CLIMATE COUNCIL

BRIEFING

IN HOT WATER: CLIMATE CHANGE, MARINE HEATWAVES & CORAL BLEACHING

KEY MESSAGES

1. 2021 was the warmest year on record for the world's oceans.

- Climate change is warming the world's oceans, leading to more frequent and severe marine heatwaves. Over the past year, excess heat absorbed by the ocean was equivalent to seven Hiroshima atomic bombs detonating every second.
- This summer, the temperature of waters offshore from Australia has been well above average, impacting coral reefs and other marine ecosystems.
- A UNESCO monitoring mission in March 2022 will assess the condition of the Great Barrier Reef, ahead of a World Heritage Committee meeting to consider listing the Reef as 'in danger'.

2. Marine heatwaves are threatening the survival of the Great Barrier Reef.

- After a summer of marine heatwaves, the Reef is again at risk of mass bleaching. Sea surface temperatures are above average across most of the Reef - up to 3°C warmer in the central parts of the Reef. Low to moderate bleaching is already occurring, with the most impacted corals near Townsville.
- In just the last six years, marine heatwaves have caused three mass bleaching events on the Reef. If climate change continues unabated, the Reef could face bleaching conditions every year after 2044. These conditions would effectively destroy the Reef, and most shallow water tropical reefs worldwide.
- Under a high emissions scenario, marine heatwaves are projected to become 50 times more frequent by the end of the century and many parts of the ocean could reach a near-permanent marine heatwave state.

3. More frequent and severe marine heatwaves also have devastating consequences for other marine ecosystems.

- The near-surface waters off southeastern Australia are warming at nearly four times the global average, leading to changes in the distribution of species, species collapse and a decline in biodiversity. This also impacts fisheries, aquaculture and tourism.
- Over the past decade, marine heatwaves have caused mass deaths of key species along 45 percent of Australia's coastline – including corals, kelp, seagrasses and mangroves.
- Every fraction of a degree of warming avoided will be measured in saved ecosystems.

4. To avoid a climate catastrophe and best protect the Great Barrier Reef, governments must commit to immediate, deep and sustained emissions reductions this decade.

- A net zero target by 2050 - setting aside the fact that the Liberal-National Government does not have a credible plan to achieve it - is not enough.
- Cutting global emissions by at least 50 percent *this decade* is key to the survival of Australia's ocean wonders, which are of natural, social, cultural, and international significance.
- The Climate Council is calling for Australia to reduce its emissions by 75% below 2005 levels by 2030. As a first step, the federal government should match key allies and commit to halving emissions this decade.

CONTENTS

1 INTRODUCTION

Australians have a special connection to the ocean. More than 85 percent of all Australians live within 50km of the coast. Australia's First Nations people and Torres Strait Islanders have had a cultural affinity with the ocean for millennia. The ocean remains very important for the Australian lifestyle and national identity. In terms of economic value, Australia's marine industry contributes more than $80 billion every year to the Australian economy - more than sectors like agriculture ($58.9 billion) or coal mining ($69.7billion) (AIMS 2021).

Yet the Great Barrier Reef and many of Australia's unique and treasured marine ecosystems are in very serious trouble. The Liberal-National Government has consistently ignored warnings that protecting the Great Barrier Reef requires stronger action on climate change; it has censored key reports; and the government has lobbied against the World Heritage Committee listing the Reef as 'in danger'. The decision whether or not to place the Great Barrier Reef on the 'in danger' list will be revisited by the World Heritage Committee in June 2022. A UNESCO delegation has been sent to assess the current state of the Reef and will visit in late March.

This briefing considers the ways that ocean warming is affecting Australia's marine ecosystems and the communities that depend on them. More frequent and severe marine heatwaves have already had devastating impacts on Australia's unique ecosystems, including mass bleaching on the Great Barrier Reef and the Ningaloo Reef, a loss of seagrass meadows in Western Australia's Shark Bay, widespread death of mangroves in the Gulf of Carpentaria, and a rapid decline of giant kelp forests.

Much more ambitious action to reduce emissions this decade is key to the survival of Australia's precious marine ecosystems.

Image 1: Climate change is driving a rapid decline in Australia's giant kelp forests.

Much more ambitious action to reduce emissions *this decade* is key to the survival of Australia's precious marine ecosystems. A net zero target by 2050 - setting aside the fact that the Liberal-National Government does not have a credible plan to achieve it - will not be enough. To do our share Australia should aim to cut its emissions by 75% below 2005 levels by 2030 (Climate Council 2021).

