CLIMATE COUNCIL

CODE BLUE: OUR OCEANS IN CRISIS

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Key findings

1 The health of the planet's oceans, and human survival, are intrinsically linked.

› The ocean and the atmosphere form a coupled system that shapes the Earth's climate. This global dance between the ocean and the atmosphere underpins life as we know it.

› All life on Earth depends on the water cycle that starts in the ocean. Humans also need the ocean in other fundamental ways. More than half the oxygen we breathe comes from the ocean.

› Climate change - driven by the burning of coal, oil and gas - is rapidly transforming our oceans. In a very real sense, the climate crisis is an oceans crisis.

› A warmer ocean can drive serious impacts thousands of kilometres away on land, like fuelling the conditions that sparked Australia's Black Summer, or generating monstrous cyclones that decimate coasts and cities.

› The ocean connects all communities around the planet. It is a key part of our life support system. For many it is also core to our identity and culture.

2 The world's oceans are absorbing mind-boggling amounts of excess heat resulting from human-induced global warming.

› The ocean has absorbed 93 percent of the excess heat trapped by greenhouse gas emissions.

› The rate of ocean warming has more than doubled since the mid 1990s.

› Today the ocean is absorbing excess heat energy equivalent to five Hiroshima bomb explosions every second, or enough to boil Sydney Harbour every eight minutes.

› By absorbing so much heat, the ocean has lulled us into a false sense of security, masking the true extent of human interference in the climate system. It is now beginning to buckle, with serious consequences.

› The oceans are also absorbing more than 30 percent of the extra carbon dioxide emitted from human activities, slowing its build-up in the atmosphere. However, as emissions rise, the ocean will become less effective as a carbon sink.

3 Abrupt and concerning changes to the ocean are now starting to outpace scientific predictions. Experts are deeply worried.

› In a survey of 30 ocean and climate scientists around the world, more than half said ocean changes are occurring faster than models projected.

› Almost two-third (60 percent) said ocean surface temperature changes are happening faster than expected and more than half (53 percent) said loss of Antarctic sea ice is happening faster than expected.

› Every scientist surveyed expressed extreme or very high levels of concern about the impact climate change is having on the world's oceans.

4 Marine heatwaves are becoming more severe and frequent, with devastating consequences for iconic coral reefs, kelp forests and other marine ecosystems.

› The incidence of marine heatwaves has doubled since the 1980s.

› Marine heatwaves have already caused mass deaths of key species along 45 percent of Australia's coastline. Australia's giant kelp forests have declined by more than 90 percent due to ocean warming.

- Parts of the ocean could reach a near permanent heatwave state by the end of this century, unless urgent action is taken to reduce fossil fuel emissions.
- The Great Barrier Reef has suffered mass bleaching four times since 2016 and faces a very difficult period ahead as an El Niño, against the backdrop of ocean warming, drives extreme heat conditions.

5 Coastal communities across Australia and the Pacific are all threatened by warming oceans and ocean acidification, from robbing us of our big ocean playground, to decimating entire communities.

- Global sea levels have risen 20cm since the start of the 20th century, with the rate of rise accelerating.
- Australia's iconic beaches and sandy shorelines are projected to retreat by around 100m by the end of the century.
- Low-lying Pacific atoll nations face threats to habitability and food security from sea level rise.
- The rate of sea level rise will continue to accelerate. Through stronger action to reduce emissions this decade, we can still limit the rate and extent of sea level rise over the long term, saving many communities and species from forced displacement.
- As the oceans absorb more carbon dioxide, they become more acidic. This makes it more difficult for organisms like corals, mussels and oysters to form shells or skeletons. Ocean acidification is already reducing the size of Sydney rock oysters.
- Sea level rise and changing wind and swell patterns threaten to undermine treasured surf spots around the country, disrupting one of Australia's most iconic pastimes.

6 Urgent action is needed to protect our oceans and limit warming, starting with rapidly phasing out coal, oil and gas.

- Rapidly phasing out fossil fuels is critical to limit further ocean warming and acidification.
- To play our part in limiting warming as close to 1.5°C as possible, and avoiding catastrophic tipping points for our ocean, Australia must aim to reduce emissions by 75 percent below 2005 levels by 2030, and reach net zero by 2035.
- Reform of Australia's flawed environmental laws – to fully account for the climate impacts of new projects – is urgently required to put an end to new fossil fuel developments. Climate change impacts must be considered when assessing any new development.
- Our oceans also harbour many climate solutions. Mangroves and coastal wetlands absorb carbon at a rate two to four times greater than mature tropical forests. They potect coastlines from erosion and coastal communities from storm surges.
- Expanding marine protected areas and restoring blue carbon ecosystems will be vital to give our oceans and all the life that inhabits them a fighting chance.
- More support is urgently needed for communities adapting to ocean changes. First Nations stewardship and leadership must be supported and resourced.

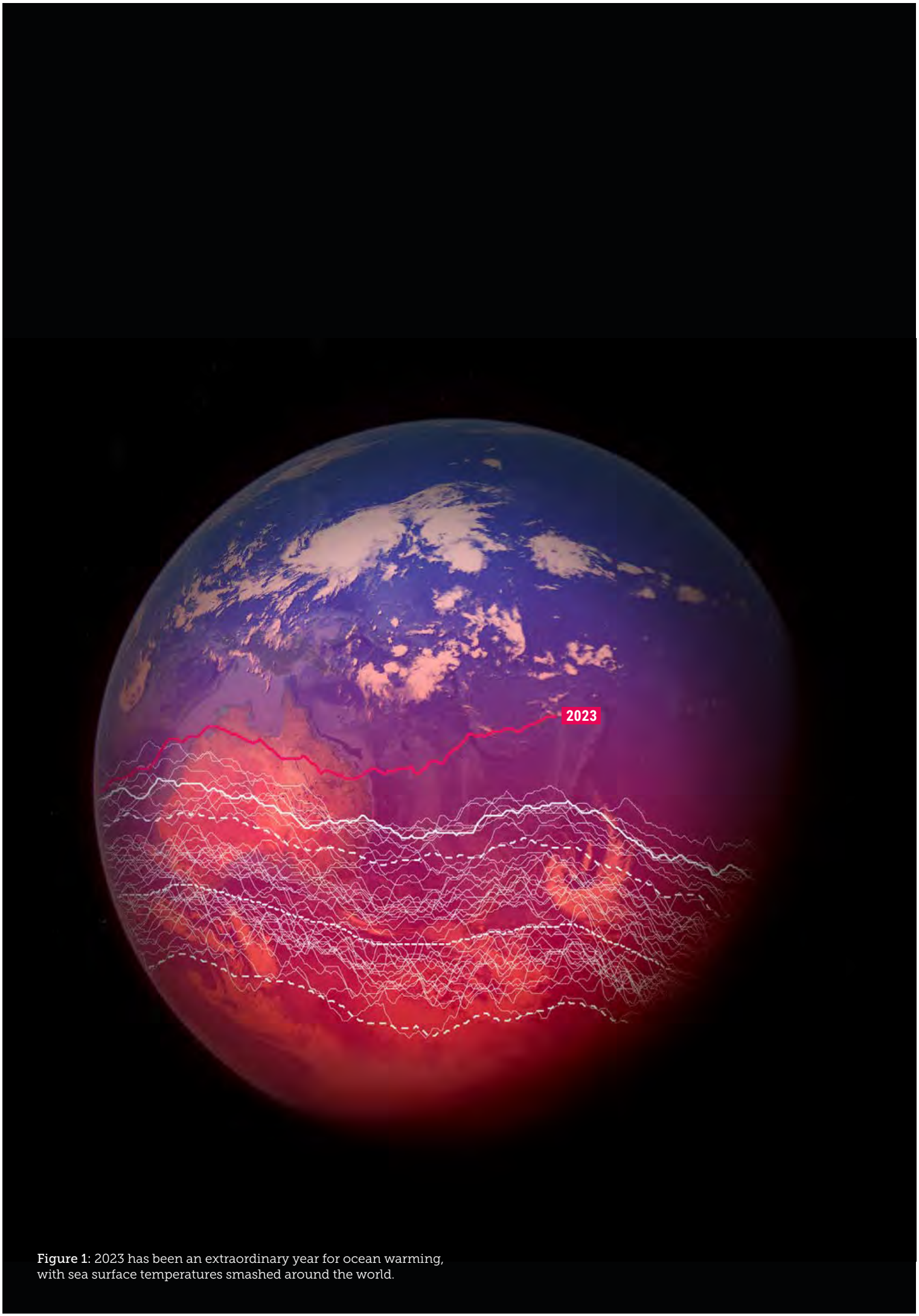


Figure 1: 2023 has been an extraordinary year for ocean warming, with sea surface temperatures smashed around the world.

1. Introduction

In Australia, our love of the ocean is truly profound - most of us live near the coast, we surf it, camp by it, we marvel at its incredible beauty from its many pristine sandy shores and we are proud of the unique and wondrous sea life that inhabits it.

Our oceans are in trouble. As our climate changes, driven by the unchecked burning of fossil fuels, our seas are transforming before our eyes. Marine heatwaves are surging, coral reefs are on the brink, ice sheets are melting at an alarming rate, currents are slowing and seas are rising. Put simply: the climate crisis is an ocean crisis.

The ocean is the beating heart of planet Earth, and the lifeblood for all humanity. It produces over half the oxygen we breathe. Its currents regulate our climate and weather. The marine life within it provides sustenance for billions. Our cultures, economies and very identity are tied to the sea.

We have pushed this wondrous, life-giving system to the brink by burning coal, oil and gas. More than 90 percent of the heat trapped by greenhouse gas emissions has been absorbed by the ocean. Parts of the ocean could reach a near-permanent heatwave state within decades.

Our iconic Great Barrier Reef may soon face annual mass coral bleaching. Entire island nations like Tuvalu and Kiribati could become uninhabitable this century as seas rise.

The ocean is a vital carbon sink, absorbing more than 30 percent of the carbon dioxide that humans emit by burning fossil fuels and clearing land. This has changed the chemical make-up of the entire ocean, making it more acidic.

By absorbing excess heat, and carbon, the ocean has shielded us from the worst of climate change so far. But we are now seeing the consequences of its sacrifice. The climate crisis is no longer a far-off threat. The ocean is screaming a warning that cannot be ignored.

We must heed the call and act with urgency. We must show a commitment to protecting our precious ocean and all the life that depends on it, starting with the urgent phase out of coal, oil and gas, restoring damaged ecosystems, expanding marine sanctuaries and supporting Indigenous stewardship. The solutions are clear. What is needed is for governments to understand and act with the urgency that is required to meet this mighty challenge.

To play our part in the world's efforts to limit global warming to 1.5°C – beyond which our ocean and all humanity face enormous dangers – Australia must aim to reduce its emissions by 75 percent below 2005 levels by 2030 and reach net zero by 2035 (Climate Council 2023b). This must be accompanied by a plan to rapidly phase out fossil fuel production and export, and the urgent reform of our national environment law to prevent the reckless approval of new coal and gas developments (Climate Council 2023c).

The era of climate consequences is here. The fate of the ocean is our fate. We still have a chance to change course, but the window for action is closing fast. Every action we take now is important, and every fraction of a degree of warming we can avoid will be pain and suffering averted. For the sake of all we hold dear, we must seize this decisive decade to do everything in our power to protect our oceans, which in turn, will then continue to protect us.

Figure 2: All life on Earth depends in some way upon a healthy ocean. Together, the ocean and atmosphere shape our climate, affecting weather conditions worldwide. The ocean produces more than half of our oxygen. It connects communities around the planet, and for many it is core to our identity and culture.

Figure 3: For Australians, the ocean is core to our identity and culture. Most of us live near the coast. We surf on the ocean, camp by it, fish, and marvel at its beauty.

2. Ocean scientists sound the alarm

While the impacts of climate change on our planet's ocean are tremendous, they remain largely hidden to most of the public. Scientists, meanwhile, are extremely worried.

To gain a deeper understanding of the situation, the Climate Council ran a highly targeted online survey for ocean and climate scientists between the 27 September and 10 October, 2023.

The survey attracted 30 responses from scientists in five regions: Australia, the USA, the UK, New Zealand and the Pacific. Of these, 70% were ocean scientists, 10% were climate scientists and the remaining straddled both disciplines or were fisheries or ecology experts.

Many of these experts were from leading academic institutions, including Princeton University, CSIRO, the Bureau of Meteorology, University of Queensland, Macquarie University, University of Tasmania, University of Exeter, James Cook University and more. You will find comments and insights from those who took the survey throughout this report.

More than half the scientists surveyed (53%) said changes to the world's oceans driven by climate change are occurring faster than models have projected.

> *"We are seeing huge changes about which we have little information or understanding. Once these changes have begun, it will take thousands of years to reverse them. Without appreciating this as a case of 'fierce urgency'', we will not be able to turn the climate around and avoid catastrophic outcomes for most of humanity and the ecosystems on the planet."*
>
> - Professor Ove Hoegh-Guldberg, University of Queensland (from the Climate Council ocean scientists survey, 2023).

When it comes to particular observations:

- **60%** said changes to ocean surface temperature are happening faster than projected.
- **53%** said loss of ice in Antarctica is happening faster than projected.
- **26%** said changes to ocean currents are happening faster than projected.

The vast majority (89%) said climate change was the number one threat to the world's oceans. The remaining scientists named overfishing as the greatest threat.

Perhaps the most striking result of this survey was that every scientist who took it (100%) indicated they were either 'extremely' (83%) or 'very' (17%) concerned about the impact climate change is having on the world's oceans.

