outstanding universal value of the Great Barrier Reef, builds resilience, improves ecosystem health and benefits communities.

The public consultation period for the draft Reef 2050 Water Quality Improvement Plan 2017-2022 closed on 10 October 2017. Feedback from the online survey and other submissions will inform the final plan and will contribute to implementation planning.

- Draft Water Quality Improvement Plan: www.reefplan.qld.gov.au

Great Barrier Reef Report Card 2016

The Great Barrier Reef Report Card 2016 measures progress against Reef Water Quality Protection Plan 2013 goals and targets.

The report card assesses the combined (cumulative) results of water quality actions from 2009 up to June 2016 for management practice adoption, pollutant loads, ground cover, wetland condition and inshore marine condition.

Results show that land management improvements are paying off with some progress to the water quality targets as a direct result of our on ground investments through the Australian Government Reef Program and the first phase of Reef Trust.

Key messages

There has been steady improvement in all pollutant reductions and we are seeing positive benefits for the reef.

This report card shows:

- Dissolved inorganic nitrogen reduced by 5.5% in the Burdekin to achieve an overall 25.5% reduction as a result of improved nitrogen and irrigation management by sugarcane growers.
- In the Fitzroy region we saw a reduction of 4.1% of fine sediment to achieve an overall reduction of 9.6% – this was primarily due to streambank protection projects.
- Ground cover scored an 'A' overall, with results increasing from 77% to 80% cover. The target was exceeded in all regions including Burdekin and Fitzroy despite being drought declared.
- Overall inshore marine condition was moderate in 2015-2016 with increased confidence in the result due to an improved water quality metric.

For the first time:

- Grains reported in the Burnett Mary with 74% of land managed using best management practice systems.
- The state of and pressures on wetland environmental values reported across the Great Barrier Reef. Overall, wetlands are in moderate condition.

Coral bleaching and mortality is highly variable across the Great Barrier Reef with inshore coral reefs south of the Daintree (Wet Tropics) in moderate condition in 2015-2016. Corals in the northern region between Port Douglas and the tip of Cape York were most affected by the 2016 coral bleaching.

- Great Barrier Reef Report Card 2016: www.reefplan.qld.gov.au

Reef horizon – looking forward to future report cards

At report card time it's natural to focus on the progress already made towards goals and targets. However, it is important to also recognise the large amount of on-ground work underway that is yet to be reflected in the results.

So why are some management practice improvements not reflected in Report Card 2016?

- **New investment** – recently funded on-ground programs, some new, some ongoing, need time to achieve results.
- **Time lag** – the results detail progress to June 2016 with achievements since that time being recorded in future report cards.
- **Land management change is complex** – making changes often involves gaining new knowledge and skills. In some cases, it also requires considerable investment in farm equipment and infrastructure. This takes time but the willingness of producers to improve practices is higher than ever and the results will follow.
- **Trial first** – various trials of innovative solutions to reduce pollutant run-off are taking place but need to be completed and evaluated before they can be rolled out on a larger scale, or in more catchments.

- Fact Sheet – Reef horizon – looking forward to future report cards:
www.reefplan.qld.gov.au/measuring-success/report-cards/2016/reef-horizon/

Australian Government Reef Program

The Australian Government's Reef Program builds on the success of Reef Rescue (2008-2013) where more than 3,200 land managers received water quality grants for on-farm projects to adopt better land management practices and improve quality of water entering the Great Barrier Reef lagoon.

Over the next five years (2013-2018), the program has already contracted the delivery of approximately \$142 million to support the health of the reef.

- More about the program: www.nrm.gov.au/national/continuing-investment/reef-programme

Australian Government Reef Achievements (2008-2013) report

The *Australian Government Reef Achievements* report provides information on the success of the Australian Government's investments through the Reef Rescue Program to reduce nutrients, pesticides and sediment discharge into the reef from broadscale land use over the period 2008 to 2013.

- *Australian Government Reef Achievements (2008-2013)* report:
www.environment.gov.au/marine/gbr/publications/australian-government-reef-achievements-2008-2013
- Regional achievements summaries:
www.environment.gov.au/marine/gbr/publications/australian-government-reef-achievements-2008-2013#regional
– regional summaries are available for Burnett Mary, Cape York, Fitzroy Basin, Mackay Whitsunday, NQ Dry Tropics and Wet Tropics regions.

North-East Shipping Management Plan

The North-East Shipping Management Plan sets out Australia's intention to enhance ship safety and environmental protection and identifies measures to manage risks associated with shipping in the Great Barrier Reef, Coral Sea and Torres Strait regions.

- North-East Shipping Management Plan:
www.amsa.gov.au/north-east-shipping-management-plan

Comprehensive strategic assessment of the Great Barrier Reef World Heritage Area

The Australian Government, including the Great Barrier Reef Marine Park Authority, and the Queensland Government have completed a comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone.

- More about the comprehensive strategic assessment:
www.environment.gov.au/marine/gbr/comprehensive-strategic-assessment

Great Barrier Reef Outlook Report

The *Great Barrier Reef Outlook Report 2014* provides an important stocktake on the state of the reef and its outlook, based on the best available information at the time.

- *Great Barrier Reef Outlook Report 2014*:
www.gbrmpa.gov.au/managing-the-reef/great-barrier-reef-outlook-report

Independent Review of the Port of Gladstone

As part of the Australian Government's response to the 2012 decision of the World Heritage Committee regarding the ongoing protection and management of the Great Barrier Reef World Heritage property, the Australian Government commissioned an Independent Review of the Port of Gladstone.

- More about the Independent Review of the Port of Gladstone:
www.environment.gov.au/marine/gbr/port-gladstone-review

An addendum to the independent review was commissioned in January 2014 so that an independent panel could examine the latest information.

- Gladstone Bund Wall Review:
www.environment.gov.au/topics/marine/gbr/gladstone-bund-wall-review

Great Barrier Reef Intergovernmental Agreement

In 2009, the Australian and Queensland governments developed a Great Barrier Reef Intergovernmental Agreement for the Great Barrier Reef World Heritage Area to secure the long-term conservation and protection of the reef. The aim was to enhance coordinated and collaborative approaches between the Australian and Queensland jurisdictions.



- More about the Great Barrier Reef Intergovernmental Agreement: www.environment.gov.au/marine/gbr/protecting-the-reef/intergovernmental-agreement

Protective legislation

The reef is protected by two complementary pieces of federal legislation:

- The *Great Barrier Reef Marine Park Act 1975* oversees activities in the marine park
- Australia's key national environment law, the *Environment Protection and Biodiversity Conservation Act 1999*, protects nationally significant matters including the Great Barrier Reef World and National Heritage areas.

These acts provide an internationally-recognised, world-class system of environment and heritage protection.

To ensure use of the Great Barrier Reef remains sustainable, activities in the World Heritage Area and marine park are tightly controlled under these laws, as well as other relevant state and federal laws.

- *Great Barrier Reef Marine Park Act 1975*: www.legislation.gov.au/Details/C2011C00149
- *Environment Protection and Biodiversity Conservation Act 1999*: www.legislation.gov.au/Series/C2004A00485

In 2006, the *Great Barrier Reef Marine Park Act 1975* was reviewed and a series of measures proposed to strengthen the legal, governance and policy frameworks relating to the management and long-term protection of the Great Barrier Reef Marine Park.

- Review Panel Report – *Review of the Great Barrier Reef Marine Park Act 1975*: www.environment.gov.au/marine/gbr/publications/review-great-barrier-reef-marine-park-act-1975-review-panel-report

Great Barrier Reef Marine Park Amendment Act 2007

A body of new measures was implemented to protect the reef during 2007 – principally via the *Great Barrier Reef Marine Park Amendment Act 2007*.

The Act commenced on 1 July 2007 and amended the governance, accountability and transparency requirements of the *Great Barrier Reef Marine Park Act 1975*.

In particular, the amendments provided for:

- A five-yearly, peer-reviewed Outlook Report to document the overall condition of the marine park to be tabled in Parliament and published
- An enhanced process to engage stakeholders in the development of zoning plans for the marine park
- Zoning plans to be 'locked down' for a minimum of seven years from the date they come into force to provide stability for business, communities and biological systems.

Great Barrier Reef Marine Park and Other Legislation Amendment Act 2008

A second amendment Act – the *Great Barrier Reef Marine Park and Other Legislation Amendment Act 2008* – was passed by Parliament on 12 November 2008. The Act put in place a modern, future-focused regulatory framework to secure the long-term protection and ecologically sustainable management of the reef.

A multi-use property

The Great Barrier Reef Marine Park is a multiple-use area in which a wide range of activities and uses are allowed, including extractive industries but not mining. A new Zoning Plan for the entire Marine Park came into effect on 1 July 2004 and protects over 33 per cent of the Park though no-take zones (known also as green zones).

The comprehensive, multiple-use zoning system minimises impacts and conflicts by providing high levels of protection for specific areas. A variety of other activities are allowed to continue in a managed way in certain zones (such as shipping, dredging, aquaculture, tourism, boating, diving, research, commercial fishing and recreational fishing).

- More about the Zoning Plan: www.gbrmpa.gov.au/zoning-permits-and-plans/zoning/about-zoning

Further information

- www.environment.gov.au/marine/gbr/publications

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Department of the Environment and Energy. *Managing and protecting the Great Barrier Reef*. Retrieved from www.environment.gov.au on 4 December 2017.

Postscript: 29 April 2018

Government invests \$500 million to protect reef

The federal government announced it will invest \$500 million – the largest ever single investment – to protect the reef, secure its viability and the 64,000 jobs that rely on it. The government will partner with the Great Barrier Reef Foundation through a \$444 million agreement to tackle crown-of-thorns starfish, reduce pollution into the reef and mitigate the impacts of climate change.

The Great Barrier Reef Foundation partnership includes:

- \$201 million further improving water quality with changed farming practices such as reduced fertiliser use, and adopting new technologies and land management practices.
- \$100 million harnessing the best science to implement reef restoration and funding science that supports reef resilience and adaptation.
- \$58 million expanding the fight against the coral-eating crown-of-thorns starfish.
- \$45 million supporting other work, particularly increasing community engagement such as indigenous traditional knowledge for sea country management, coastal clean-up days and awareness raising activities.
- \$40 million enhancing reef health monitoring and reporting to track progress and inform better management.

More at: Great Barrier Reef Foundation, www.barrierreef.org

WHAT AUSTRALIA IS DOING TO MANAGE THE GREAT BARRIER REEF

A FACT SHEET FROM THE DEPARTMENT OF THE ENVIRONMENT AND ENERGY

The new Reef 2050 Long-Term Sustainability Plan is the blueprint for Australia's continuing efforts to preserve the Great Barrier Reef, building on our long history of successful management. The first of its kind for a property of this scale, the 35-year plan will strengthen the resilience of the reef and maintain its Outstanding Universal Value.