At a minimum, we should be matching our allies by committing to at least halving our emissions by 2030. Ultimately, with the window for action closing fast, doing what it takes to protect our ocean wonders is also key to avoiding catastrophic global warming.

2 HOW DOES CLIMATE CHANGE IMPACT OCEANS?

Climate change is not just an atmospheric phenomenon, it profoundly affects the world's oceans – which cover more than 70 percent of the global surface and significantly influence Earth's weather and climate. In a very real sense, climate change is ocean change. Around 25 percent of carbon emissions since the 1980s have ended up in the ocean, changing ocean conditions. As a result, the ocean is now 30 percent more acidic, and contains less oxygen (IPCC 2019).

The vast majority of excess heat in the Earth's climate system from greenhouse gas emissions – around 93 percent – has been absorbed by the oceans (IPCC 2019). Over the past year, the excess heat absorbed by the ocean was equivalent to the energy of seven Hiroshima atomic bombs detonating every second (Cheng et al. 2022; Abraham 2022). Since the early 1990s the rate of ocean warming has more than doubled (IPCC 2019).

These observed changes are only the beginning. Over the 21st Century, the world's oceans are expected to transition to unprecedented conditions, with increasing temperatures, rising sea levels, further acidification and oxygen decline. As the ocean changes, it also feeds back into the climate system, with significant impacts for life on land as well. For example, more powerful cyclones are supercharged by more heat drawn from warming water, and more destructive storm surges will impact our populous and asset-rich coastlines as they ride on even higher seas.

The ocean absorbs most of the Earth's excess heat from greenhouse gas emissions. Over the past year this was equivalent to seven Hiroshima atomic bombs detonating every second.