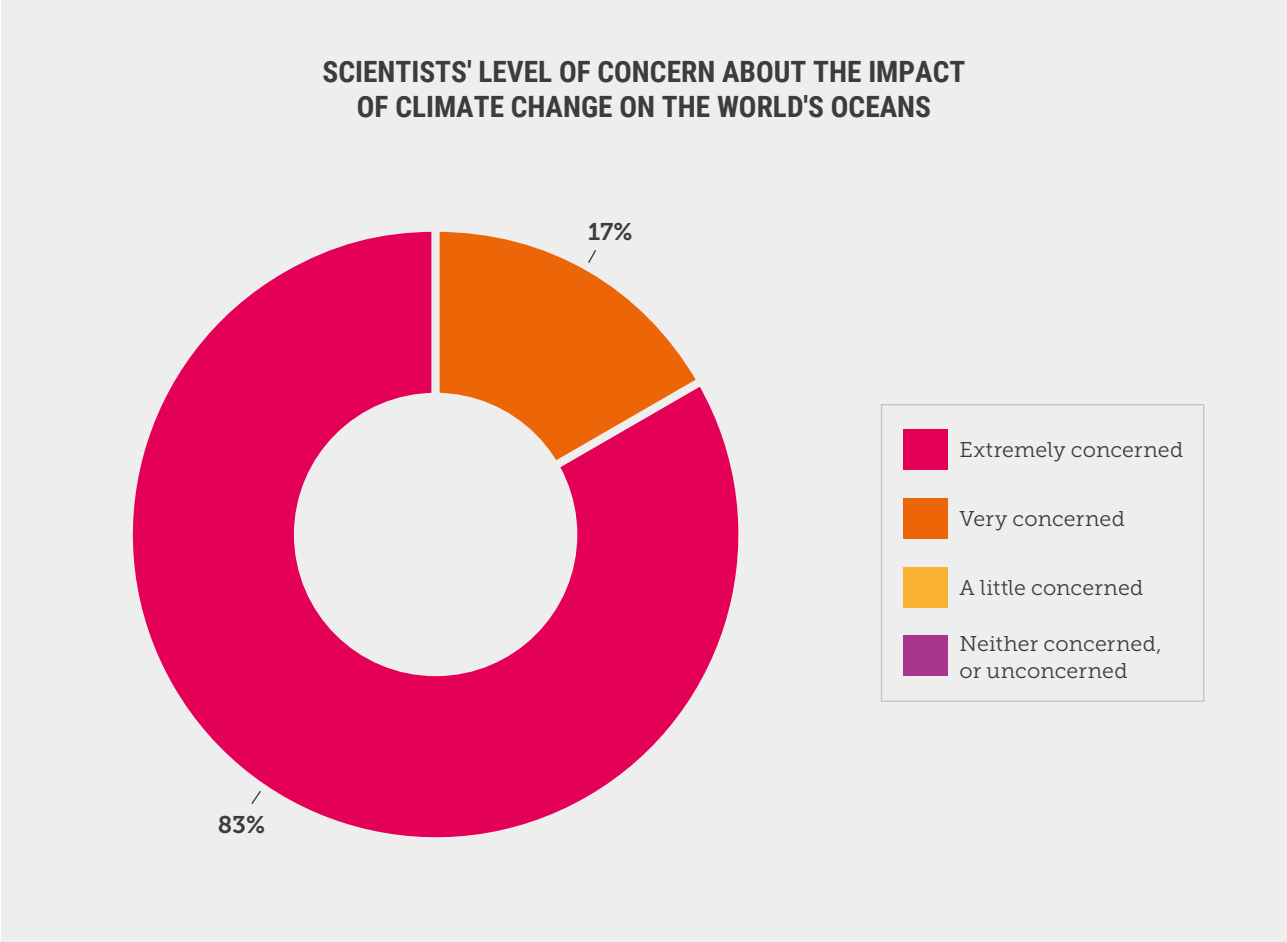


Figure 4: The majority of ocean and climate scientists are extremely concerned about the impact of climate change on our ocean.

When asked about their level of concern for specific observations, they responded:

- **94%** are concerned about ocean *surface temperature anomalies* (67% 'extremely' and 27% 'very' with the remainder choosing 'outside my area'. No survey takers said they were not concerned).
- **97%** are concerned about *declines in Antarctic sea ice* (67% 'extremely' and 30% 'very', with the remainder choosing 'outside my area').
- **90%** are concerned about the *slowdown in Antarctic overturning circulation* (50% 'extremely' and 27% 'very', 13% 'a little' and 10% 'outside my area'). No scientist in this poll stated they were not concerned at all.
- **83%** are concerned about the outlook for the *Atlantic Meridional Overturning Circulation*[1] (37% 'extremely', 33% 'very', and 13% 'a little' and 13% 'outside my area'). A small number (3%) chose 'neither concerned nor unconcerned'.

Scientists ranked **'rapidly phasing out fossil fuels'** as the single most important action governments could take to address ocean warming.

WHAT ARE THE MOST IMPORTANT MEASURES THAT GOVERNMENTS COULD IMPLEMENT TODAY TO ADDRESS WARMING OCEANS?

1. Rapidly phase out fossil fuels (note 93% of respondents ranked this first).
2. Rehabilitate mangroves, seagrasses, marshes and swamps to increase carbon sinks.
3. Expand or create marine-protected areas.
4. Address overfishing.
5. Invest in carbon capture and storage solutions.
6. Address chemical runoff from farms and factories.
7. Ban plastic.

1 See page 30 for information on the Atlantic Meridional Overturning Circulation.

3. Understanding climate and oceans

PLANET OCEAN

We tend to think of climate change as an atmospheric phenomenon,with an increase of greenhouse gases trapping heat in the Earth's atmosphere and driving global warming. But the ocean is at the heart of the climate change story. This is because the ocean, land and atmosphere together form a joined-up system that distributes water, heat, nutrients and carbon around the Earth. The ocean-atmosphere nexus has shaped the stable climate that human societies have developed in over thousands of years. Today - by burning coal, oil and gas - we are modifying the Earth's atmosphere *and* transforming the ocean: climate change *is* ocean change.

We live on a blue planet. If we were to approach our planet from space, we might well call it 'Ocean' instead of Earth. The ocean covers more than 70 percent of the Earth's surface, and has an average depth of about 3,700 metres. Most people don't often think about the open ocean, beyond the coastal fringe. When they look out to sea they might imagine a blue void beyond the horizon - a vast, empty space that is not owned by anyone, and across which navies and merchant ships (and the occasional adventurous sailor) might roam. But the ocean plays a key role in our everyday life, even if we live nowhere near the sea.

Figure 5: The ocean covers more than 70 percent of the Earth's surface. The ocean, land and atmosphere together form a joined-up system that distributes water, heat, nutrients and carbon around the Earth. (Image source: Google Earth.)

ENGINE OF EARTH'S CLIMATE

The ocean is the engine of the Earth's climate system. It helps to regulate global temperatures and the carbon dioxide concentration in the atmosphere and to distribute freshwater as rain. Most of the solar radiation from the Sun is absorbed by the ocean, especially in tropical waters around the equator. This acts like a massive, heat-retaining solar panel for the whole planet. This heat also causes evaporation, creating rain clouds and storms. Most of the rain that falls on land is formed in the world's tropical oceans. All life on Earth depends on the water cycle that starts in the ocean.

Away from the tropics, weather patterns are influenced by ocean currents that are driven by surface winds, tides, differences in temperatures and salt content, and by the spinning of the Earth. These ocean currents help shift warm water and rain away from the equator toward the poles, and move cold water back toward the tropics. By doing so they help to regulate temperatures in different parts of the world. Without them, large parts of the Earth would be uninhabitable - it would be too hot toward the equator and too cold near the poles.

LUNGS OF OUR PLANET

Human beings need the ocean in other fundamental ways. More than half of all the oxygen we breathe comes from the ocean. Vast clouds of tiny marine plants, called phytoplankton, swirl across the seas. These microorganisms are the fundamental basis of the food chain in the ocean, providing nutrients for other marine life. Like trees and plants on land, they also absorb carbon dioxide and produce oxygen. The smallest species of phytoplankton produce up to 20 percent of all oxygen on Earth - a higher percentage than all the tropical rainforests on land combined (NOAA 2023).

All life on Earth depends on the water cycle that starts in the ocean.

STORER OF CARBON

Phytoplankton also plays a key role in the Earth's carbon cycle, enabling the ocean to act as the world's greatest carbon sink. Carbon is continually being exchanged between the atmosphere and the ocean's surface as part of the Earth's active carbon cycle. Carbon is also transferred from the surface to the deep ocean by a combination of physical and biological processes. As phytoplankton and other microorganisms take up dissolved carbon in the upper layers of the ocean, this carbon is gradually transferred to the deep ocean through the food chain as organic matter sinks to the sea floor. This is known as the ocean's carbon "biological pump". The total amount of carbon in the ocean is 50 times greater than in the atmosphere, and the vast bulk of this carbon is found in the deep ocean.

Much of the carbon in the deep ocean is returned to the surface over hundreds of years through ocean circulation and overturning, but some of it is also stored for much longer periods in seafloor sediments (where, over millions of years it may become fossilised as oil and gas deposits).

Worryingly, as the world's oceans continue to warm they will have decreasing capacity to absorb carbon dioxide, both near the surface and in the deep ocean. This means a greater proportion of carbon emissions will end up in the atmosphere, which will in turn drive higher global temperatures (IPCC 2021a, Section B4).

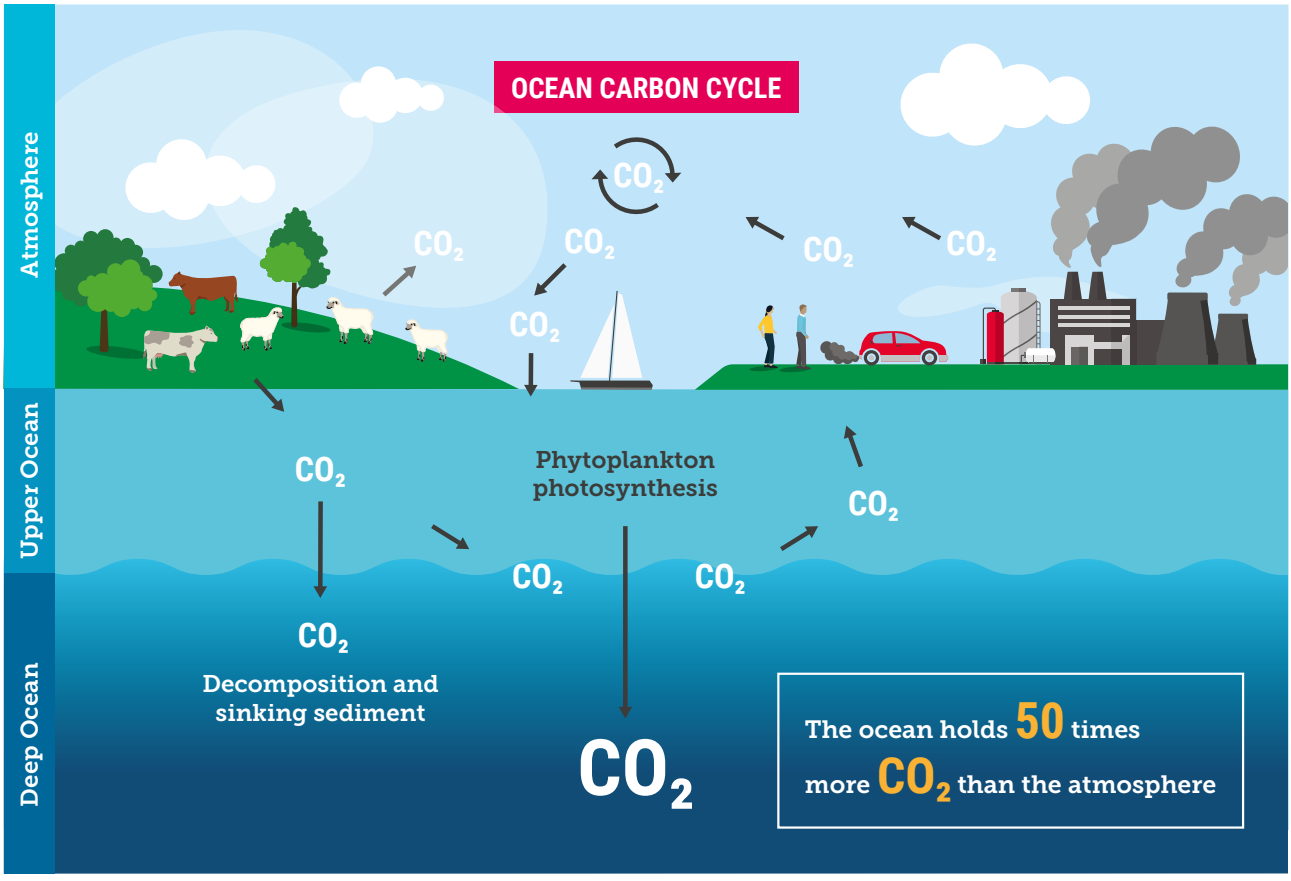


Figure 6: Carbon is continually exchanged between the atmosphere and the upper layer of the ocean as part of the Earth's active carbon cycle. Carbon is also gradually transported from the upper layers of the ocean to the deep ocean by a "biological pump".