The reef's Outstanding Universal Value remains intact

A maze of 3,000 coral reefs and 1,050 islands, the Great Barrier Reef covers an area the size of Italy and stretches 2,300 km along Australia's north-east coast.

The Great Barrier Reef Marine Park Authority's independent and scientifically robust *Outlook Report 2014* found the reef retains its Outstanding Universal Value and the overall integrity of this vast property also remains in good condition.

Strong and decisive action to protect the reef

Australia has permanently banned the disposal of port-related capital dredge material in the entire World Heritage Area.

The federal ban was announced at the World Parks Congress on 12 November 2014 and came into law on 2 June 2015.

In the past 18 months the number of capital dredging proposals to place dredge material in the marine park has been reduced from five to zero.

Capital dredging for ports will be restricted to within the long established priority ports of Gladstone, Hay Point/Mackay, Abbot Point and Townsville – and only within the legislated port limits. Legislation to this effect has been introduced into the Queensland Parliament.

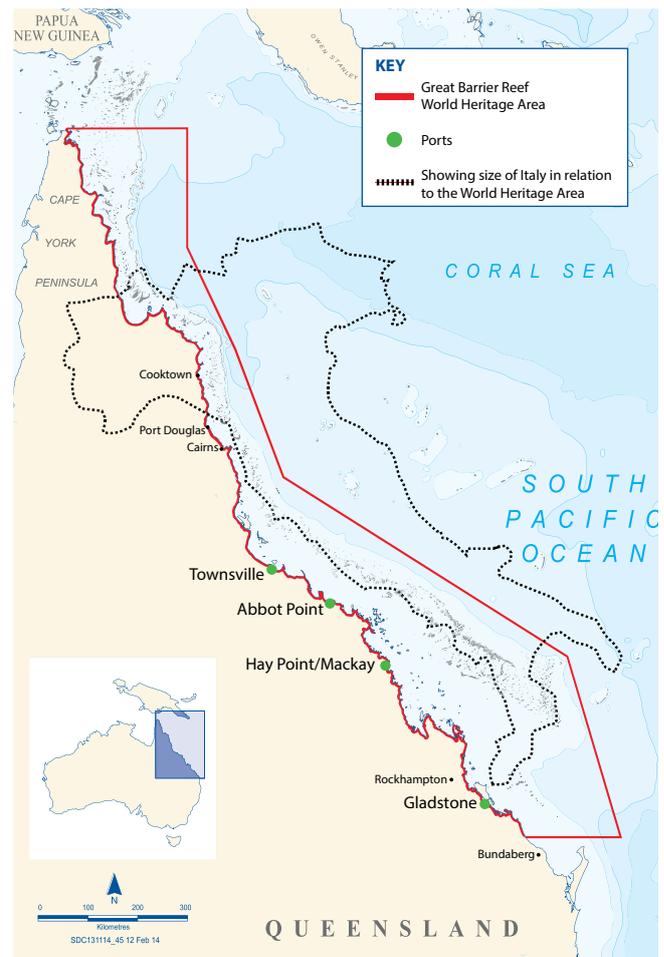
We have doubled funding to control crown-of-thorns starfish, to further protect the reef's corals.

Tough new penalties against poaching will provide extra protection for turtles and dugongs, as will increased funding to reduce marine debris.

The Reef 2050 Long-Term Sustainability Plan

The new Reef 2050 Plan strengthens Australia's management of the reef to protect and preserve the living reef and its Outstanding Universal Value. By working together, all levels of government, the community, traditional owners, industry and the scientific community will improve, enhance and maintain the reef's health and deliver ecologically sustainable development.

The Reef 2050 Plan is based on the best available scientific research, as well as lessons learnt from 40 years of cooperative management, and analysis of the entire reef region from the comprehensive strategic assessment.



The plan has concrete targets and actions, and everyone with a stake in the reef has clear responsibilities. Both the Australian and Queensland governments are committed to delivering the best possible outcomes for the future protection and management of the reef.

Implementation of the Reef 2050 Plan is already underway and with ongoing scientific and community input we are focussing on prioritising investments and improving monitoring.

Sustained investment into the future

Australian and Queensland government investment in reef management and research activities is projected at more than \$2 billion over the coming decade. This includes:

- \$140 million in funding for the Reef Trust – including the additional \$100 million for improved water quality announced by Australia's Prime Minister
- \$100 million in addition to the current \$35 million per year from the Queensland Government for improving water quality and further reducing the impacts of fishing.

We have finalised a baseline of all federal, state and local government investment in protecting the reef, as

well as private and philanthropic investment, as part of the Reef 2050 Plan's investment framework. With the help of an Independent Expert Panel chaired by Australia's Chief Scientist and a Reef Advisory Committee chaired by the former governor of Queensland, we will now determine investment priorities for the future and set out a strategy for boosting investment and diversifying resources over time.

We are starting to see results

Over recent years we have halted and reversed the decline in water quality in the reef's catchments. Based on state-of-the-art modelling and extensive monitoring, estimated annual average pesticide load has been reduced by 28 per cent, sediment load by 11 per cent, total nitrogen load by 10 per cent, and dissolved inorganic nitrogen by 16 per cent compared to a 2009 baseline.

Over \$29 million has been allocated from the Reef Trust so far to improve the quality of water flowing into the reef, enhance species protection and control outbreaks of crown-of-thorns starfish.

Queensland has established the Great Barrier Reef Water Science Taskforce to provide advice on the best approach to achieve up to 80 per cent reduction in nitrogen run-off and up to 50 per cent reduction in sediment run-off in key catchments by 2025.

We will continue working with landholders to reduce nutrient and sediment run-off into the reef and improve the condition of native vegetation across the catchment.

We expect a lag time between interventions to reverse negative impacts and the emergence of evidence that they are having an effect. A reef-wide Integrated Monitoring and Reporting Program is being developed

AUSTRALIA'S RESPONSE TO THE WORLD HERITAGE COMMITTEE

Australia has responded comprehensively to all of the requests of the World Heritage Committee and has taken unprecedented action to address concerns about the health and management of the Great Barrier Reef.

The need for a long-term plan

The ground-breaking Reef 2050 Long-Term Sustainability Plan is a 35-year plan for the management of the reef based on the strategic environmental assessment of the reef and the *Great Barrier Reef Outlook Report 2014*. The plan focuses on actions to address key threats and directly boost the health and resilience of the reef so that it is best able to cope with pressures, including the effects of climate change. The plan is a schedule of the updated Great Barrier Reef Intergovernmental Agreement. This gives it the highest status available under Australia's federated system of government.

www.environment.gov.au/protection/assessments/strategic/great-barrier-reef
www.gbrmpa.gov.au/managing-the-reef/great-barrier-reef-outlook-report
www.environment.gov.au/reef2050

In place


Managing development in Gladstone Harbour and on Curtis Island

The recommendations from the Independent Review of the Port of Gladstone will improve port operation and inform the work of the new Gladstone Healthy Harbour Partnership and other efforts to protect the Great Barrier Reef World Heritage Area.

www.environment.gov.au/gladstonereview
www.ghhp.org.au

In place


Water quality

The latest report card based on state-of-the-art modelling and informed by extensive monitoring shows water quality has improved. Estimated annual average sediment load has been reduced by 11 per cent, pesticide load by 28 per cent, and total nitrogen load by 10 per cent compared with 2009. This is the result of investments by the Australian and Queensland governments of more than \$375 million over the past five years, complemented by substantial in-kind investment by industry. Water quality will also be a focus for the \$140 million Reef Trust as well as the Queensland Government's additional \$100 million over five years towards water quality initiatives, scientific research and better environmental practices in the primary production and fishing industries.

www.reefplan.qld.gov.au/measuring-success/report-cards/2012-2013-report-card.aspx

In place


No development to impact individually or cumulatively on the reef's Outstanding Universal Value

Rigorous environmental assessment under the *Environment Protection and Biodiversity Conservation Act 1999* using the new *EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area* ensures that Outstanding Universal Value is central to the protection of the property. Developments with an unacceptable impact on the Great Barrier Reef will not be approved.

In response to commitments made in the strategic environment assessment, Cumulative Impact Assessment Guidelines and a Net Benefit Policy are being prepared to guide decision making.

www.environment.gov.au/protection/environment-assessments

In place


Limiting the impact of ports and port development

The Australian Government has permanently banned the disposal of capital dredge material in the Great Barrier Reef Marine Park. In the past 18 months the number of capital dredging proposals to place dredge material in the marine park has been reduced from five to zero.

The Queensland Government has introduced the *Sustainable Ports Development Bill 2015* to the Queensland Parliament, which complements the Australian Government's ban. Under this legislation, sea-based disposal of any port-related capital dredged material in the Great Barrier Reef World Heritage Area will be banned. Port-related capital dredging will be restricted to within the long established port limits of the regional priority ports of Gladstone, Hay Point/Mackay, Abbot Point and Townsville. The Bill mandates the beneficial reuse of dredged material. If beneficial reuse is not possible, the Bill mandates disposal on land where it is environmentally safe to do so.

Greenfield areas are protected from the impacts of port development. The Port of Rockhampton is not a priority port and is not included in the proposed boundary for the Gladstone port master planned area. This delivers on the Queensland Government's commitment to protect the Fitzroy Delta, including North Curtis and Keppel Bay.

In place


Best practice port planning

An action of the Reef 2050 Long-Term Sustainability Plan is to adopt the best practice principles identified in the Gladstone Independent Review reports and integrate them into port planning and development. Queensland's *Sustainable Ports Development Bill 2015* will legislate for long-term master planning at the four priority ports. Mandatory port master planning will deliver certainty to priority ports and their associated industry sectors while also ensuring the protection of the reef's Outstanding Universal Value.