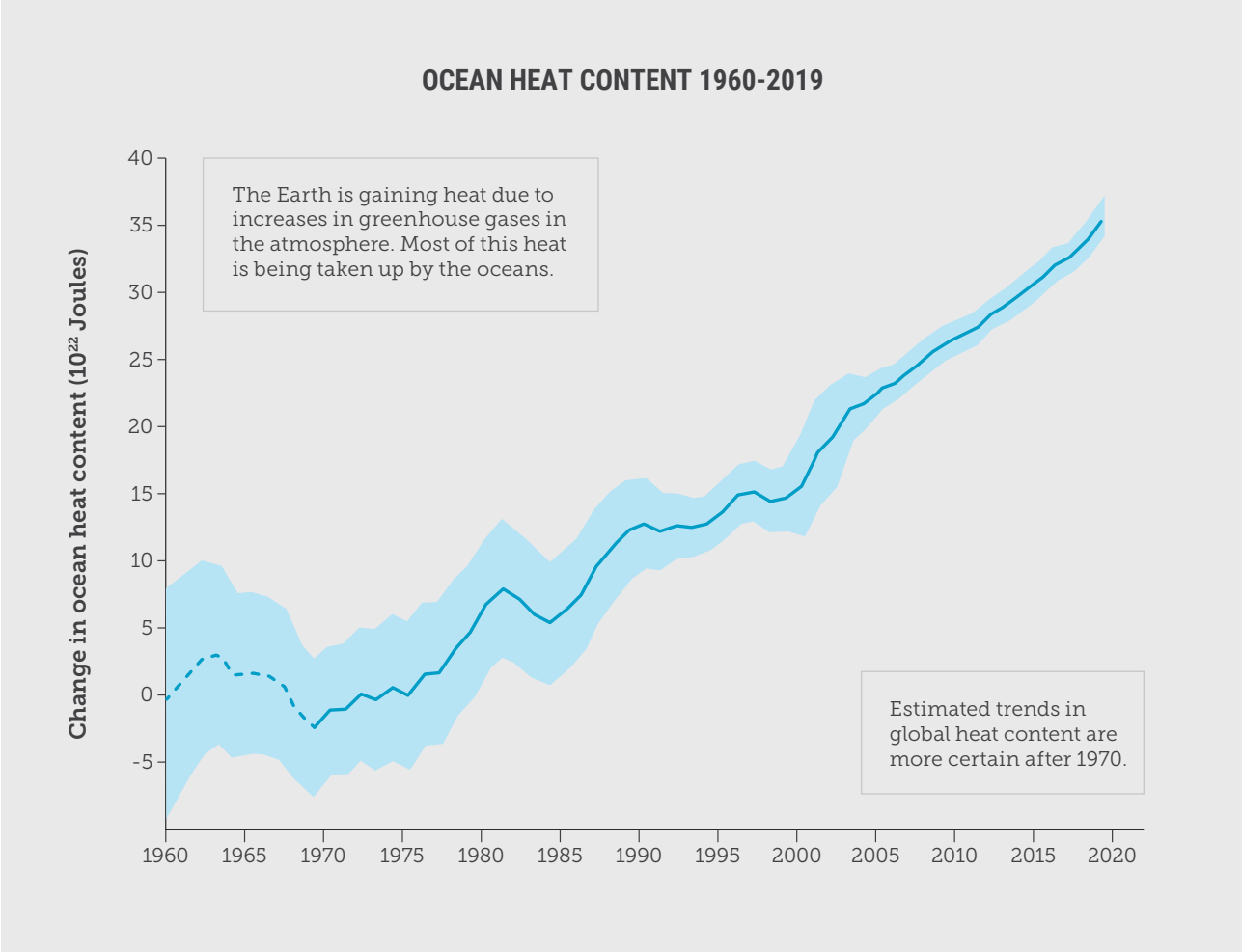


Figure 1: Estimated change in ocean heat content over the full ocean depth, from 1960 to 2019. Shading provides an indication of the confidence range of the estimates. The measurements contributing to the early part of the record, before 1970, are sparse and trends estimated over this period are small compared to the confidence range and hence are considered. Adapted from BoM (2020), data from UK's National Oceanography Centre, CSIRO, IMAS/University of Tasmania.

This summer, waters offshore from some of our major cities have been warm. Too warm. In the waters around Sydney, ocean temperatures in January were some of the warmest on record - 3°C above average (ABC 2022). Ocean temperatures were above average off the coast of Victoria as well. In Queensland, waters around the Great Barrier Reef are experiencing higher than average temperatures. This is part of a worrying long-term trend. Climate change is heating the world's oceans at an alarming rate, and 2021 was the warmest year on record for ocean heat content (Cheng et al. 2022).

In many respects, the oceans are the best indicator we have of our warming planet. While we see annual variations in atmospheric temperature, linked with climate cycles like the El Niño Southern Oscillation, the warming trend in the world's oceans points toward a year-on-year temperature increase. Since the mid 1990s, the rate of warming of the world's oceans has more than doubled (IPCC 2019).

2.1 MARINE HEATWAVES

Warming of the world's oceans - driven primarily by the burning of fossil fuels – interacts with regular climate cycles and regional factors like ocean currents and prevailing winds. This is driving an increase in the incidence and severity of marine heatwaves like the ones we have seen off the coast of southeast Australia this summer. Around the world, the incidence of marine heatwaves has doubled since the early 1980s, and they have become longer-lasting, more intense, and more extensive (IPCC 2019).

Marine heatwaves can be devastating for ocean ecosystems, including coral reefs, kelp forests and seagrass, and for coastal fisheries and aquaculture industries (Oliver et al. 2017; BoM 2018). As our understanding of them improves, marine heatwaves are 'emerging as pivotal in shaping ecosystems, by driving sudden and dramatic shifts in ecological structure and functioning' (Smale et al. 2019).

BOX 1: WHAT IS A MARINE HEATWAVE?

A marine heatwave is similar to a heatwave on land. It refers to a prolonged period of anomalously warm water in a particular location. Marine heatwaves are categorised as moderate, strong, severe or extreme. They can last much longer than heatwaves on land, sometimes lasting many months (Hobday et al. 2016).