BOX 1: THE GREAT OCEAN CONVEYOR BELT

The world's oceans are in constant motion, driven by global currents that act together as a huge 'conveyor belt' to move heat, carbon, oxygen and nutrients around the planet. The motor for this ocean conveyor belt can be found in the cold waters around the Earth's polar regions. These waters are so cold that the ocean freezes, forming sea ice and expelling salt into surrounding waters which causes them to become more dense and sink.

Every year, trillions of tonnes of cold, dense, salty and oxygen-rich and carbon dioxide-rich water falls toward the ocean floor in the North Atlantic, and in the Southern Ocean around Antarctica. As these cold waters sink, warmer surface waters flow in to replace the sinking water, which in turn becomes cold and salty enough to sink. This is the engine that drives a continuous global ocean conveyor belt that links together warm surface currents and cold, salty, deepwater currents.

These currents are critical for regulating the Earth's climate system and play a key role in the ocean's carbon and nutrient cycles. As waters sink around the Earth's polar regions they carry oxygen to the deep ocean. In turn, upwellings of coldwater currents in the Earth's mid-latitudes bring up nutrients from the depths that nourish rich fishing grounds off the west coast of southern Africa, South America and North America.

Taken together, the ocean and the atmosphere form a coupled system that shapes the Earth's climate. It is the global dance between the ocean and the atmosphere that shapes life as we know it.

GREAT OCEAN CONVEYOR BELT

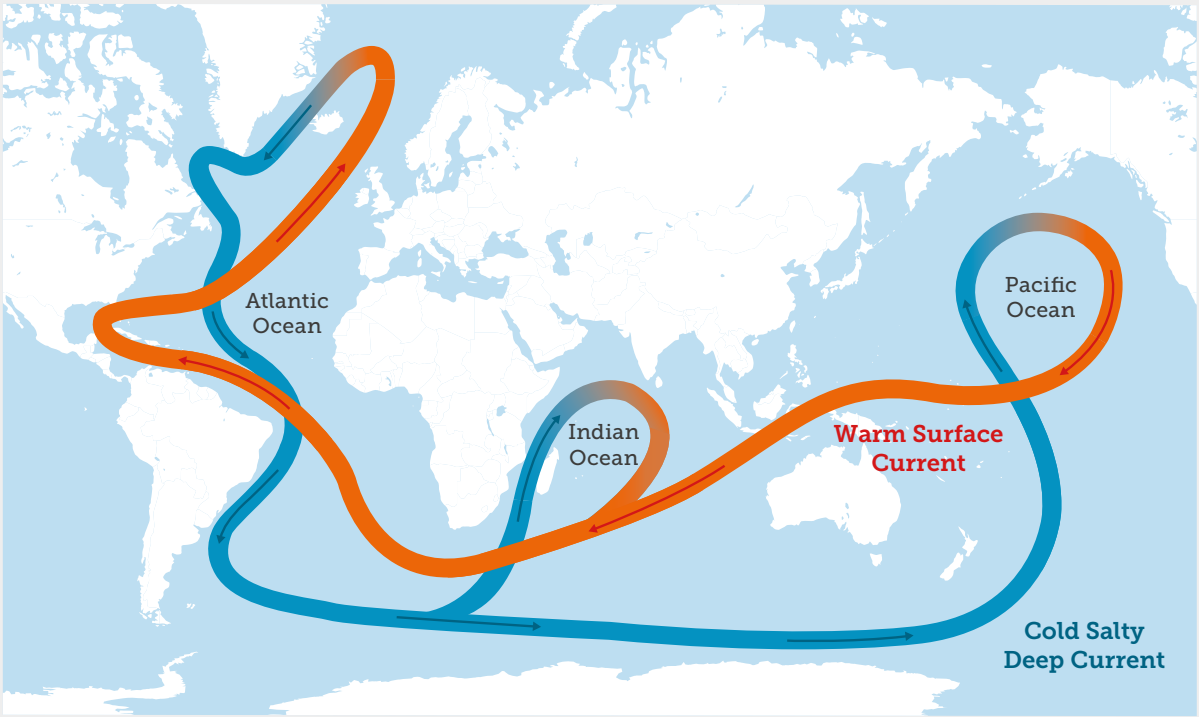


Figure 7: The global ocean conveyor belt - a network of ocean currents - moves heat, carbon, nutrients and oxygen around the planet.

The global dance between the ocean and atmosphere shapes life as we know it.

> *"By absorbing all this heat, the ocean lulls people into a false sense of security that climate change is progressing slowly. But there is a huge payback. It's overwhelming when you start to go through all the negative impacts of a warming ocean. There's sea level rise, coastal inundation, increased floods and drought cycles, bleached corals, intensification of cyclones, ecological impacts, melting of ice at higher latitudes in the coastal margins — that gives us a double whammy on sea level rise. The oceans have stored the problem but it's coming back to bite us."*
>
> - Professor Matthew England, 2023.

Figure 8: We tend to think of climate change as an atmospheric phenomenon, but the ocean is at the heart of the climate change story. By burning coal, oil and gas we are transforming the world's oceans.

4. Our changing ocean: Impacts today and tomorrow

The ocean is at the heart of the Earth's climate system. This means climate change - driven by the burning of coal, oil and gas - is rapidly transforming our oceans as well as our climate. In a very real sense, the climate crisis is an oceans crisis. In this section we explore the observed and projected impacts of greenhouse gas emissions and climate change on our ocean.

GLOBAL BOILING

In July 2023, the UN Secretary General Antonio Guterres responded to record worldwide temperatures by declaring that "the era of global warming has ended; the era of global boiling has arrived" (UN 2023). His comments were intended to rouse policymakers to take action, but they also point towards the rapid heating of our ocean. Climate change means the world's oceans are absorbing vast amounts of excess heat, with devastating consequences that are now unfolding.

Water has a much higher heat capacity than air. Heating a cubic metre of sea water by one degree Celsius requires around three thousand times the amount of energy it takes to heat a cubic metre of air by the same amount.[2] This immense capacity to absorb and store heat means that the vast majority of the excess heat in our climate system from greenhouse gas emissions - around 93 percent - has been absorbed by the ocean (IPCC 2019).

2 Assuming a density for air of 1.2kg/m^3 – the approximate density of air at sea level – and a heat capacity of 1 J/g/K; and a density for sea water of 1,025kg/m^3 and a heat capacity of 3.85J/g/K.

In many respects, the oceans are the clearest indicator we have of our warming planet. While we see annual variations in atmospheric temperature, linked with climate cycles like El Niño-Southern Oscillation, in the global ocean we see a consistent year-on-year temperature increase and an acceleration in the rate of warming.

The observed rate of ocean warming has increased dramatically in recent decades, more than doubling since the mid-1990s (IPCC 2019; Cheng et al. 2023). Today, we are putting more than 10 zeta joules of extra heat energy into the ocean each year. That's the equivalent energy of five Hiroshima bomb explosions every second or 150 million each year (Cheng et al. 2022, Cheng et al. 2023). Put another way, it's enough energy to boil all the water in Sydney Harbour every eight minutes.

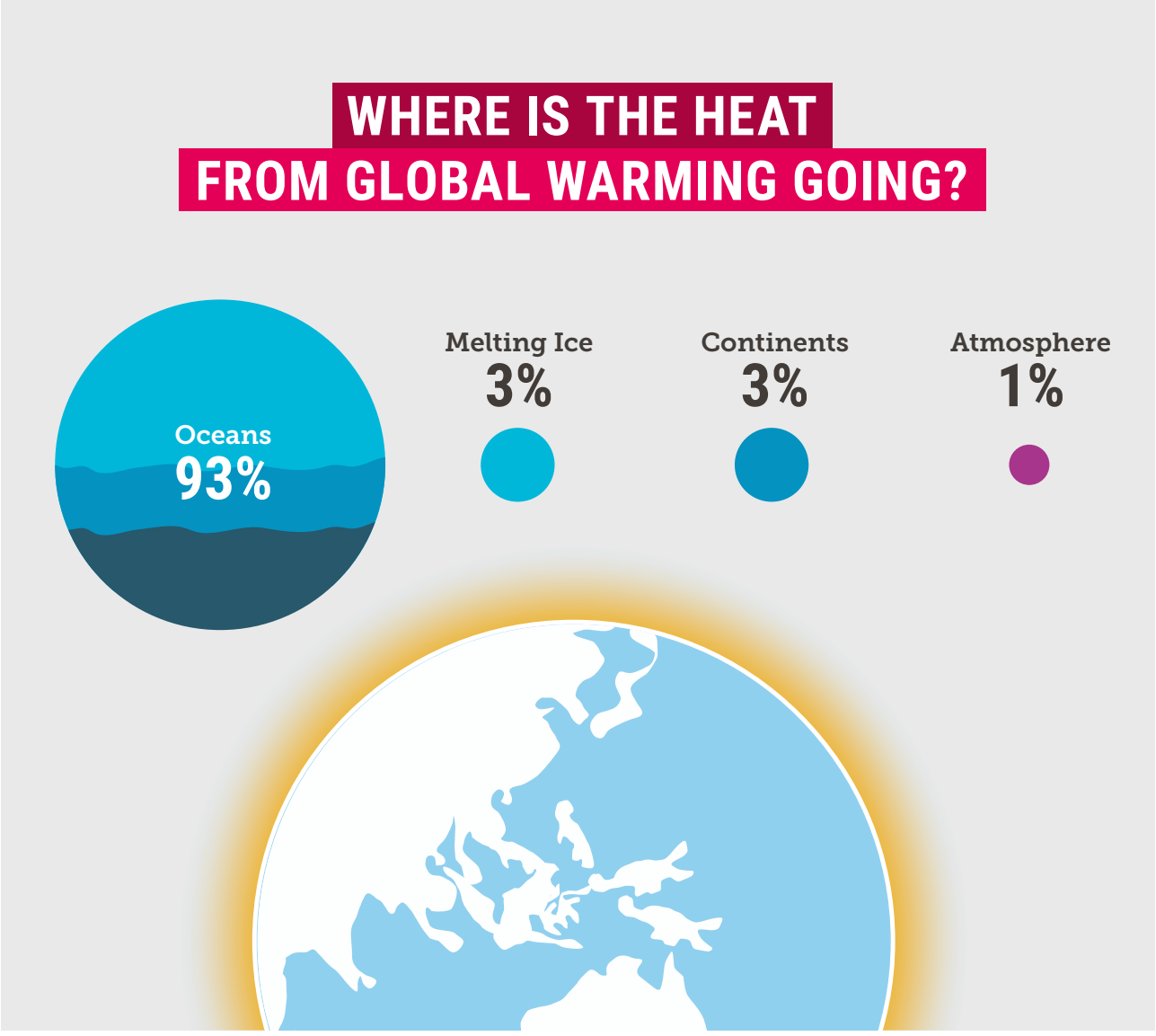


Figure 9: Almost all (93%) of the excess heat trapped by greenhouse gas emissions has been absorbed by the ocean.

Today the ocean is absorbing excess heat energy equivalent to five Hiroshima bomb explosions every second, or enough to boil Sydney Harbour every eight minutes.

By absorbing so much of the excess heat in the Earth's climate system, the ocean may be masking the extent of the changes we have made to our ocean-atmosphere system, making it harder to see the true scale of damage that has already been wrought by burning coal, oil and gas. Unfortunately, the ocean's capacity to absorb heat is not limitless, and there are signs that ocean heat may now be coming back to bite us.

> *"The latest evidence is extremely serious. Rates of change this year have exceeded that seen over the past 400 years."*
>
> - Professor Ove Hoegh-Guldberg, University of Queensland (from the Climate Council ocean scientists survey, 2023).