In place
✓

Rigorous management of shipping

The Queensland Government has announced it will not support trans-shipping projects within the Great Barrier Reef Marine Park. The North-East Shipping Management Plan, released in late 2014 is being implemented to further reduce risks from shipping incidents. It builds on existing arrangements to provide an integrated approach to shipping management in the Great Barrier Reef World Heritage Area, Coral Sea and Torres Strait regions and gives explicit consideration to the Outstanding Universal Value of the World Heritage Area. At Australia's request, in May 2015 the International Maritime Organization more than doubled the size of the Great Barrier Reef Particularly Sensitive Sea Area to cover a further 565,000 km² of the South-West Coral Sea. This will help ensure that ships keep away from areas where they could cause significant damage.

www.amsa.gov.au/forms-and-publications/Publications/AMSA439.pdf

In place
✓

Address climate change and other forms of environmental degradation

An international solution on climate change is required. Australia is playing its part. Internationally we are working constructively towards a new global climate change agreement that involves all countries and by pledging \$200 million to the Green Climate Fund. Domestically we are meeting our 2020 emissions reduction targets and will mitigate climate change through the new \$2.55 billion Emissions Reduction Fund. The fund is already providing the impetus for businesses and the community to improve practices, invest in new technologies and reduce our emissions through activities such as revegetation, investing in soil carbon, cleaning up power stations, capturing gas from landfill and increasing energy efficiency. In the first Emissions Reduction Fund auction the Australian Government awarded contracts to the value of \$660 million to buy 47 million tonnes of carbon abatement. This is the largest emissions reduction commitment by business ever in Australia and will be built upon in subsequent auctions. We are implementing the Great Barrier Reef Climate Change Adaptation Strategy and Action Plan (2012-2017) which outlines how the Great Barrier Reef Marine Park Authority, in collaboration with industry, science and community partners will work to improve the resilience of the reef so it is better able to cope with stress and reduce the impacts of climate change.

elibrary.gbrmpa.gov.au/jspui/handle/11017/1140

In place
✓

Independent review of institutional and management arrangements for the reef

This review was completed in September 2014. The review identified that legislation for the protection and management of the reef is generally comprehensive.

www.environment.gov.au/marine/gbr/publications/independent-review

In place
✓

Ensure legislation remains strong and adequate to maintain and enhance Outstanding Universal Value

Australia will progress streamlined environmental assessments and approvals that maintain existing high environmental standards including consideration of the Outstanding Universal Value and integrity of the property when development proposals are being considered. Queensland has also committed to strengthen legislation to protect native vegetation, including in Great Barrier Reef catchments, effectively manage the coastal zone including wetlands, and ensure that water extraction is managed in accordance with the principles of ecologically sustainable development.

www.environment.gov.au/one-stop-shop

In place
✓

Overall protection and management of the property

Australia is fully committed to maintaining the Outstanding Universal Value and integrity of the reef. Strong protection and management foundations are already in place. The integrated delivery of existing and new measures will be given effect through the Reef 2050 Long-Term Sustainability Plan. The plan and the updated Great Barrier Reef Intergovernmental Agreement will ensure that the reef's Outstanding Universal Value is maintained and is central to the protection of the property.

In place
✓

Request for progress reports on the state of conservation of the reef

Australia has responded to all World Heritage Committee requests since 2011 for progress reports on the state of conservation of the reef, most recently through the 2015 State Party Report and Addendum, the *Great Barrier Reef Outlook Report 2014* and the Reef 2050 Long-Term Sustainability Plan.

www.environment.gov.au/world-heritage/gbr

In place
✓

to monitor the success of the Reef 2050 Plan and inform adaptive management. Annual reporting will highlight progress in delivery. A full review will occur every five years to ensure the plan remains consistent with the best scientific advice and relevant to addressing pressures on the reef.

Our commitment into the future

Australia is determined the Great Barrier Reef World Heritage Area remains internationally recognised for its Outstanding Universal Value. We are confident that we have the environmental protection and investment in

place to ensure the reef continues to be among the best managed and protected marine ecosystems in the world.

For further information

- www.environment.gov.au/gbr
- www.gbrmpa.gov.au
- www.Reefplan.qld.gov.au

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Department of the Environment and Energy (June 2015).
What Australia is doing to manage the Great Barrier Reef.
Retrieved from www.environment.gov.au on 4 December 2017.

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Reef 2050 long-term sustainability plan

Executive summary and recommendations from the *Reef 2050 Long-Term Sustainability Plan – progress on implementation, a review by the Great Barrier Reef Independent Review Group, courtesy of WWF-Australia*

The Great Barrier Reef Independent Review Group (the Reef Review Group) prepared this report to provide an independent analysis of the Australian and Queensland governments' progress in implementing the Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan).

We have reviewed the 2016 Reef 2050 Plan Annual Report and Addendum and the 2016 Update Report on Progress and Investment Framework. These reports cover the first 18+ months of a 5-year plan which is the first implementation phase of the 35-year Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan). We have also considered government policy responses to issues not covered in the Reef 2050 Plan but critical to the long-term management of the reef. Finally, we have looked at the implications of the 2016 mass coral bleaching event on future management of the reef.

We welcome the World Heritage Committee's active engagement on assessing the adequacy of management for ensuring the integrity and improvement of the Outstanding Universal Value (OUV) of the Great Barrier Reef World Heritage Area (GBR WHA). The Committee's ongoing interest reflects the global significance of the Great Barrier Reef, as well as the expectation that if any country can effectively manage its coral reefs in light of the many local to global pressures, then it should be Australia – a relatively prosperous country that derives considerable economic benefit from the GBR.

The Reef 2050 Plan has a number of very important strengths that will be the foundation for its success in the coming decades; so too there have been some promising achievements since its inception 18 months ago. These include Reef 2050 Plan's strong model of partnerships and cooperative federalism, delivery of key actions including commitments relating to managing the impacts of the removal and dumping of dredge spoil, limiting the locations of major trading ports, establishing net free fishing zones and the continuing focus on improving water quality.

However, the unprecedented severe bleaching and mortality of corals in 2016 in the Great Barrier Reef is a game changer. Given the severity of the damage and the slow trajectory of recovery, the overarching vision of the 2050 Plan, to ensure the Great Barrier Reef continues to improve on its OUV every decade between now and 2050, is no longer attainable for at least the next two decades.

As corals make a substantive contribution to the WHA's OUV for all four of the natural criteria for World Heritage listing, we consider that this event has substantially diminished the Outstanding Universal Value of the GBR WHA. The bleaching also highlights



the urgency of bolstering the resilience of the GBR WHA to maximise its capacity to recover before the next bleaching inevitably occurs. The Reef 2050 Plan is a key element of building resilience, but improving water quality can never climate-proof the reef.

The elevated sea temperatures that caused the 2016 severe coral bleaching and mortality event were due to the global warming effects of climate change. Effective action to address climate change and protect coral reefs worldwide depends on cooperative efforts by the entire international community. Responding to the threat of climate change on the Great Barrier Reef WHA is in part a shared responsibility for all state parties to the *World Heritage Convention*, with Australia holding a special role. Australia's current national emission reduction targets are not commensurate with a fair contribution to the reduced global carbon budget required to meet the Paris Agreement targets and protect the GBR WHA and coral reefs worldwide. As the guardian of the world's largest coral reef WHA, Australia has an opportunity to play an important leadership role on climate change and to do its fair share of emission reductions, consistent with meeting the 1.5C target. Australia must do more and do it urgently.

Implementation of the Reef 2050 Plan is critically dependent on an effective investment framework. The Investment Framework released alongside the December 2016 Update on Progress is an important initial attempt to quantify the scale of additional investment that will be required to implement the Reef 2050 Plan. However, the analysis provided in the Investment Framework falls short in a number of ways. In particular, it is disappointing that the Investment Framework commits no significant new funding to meeting the targets despite the recognised gaps presented.

The Investment Framework identifies a funding gap of between \$143 and \$408 million to implement all the existing actions committed to in the Reef 2050 Plan (the bulk of the costs is in meeting the water quality targets). It does not estimate the cost of meeting all 33 of the Reef Plan's targets for 2020.

As discussed elsewhere in this report, in many cases the existing suite of actions seems unlikely to be sufficient to meet the agreed targets, and additional actions will be required. Hence, the cost of meeting the 2020 targets is likely to be higher than the sum of the cost of meeting each of the individual actions listed. Strategies to address funding gaps through increased government and private sector investment are poorly constructed, non-comprehensive and add little to the achievement of the Reef 2050 Plan.

Documented gaps in future funding for GBR Marine Park field management and monitoring and reporting are concerning because adequate funding is central to the effective management of the GBR WHA and the adaptive management approach of the Reef 2050 Plan.

Improving the quality of water entering the GBR from the catchments is a key action in improving the health and resilience of the Reef. Progress towards achieving the nitrogen and sediment load reduction targets by 2018, and the uptake of best management practice (BMP) by cane farmers and graziers is very poor, despite the assertion in the Update Report that these actions are on track. The current voluntary uptake of BMP by both sugarcane farmers and graziers is unlikely to meet either 2018 or 2025 targets. Additionally, the widespread failure to meet existing regulated minimum standards must be addressed urgently. The Queensland GBR Water Science Taskforce, in their 2016 report, provided an extensive list of regulative changes that should be introduced in a staged way to accelerate progress towards meeting the Reef 2025 water quality targets.

To date there has not been adequate progress toward the Reef 2050 Plan's targets in relation to protecting native vegetation in Reef catchments. Queensland's acknowledged failure to strengthen its vegetation management laws makes it necessary for both the Australian and Queensland governments to find alternative mechanisms to fulfil their commitments under the Reef 2050 Plan. Both governments have existing legal powers which could be applied to make the expected progress toward the targets of no net loss in riparian vegetation and wetlands in reef catchments by 2020 and to contribute to the promised cuts in sediment pollution by 2025.

To address the outstanding risks to the GBR WHA by fishing activities that were identified in the *2014 GBR Outlook Report*, the implementation of the fisheries reforms contained within the Queensland government's Green Paper is urgently required. Reducing these risks should also contribute to the achievement of Biodiversity Target 3 and Economic Benefit Target 5 in the Reef 2050 Plan. To provide clear guidance in the delivery of these reforms for fisheries operating in the GBR WHA, we consider that GBRMPA should develop a position statement on what constitutes sustainable fishing within the WHA. This position statement should then guide the development by Fisheries Queensland of fisheries management targets and associated

management strategies.

We have noted a number of inherent limitations with the Reef 2050 Plan which need to be recognised in any analysis. These limitations mean that, to date, the scale of intervention required to achieve a target or objective is frequently substantially underestimated. As the 2016 Annual Report covers the first 18+ months of a 5-year plan, some measure of progress to targets would provide insight into the likelihood of success, or risk of failure. Leaving an assessment of progress to targets and outcomes until 2019 is unsatisfactory. We have identified a number of issues with the status rating given to each action and have made a number of suggestions on improving the current approach. In our consideration, up to a third of the 103 actions flagged as "on track/underway" are really just starting, or are seriously under-resourced. We also note that many important actions that will underpin good decision-making are constrained by the slow progress in developing and implementing the proposed Reef Integrated Monitoring and Reporting Program (RIMREP).

The Reef 2050 Plan recognises the importance of good governance to support its implementation and goes some way to addressing the complexity of the system. In many respects, the Plan's 15 governance actions are world's best practice as they strive for governance arrangements that are transparent, accountable, and co-operative and with the principle of subsidiarity paramount. However, the significance and urgency of the issues in the GBR, combined with the complexity of the governance arrangements in the broader GBR catchment, suggest that the governance actions proposed in the Reef 2050 Plan do not go far enough to support its outcomes.

Further reforms are needed. We have made recommendations to improve the independence of future GBR Outlook Reports, strengthen GBRMPA and establish a Queensland GBR Catchment Authority to provide a single point of contact for all Queensland reef-related matters and investment. We also note that significant changes are still required in planning and environmental policy, decision-making and implementation to ensure that the Queensland government meets its commitments in the Reef 2050 Plan to the long-term protection of the reef's OUV.