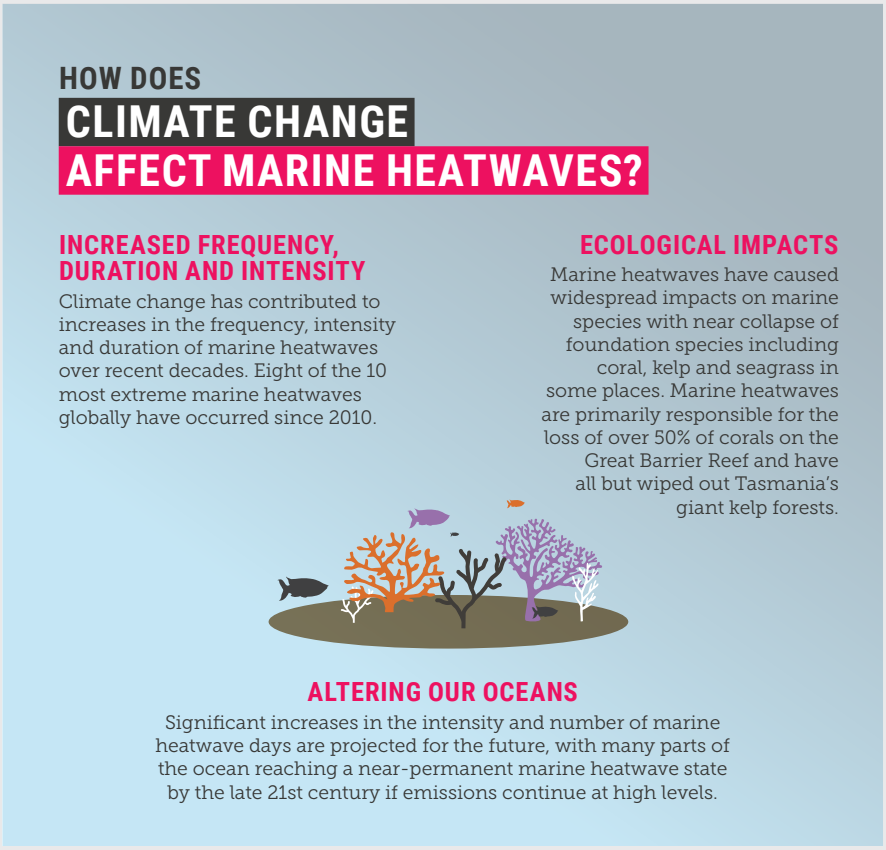


Figure 2: Climate change is making heatwaves more frequent and intense.
Source: (Climate Council 2022).

2.2 MASS BLEACHING AND CORAL REEFS

As the ocean warms and marine heatwaves become more common, prospects for the world's coral reefs are increasingly dire. These immensely important ecosystems are especially vulnerable to increasing water temperatures, which can lead to mass bleaching and widespread coral mortality.

Elevated ocean temperatures disrupt the critically important symbiotic relationship between corals and single-celled algae called *zooxanthellae*. During marine heatwaves, corals develop a stress response which involves expelling these organisms, which in turn leads to coral bleaching (BoM 2020). Without *zooxanthellae* most corals struggle to survive. While some corals recover after bleaching, mortality occurs if warm conditions persist or are too severe.

In recent decades, as marine heatwaves become more common around the world, mass bleaching events have become more frequent and severe. Australia's Great Barrier Reef has been affected by three mass bleaching events in the past decade – in 2016, 2017 and 2020. The 2016 event was the worst coral bleaching on record, affecting more than 90 percent of the reef (Hughes at al. 2018). Nearly 30 percent of corals on the reef died as a result (Climate Council 2018). The 2016 event was at least 175 times more likely to occur due to climate change (King et al. 2016). Taken together, the 2016 and 2017 marine heatwaves saw the loss of 50 percent of corals across the Great Barrier Reef (IPCC 2019).

Nearly 30 percent of corals on the Great Barrier Reef died as a result of mass bleaching in 2016. The event was at least 175 times more likely to occur due to climate change.

Image 2: As the ocean warms, coral reefs face repeated bleaching events.

After a bleaching event, coral needs time to recover. Even fast-growing corals take at least a decade to develop and if bleaching reoccurs during this period, it will set back or prevent recovery (Hughes et al. 2018a). Unfortunately, the time period between events has shrunk in recent decades. The average return period for coral bleaching has decreased from 27 years in the 1980s to only 5.9 years now (Hughes et al 2018). This means that there is a low probability that coral reefs will ever fully return to their pre-bleaching state (Climate Council 2018).

The only chance for the survival of at least some coral reefs is limiting global warming to no more than 1.5°C above the long-term average (Schleussner et al. 2016). However, a global average temperature rise of 1.5°C would be insufficient to prevent more frequent mass bleaching events (IPCC 2022a) and would still see the majority (70-90%) of tropical reefs disappear (IPCC 2018). Multiple lines of evidence suggest that the world is now likely to reach 1.5°C of warming in the early 2030s (Climate Council 2021). According to the IPCC, under a very low greenhouse gas emissions scenario, warming could be limited to 1.5°C by the end of the century with only a small and temporary overshoot (IPCC 2021).

BOX 2: WHY ARE CORAL REEFS IMPORTANT?