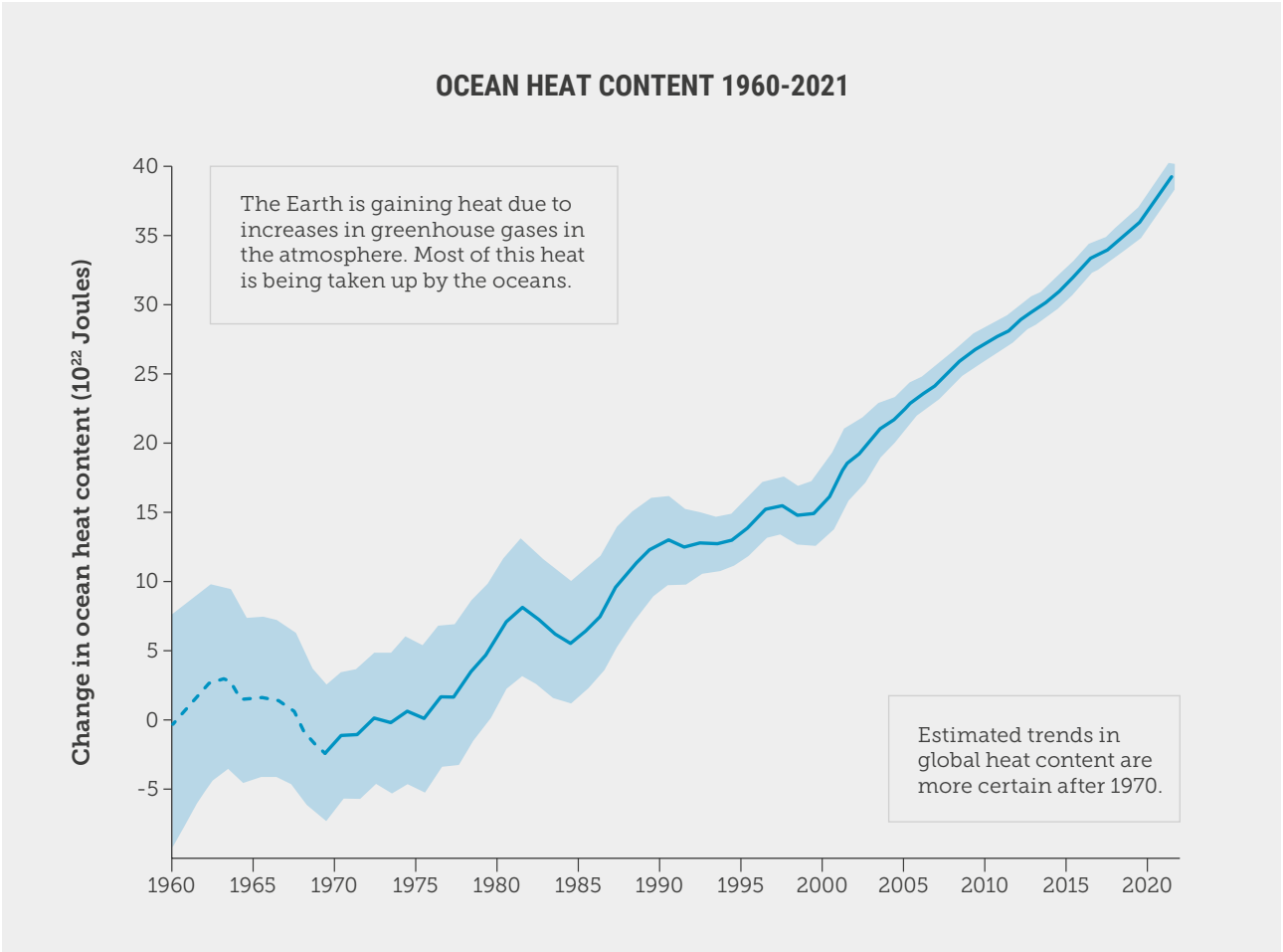


Figure 10: The rate of ocean warming has more than doubled since the mid 1990s. (Adapted from BoM and CSIRO 2022.)

OCEAN HEAT: COMING BACK TO BITE US

In 2023, the average global sea surface temperature has been unusually high, and rising (Hobday et al. 2023). Since April, global sea-surface temperatures have been higher than for any other year on record (Saunders 2023). Daily sea surface temperature records have been broken for more than 200 days in a row. In August, following weeks of reports of record high ocean surface temperatures in multiple regions, the world set a new record when the average daily global sea surface temperature reached 21.02°C (Copernicus 2023). Every single day in August saw warmer temperatures than the previous record of 20.95°C, set in March 2016. Remarkably, August is not typically one of the warmest months for the global ocean, with the highest average sea surface temperatures usually recorded in March.

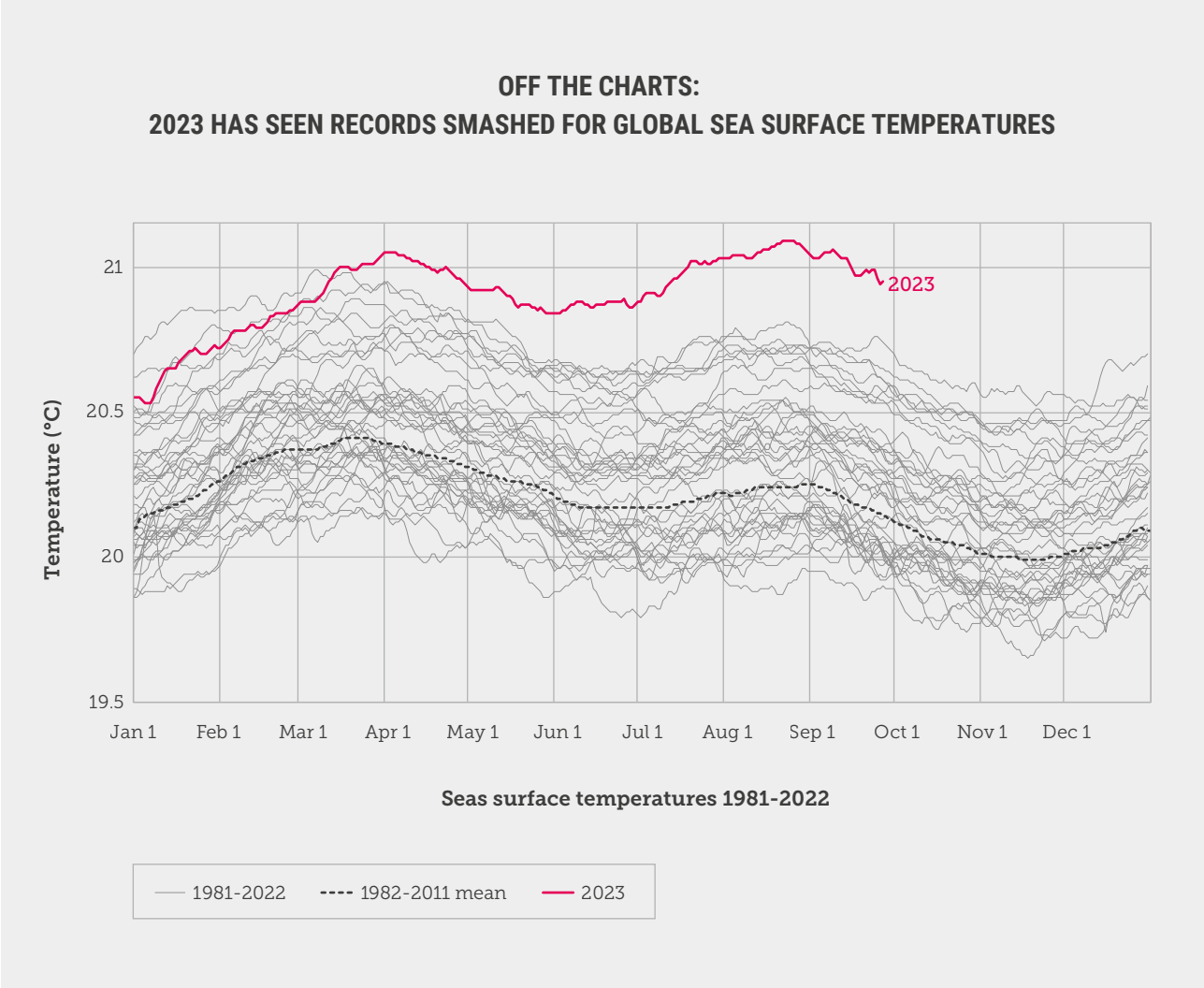


Figure 11: The average global sea surface temperature has been unusually high in 2023. Daily sea surface temperature records have been broken for more than 200 days in a row. (Data: climatereanalyzer.org.)

MARINE HEATWAVES

Global ocean warming, caused primarily by the burning of fossil fuels, is driving an increase in the incidence and severity of marine heatwaves. Similar to a heatwave on land, a marine heatwave is a prolonged period of anomalously warm water in a particular location. Ocean heatwaves can be more prolonged than those on land, sometimes lasting many months. 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).

This year record breaking marine heatwave conditions were experienced across large parts of the globe. July saw the hottest sea-surface temperature on record when temperatures of 38°C, the equivalent of a warm bath, were recorded in waters near Florida (BBC 2023). In August 2023, around 40 percent of the world's oceans experienced marine heatwave conditions, the greatest extent on record (NOAA 2023b). During the Northern Hemisphere summer, surface temperatures around the United Kingdom and the Republic of Ireland were 4-5°C warmer than usual (Hobday et al. 2023).

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).

> *"The surface ocean is a key concern for me, because it has a major effect on coastal ecosystems, particularly marine heatwaves. It is very rapidly warming, it has a real and visible impact to all of us; and there is much more to come."*
>
> - Dr Pep Canadell, CSIRO (from the Climate Council oceans scientists survey 2023)

Marine heatwaves also have huge social and economic costs. Australian scientists studying the economic consequences of marine heatwaves found a single event in 2016 in southern Chile cost more than AUD$1billion in direct economic losses to fisheries (Smith et al. 2021). They also found individual marine heatwaves have caused up to AUD$4.1billion in indirect losses of ecosystem services for multiple years (Hobday et al. 2021).

In coming decades we can expect to see more frequent and widespread marine heatwaves. Without urgent action to move away from fossil fuels, marine heatwaves are expected to become 50 times more frequent by the end of the century (IPCC 2019). Before the end of the 21st Century, many parts of the ocean could reach a near permanent heatwave state (Oliver et al. 2019).

In August 2023, around 40 percent of the world's oceans were experiencing marine heatwave conditions.

BOX 2: OUR WARMING WATERS - MARINE HEATWAVES AROUND AUSTRALIA

The seas around Australia are a global ocean warming hotspot. Near-surface waters offshore from southeastern Australia, especially around Victoria and Tasmania, are warming at nearly four times the global average (Hobday and Pecl 2014; Oliver et al. 2017). This is because 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 (Hobday and Pecl 2014).

Ocean warming has devastating impacts on Australia's marine ecosystems and the industries and communities that depend on them. More frequent marine heatwaves have already brought rapid changes to 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 offshore from Tasmania (Climate Council 2021).

Since 2011, marine heatwaves have caused mass deaths of key marine species along 45 percent of Australia's coastline - including corals, kelp, seagrasses and mangroves (Babcock et al 2019).

As Australian waters warm, many marine species, such as those that form kelp forests and seagrass meadows, are shifting their geographical range – moving south toward cooler waters. These ecosystems are also shrinking. More than 90 percent of Tasmania's giant kelp forests, for example, 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

TREND IN SEA SURFACE TEMPERATURE (°C PER DECADE) 1950-2021

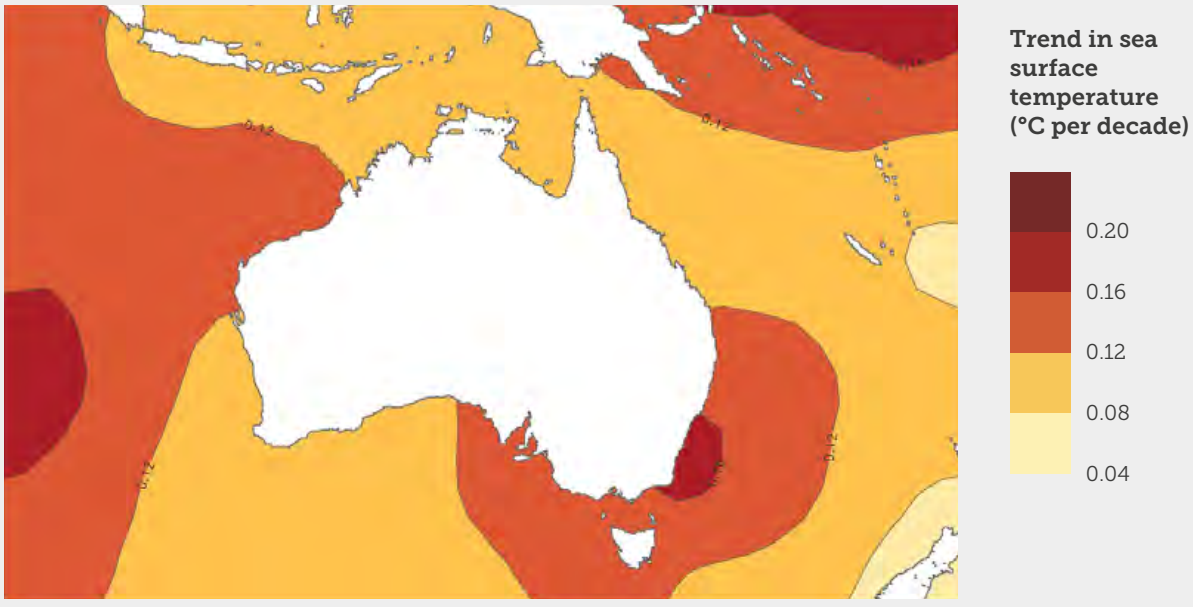


Figure 12: Waters around Australia are warming rapidly, particularly around the southeast. Adapted from Bureau of Meteorology.

BOX 2: CONTINUED

species replace cooler water species. As cool water species are increasingly displaced, many simply have nowhere to go.

Scientists warn that this summer, with the arrival of an El Niño event in the Pacific Ocean, we are likely to see stronger marine heatwaves in waters around Australia. The Bureau of Meteorology has forecast a patch of the Tasman Sea around Tasmania could be at least 2.5°C warmer than average during summer (BoM 2023). The Bureau's oceanographer Grant Smith explains that the colour-coded scale that the Bureau uses to map forecast sea surface temperatures stops at 2.5°C, but this summer's forecast is literally off the scale. "We didn't account for anomalies that high when we developed this", Smith said. "It could be 3°C, it could be 3.5°C, but we can't see how high it goes" (AAP 2023). A severe marine heatwave could lead to significant losses in fisheries and aquaculture.

Marine heatwaves are more common during El Niño years, and previous events have had major impacts on fisheries (Dawkins 2023). During the last El Niño event, in 2016, marine heatwaves saw the Great Barrier Reef suffer mass bleaching. Waters in the Tasman Sea also suffered through the region's longest-ever marine heatwave, around 250 days, and saw waters reach 2.9°C above average - with profound impacts on marine life including important commercial species (Oliver et al. 2017; Pecl et al 2019). Oyster farmers lost millions of dollars, and jobs were lost following the death of more than 60 million Pacific oysters from disease outbreaks (Smith 2023).