Below we present the Review Groups' recommendations to strengthen the Reef 2050 Plan and to clarify key priorities and/or reforms for the remainder of the first 5-year period. We urge that these improvements are reflected in the mid-term review of the Plan scheduled for 2018, and that the review is completed no later than March 2018 and submitted to the 2018 World Heritage Committee meeting.

We also reiterate the increased urgency for effective interventions as a result of the 2016 severe coral bleaching event. Based on the evidence to hand, we consider that key values of the GBR's OUV are in serious decline, particularly since the recent coral bleaching event.

Through the Reef 2050 Plan the Australian and Queensland governments, industries, communities and research partners are making genuine efforts to improve the protection and management of the GBR WHA. However, this Review Report has shown that Australia's overall progress in implementing the Reef 2050 Plan actions and making progress toward the 5-year targets has been less than anticipated in a number of important areas.

For these reasons, it is our view that it would not be constructive for the World Heritage Committee to include the Reef on the 'In Danger' list at this point in time, but it is important that the WHC and its advisory bodies maintain active oversight and continue to engage regularly with the Australian and Queensland governments to address the identified shortcomings in implementation of Reef 2050 and assist Australia's response to the recent coral bleaching event.

The Review Group therefore recommends that the state of conservation of the GBR WHA be examined by the WHC in 2017, with a view to requesting Australia to submit the scheduled mid-term review of the Reef 2050 Plan for consideration by the WHC in 2018. This will allow the Australian and Queensland governments to address any WHC recommendations in their December 2019 State Party state of conservation report.

In short, good work is underway. However, it needs to be scaled-up and adequately financed, and the capacity of key sectors such as local government and agricultural industries must be enhanced. Equally important is the need for the spirit of Reef 2050 Plan's cooperative federalism to be translated into bipartisan support for more effective policy, management and investment.

RECOMMENDATIONS

Limitations of Reef 2050 Plan and challenges inherent in the Annual Report and Update Report

1. Subsequent reviews of the Reef 2050 Plan must be underpinned by program logic and more quantitative approaches to either confirm or revise the existing framework of objectives and outcomes, and to determine 5-yearly targets. Each action should include measurable milestones for their delivery over the coming 5 years.

Meeting the 2018 water quality targets

2. Ensure the updated Reef Water Quality Protection Plan is achieved by mid-2017, and that it contains: revised load targets for each of the 35 major GBR catchments; measurable actions needed to achieve catchment targets; as well as a properly costed investment strategy to deliver actions; and that its implementation is given high priority.
3. Implement all of the recommendations made by the Queensland GBR Water Science Taskforce particularly the 'incentives' and 'regulations' recommendations to assist in driving agricultural management practice changes which should also include consideration of 'land use change' for the marginal agricultural lands. Need for more effective regulations to reduce reef pollution.
4. That the Queensland government move urgently to implement the regulatory recommendations of the GBR Water Science Taskforce.

5. That the Queensland and Australian governments provide sufficient resources to ensure that existing and proposed regulations are fully implemented and the necessary education and support services are provided.
6. Meanwhile the Queensland government should rapidly escalate its renewed compliance effort for the existing agricultural water quality regulations to ensure the current 40% non-compliance levels are quickly reduced.

Controlling vegetation loss in reef catchments

7. As soon as possible, Queensland should act again to strengthen state vegetation management legislation as required by Reef 2050 Plan Action Ecosystem Health Action 20.
8. In the meantime, the Australian and Queensland Governments should work together to rapidly reduce vegetation loss in reef catchments using existing legal mechanisms, with a particular focus on protecting riparian and wetland vegetation as intended under Reef 2050 Plan targets Ecosystem Health Target 3 and Water Quality Target 2. This can be achieved by a combination of the following steps:
 - (i.) Australian Government:
 - Improve reporting and monitoring systems to ensure vegetation clearing proposals that may impact the GBR WHA are referred and assessed as required under the *Environment Protection and Biodiversity Conservation (EPBC) Act*
 - (ii.) Queensland Government:
 - Use powers under the *Vegetation Management Act 1999* to make a declaration to protect riparian and wetland vegetation in reef catchments.
 - Further tighten self-assessable codes to reduce clearing in GBR catchments that will impact the reef.

Planning framework and protecting the reef's OUV

9. Maintaining and enhancing the GBR WHA OUV should be a top priority strategic outcome sought in all land use planning laws and policies and development approvals.
10. Ensure that Reef 2050 Plan Ecosystem Health Action 24 is effectively implemented so that local government has the capacity to effectively implement coastal planning laws and policies to protect the reef, commencing with a thorough assessment of the implementation chain within local government and the development industry.

Fisheries management

11. Ensure that a clear position statement is developed by GBRMPA to outline what constitutes sustainable fishing within the WHA and this is explicitly recognised by Fisheries Queensland during the development of fisheries management targets and strategies for GBR fisheries.

Governance arrangements underpinning reef management

12. Enhance the independence of the *Great Barrier Reef Outlook Report* by establishing an independent steering committee drawing on the expertise of the Reef 2050 Plan's Independent Expert Panel (IEP), Reef Advisory Committee (RAC) and the proposed Queensland GBR Catchment Authority.
13. Strengthen the Great Barrier Reef Marine Park Authority by establishing an expertise-based Board with an Independent Chairman and strong links with Reef 2050 Plan's IEP and RAC and the proposed Queensland GBR Catchment Authority.
14. Establish a Queensland Great Barrier Reef Catchment Authority with effective linkages with GBRMPA Board and Reef Plan's Independent Expert Panel and Reef Advisory Committee.

Monitoring, modelling, evaluation and reporting

15. Review the scope and complexity of the Reef 2050 Integrated Monitoring and Reporting Program and ensure a revised version commences in mid-2017.
16. Increase investment in GBR monitoring, modelling, evaluation and reporting.

Reef 2050 Plan Investment Framework

17. Develop an effective, adequate and comprehensive Investment Framework, Strategy and Business Plan capable of catalysing the additional funding from public and private sector sources required to meet the Reef 2050 targets. Meanwhile the Australian and Queensland governments should increase their investments to better reflect the recommendations of the 2016 Alluvium and Jacobs reports.
18. Include annual targets for investment, actions and pollution load reductions in the Investment Plan to be developed by June 2017 as part of the new Reef Water Quality Protection Plan.
19. Consolidate investment related to Reef 2050 outcomes across multiple jurisdictions and entities into a single entity to ensure effectiveness and accountability.
20. Implement regulation to cap pollution sources and provide supportive and 'fit for purpose' institutional and market mechanisms to encourage private investment in pollution reduction.
21. Develop a strategic implementation plan for the Reef Fund to ensure significant water quality outcomes.
22. Provide adequate investment in GBR Marine Park field management and monitoring and reporting programs to ensure effective adaptive management.

Implications of the 2016 coral bleaching event for the GBR World Heritage Area

23. Given the scale of impacts on the northern region of the

GBR WHA from the 2016 mass coral bleaching event, a reassessment of individual GBR values should be done in time for the mid-term review of the Reef 2050 Plan (scheduled for 2018), rather than waiting until the *2019 Outlook Report*.

24. Use the mid-term review of the Reef 2050 Plan to recalibrate the Plan to accelerate and enhance current reform efforts in a way that will make a significant difference to the reef's chances of survival in the face of climate change.
25. By March 2017 GBRMPA should confirm an immediate program of work to respond to the 2016 mass coral bleaching event.

Addressing climate change to protect the Great Barrier Reef

26. That the World Heritage Committee respond to the 2015-2016 global coral bleaching event by urging all state parties to redouble their efforts to address climate change, and note the importance of achieving the targets in the UNFCCC Paris Agreement, for the purpose of the *World Heritage Convention*.

Mid-term review of the Reef 2050 Plan

27. Ensure that the mid-term review of the Reef 2050 Plan is completed in the first quarter of 2018 and the updated Plan is submitted to the 2018 World Heritage Committee along with the updated assessment of individual values of the GBR WHA (see recommendation #23). To facilitate the ongoing engagement of the World Heritage Committee, we recommend that the state of conservation of the GBR WHA be examined by the WHC in 2017, with a view to requesting Australia to submit the scheduled mid-term review of the Reef 2050 Plan for consideration by the WHC in 2018.

WWF-Australia (February 2017). *Reef 2050 Long-Term Sustainability Plan – Progress on Implementation*, Executive Summary & Recommendations, pp. 4-7. Retrieved from www.wwf.org.au on 4 December 2017.



WHY THE GREAT BARRIER REEF IS DYING

GREENPEACE AUSTRALIA PACIFIC POST AUTHORED BY JUSTIN HAWK

Fish of every imaginable colour race between the corals as the sun's rays dance through the ocean's surface. A stingray slowly drifts by, taking its leisurely time.

I encountered this breathtaking scene last month and it reminded me of how extraordinary the natural world truly is. Yet, coral reefs could soon be gone forever. The Great Barrier Reef, the largest living thing on the planet, is deteriorating at an alarming rate. Over the past 30 years, we have seen it lose about 50% of its coral. We must act now if it is going to survive through future decades.

The Great Barrier Reef, the largest living thing on the planet, is deteriorating at an alarming rate. Over the past 30 years, we have seen it lose about 50% of its coral. We must act now if it is going to survive through future decades.

Understanding what is actually causing the reef to die can seem overwhelming given all the various reasons. So what is actually threatening it? The coal industry, coral bleaching, and poor water quality are among the ways that humans are hurting the Great Barrier Reef and it is becoming clear that if we plan on keeping the reef around for future generations, we must protect it now.

Coal

The "little, black rock" is playing a huge role in threatening the reef's existence. For unexplainable reasons, the Queensland government has continued to support expanding coal mines and ports. Coal is considered a dying industry and it also damages the Great Barrier Reef's health.

The craziest part, though? Just recently, the Queensland Labor Party approved Adani's Carmichael megamine – set to be the largest in Australia. The mine will have a footprint ten times larger than the city of Sydney and consume an olympic swimming pool of water every two hours. Given the poor state of the coal market, the mine has been called "economically disastrous" by experts. Expanding the coal industry means more pollution and more ships. Coal is a "dirty" energy source that is accelerating climate change.

The quickest shipping routes to Asia go right near the reef, which is why coal companies have drafted plans to dredge nearby areas. This puts the turtles and clown fish we love at risk. The Abbot Point Coal Terminal expansion includes digging up 1.1 million cubic metres of spoil near the reef and disposing of it next to nearby wetlands. While this has changed from the original plan of dumping the dredge into the ocean, coastal ecosystems will now be severely damaged.

Bleaching

The brightly coloured corals are quickly turning ghostly white as the reef experiences the worst bleaching event in its history. The Great Barrier Reef Marine Park Authority (GBRMPA) has issued the highest bleaching response level for the northern part of the reef, indicating "severe regional bleaching." 516 of the 520 reefs Professor Terry Hughes, the Director of the Australian Research Council Centre of Excellence for Coral Reef Studies, recently surveyed were experiencing bleaching and may not be able to ever recover.