Coral reefs are among the most biologically diverse and valuable ecosystems on Earth (e.g. IUCN 2021). While they cover less than 0.1% of the ocean floor, more than a quarter of all marine life - including over 4,000 species of fish - are dependent on coral reefs at some point in their life cycle (EPA 2022). Coral reefs provide daily needs for more than 500 million people and are particularly important for communities on small islands. Reef systems also provide coastal protection and billions of dollars in income from tourism and fisheries. Australia is home to some of the world's most significant tropical reefs. The Great Barrier Reef is the single largest marine structure on Earth and one of the world's seven natural wonders. It also contributes around $6.4 billion per year to the Australian economy and supports 64,000 jobs (Deloitte Access Economics 2017).

Image 3: Coral reefs are immensely important ecosystems.

Coral reefs directly support more than 500 million people worldwide.

Figure 3: Coral and impacts of coral bleaching.

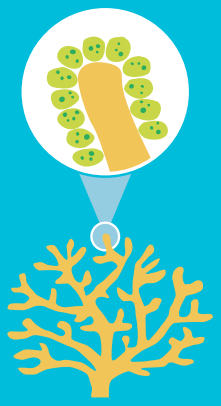
WHAT IS CORAL BLEACHING?

Coral reefs are highly vulnerable to a changing climate. Warmer ocean temperatures and other stressors cause coral bleaching events which can damage and destroy coral reefs and the ecosystems they support.

1 HEALTHY CORAL

Coral and algae depend on each other to survive.

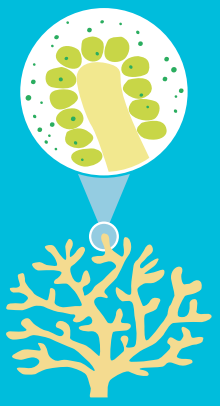
Corals have a symbiotic relationship with microscopic algae called zooxanthellae that live in their tissues. These algae provide their host coral with food and give them their colour.



2 STRESSED CORAL

If stressed, algae leave the coral.

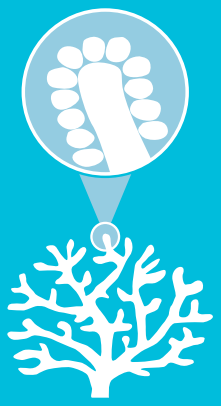
When the symbiotic relationship becomes stressed due to increased ocean temperature or pollution, the algae leave the coral's tissue.



3 BLEACHED CORAL

Coral is left bleached and vulnerable.

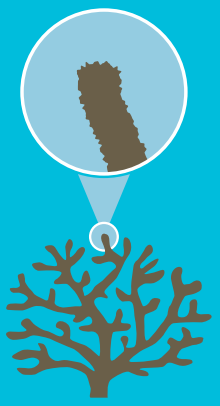
Without the algae, the coral loses its major source of food, turns white or very pale, and is more susceptible to disease.



4 DEAD CORAL

Coral is left bleached and vulnerable.

Without enough plant cells to provide the coral with the food it needs, the coral soon starves or becomes diseased. Soon afterwards, the tissues of the coral disappear and the exposed skeleton gets covered with algae.



CHANGE IN OCEAN TEMPERATURE

Increased ocean temperature caused by climate change is the leading cause of coral bleaching. Water temperature higher than the average summer maximum – just 1°C higher for four weeks can cause bleaching.

RUNOFF AND POLLUTION

Storm generated precipitation can rapidly dilute ocean water and runoff can carry pollutants - these can bleach near shore corals.

OVEREXPOSURE TO SUNLIGHT

When temperatures are high, high solar irradiance contributes to bleaching in shallow-water corals.

EXTREME LOW TIDES

Exposure to air during extreme low tides can cause bleaching in shallow corals.

Sources: Adapted from NOAA 2015; Underwater Earth 2015.

2.3 THE GREAT BARRIER REEF

Prospects for Australia's reefs are dire, including for the Great Barrier Reef. By 2034, the extreme ocean temperatures that led to the recent bleaching events on the Great Barrier Reef could be occurring every two years (CoECSS 2016). Under a high emissions scenario, bleaching conditions could be occurring each year as soon as 2044 (IPCC 2022, Heron et al. 2018). These conditions would effectively destroy the Great Barrier Reef, and most shallow water tropical reefs worldwide.

This summer, low-to-moderate bleaching has been observed in parts of the Great Barrier Reef. At the time of publication of this briefing, surveys and monitoring for more substantial bleaching were underway. In December, sea surface temperatures were up to 1.5°C warmer than average across much of the Great Barrier Reef (GBRMPA 2022). In early January, modelling from both the Bureau of Meteorology and the National Oceanic and Atmospheric Administration (NOAA) pointed to a build-up of heat stress with the potential for mass bleaching.