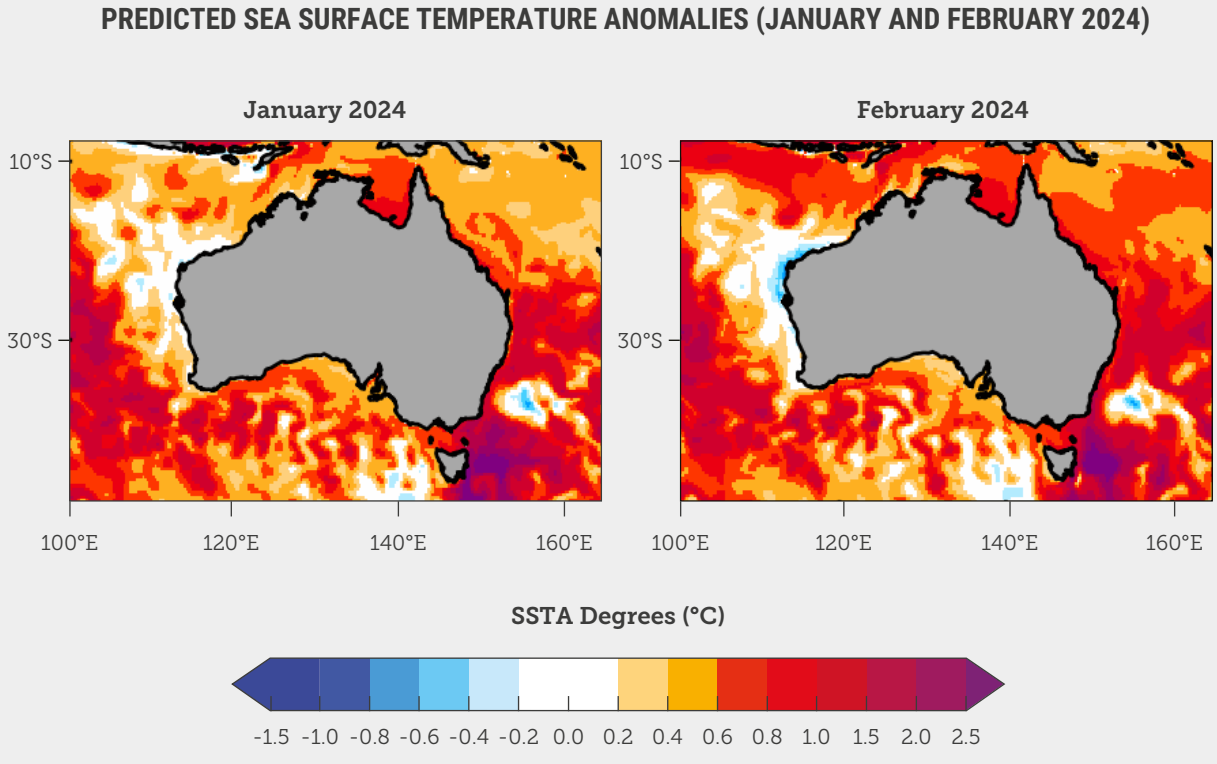


Figure 13: Waters around Australia are warming rapidly, particularly around the southeast. Adapted from Bureau of Meteorology.

BOX 2: CONTINUED

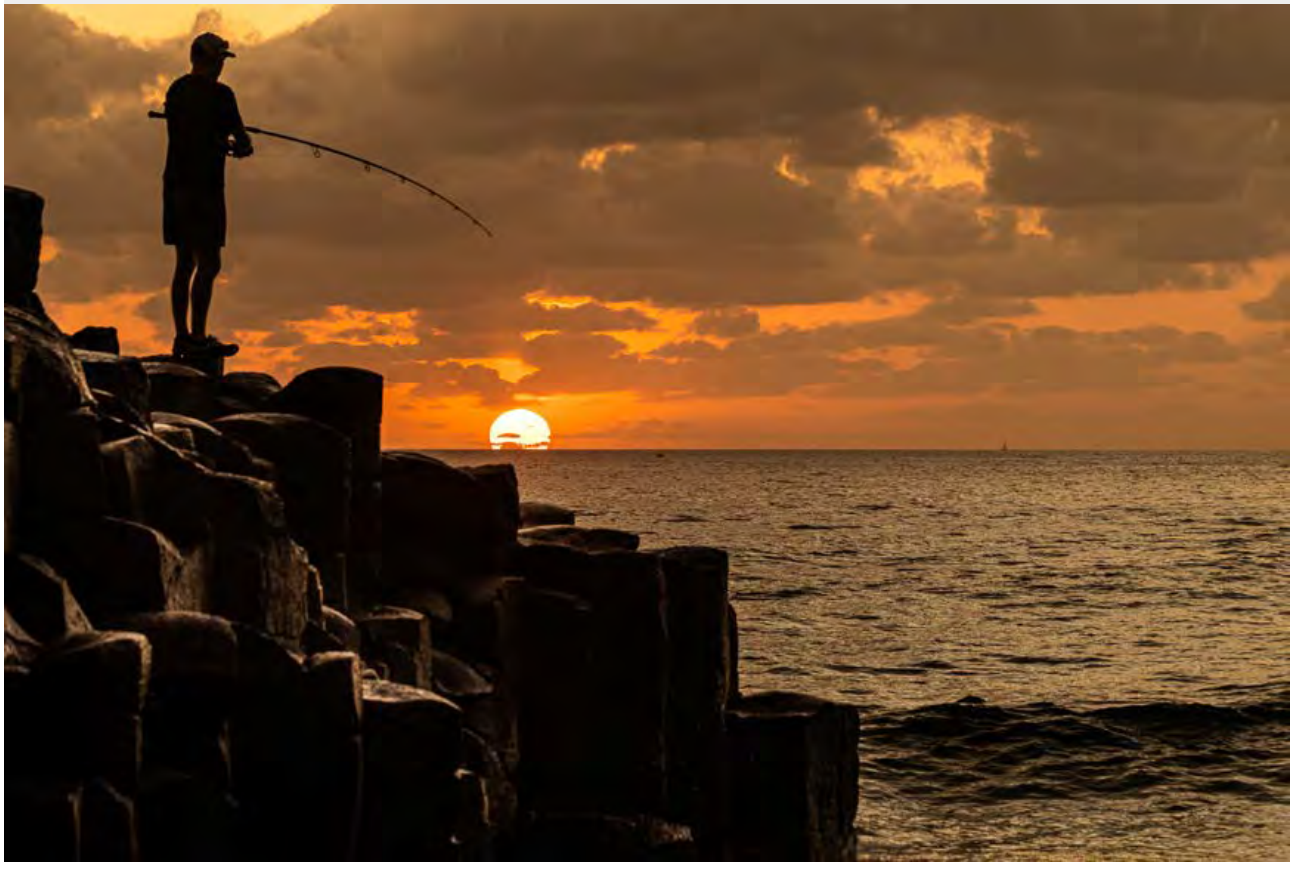
HEADING SOUTH: SPECIES ON THE MOVE

As waters around Australia warm up, marine species are heading south, and everyday Australians are helping ocean scientists track dramatic changes along our coastlines.

Many marine species live in a narrow temperature range. If the water heats up, they have to move, and if they don't they might die. So those that can are shifting poleward to find cooler climes. In Australia, at least 200 marine species have shifted distribution since 2003, with the vast majority (87 percent) headed south (Gervais et al 2021).

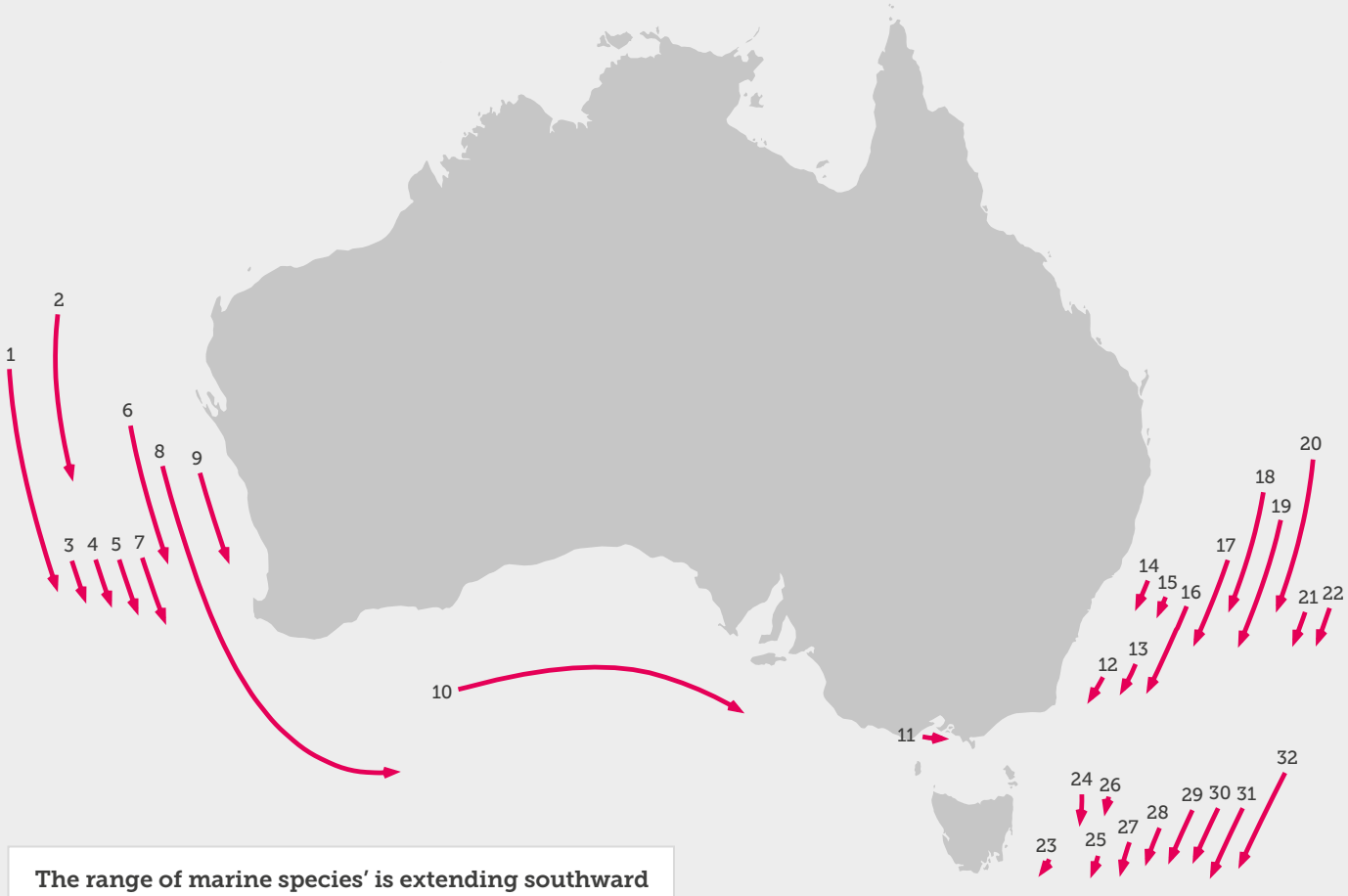
Australians enjoying the ocean - fishing, diving, snorkelling and beachcombing - are helping to map species on the move. If people spot a creature they wouldn't normally see at a particular location, like a whitetip reef shark or a dugong that might normally be seen in tropical waters, they can upload a photo log of their sighting to the 'REDMAP' website (www.redmap.org.au). These sightings help researchers to understand species range extensions.

Figure 14: Everyday Australians - fishing, diving and snorkelling - are helping scientists track the movement of species responding to warming sea temperatures.



WARMING WATERS
MARINE SPECIES MOVING SOUTH

As waters warm with climate change, Australia's species are shifting in response. Redmap (Range Extension Database and Mapping Project) has documented over a decade (2012-2022) of out-of-range marine species sightings with the help of Australia's citizen scientists.



The range of marine species' is extending southward

\# — Species' number (see next page for species name)

Species' historical southern range limit (as of 2012)

How far out-of-range the species was spotted

479 Citizen scientists logged unusual or out-of-range species sightings

Sightings contributed by:

Snorkelers/divers · Fishers · Beach-combers · Spear- fishers

3 Citizen science programs providing out-of-range species observations

redmap · iNaturalist · Australasian Fishes Project · RLS REEF LIFE SURVEY

2045 Out-of-range or unusual species photographs

205 Marine species tracked for out-of-range sightings

91 Scientists involved in verifying species identifications

Figure 15: Through the Redmap project (Range Extension Database and Mapping Project), citizen scientists are helping track the movements of Australian species in response to changes in the marine environment, including ocean warming. For more information and to share sightings, head to www.redmap.org.au.