Coral bleaching occurs when the ocean stays at higher than normal temperatures, causing the corals to expel the algae, zooxanthellae, that live on them. Losing this algae puts stress on the coral and causes it to turn completely white. While it is possible for coral to recover from a bleaching event, the severity and length of the bleaching determines whether the coral will recover or die. It is estimated that up to 50% of the currently bleached coral will die.

As the globe continues to warm and ocean temperatures increase, bleaching events like this will become more frequent and could occur annually as soon as 2030. The current bleaching is due to abnormally high ocean temperatures, partly influenced by the El Niño weather system, and is the worst instance we've ever seen on the reef. Soon we could be losing Nemo, rather than finding him.

Acidification

As we pump more and more greenhouse gases into the sky, the oceans too have become poisoned. Oceans absorb carbon dioxide and it is estimated that they have soaked up over 25% of the excess CO₂ that has been released by humans.

When they absorb this carbon dioxide, the oceans actually undergo chemical changes and become more acidic. Fragile locations like the Great Barrier Reef feel the effects the most and even a slight increase in acidity can lead to death for areas of the reef. It takes about 50 years for the effects of acidification to reverse so if climate change is not addressed now, the reef may never be able to recover.

Poor water quality

The water is also becoming dirtier and dirtier as human-caused pollution and run-off continues. Approximately 80% of Queensland coastline is used for agriculture, causing pesticides, fertilisers and animal waste to enter the ocean and degrade the water quality. This cloudy water makes photosynthesis difficult, resulting in less of the algae that coral desperately need.

A new paper published by the Australian Institute of Marine Science (AIMS) shows that the Great Barrier

Reef's water quality is unlikely to meet the sediment and nitrogen targets outlined in the Reef 2050 Plan. Experts say that more regulations must be implemented in addition to voluntary and incentive-based approaches.

Natural disasters

Cyclones and other natural disasters break coral and seagrass meadows become wiped by flood plumes. Over time, dugong and turtle populations are impacted by the damaged meadows. The frequency of these extreme disasters will increase as climate change worsens. With wind gusts of up to 285km per hour, Cyclone Yasi tore through the reef in 2011 and damaged about 13% of the reef.

Crown-of-thorns starfish

The crown-of-thorns starfish, a consumer of over a dinner plate's worth of coral daily, has been responsible for 42% of the lost coral. The starfish have been known to cyclically outbreak, with this latest event beginning in 2010.

The starfish play such a large role that it is estimated that over the past 30 years the reef would have actually increased in coral cover had it not been for the crown-of-thorns. The short-term strategy is for teams to control the starfish populations using various injection methods, while in the long-run the goal is to be better prepared to respond quickly to future outbreaks.

The Reef 2050 Plan

The state of the reef caused the UNESCO World Heritage Committee to debate listing the site as 'In danger'. In response to this, the Reef 2050 Long-Term Sustainability Plan was produced by the Australian Government Department of the Environment. The plan includes emission-reduction goals, government commitments to controlling pollution and limiting the effects of nearby dredging.

So what is actually threatening it? The coal industry, coral bleaching, and poor water quality are among the ways that humans are hurting the Great Barrier Reef and it is becoming clear that if we plan on keeping the reef around for future generations, we must protect it now.

The plan is inadequate, though, as there are not many concrete actions listed but rather only broad guidelines and goals. It pays little attention to the threats associated with climate change and allows for the expansion of the coal industry near the reef.

What should we do?

The question then becomes what must be done to protect the reef? Fighting against climate change is the most meaningful way since many of the threats



to the reef are related to human emissions. We must move towards renewable sources of energy, not coal, and reduce our footprint on the environment as much as possible. Regulations must be created that bring our emissions to the needed levels.

Tell your family, your friends and your government officials that you don't think we should have more coal mines near the reef and that the current bleaching event worries you. Stand up for the Great Barrier Reef, because if we don't fight to protect it, soon it will become a thing of the past.

Greenpeace (12 April 2016). *Why the Great Barrier Reef is Dying*. Retrieved from www.greenpeace.org.au on 4 December 2017.

Australia falling behind on reef promises

A new analysis finds that Australia has failed on a promise to control tree clearing to protect the Great Barrier Reef, is falling behind on other key commitments, and risks being called before the World Heritage Committee again in 2017. The [Australian Marine Conservation Society](#) explains

The *Reef Probation Report*, prepared by Fight For The Reef, calls on Australia to urgently lift its game on tree clearing, water pollution, investment in reef repair, and responding to climate change. With Australia due to give the World Heritage Committee a progress report on its Reef 2050 rescue plan by December 1, FFTR partners WWF-Australia and the Australian Marine Conservation Society have prepared their own assessment.

The fact that Australia lived up to its promise to ban sea-dumping of industrial dredge spoil in the Reef World Heritage Area and limit port development is a landmark win for the reef and proof that big actions can be taken to save the reef. But the failure on tree clearing, slow progress on water pollution targets, insufficient funding for reef repair, and inadequate action on climate change are cause for major concern.

"Global warming, caused by the mining and burning of fossil fuels like coal, has just triggered the worst bleaching event in recorded history," said Imogen Zethoven, Great Barrier Reef Campaign Director at the Australian Marine Conservation Society.

"Huge sections of the northern reef have died, and its World Heritage value has been seriously damaged.

"Despite this, Australia is not doing its fair share to tackle global warming and prevent coral bleaching events becoming more frequent and severe.

"A bigger effort is urgently needed on climate change and the other reef promises where Australia is falling behind," she said.

Latest government figures show that 108,000 hectares of bushland was cleared in Great Barrier Reef catchments in 2014-15 – an increase of 46% since 2011-2012 – despite the crucial role of bushland in preventing sediment smothering the reef.

The Great Barrier Reef Water Science Taskforce this year welcomed the efforts so far by farmers and land managers to reduce water pollution, but concluded that "the resulting changes have not been rapid or widespread enough to improve or even maintain water quality on the reef".

A government study shows there is a funding gap of about \$6 billion between what the Australian and Queensland Governments have committed so far to achieve water quality targets, and what's needed over the next ten years.

"The Australian and Queensland governments have not met their promise to control tree clearing in reef catchments, and need to do more to meet their promises to cut farm pollution and invest the funds required to repair the reef catchment," said WWF-Australia CEO Dermot O'Gorman.

"We need innovation and immediate action. If not, we're not meeting UNESCO's probation, and our governments are risking the reef's World Heritage status. The world is watching," he said.

WWF-Australia and AMCS say urgent action is needed to:

- | | |
|---|--|
| <ul style="list-style-type: none">➤ Control tree clearing in reef catchments➤ Make a rapid shift to renewable energy, with no new coal mines➤ Stop farm pollution harming the reef➤ Commit the funds needed to implement the Reef 2050 | <ul style="list-style-type: none">➤ Plan's promises➤ Create a strong, independent champion for the reef (by empowering and better resourcing the Great Barrier Reef Marine Park Authority). |
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Australian Marine Conservation Society (24 November 2016).

Australia falling behind on reef promises (Media release). Retrieved from www.fightforourreef.org.au

REEF PROMISES AND REALITIES

Extracts from the *Reef Probation Report* by [WWF-Australia](#) and the [Australian Conservation Society](#)

PROMISE

"The [Reef 2050] Plan changes the path for the future ... This Plan will work. The commitment is absolute."

– Greg Hunt, Australian Minister for the Environment and Stephen Miles, Queensland Minister for the Great Barrier Reef, 2015.

REALITY

This report outlines four major areas where Australia is currently not living up to its promises to the World Heritage Committee to protect the Great Barrier Reef: water pollution, tree-clearing, investment in reef repair, and responding to coral bleaching. The report recognises the welcome action by the state and federal governments to fulfil their promise to ban sea-dumping of industrial dredge spoil, and explains the rapid changes needed from both governments to get back on track to meet all our promises and protect the reef for future generations.

PROMISE

"This [Reef 2050] Plan will provide the best insurance for the Great Barrier Reef against climate change by reducing direct and indirect threats and therefore increasing its resilience."

REALITY

In 2016 at least 22% of the reef's corals were killed during the worst ever coral bleaching event to hit the Great Barrier Reef. Unless the Paris targets are met, climate change will cause more bleaching events.

PROMISE

"Australia is committed to taking strong domestic and international action on climate change." Under the Paris Agreement on climate change Australia has committed to reduce our greenhouse emissions by:

- Five per cent below 2000 levels by 2020.
- 26-28% below 2005 levels by 2030.

REALITY

- Australia's climate targets are less than our fair share of the global effort needed to keep global warming below the dangerous threshold of 2 °C, or work towards the Paris Agreement limit of 1.5 °C
- Australia's greenhouse emissions are now 3 per cent above 2000 levels.
- Expert analysis shows Australia's current policies will fall well short of meeting our promise under the Paris Agreement. Without major policy changes, Australia's emissions are set to increase to more than 21% above 2005 levels by 2030.
- In 2017 construction is due to begin on a massive new coal mine in Queensland's Galilee Basin, with the coal to be shipped out across the Great Barrier Reef.

PROMISE

Strengthen Queensland laws to control tree-clearing in reef catchments.

REALITY

This promise has not been met. Queensland's tree-clearing crisis continues, with 108,000 hectares of bushland lost in reef catchments alone in 2014-15. Queensland Parliament blocked a government bill to strengthen tree-clearing controls, and other existing state and federal laws are not being used to control tree-clearing.

PROMISE

No net loss of wetlands and riverside vegetation in reef catchments.

REALITY

Latest government figures show that in 2014-15 almost 15,000 hectares of riverside vegetation was bulldozed in reef catchments, that's over 1,300 kilometres of riverbank left vulnerable to soil erosion.

PROMISE

- By 2018 cut farm pollution from nitrogen fertilisers by at least 50% and from sediment by 20% in priority catchments.
- By 2025 cut farm pollution from nitrogen fertilisers by up to 80% and from sediment by up to 50% in priority catchments.

REALITY

Water pollution is still high and it's damaging the Reef. Annual reef report cards show that currently not enough is being done to cut farm pollution. However, if we rapidly implement the Reef Taskforce Recommendations and urgently ramp up actions we can achieve the transformational change needed to give the reef clean water.

PROMISE

In the Reef 2050 Plan the Queensland Government promised to ensure agricultural businesses would have an accredited best management practice (BMP) program in place or operate under a regulated management plan for pollution.

REALITY

Although farmers are starting to get involved in best management practice programs, not nearly enough have accredited BMP plans in place:

- There are 836 sugarcane farmers engaged in BMP programs (out of over 3,700 properties) including 86 farmers with an accredited BMP.
- There are 402 graziers engaged in BMP programs (out of over 8,500 properties) including 27 graziers with an accredited BMP.

Recently the Queensland Government recommenced enforcement of pollution regulations but there are no regulated farm management plans, and compliance with regulated standards is low.

PROMISE

"The Australian and Queensland governments will ensure sufficient financial and other resources are available to achieve the [Reef 2050] Plan's outcomes".