Thankfully, extensive cloud cover and heavy rainfall in January and early-February brought milder conditions (GBRMPA 2022a). However a severe to extreme heatwave across north Queensland in early March reignited concern. Waters offshore from Townsville were up to 3°C above average and low-to-moderate coral bleaching was recorded across multiple areas of the Great Barrier Reef (GBRMPA 2022b).

The United Nations Educational, Scientific and Cultural Organisation (UNESCO) has recommended the Great Barrier Reef be placed on a list of World Heritage sites that are 'in danger', noting that the condition of the Reef had deteriorated as a result of recent mass bleaching events (UNESCO 2021). In March 2022, a monitoring mission for UNESCO will visit Australia to consider the reef's current condition and will report to a 21-country World Heritage Committee meeting in June. The committee will consider inscribing the Reef on the list of World Heritage sites 'in danger'.

The Great Barrier Reef and other tropical reefs could bleach every year by 2044 under a high emissions scenario.

2.4 AROUND AUSTRALIA

As the world's oceans warm, coastal ecosystems and marine species are being heavily impacted. In our region, the ocean is warming fastest around southeastern Australia and Tasmania. The East Australian Current - which featured in the popular children's movie 'Finding Nemo' - now extends further south, creating an area of rapid warming in the Tasman Sea. The ocean off southeastern Australia is a global warming hotspot (Hobday et al. 2014). In this area the near surface waters are warming at nearly four times the global average (Ridgway et al. 2007; Oliver et al. 2017, ABC 2020).

Warming waters lead to changes in species distribution, a decline in biodiversity and the collapse of key species (IPCC 2022). This also means a decline in economic values of fisheries, aquaculture and the tourism industry. In Australian waters, many marine species are shifting their geographical range – moving southward as southern waters become warmer. The range for seagrass meadows and kelp forests, for example, is shifting southward. For some species there is nowhere to go. More than 90 percent of Tasmania's giant kelp forests have already vanished (Butler et al. 2020). We are also seeing increasing tropicalisation of temperate reefs on Australia's east and west coasts, as warm water species replace cooler-water species.

La Niña conditions can also cause marine heatwaves off the Western Australian coast (BoM 2021). The last significant La Niña event was in 2010-2012, and it strengthened tropical ocean currents offshore from Western Australia. In turn, record water temperatures - up to 5°C above average in places - had dramatic impacts across 1,000km of WA's coast including: coral bleaching on Ningaloo Reef; a dieback of seagrass in the Shark Bay World Heritage Area; and losses of spawning stocks of abalone, prawns and rock lobsters. There was also widespread and lasting damage to temperate kelp forests, which contracted 100km southward (Bennett et al. 2016). In December 2021 scientists raised the alarm that La Niña conditions could bring another severe marine heatwave along the WA coast (ABC 2021). So far this summer, Western Australia has avoided that outcome, but concerns remain.