AUSTRALIAN SPECIES ARE SHIFTING THEIR RANGE

1 Red Emperor
Lutjanus sebae

2 Green Jobfish
Aprion virescens

3 Black Rabbitfish
Siganus fuscescens

4 Indo-Pacific Sergeant
Abudefduf vaigiensis

5 Common Lionfish
Pterois volitans

6 Redthroat Emperor
Lethrinus miniatus

7 Moorish Idol
Zanclus cornutus

8 Shark Mackerel
Grammatorcynus bicarinatus

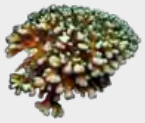
9 Barred Soapfish
Diploprion bifasciatum

10 Redband Wrasse
Pseudolabrus biserialis

11 Whitebarred Boxfish
Anoplocapros lenticularis

12 Banded Rockcod
Hyporthodus ergastularius

13 Crested Hornshark
Heterodontus galeatus



14 Branching Coral
Pocillopora aliciae

15 Stout Moray
Gymnothorax eurostus

16 Bluespine Unicornfish
Naso unicornis

17 Green Moon Wrasse
Thalassoma lutescens

18 Headband Humbug
Dascyllus reticulatus

19 Paradise Threadfin Bream
Pentapodus paradiseus

20 Dogtooth Tuna
Gymnosarda unicolor

21 Spangled Emperor
Lethrinus nebulosus

22 Bluebarred Parrotfish
Scarus ghobban

23 Yellowtail Kingfish
Seriola lalandi

24 Grey Morwong
Nemadactylus douglasii

25 Dusky Morwong
Dactylophora nigricans

26 Tiger Shark
Galeocerdo cuvier

27 Greater Argonaut
Argonauta argo

28 Threadfin Leatherjacket
Arotrolepis filicauda

29 Rock Blackfish
Girella elevata

30 Eastern King Prawn
Melicertus plebejus

31 Eastern Rock Lobster
Sagmariasus verreauxi

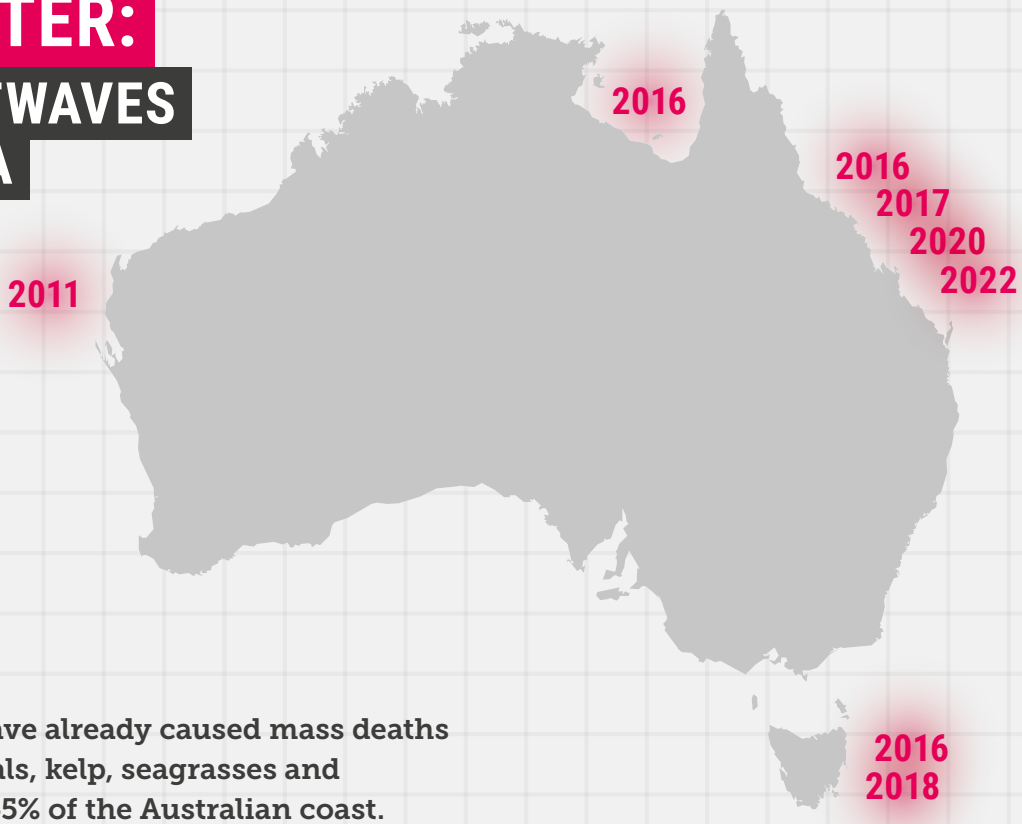
32 Mahi Mahi
Coryphaena hippurus

These are examples of the 100s of species that are shifting their range. These are a select sample only.

HAVE YOU SEEN A FISH OUT OF PLACE?

If you are out fishing or diving and you see something you wouldn't normally, use this QR code to log your sighting.

IN HOT WATER:
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 aquaculture, 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 aquaculture

2020
Marine heatwave, Great Barrier Reef
Mass coral bleaching

2022
Marine heatwave, Great Barrier Reef
Mass coral bleaching

Figure 16: Marine heatwaves have already caused immense damage to coral reefs, mangroves, kelp forests and other marine ecosystems around Australia. Stronger action to reduce greenhouse gas emissions is fundamental to protecting our precious marine ecosystems.

CORAL REEFS: THE RAINFORESTS OF THE OCEAN

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.

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 and CSIRO 2020). While some corals can recover after mild bleaching, mortality occurs if warm conditions persist or are too severe.

As the oceans warm, mass bleaching events have become more frequent and severe in recent decades. Australia's Great Barrier Reef has been affected by six mass bleaching events, and all of them have occurred in the last quarter century – in 1998, 2002, 2016, 2017, 2020 and 2022. The bleaching event in 2022 was the first to take place during a La Niña event, which is unusual as a La Niña event usually brings a reprieve due to greater cloud cover.

This summer, as we experience another El Niño event, ocean scientists are gravely worried the Great Barrier Reef again faces the prospect of severe marine heatwaves and mass bleaching because an El Niño summer typically brings hotter and drier atmospheric conditions and reduced cloud cover (Heron et al. 2023).

The last El Niño event - in 2015/16 - led to the worst coral bleaching on record for the Great Barrier Reef, affecting more than 90 percent of the reef (Hughes at al. 2018). Nearly 30 percent of corals on the reef died as a result of the 2016 event (Climate Council 2018; Hughes et al. 2018). The 2016 event was at least 175 times more likely to have occurred due to climate change (King et al. 2016).

Prospects for the world's coral 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 occur every two years (CoECSS 2016). Under a high emissions scenario, bleaching conditions could occur each year as soon as 2044 (Heron et al. 2018). These conditions would effectively destroy the Great Barrier Reef, and most shallow water tropical reefs worldwide.

In short, for the Great Barrier Reef, stronger action this decade to reduce greenhouse gas emissions could be the difference between giving the Reef a fighting chance of survival or watching it mostly disappear.

> *"The three biggest threats [to the oceans] are climate change, overfishing and coastal pollution. They act together in synergy - an overfished and polluted reef is further compromised by climate change impacts. Climate change affects even the most remote and best managed locations - there is nowhere to hide."*
>
> - Professor Terry Hughes, James Cook University (from the Climate Council ocean scientists survey 2023)

Why are coral reefs so important?

Coral reefs are among the most biologically diverse and valuable ecosystems on Earth. While they cover less than 0.1 percent 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 the daily protein 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 biological structure on Earth and one of the world's seven natural wonders. In 2017, the Reef was estimated to contribute around $6.4 billion per year to the Australian economy and support 64,000 jobs (Deloitte Access Economics 2017). If coral bleaching persists, an estimated 10,000 jobs and A$1billion in revenue could be lost each year from declines in tourism alone (Swann and Campbell 2016)

Figure 17: More than half a billion people depend on coral reefs for food, income and the protection of their coasts.

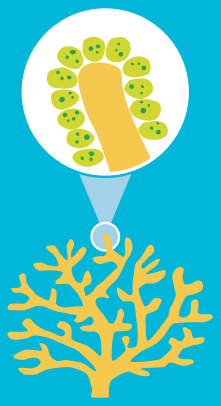
WHAT IS CORAL BLEACHING?

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.

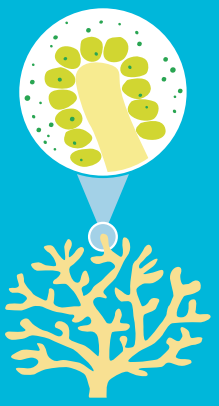
Corals have a symbiotic relationship with microscopic algae called zooxanthellae that live in their tissues. These algae provide their host coral with food and give them their colour.



2 STRESSED CORAL

If stressed, algae leave the coral.

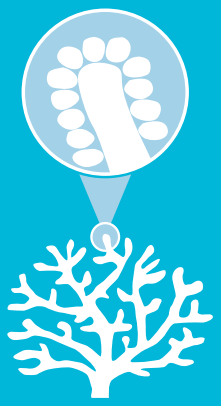
When the symbiotic relationship becomes stressed due to increased ocean temperature or pollution, the algae leave the coral's tissue.



3 BLEACHED CORAL

Coral is left bleached and vulnerable.

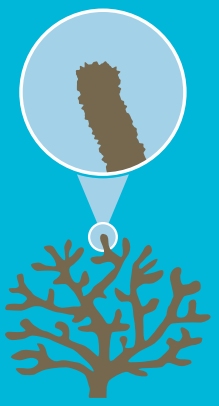
Without the algae, the coral loses its major source of food, turns white or very pale, and is more susceptible to disease.



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.

Figure 18: Elevated ocean temperatures disrupt the critically important symbiotic relationship between corals and single-celled algae called *zooxanthellae*, causing the coral to bleach.

DECLINING SEA ICE

As the oceans warm, less sea ice is forming in the Earth's polar regions. In June 2023, polar scientists sounded the alarm on rapid changes in the Arctic and Antarctic (WMO 2023). Sea ice is in decline, with serious implications not only for polar environments but for global climate and weather. The extent of sea ice in the Earth's polar regions in 2023 was lower than for any other year on record.

The seas around Antarctica were especially slow to refreeze during the southern hemisphere winter in 2023. The area of sea ice around the Antarctic changes significantly across the course of a year, between the southern hemisphere's summer and winter. After reaching its minimum extent around March, the sea surface begins to freeze again and the area of sea ice peaks around September before beginning to thaw and retreat again. However, in 2023, the sea ice was much slower to recover. By late June, the total area of sea ice was 2.44 million km^2 below the mean for that time of year, and 1.33 million km^2 below the previous record for this day of the year. For context, 1.33 million km^2 is an area around 20 times the size of Tasmania (Arctic Data Archive System 2023).

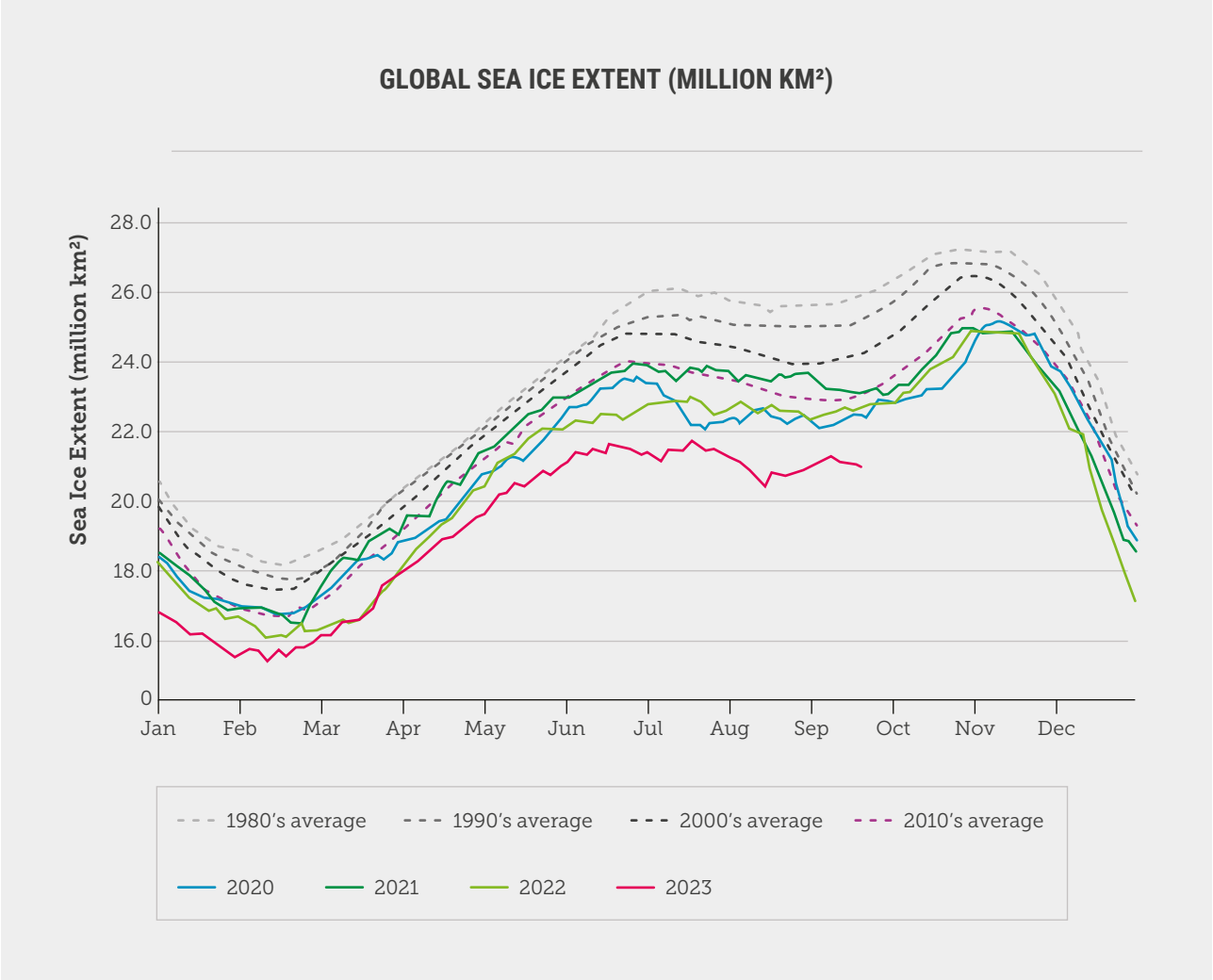


Figure 19: As the oceans warm, less sea ice is forming in the Earth's polar regions. 2023 saw an extraordinary decline in sea ice in the Antarctic. (Data: Arctic Data Archive System.)