REALITY

A government study shows there is a funding gap of at least \$6 billion between what the Australian and Queensland governments have committed so far, and what's needed to save the reef over the next ten years.

PROMISE

Ban sea-dumping of industrial dredge spoil within the Great Barrier Reef World Heritage Area.

REALITY

The Australian and Queensland governments worked together to impose an immediate ban on sea-dumping of dredge spoil from port developments across the whole World Heritage Area. Sea-dumping from other dredging operations is exempt.

PROMISE

Protect greenfield areas by restricting new port development within and adjoining the World Heritage Area.

REALITY

Unspoiled parts of the reef coast like the Fitzroy River Delta and Cape York are now protected from major port developments, but there are still plans to expand a number of existing ports on the reef coast, including millions of tonnes of dredging.

© WWF-Australia and the Australian Marine Conservation Society (November 2016). *Reef Probation Report*, extracts pp. 5-20. Retrieved from www.fightforourreef.org.au on 4 December 2017.

Protecting the Great Barrier Reef ... the solutions are within our reach

Recommendations from the *Reef Probation Report* by WWF-Australia and the Australian Conservation Society

Urgent action is needed from the Australian and Queensland governments to:

1. Control tree-clearing in reef catchments
2. Stop farm pollution harming the reef
3. Commit to fully fund the Reef 2050 Plan, and make a down-payment right now
4. Deliver a rapid shift to renewable energy and away from fossil fuels
5. Create a strong new champion for the reef.

1. Control tree-clearing in reef catchments

There are many things the state and federal governments could do right now to protect native bushland in reef catchments, and across Queensland.

For example:

The Queensland Government should:

- Create 'declared areas' along reef watercourses, to ban clearing of riverside vegetation where it poses a high risk to the reef
- Tighten the 'self-assessable' codes that now regulate most tree-clearing activities
- Update official vegetation maps to reflect the latest science, to make sure all known threatened species habitat is protected.

The Australian Government should:

- Enforce existing laws that require landholders to get a federal environmental approval before clearing bushland that could contain nationally threatened plants or animals and other matters of national environmental significance
- Publicly and politically support the Queensland Government's proposed legislation to control tree-clearing.

2. Stop farm pollution harming the reef

We know that precision farm practices can cut pollution whilst boosting profits. With the right mix of regulations and incentives, widespread uptake of these reef safe practices can help give the reef the clean water it needs to rebuild its coral gardens.

Successive governments have set pollution reduction targets and invested in programs to help farmers adopt cleaner, more efficient practices.

However, as the Reef Taskforce Report found, current programs and investments, while making progress, fall far short of targets and unless there is rapid scaling up, pollution reduction targets are unlikely to be achieved.

To deliver clean water for the reef, the full package of reforms recommended by the Reef Water Science



Taskforce must be adopted by the Queensland and Australian governments, and rapidly implemented.

These include:

- A legislated limit on pollution loads entering the Reef which reduces until clean water targets are met.
- Minimum standards for all industries which improve over time to meet clean water targets.
- No increases in pollution from new development.
- A broadscale communications program to assist all farm businesses to implement the latest profitable pollution cutting practices.
- Catchment restoration to repair degraded pollution hot spots.

Meeting the 2025 clean water targets is critical if we are to avoid the next crown-of-thorns starfish outbreak, and give the reef the best chance of recovery from coral bleaching. A legal cap on pollution entering the reef is the only mechanism that can provide certainty that the targets will be met. The Australian and Queensland governments can support agricultural enterprises to meet this challenge by providing a major investment package to assist farmers to adopt profitable, low-polluting practices, and repair the landscape, as described below.

3. Commit to fully fund the Reef 2050 Plan, and make a down-payment right now

A long-term, multi-billion dollar investment package is needed to support agricultural enterprises to adopt

precision farm practices that can cut pollution whilst boosting profits. The investment package must also fund much needed catchment repair, such as restoring wetlands and riparian forests, and rehabilitating streambanks and gullies to halt soil erosion and filter out pollutants before they reach the reef.

The Queensland Government's costings report has estimated that it will cost over \$8 billion to achieve the clean water targets by 2025 or \$800 million a year. Governments need to fully deliver the investment needed to achieve Reef 2050 targets.

Initially the most cost-effective actions should be funded to drive rapid progress with \$800 million a year over five years.

Step 1 – Commit to an Investment Strategy that will fully fund all the actions promised in the Reef 2050 Plan and specifies the budget that each government will allocate each year.

Step 2 – Immediately commit the funds needed over the next 5 years to implement the most cost-effective actions to clean up water pollution. The new Reef Water Quality Protection Plan for 2017-2021 should set out the annual actions and investment to deliver specified pollution reduction targets including:

- The actions and investment needed to deliver the full nitrogen reduction target of up to 80% (estimated to be around \$400 million) as this is the most cost-effective area to cut reef pollution
- The actions and investment needed to deliver 75% of the 2025 target to halve sediment pollution (estimated to be \$3.6 billion) by 2021
- Innovations programs to prove up more cost-effective actions to fully achieve the 2025 clean water targets by the due date.

4. Deliver a rapid shift to renewable energy and away from fossil fuels

The devastating coral bleaching event that hit the reef earlier this year shows how urgent it is for all countries to limit global warming to 1.5C or less. As guardians of the Great Barrier Reef, Australia should lead the way by doing its fair share.

- Commit to a target of 100% renewable electricity by 2035.
- Commit to targets of at least 50% of total renewable energy (electricity, transport, and industrial process) by 2030 and 100% before 2050.
- Implement policies to support the rapid growth of renewable energy
- Phase out fossil fuel subsidies
- Rule out any new thermal coal mines or coal mine expansions
- Transition out coal-fired power plants before 2035.

5. A strong new champion for the reef

The problems facing the Great Barrier Reef have outgrown the capacity of the institutions and systems

put in place to protect it a generation ago.

There is often a disconnect between the long-term and stable policies required to conserve and recover the reef and federal and state electoral cycles. That's why the reef needs a strong, independent watchdog that can ensure the Reef's interests are represented and defended when important decisions are made and developments proposed.

A stronger, better resourced and more independent Great Barrier Reef Marine Park Authority (GBRMPA) is needed, that places conservation and recovery of the reef above all other priorities and strengthens the way Australia manages this World Heritage icon.

To meet the many challenges facing the reef, GBRMPA should have the following roles, powers and resources:

- 1. Independence:** Governed by an independent chair and an expertise-based board of international stature
- 2. Strong:** Ensure GBRMPA has approval powers for all developments and activities that are likely to have a significant impact on World Heritage values of the Great Barrier Reef Region
- 3. Leadership:** As the government champion for the Great Barrier Reef, GBRMPA should be given responsibility to lead implementation of the Reef 2050 Plan and investment strategy.
- 4. Smarter government investment:** Increase GBRMPA's budget by approx. \$20 million per year.
- 5. On-ground:** Increase resourcing and effectiveness of GBRMPA's field management and compliance programs to stop the current high rate of breaches of marine park rules.
- 6. Innovative:** Establish a Great Barrier Reef research strategy to deliver the critical research required to underpin effective management of the Great Barrier Reef and coastal ecosystems.
- 7. Transparent and accountable:** Enhance the independence and credibility of the 2019 *Great Barrier Reef Outlook Report* given its crucial role for deliberations by the World Heritage Committee in 2019/2020.

WWF-Australia and the Australian Marine Conservation Society (November 2016). *Reef Probation Report*, pp. 23-25. Retrieved from www.fightforourreef.org.au on 4 December 2017.

PRESERVE THE WONDER: HOW YOU CAN HELP

The Great Barrier Reef is our shared natural wonder. It is home to diverse marine life including seagrasses, corals, whales and marine turtles; it's a precious ecosystem that needs our protection, according to the [Queensland Government](#)



There are actions that everyone can take to help preserve the wonder of the Great Barrier Reef by reducing waste, pollution and carbon emissions, cleaning up waterways and coastlines, and supporting conservation efforts.

What can you commit to today?

- Reduce your purchase of plastics and/or excessive packaging.
- Recycle as much as you can and make sure you follow recycling guidelines.
- Use less chemicals, pesticides and fertilisers.
- Use reusable shopping bags, water bottles and coffee cups.
- Enjoy the reef without damaging it.
- Reduce your carbon footprint – for example, choose a car based on its fuel efficiency, use public transport, walk or ride where possible, wash clothes in cold water, buy green energy and select energy-efficient appliances.
- Reduce food wastage in your household with a worm farm.
- Buy locally grown food to reduce food transportation and emissions associated with your food.

Highlights

Unleash your inner scientist and participate in a citizen science program when you next visit the Great Barrier Reef. You can support scientific research by capturing information on corals, marine animals, mangroves and more.

Grab your snorkel or scuba gear and contribute to reef science. Find programs online by searching 'Great

Barrier Reef Citizen Science'.

Rubbish and chemicals in waterways and the ocean can prove fatal to marine life. It is always essential to dispose of rubbish and chemicals correctly to preserve the health of the Great Barrier Reef.

If you want to make a greater positive impact, you can also explore the different community organisations and events throughout Queensland whose mission is to clean up and keep our waterways healthy. When visiting the reef, you can find organisations who clean up marine debris.

On the reef

If you're visiting or live near the Great Barrier Reef, you can get involved through many programs including the following:

- Reef Blitz: www.reefcitizenscience.org/get-involved/reefblitz-2018
- CoralWatch: www.coralwatch.org/web/guest;jsessionid=2DDACBAoAABF4127D844B7D4C76FEB7
- Eye on the Reef: www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/eye-on-the-reef
- Reef Check Australia: www.reefcheckaustralia.org
- Great Barrier Reef Citizen Science Alliance: <http://greatbarrierreefcitizenscience.org.au>
- Project Manta: www.ladyelliott.com.au/content/project-manta-o

Other resources

- Learn about volunteering opportunities <https://environment.ehp.qld.gov.au/park-volunteers/>
- Become a Citizen of the Great Barrier Reef <https://citizensgbr.org/>

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Queensland Government. *How you can help* (Last updated 17 October 2017). Retrieved from www.qld.gov.au on 4 December 2017.

Great Barrier Reef: scientists use new technology to regenerate Australian icon

Scientists are regrowing coral from larvae on damaged patches of the Great Barrier Reef in a project that could change the management of reef systems worldwide.

A report by [Nicole Chettle](#) for *ABC News*

Professor Peter Harrison from Southern Cross University has been collecting coral spawn off Heron Island on the Great Barrier Reef (GBR), and maturing it in tanks.

“It’s really exciting, this essentially is the rebirth of the reef,” Professor Harrison said.

A team of scientists has deposited millions of coral larvae back onto damaged areas that may not regenerate naturally.

They created large enclosures around the coral using mesh curtains and special tiles to monitor growth. Days later, photographs reveal coral polyps had survived, and were settling into their new home.