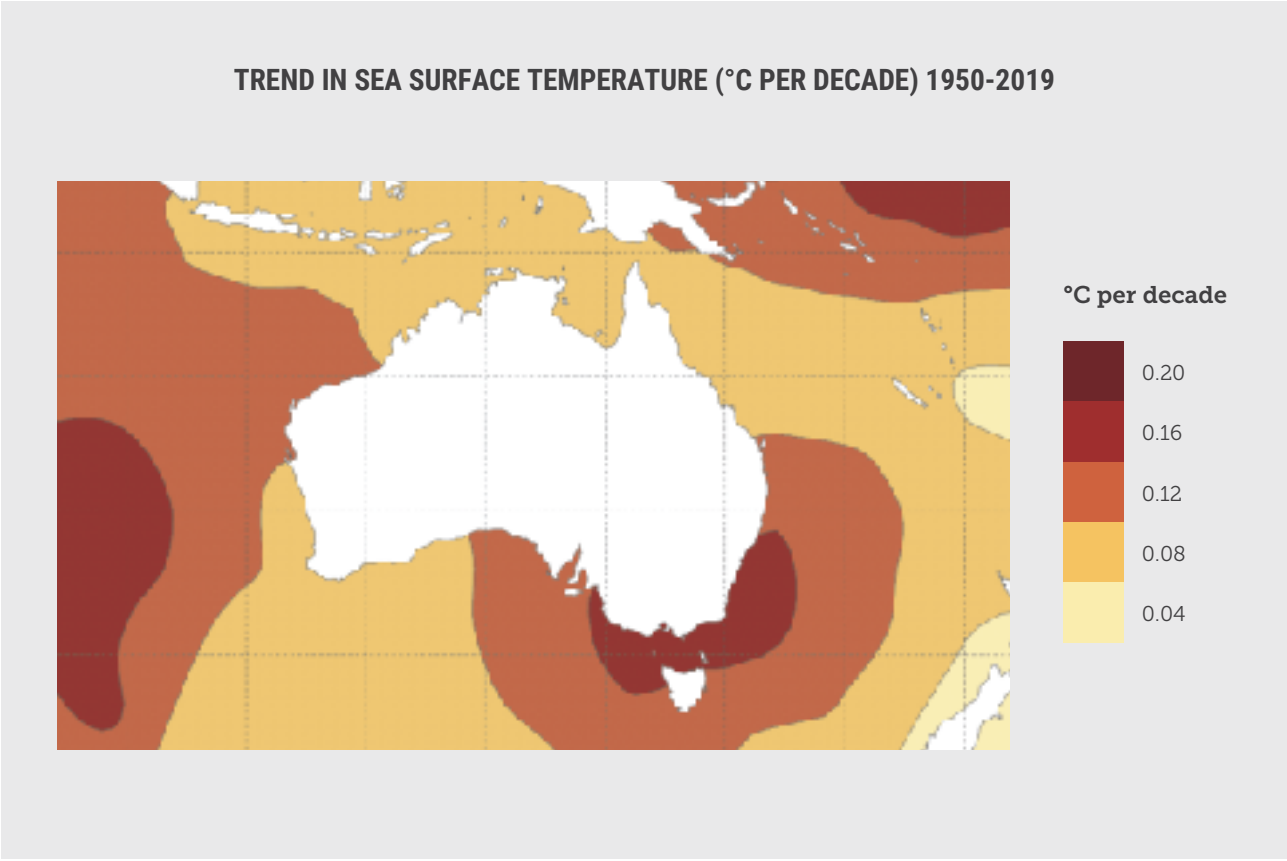
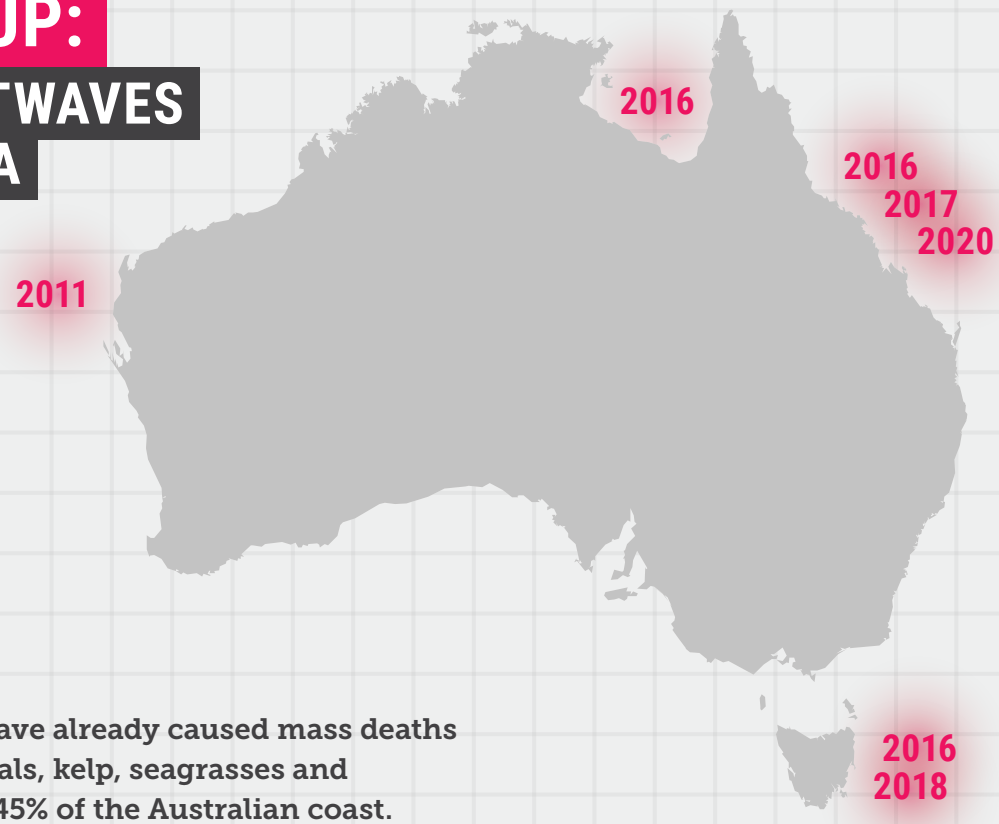


Figure 4: Trends in sea surface temperatures in the Australian region (4–46° S and 94–174° E) from 1950 to 2019, adapted from BoM (2020).