In September 2023, sea ice around Antarctica reached its maximum extent for the year, setting a new record low, more than a million square kilometres below the previous record low (NOAA 2023c). Australian climate and ocean scientists have found 'preliminary indications' that ocean warming may have pushed Antarctic sea ice into 'a new low-extent state' (Purich and Doddridge 2023).

> *"The expansion of coal, oil and gas must cease as soon as possible, given that we are currently on track to reach a disastrous 3°C by mid to late century. We must contract, not expand, our exploitations of fossil fuels. Anything else is a false and catastrophic logic."*
>
> - Professor Ove Hoegh-Guldberg, University of Queensland (from the Climate Council ocean scientists survey 2023)

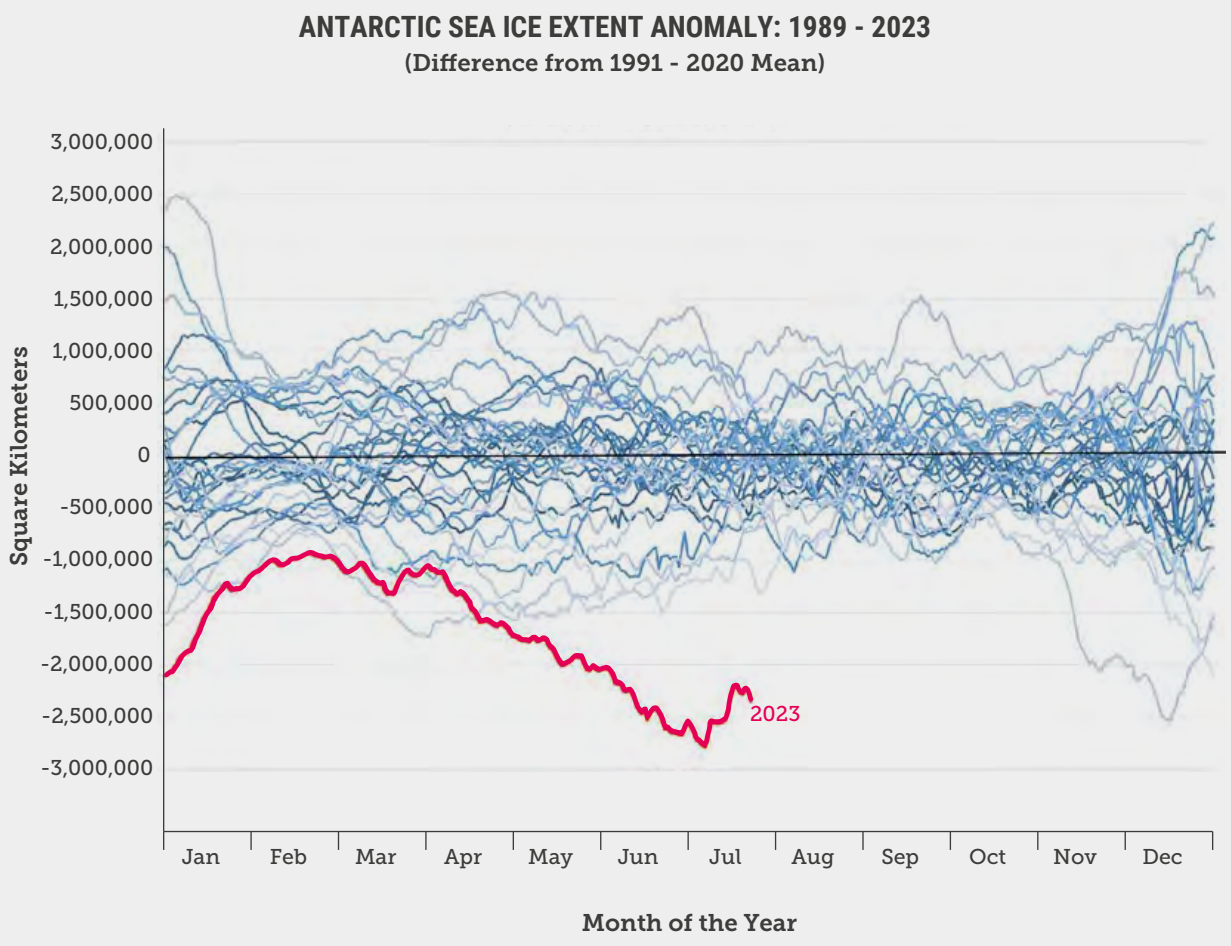


Figure 20: Antarctic sea ice was especially slow to form in 2023. By late June, the area of Antarctic sea ice was 2.44 million km^2 below the mean for that time of year. (Data: Arctic Data Archive System.)

Figure 21: Declining sea ice can be deadly for animals, including emperor penguins, that rely on the ice as a breeding habitat.

A reduction in sea ice can contribute to further warming, as less heat is reflected back into space by bright white surface of sea ice, and is instead absorbed into the dark ocean.

Declining sea ice in Antarctica presents a major challenge for animals that rely on the ice as a breeding habitat. Late in 2022, thousands of emperor penguin chicks drowned at sea when record low sea ice caused "catastrophic breeding failure" in a number of penguin colonies (Fretwell et al. 2023). Worryingly, Antarctic sea ice extent hit the lowest ever recorded in February 2023, and ahead of the 2023 breeding season, Antarctic sea ice extent was even lower than it was in 2022. About 30 percent of emperor penguin colonies in Antarctica have been affected by partial or total sea ice loss since 2018. If present rates of warming persist, 90 percent of emperor penguin colonies could be extinct by the end of the century (Fretwell et al. 2023).

Warming waters and loss of sea ice around Antarctica are also impacting keystone species like Antarctic krill, which is at the heart of food webs in the Southern Ocean. Warmer temperatures are changing the distribution of krill populations and deteriorating growth habitats, with significant implications for the fish, seals, penguins, albatross and whales that depend on the finger-sized crustaceans for their diet (Cavan et al 2019; Veytia et al. 2020).

The loss of sea ice is devastating enough on its own, but it can also accelerate global warming. When solar radiation hits the bright surface of sea ice, much of it is reflected back into space. When that ice disappears and the radiation is instead hitting the dark open water, more is absorbed into the ocean. This is known as the ice-albedo feedback and is an example of a positive feedback in the Earth's climate system.

OCEAN CURRENTS SLOWING, AND HEADED FOR COLLAPSE

Global warming is affecting the ocean currents that distribute heat, carbon, oxygen and nutrients around the world. Research released in 2023 suggests some of the world's major ocean currents are slowing faster than had been projected and could be headed for collapse altogether, with the potential for widespread climatic disruption.

Every year 250 trillion tonnes of dense, icy cold, oxygen-rich and carbon dioxide-rich water falls to the ocean floor around Antarctica, in what has been described as the world's biggest waterfall (Gunn et al. 2023a). These waters spread north along the ocean floor as deep ocean currents, before rising to the surface again thousands of kilometres away as nutrient-dense upwellings that are important for some of the world's richest fisheries. A similar process occurs around the Arctic and Greenland, in the icy waters of the North Atlantic. Together, these are part of a network of global 'overturning' currents that are the main way that oxygen gets to the deep ocean. These currents help to regulate climate and temperature around the world.

Ocean scientists have long warned of possible declines in ocean circulation due to climate change and the rapid melting of ice sheets in the Earth's polar regions. Satellite data shows that since 2002, Antarctica has lost around 150 billion metric tonnes of ice each year, while Greenland has lost around

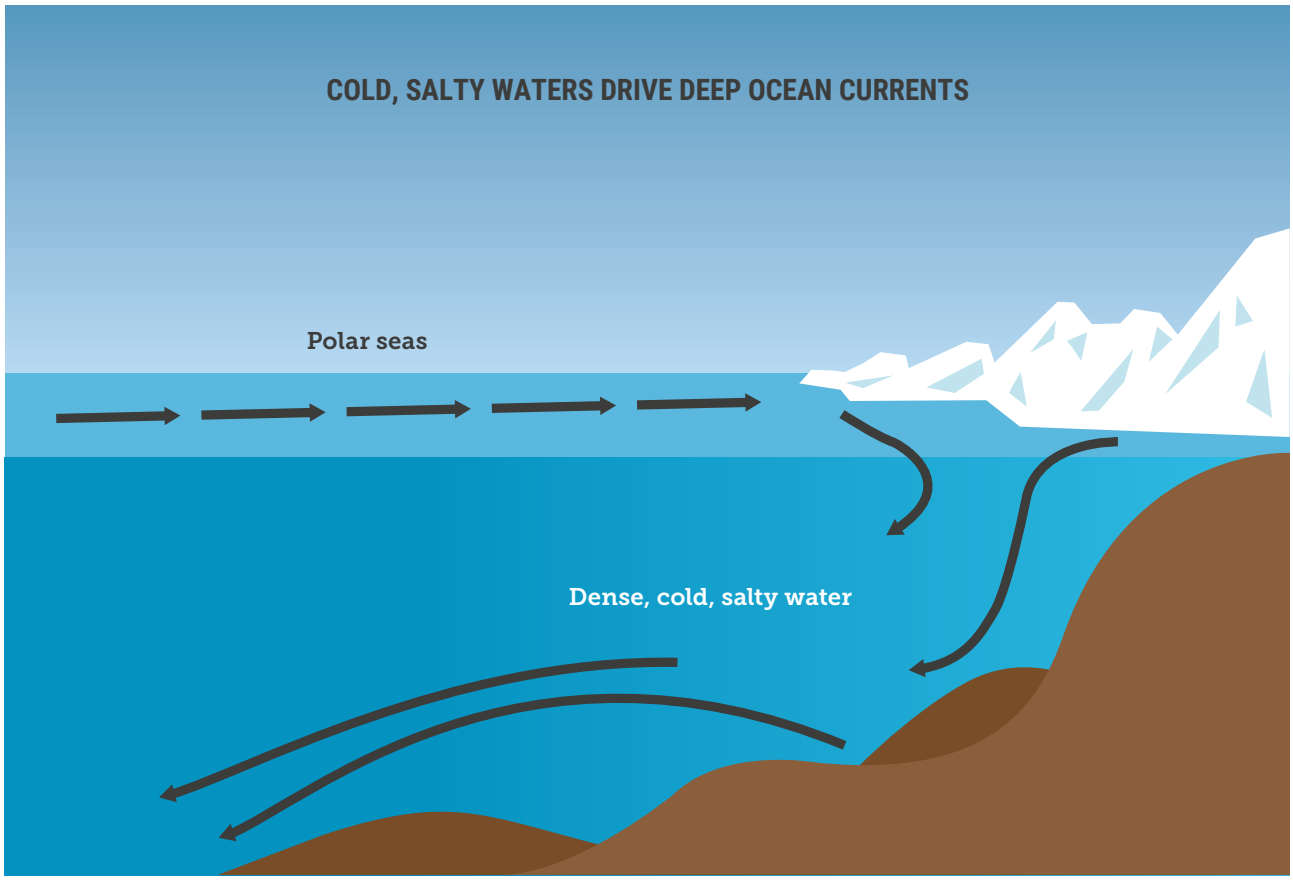


Figure 22: As cold water around Antarctica freezes, salt is expelled into the surrounding ocean. This dense, salty water sinks, which pulls more surface-water toward Antarctica. However, excess meltwater is making Antarctic surface waters less salty and dense, and therefore less likely to sink. This is putting the brakes on the overturning circulation that provides oxygen and nutrients to the deep ocean.

> *"We don't have a great handle on how the ocean circulation is actually changing ..but we do know that climate models don't represent the processes involved in the ocean overturning circulation properly, and so we really need better models to predict changes into the future."*
>
> - Dr Veronica Tamsitt, US-based ocean scientist (from the Climate Council ocean scientists survey 2023)

270 billion metric tonnes per year (NASA 2023). Altogether it is estimated that Antarctica and Greenland have lost 49,000 gigatonnes of ice since the start of the 20th Century. This much ice would be enough to cover the entire surface of the moon in a 1.5 metre high ice sheet (NASA 2020). As this ice melts, more freshwater is flowing into the surrounding polar waters, making them less dense and salty and slowing their sinking to the ocean floor.

Today, there are clear signs that the oceans' overturning currents are slowing down, and that it's happening decades faster than expected. Modelling published by Australian scientists in 2023 projects that ocean circulation around Antarctica will slow by more than 40 percent by the middle of the century (Li et al. 2023). Even more worryingly, recent observations suggest some of the changes expected by 2050 are already underway (Gunn et al. 2023a). New observations show deep ocean currents around Antarctica have already slowed by almost 30 percent since the early 1990s (Gunn et al. 2023b).

Some of the world's major ocean currents are slowing faster than expected. Their collapse would be catastrophic, and must be avoided at all costs.