It is the first time this technique has been used in Australia, and it follows a successful trial in the Philippines that transformed reefs devastated by blast fishing.

“We can grow these corals from microscopic larvae to dinner-plate size, breeding corals in just three years,” Professor Harrison said.

“It’s a new way of looking at the problem and it’s probably the only hope for the future in terms of larger-scale restoration using hundreds of millions of coral larvae.”

‘The reef is battered and bruised’

Chief scientist at the Great Barrier Reef Marine Park Authority (GBRMPA), Dr David Wachenfeld, said the size of the coral was important.

“It’s not just about having any coral. It’s about getting coral big enough to reproduce,” he said.

The mesh curtains cover a hundred square metres of damaged coral, and the next challenge will be covering several kilometres.

“Then we’ve really cracked this problem, because we’ve kickstarted the natural recovery process of the reef,” Dr Wachenfeld said.

This project is not designed to

restore the vast network of more than 3,000 reefs over 344,000 square kilometres.

But it has huge potential for smaller, “feeder reefs” that supply coral to other areas and support the broader marine ecosystem.

“I think that this could be something that changes management of reefs worldwide. All of the reefs, everywhere in the world, are suffering at the moment,” Dr Wachenfeld said.

“In the past, the Marine Park Authority has had a philosophy of basically getting out of nature’s way.

“But climate change is really changing that. The reef is battered and bruised. It’s more impacted than it’s ever been before.”

Professor Harrison was part of the team that discovered the mass coral spawning on the Great Barrier Reef in the early 1980s.

“I don’t know of any reef system on the planet that is now healthier than it was 35 years ago, and that’s really sad,” he said.

“In South-East Asia, which is the centre of marine biodiversity on the planet, it’s estimated that 95 per cent of those reefs are highly

“I don’t know of any reef system on the planet that is now healthier than it was 35 years ago, and that’s really sad.”

Professor Peter Harrison





“The GBR is the largest coral reef system in the world. It’s unique. There’s vast quantities that we don’t know about it still. To lose it would be an absolute travesty of justice.”

Professor Peter Harrison

degraded and are facing serious threats in the coming decades.”

Scientists call for ‘reality check’

Dr Wachenfeld said it had never been more urgent to tackle climate change.

“This is a moment for a reality check about the condition of the reef. But it’s also a call to action. This is a time for us to do more and act now to save the Great Barrier Reef,” he said.

Federal Environment Minister Josh

Frydenberg announced \$400,000 for Professor Harrison’s research, and said he was excited by its potential and would consider more funding if it was successful.

An additional \$200,000 is being spent by the GBRMPA to identify the best sites to roll out the technology, which is also supported by the Queensland Parks and Wildlife Service (QPWS) and the Great Barrier Reef Foundation.

But Mr Harrison said another \$1 to \$2 million a year is needed over the next five to 10 years to expand the project on a meaningful scale.

The ABC was escorted to the test site by senior ranger with the QPWS, Andrew Congram, who has worked on these waters for more than 30 years.

“The GBR is the largest coral reef system in the world,” he said.

“It’s unique. There’s vast quantities that we don’t know about it still. To lose it would be an absolute travesty of justice.”

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Chettle, N (26 November 2017). ‘Great Barrier Reef: Scientists use new technology to regenerate Australian icon’, *ABC News*. Retrieved from www.abc.net.au/news on 4 December 2017.

The Great Barrier Reef can repair itself, with a little help from science

How the Great Barrier Reef can be helped to help repair the damaged reef. A group of scientists explains in this article from *The Conversation*

The Great Barrier Reef is suffering from recent unprecedented coral bleaching events. But the answer to part of its recovery could lie in the reef itself, with a little help.

In our recent article published in *Nature Ecology & Evolution*, we argue that at least two potential interventions show promise as means to boost climate resilience and tolerance in the reef's corals: assisted gene flow and assisted evolution. Both techniques use existing genetic material on the reef to breed hardier corals, and do not involve genetic engineering.

But why are such interventions needed? Can't the reef simply repair itself?

At least two potential interventions show promise as means to boost climate resilience and tolerance in the reef's corals: assisted gene flow and assisted evolution.

Damage to the reef, so far

Coral bleaching in 2016 and 2017 took its biggest toll on the reef to date, with two-thirds of the world's

largest coral reef ecosystem impacted in these back-to-back events. The consequence was widespread damage.

Both techniques use existing genetic material on the reef to breed hardier corals, and do not involve genetic engineering.

Reducing greenhouse gas emissions will dampen coral bleaching risk in the long term, but will not prevent it. Even with strong action to tackle climate change, more warming is locked in.

So while emissions reductions are essential for the future of the reef, other actions are now also needed.

Even in the most optimistic future, reef-building corals need to become more resilient. Continued improvement of water quality, controlling crown-of-thorns starfish, and managing no-take areas will all help.

But continued stress from climate change – in frequency and intensity – increasingly overwhelms the natural resilience despite the best conventional management efforts.



Although natural processes of adaptation and acclimation are in play, they are unlikely to be fast enough to keep up with any rate of global warming.

So to boost the reef's resilience in the face of climate change we need to consider new interventions – and urgently. That's why we believe assisted gene flow and assisted evolution could help the reef.

Delaying their development could mean that climate change degrades the reef beyond repair, and before we can save key species.

What is assisted gene flow?

The idea here is to move warm-adapted corals to cooler parts of the reef. Corals in the far north are naturally adapted to 1C to 2C higher summer temperatures than corals further south.

This means there is an opportunity to build resistance to future warming in corals in the south under strong climate change mitigation, or to decades of warming under weaker mitigation.

There is already natural genetic connectivity of coral populations across most of the reef. But the rate of larval flow from the warm north to the south is limited, partly because of the South Equatorial Current that flows west across the Pacific.

The South Equatorial Current splits into the north-flowing Gulf of Papua Current and south-flowing East Australian Current off the coast of north Queensland. This means coral larvae spawned in the warm north are often more likely to stay in the north.

So manually moving some of the northern corals south could help overcome that physical limitation of natural north-to-south larval flow. If enough corals could be moved it could help heat-damaged reefs recover faster with more heat-resistant coral stock.

We could start safe tests at a subset of well-chosen reefs to understand how warm-adapted populations can be spread to reefs further south.

What is assisted evolution?

While assisted gene flow may be effective for southern or recently degraded reefs, it will not be enough or feasible for all reefs or species. Here, we argue that assisted evolution could help.

Assisted evolution is artificial selection on steroids. It combines multiple approaches that target the coral host and its essential microbial symbionts.

These are aimed at producing a hardier coral without the use of genetic engineering. Experiments at the Australian Institute of Marine Science are already making progress, with results yet to be published.

First, evolution of algal symbionts in isolation from the coral host has been fast-tracked to resist higher levels of heat stress. When symbionts are made to re-engage with the coral host, benefits to bleaching resistance are still small, but with more work we expect to see a hardier symbiosis.

Secondly, experiments have created new genetic diversity of corals through hybridisation and research-

ers have selected these artificially for increased climate resilience.

Natural hybridisation happens only occasionally on the reef, so this result gives us new options for climate-hardening corals using existing genetic stocks.

The danger of doing nothing?

The right time to start any new intervention is when the risk of inaction is greater than the risk of action.

Assisted gene flow and assisted evolution represent manageable risk because they use genetic material already present on the reef. The interventions speed up naturally-occurring processes and do not involve genetic engineering.

These are just two examples of new tools that could help build climate resilience on the reef. Other interventions are developing and should be put on the table for open discussion.

These interventions would not introduce or produce new species. Assisted gene flow would simply enhance the natural flow of warm-adapted corals into areas on the reef that desperately need more heat tolerance.

Risk of increasing the spread of diseases may also be low because most parts of the reef are already interconnected. A full understanding of risks is an area of continued research.

These are just two examples of new tools that could help build climate resilience on the reef. Other interventions are developing and should be put on the table for open discussion.

DISCLOSURE STATEMENT

Ken Anthony receives funding from the Australian Government, the Queensland Government and the Great Barrier Reef Foundation. **Britta Schaffelke** works for the Australian Institute of Marine Science, a publicly-funded research organisation that receives funding from the Australian Government, State Government Departments, foundations and private industry. **Line Bay** receives funding from the Australian Government through their National Environment Science Program. **Madeleine van Oppen** receives funding from the Australian Research Council, The Paul G. Allen Foundation, the Great Barrier Reef Foundation and the Australian Institute of Marine Science.

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THE CONVERSATION

Anthony K, Schaffelke B, Bay L and van Oppen M (10 October 2017). *The Great Barrier Reef can repair itself, with a little help from science.* Retrieved from <http://theconversation.com> on 4 December 2017.

EXPLORING ISSUES

WORKSHEETS AND ACTIVITIES

The Exploring Issues section comprises a range of ready-to-use worksheets featuring activities which relate to facts and views raised in this book.

The exercises presented in these worksheets are suitable for use by students at middle secondary school level and beyond. Some of the activities may be explored either individually or as a group.

As the information in this book is compiled from a number of different sources, readers are prompted to consider the origin of the text and to critically evaluate the questions presented.

Is the information cited from a primary or secondary source? Are you being presented with facts or opinions?

Is there any evidence of a particular bias or agenda? What are your own views after having explored the issues?

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Brainstorm, individually or as a group, to find out what you know about the Great Barrier Reef.

1. What is the Great Barrier Reef? Include where it can be found and its approximate size.

2. What is a crown-of-thorns starfish, and why is it considered a problem on the Great Barrier Reef?

3. What is coral bleaching, and what is its ecological impact?

4. What are zooxanthellae, and why are they important to the health of the Great Barrier Reef?



Complete the following activities on a separate sheet of paper if more space is required.

“The Great Barrier Reef, one of the earliest properties to be inscribed as World Heritage is a global icon. Unfortunately, a number of values for which the property was inscribed are declining.”

IUCN, *Great Barrier Reef: World Heritage Outlook.*

Consider the above statement, and address how each of the following are having a negative impact on the Great Barrier Reef World Heritage Area. Provide examples and suggest strategies that could be, or have been, implemented to reduce adverse impacts and protect the values of the reef.

POLLUTION

COASTAL DEVELOPMENT

TOURISM

FISHING



Complete the following activity on a separate sheet of paper if more space is required.

“Fighting against climate change is the most meaningful way since many of the threats to the reef are related to human emissions. We must move towards renewable sources of energy, not coal, and reduce our footprint on the environment as much as possible. Regulations must be created that bring our emissions to the needed levels.”

Greenpeace, *Why the Great Barrier Reef is dying.*

Form into groups of two or more people to discuss climate change and its likely effects on the Great Barrier Reef and its surrounding areas. Investigate the following topics which examine climate change, its impacts and potential solutions, and compile and present a final report to other groups in the class.