The ocean off southeastern Australia is a global warming hotspot, greatly affecting unique ecosystems, such as Tasmania's giant kelp forests, which are being decimated.

Figure 5: Marine heatwaves have had dramatic impacts around the Australian coastline over the past decade.

HOTTING UP:
MARINE HEATWAVES IN AUSTRALIA



Marine heatwaves have already caused mass deaths of key habitats – corals, kelp, seagrasses and mangroves – along 45% of the Australian coast.

2011
Marine heatwave, Western Australia
Kelp loss, seagrass dieback, bleaching of the Ningaloo Reef, tropicalisation of temperate reefs, abalone dieback, fishery closures

2016
Marine heatwave, Tasman Sea
Loss of giant kelp, compromised salmon fisheries, oyster mortality

2016
Marine heatwave, Great Barrier Reef
Unprecedented mass coral bleaching – 90% of reef impacted

2016
Marine heatwave, Gulf of Carpentaria
Unprecedented mangrove dieback

2017
Marine heatwave, Great Barrier Reef
Mass coral bleaching

2018
Marine heatwave, Tasman Sea
Loss of giant kelp, compromised salmon fisheries

2020
Marine heatwave, Great Barrier Reef
Mass coral bleaching

2022
Marine heatwave, Great Barrier Reef
Reef on watch for severe bleaching

3 THE FUTURE

Extreme events, such as marine heatwaves, are very likely to become more severe and destructive over the next two decades because past greenhouse gas emissions have "locked in" significant levels of climate change. Over the 21st Century the ocean will continue to warm, and is expected to transition to 'unprecedented conditions', with widespread consequences for coastal ecosystems and marine species (IPCC 2019). The full extent of change depends on efforts now to reduce emissions. Under a high emissions scenario, the ocean is projected to absorb between five and seven times more heat by the end of this century. Over the same period, extreme El Niño events – like the one that led to unprecedented bleaching on the Great Barrier Reef in 2016 – are projected to occur about twice as often. In such a high emissions scenario, marine heatwaves are projected to become 50 times more frequent (IPCC 2019). By the late 21st Century, many parts of the ocean could reach a near-permanent marine heatwave state (Oliver et al. 2019).

As the ocean continues to warm and marine heatwaves occur more frequently, ocean species will continue to shift their distribution and in many cases will decline in numbers. Some continued damage is now unavoidable. Around the world, almost all warm-water reefs are projected to suffer significant loss of area and local extinctions (IPCC 2019). Bleaching will continue for the Great Barrier Reef. Under high emission scenarios, bleaching conditions are projected to be an annual occurrence from 2044 (IPCC 2022, Heron et al. 2018). The decline of other ecosystems, like Australia's temperate kelp forests, is also projected to continue.

Taking action now to reduce emissions is key to the survival of Australia's valuable ocean wonders. To keep global warming as close as possible to 1.5°C, the world needs to halve emissions by 2030 (IPCC 2021, UNEP 2021). To do our share Australia should, at a minimum, be planning to cut emissions by at least 50 percent below 2005 levels by 2030. This would bring Australia into line with key allies that have committed to halving emissions by 2030 - including the European Union, the United States and the United Kingdom. As a wealthy nation with abundant renewable energy resources, Australia should aim higher, and implement national policy to reduce emissions by 75 percent this decade. As a custodian of some of the natural marine wonders of the world, Australia has a responsibility to protect unique ecosystems such as coral reefs, mangroves and seagrass, which underpin the vitality of our natural heritage and the Australian coastal way of life.

Taking action now to reduce emissions is key to the survival of Australia's valuable ocean wonders.

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IMAGE CREDITS

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Page 3, Image 1: The last significant kelp forest on the east coast of Tasmania, Munro Bight, 2012. Credit: Mick Baron.

Page 8, Image 2: 'Lizard Island, GBR, May 2016' by The Ocean Agency/XL Catlin Seaview Survey.

Page 9, Image 3: Healthy coral reef. Credit: Klaus Stiefel.

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

The Climate Council acknowledges the Traditional Custodians of the lands on which we live, meet and work. We wish to pay our respects to Elders past, present and emerging and recognise the continuous connection of Aboriginal and Torres Strait Islander peoples to Country.

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