EXPLAIN WHAT CLIMATE CHANGE IS

EFFECTS OF CLIMATE CHANGE ON THE ECOSYSTEM OF THE REEF

HOW TO HELP PROTECT THE REEF FROM CLIMATE CHANGE



MULTIPLE CHOICE

Complete the following multiple choice questionnaire by circling or matching your preferred responses. The answers are at the end of this page.

- 1. In what year was the Great Barrier Reef first inscribed on the World Heritage List?**
 - a. 1901
 - b. 1975
 - c. 1981
 - d. 1995
 - e. 2007
 - f. 2015
- 2. The Great Barrier Reef is the world's largest and most complex reef system. What is its approximate size?**
 - a. 34 square kilometres
 - b. 340 square kilometres
 - c. 3,400 square kilometres
 - d. 34,000 square kilometres
 - e. 344,400 square kilometres
 - f. 3,344,400 square kilometres
- 3. Corals contain fluorescent proteins that may reduce ultraviolet light damage. Which of the following colours are present in these proteins? (select all that apply)**
 - a. purple
 - b. red
 - c. cyan
 - d. green
 - e. orange
 - f. yellow
 - g. white
- 4. The Great Barrier Reef suffered its worst ever bleaching event in 2016 due to record-breaking summer sea surface temperatures. This was partly due to which of the following weather patterns?**
 - a. Tropical Cyclone
 - b. El Niño
 - c. Tornado
 - d. La Niña
 - e. Monsoon
 - f. Coriolis force
- 5. How many known shipwreck sites are located in the Great Barrier Reef Marine Park?**
 - a. 5
 - b. 10
 - c. 20
 - d. 30
 - e. 40
 - f. 50

MULTIPLE CHOICE ANSWERS

1 = c; 2 = e; 3 = b, c, d, f; 4 = b; 5 = d.

- The Great Barrier Reef is the only living organic collective visible from Earth's orbit (Australian Government, *Great Barrier Reef*). (p.1)
- The Great Barrier Reef is the world's largest coral reef ecosystem. It was declared a World Heritage Area in 1981 and added to the National Heritage List in 2007 (*ibid*). (p.1)
- Coral consists of individual coral polyps – tiny live creatures which join together to form colonies. Each polyp lives inside a shell of aragonite, a type of calcium carbonate which is the hard shell we recognise as coral. The polyps join together to create forests of coloured coral in interesting fan, antler, brain and plate shapes (*ibid*). (pp. 1-2)
- Since the 1960s the crown-of-thorns starfish has been destroying the corals which make up the reef. Crown-of-thorns outbreaks go through a series of stages which can take from 1 to 15 years. The impact of a crown-of-thorns infestation on sea and bird life can be significant as the corals die (*ibid*). (p.2)
- The Great Barrier Reef stretches more than 2,300 kilometres along Queensland's coastline and is made up of around 3,000 individual coral reefs (Queensland Government, *About the Great Barrier Reef*). (p.4)
- The Great Barrier Reef has lost almost half its coral cover since 1985 and is under pressure from: climate change, poor water quality from land-based run-off, impacts from coastal development, and illegal fishing (*ibid*). (p.4)
- More than 30 species of marine mammals are found along the Great Barrier Reef (Great Barrier Reef Marine Park Authority, *Animals on the Great Barrier Reef*). (p.7)
- Giant hump-headed parrotfish are integral to a healthy reef system. Parrotfish eat more than 5 tonnes of coral reef material a year, around half of which is live corals. In a healthy system, parrotfish help keep the coral growth in check, with coral growth rates roughly balancing the amount of coral eaten by the parrotfish (Australian Academy of Science, *Biodiversity of the Great Barrier Reef*). (p.10)
- The Great Barrier Reef has a economic, social and icon asset value of \$56 billion. It supports 64,000 jobs and contributes \$6.4 billion to the Australian economy (Deloitte Access Economics, *At what price? The economic, social and icon value of the Great Barrier Reef*). (p.11)
- Corals contain fluorescent proteins (green, yellow, red and cyan) that may help minimise damage from ultraviolet light (Great Barrier Reef Marine Park Authority, *Coral bleaching*). (p.15)
- Coral bleaching does not automatically mean affected corals will die. If conditions return to normal, corals can slowly repopulate their tissues with zooxanthellae and recover. During their recovery, however, they are likely to experience reduced growth and reproduction, and are more susceptible to disease (*ibid*). (p.15)
- In 2016, the Great Barrier Reef suffered the worst ever bleaching event due to record-breaking summer sea surface temperatures. This was due in part to a strong El Niño combined with the ongoing effect of climate change. An estimated 22% of coral on the Great Barrier Reef died as a result of bleaching, mainly from reefs in the northern section (*ibid*). (p.15)
- Land clearing in Queensland has accelerated rapidly in the past few years, with about 1 million hectares of native vegetation being cleared in the past 5 years. That's an area the size of the Brisbane Cricket Ground being cleared every 3 minutes. About 40% of this vegetation clearing is in catchments that drain to the Great Barrier Reef (Watson J and Maron M, *The Great Barrier Reef isn't listed as 'in danger' – but it's still in big trouble*). (p.19)
- The known causes of the observed decline in coral cover since 1985 were storm damage (48%), crown-of-thorns starfish (42%), and bleaching (10%) from extended periods of increased sea temperature (Australian Institute of Marine Science, *The state of the Great Barrier Reef*). (p.26)
- It is not known precisely what causes the periodic crown-of-thorns outbreaks but water quality is the number one suspect and, in particular, the availability of more nutrients that increase the amount of plankton for the larvae of crown-of-thorns starfish to feed on. This means that river floods and associated sediment and nutrient run-off are strongly implicated (*ibid*). (p.26)
- The frequency of large river floods affecting the central Great Barrier Reef has increased since the late 19th century. High flow events are now occurring on average every 6 years (1948-2011), compared with every 20 years in the period 1748-1847 (*ibid*). (p.26)
- Australia has permanently banned the disposal of port-related capital dredge material in the entire World Heritage Area. The federal ban was announced at the World Parks Congress on 12 November 2014 and came into law on 2 June 2015 (Department of the Environment and Energy, *What Australia is doing to manage the Great Barrier Reef*). (p.33)
- Oceans absorb carbon dioxide and it is estimated that they have soaked up over 25% of the excess CO₂ that has been released by humans. When they absorb this carbon dioxide, the oceans actually undergo chemical changes and become more acidic. It takes about 50 years for the effects of acidification to reverse (Greenpeace, *Why the Great Barrier reef is dying*). (p.40)
- Unspoiled parts of the reef coast like the Fitzroy River Delta and Cape York are now protected from major port developments, but there are still plans to expand a number of existing ports on the reef coast, including millions of tonnes of dredging (WWF-Australia and the Australian Marine Conservation Society, *Reef Probation Report*). (p.43)
- A team of scientists has deposited millions of coral larvae back onto damaged areas that may not regenerate naturally. Days later, photographs reveal coral polyps had survived, and were settling into their new home (Chettle, N, *Great Barrier Reef: scientists use new technology to regenerate Australian icon*). (p.47)

Azooxanthellate

Organisms that do not contain zooxanthellae which are commonly found in coral.

Biodiversity

The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

Coral

Coral consists of individual coral polyps. The polyps join together to create forests of coloured coral in interesting fan, antler, brain and plate shapes. The ideal environment for coral is shallow warm water where there is a lot of water movement, plenty of light, where the water is salty and low in nutrients. There are many different types of coral, some are slow-growing and live to be hundreds of years old, others are faster-growing. The colours of coral are created by algae. Only live coral is coloured. Dead coral is white.

Coral bleaching

Coral bleaching occurs in response to physiological shock due to periods of increased water temperature combined with high levels of light. It can also be caused by changes in salinity and water clarity. The phenomenon is not exclusive to the Great Barrier Reef, and has been observed on coral reefs throughout the world.

Crown-of-thorns starfish

One of the greatest dangers to the Great Barrier Reef is the crown-of-thorns starfish. Since the 1960s the crown-of-thorns has been destroying its corals. Outbreaks of the crown-of-thorns starfish go through a series of stages which can take from 1-15 years. The impact of an infestation on sea and bird life can be significant as they kill the corals.

Ecologically sustainable use

The use of natural resources to sustain natural processes while maintaining the life-support systems of nature and ensuring the benefit of their use to current and future generations.

Ecosystem

A biological community of interacting organisms living in a particular area.

Global warming

An increase in global average surface temperature due to natural or human-influenced climate change. Global warming is affecting the Earth in a number of ways, including melting polar ice caps, which in turn is leading to rising sea levels.

Great Barrier Reef

Tropical ecosystem located off the coast of north-east Australia made up of reef, seagrass, pelagic, shoals and mangrove habitats including cays, islands and coastal areas which are biologically connected.

Great Barrier Reef catchment

The area adjacent to the Great Barrier Reef which drains into the region.

Habitat

The natural environment occupied by an animal, plant or organism or groups of organisms.

Mass coral bleaching

When coral bleaching extends over large areas (from tens to hundreds of kilometres) as a result of unusually high water temperatures.

Mesophotic reefs

A reef where the coral is found at water depths with limited light.

Polyps

Coral polyps are tiny live creatures which join together to form colonies. Each polyp lives inside a shell of aragonite, a type of calcium carbonate which is the hard shell we recognise as coral. The polyps join together to create forests of coloured coral in interesting fan, antler, brain and plate shapes.

Resilience

The ability of an ecosystem to recover from disturbance, shocks and ongoing pressures.

Sink reefs

Reefs that receive larvae via ocean currents.

Source reefs

Reefs that have the potential to provide larvae to other reefs via ocean currents.

Sustainability

Activities that meet the needs of the present without having a negative impact on future generations.

Vulnerability

The degree to which a system or species is susceptible to, or unable to cope with, adverse effects.

World Heritage Area

A area selected by UNESCO that has cultural, historical, scientific, or some other form of significance, and is legally protected by international treaties. As the world's most extensive coral reef ecosystem, the Great Barrier Reef is a World Heritage Listed Area.

Zooxanthellae

Microscopic single-celled algae that form symbiotic relationships with corals, sea anemones, molluscs and several other types of marine invertebrates.

Websites with further information on the topic

ARC Centre of Excellence for Coral Reef Studies www.coralcoe.org.au
 Australian Institute of Marine Sciences www.aims.gov.au
 Australian Marine Conservation Society www.marineconservation.org.au
 CSIRO – Oceans and Coasts www.csiro.au/en/Research/Environment/Oceans-and-coasts
 Department of Agriculture and Water Resources – Fisheries www.agriculture.gov.au/fisheries
 Department of the Environment and Energy – Marine www.environment.gov.au/marine
 Fight for Our Reef www.fightforourreef.org.au
 Great Barrier Reef Foundation www.barrierreef.org
 Great Barrier Reef Marine Park Authority www.gbrmpa.gov.au
 Greenpeace Australia Pacific www.greenpeace.org.au
 Queensland Government (Coasts, waterways and marine) www.qld.gov.au/environment/coasts-waterways/reef
 WWF-Australia wwf.org.au

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