The news is just as alarming from the North Atlantic, where the Atlantic Meridional Overturning Current (AMOC) is estimated to be weaker than at any time in the past 1,600 years (Thornalley et al. 2018). A study released in 2023 warns that under the current trajectory of global greenhouse gas emissions, the Atlantic overturning current could collapse altogether by mid-century (Ditlevsen and Ditlevsen 2023). The AMOC is regarded as a major tipping point in the Earth's climate system, and its collapse would have major and potentially disastrous knock-on effects - including disrupting rains that billions of people rely on in India, West Africa and South America and bringing drier conditions and undercutting agricultural production in Europe.

In its Sixth Assessment Report, the Intergovernmental Panel on Climate Change concluded that while possible, a full collapse of the AMOC was unlikely to occur this century (IPCC 2021a). Studies predicting an imminent collapse of the Atlantic overturning current need to be seen in this context - as outliers that challenge our best estimates of where things are headed in the near term. However, given the potential for catastrophic outcomes, the collapse of ocean currents must be avoided at all costs. The only way to do this is to rapidly end the use of fossil fuels.

RISING SEAS

As the world's oceans warm and ice sheets melt, sea levels are rising, presenting a major threat to coastal communities across the world. Sea level rise is driven both by the thermal expansion of seawater as it becomes warmer, and by the melting of glaciers and major ice sheets in Greenland and Antarctica. Around 70 percent of the sea level rise seen since 1901 has occurred due to melting glaciers and ice-sheets (IPCC 2021).

Since the start of the 20th century, global sea levels have risen by around 20cm, and the rate of sea level rise has accelerated in recent decades (IPCC 2021). Almost half of all recorded sea level rise has occurred since the early 1990s. A certain amount of sea level rise is now locked in for the coming decades and centuries. As it stands, global sea level is expected to rise an additional 10-25 centimetres by 2050. How much the sea level will rise beyond that depends on decisions we make today.

Humanity is not prepared for the rising ocean. We can expect to see devastating impacts for communities across the globe as coastal inundation becomes increasingly common. More than a billion people currently live less than 10 metres above present high tide lines (Kulp and Strauss 2019). This includes people living in major cities like Bangkok, New York, Shanghai, London, Calcutta and Sydney. Around the world more than 230 million people live below 1 metre above the high tide line. Unless we urgently move away from coal, oil and gas we can expect that up to 630 million people will be living on land that faces annual flooding by the end of the century (Kulp and Strauss 2019).

Sea level rise will reshape Australian life as we know it. More than 85 percent of Australians live by the coast, within 50km of the sea (ABS 2020). So far, rates of sea level rise around the Australian continent have been similar to the global average (~ 25 cm since 1880), with significantly higher rates of sea level rise to the north and southeast of the continent (BoM and CSIRO 2022). In future, Australia's sandy shorelines are projected to retreat by around 100 metres by the end of the century (Gergis 2022). Many of our beloved beaches and coastal landscapes will degrade and eventually disappear during our lifetimes.

Sea level rise presents huge costs for the Australian economy. Hundreds of thousands of coastal properties are threatened by rising seas and billions of dollars worth of commercial, industrial, road and rail assets are exposed to flooding and coastal erosion hazards (Climate Council 2014; Kompas et al 2022). In Victoria alone, the impacts of sea level rise and storm surge are predicted to result in $442 billion in economic losses by the end of the century (Kompas et al 2022). For First Nations communities, including Torres Strait Islander peoples, the impacts of sea level rise go far beyond economic losses and the loss of physical security; profoundly affecting deep ancestral connections to land and sea Country, and undermining their very culture and identity.

While we cannot stop the seas from rising, we can still act to slow the rate at which they rise. Recent research has concluded that the melting of the West Antarctic ice sheet will continue to accelerate this century under all emissions scenarios, though stronger action now can still help limit the rate and extent of melting over the longer term (Naughten et al. 2023). For many communities, stronger global emissions reductions this decade may ultimately make the difference between a rate of sea level rise that they are able to adapt to, and one which overwhelms them.

OCEAN ACIDIFICATION

By burning vast amounts of coal, oil and gas, we are changing the very chemical make-up of the world's oceans. Around thirty percent of the carbon emitted by burning fossil fuels has been absorbed into the ocean (IPCC 2019). As carbon dioxide dissolves into seawater it creates carbonic acid. This in turn has made the entire ocean more acidic.

Globally, oceans are around thirty percent more acidic than they were in the 1850s (Brown and Gerbing 2020). Ocean acidification is expected to continue and it is projected that by the end of the 21st Century the ocean will be at least 100-150 percent more acidic than it was in the 19th Century. Surface waters around Australia are acidifying ten times faster than at any time in the past 300 million years (BoM and CSIRO 2022).

Dramatic changes in ocean chemistry makes it harder for many marine species to thrive. Ocean acidification reduces the concentration of carbonate in seawater, which makes it more difficult for organisms like corals, mussels, oysters and some plankton to form shells and skeletons (Fitzer 2019). Between 2005 and 2009 billions of oyster larvae raised in hatcheries of the north-west coast of the US died when exposed to an upwelling of acidic ocean water from the deep ocean. This event induced levels of ocean acidification that could become commonplace in the not-too-distant future (Boyer 2017). In Australia, acidification is already reducing the size of Sydney rock oysters (Fitzer et al. 2019). In coming decades acidification will have widespread consequences for ocean biodiversity, and for fisheries and aquaculture - threatening food security for millions of people.

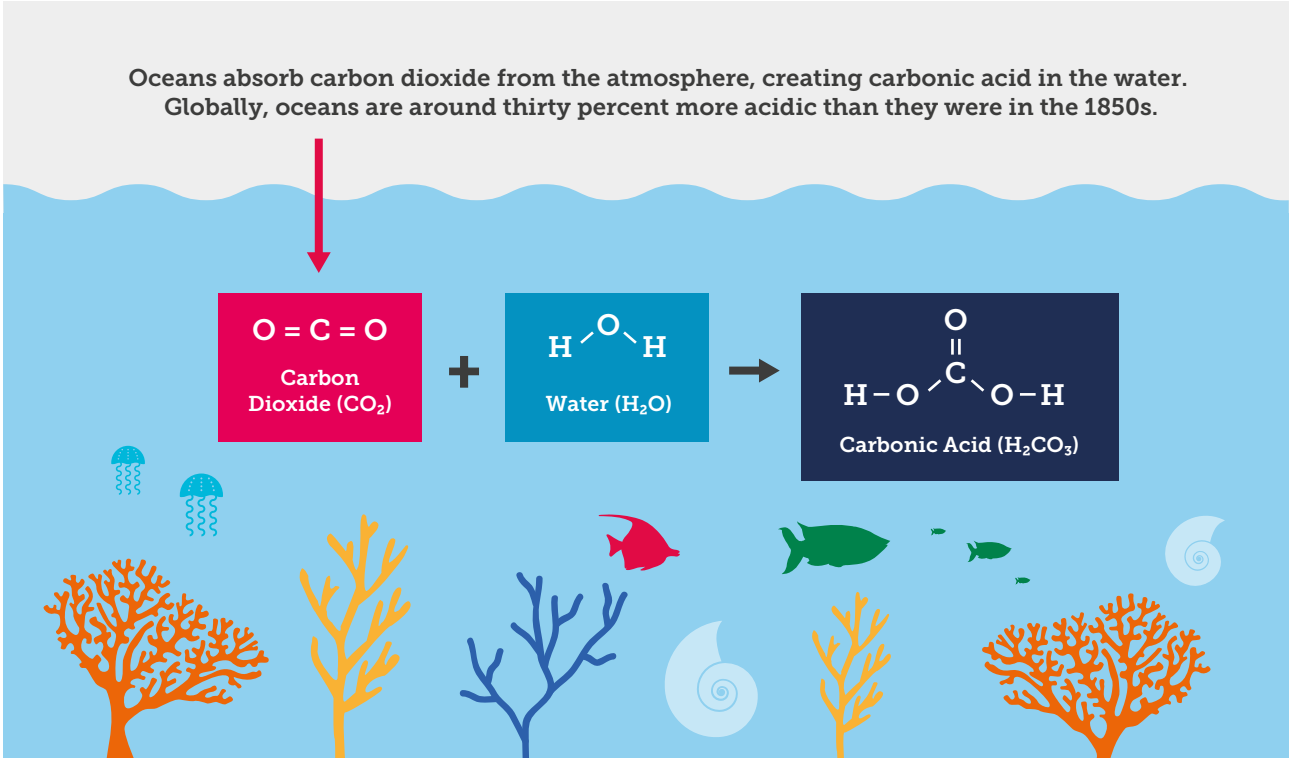


Figure 23: By burning fossil fuels, we have changed the chemical make-up of the whole world's ocean - making it much more acidic.

OUR FUTURE, OUR CHOICE

Over the 21st Century the world's oceans will continue to warm and transition to 'unprecedented conditions' with widespread consequences for coastal ecosystems and marine species (IPCC 2019).

Because of our failure to reduce emissions, marine heatwaves are very likely to become more severe and destructive over the next two decades. This is because our greenhouse gas emissions have already 'locked in' significant levels of climate and ocean change. The full range of impacts beyond that depends on decisions we make today about moving away from fossil fuels.

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 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 species 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 the early 2040s (IPCC 2022, Heron et al. 2018). The decline of other ecosystems, like Australia's temperate kelp forests found all along our Great Southern Reef, is also projected to continue.

By rapidly transitioning to renewable energy, getting our emissions plummeting this decade, and doing everything possible to limit warming to 1.5°C,[3] we can limit future losses. Every tonne of carbon left in the ground, and every increment of avoided warming, means a better future for our oceans and a safer future for us all.

While climate change has already caused immense damage to our oceans - and we'll continue to see devastating impacts for decades - the actions that governments take to reign in fossil fuels right now will dictate how much worse it will become.

3 Today almost all scenarios that see us limiting warming to 1.5°C involve a period of temporary 'overshoot'. In other words, temporarily exceeding warming of 1.5°C but then bringing the temperature back down through removing enormous quantities of greenhouse gases from the atmosphere. This involves the large-scale use of carbon dioxide removal technologies and the restoration of ecosystems. July 2023 became the first month in which the global average temperature spiked to 1.5°C above pre-industrial levels. However, breaching 1.5°C over a single month or year does not equate to exceeding the 1.5°C temperature goal as defined by the Paris Agreement and the Intergovernmental Panel on Climate Change (IPCC). The goal is based on temperatures averaged over 20 or 30 years. (30 years is the standard reference period used by the World Meteorological Organisation. However, the most recent IPCC assessment used a reference period of 20 years.)

THE CLIMATE CRISIS IS AN OCEAN CRISIS

The ocean is at the heart of the Earth's climate system. This means climate change - driven by the burning of coal, oil and gas - is rapidly transforming our oceans as well as our climate. Here are some of the ways that our ocean is being impacted.

IMPACTS OF CLIMATE CHANGE ON OUR OCEANS

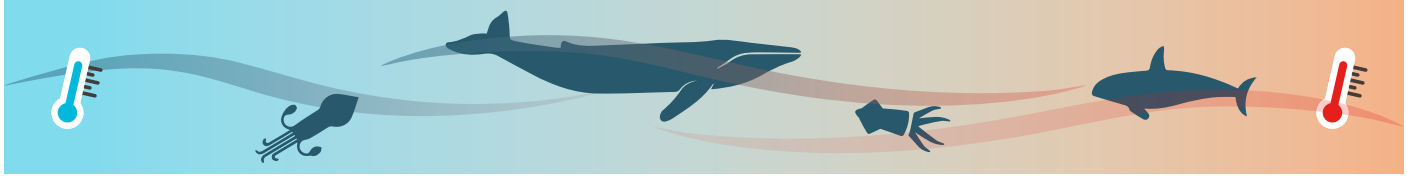
OCEAN HEAT

The ocean absorbs 93% of the excess heat in our climate system.

The ocean is absorbing extra energy at a rate equivalent to five Hiroshima bombs a second.

In 2023 global sea surface temperature records were broken for more than 200 days in a row.

By absorbing excess heat the ocean has stored some of the climate change problem, but the negative impacts of a warming ocean are huge and the problem can't be stored forever.



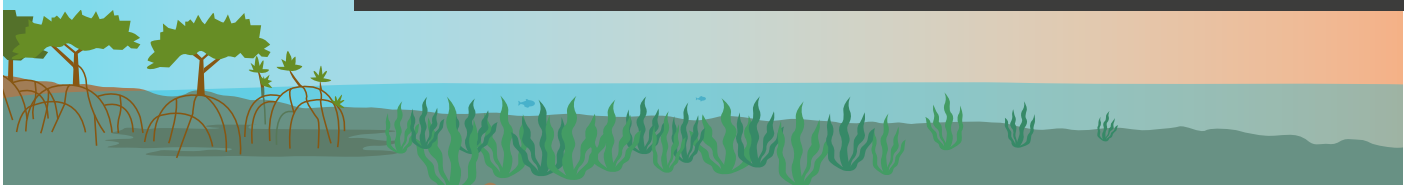
MARINE HEATWAVES

The incidence of marine heatwaves has doubled since the 1980s, and they have become more intense and widespread.

Marine heatwaves have caused mass deaths of key species along 45 percent of Australia's coastline - including corals, kelp, seagrasses and mangroves.

Before the end of the century, many parts of the ocean could reach a near permanent heatwave state.

Taking action today to limit warming will be measured in marine species and ocean ecosystems saved.



CORAL BLEACHING

Tropical reefs are especially vulnerable to rising water temperatures - which can lead to coral bleaching.

The Great Barrier Reef has been affected by four mass bleaching events since 2016, with widespread coral loss.

By the 2040s bleaching conditions could occur on the Great Barrier Reef every year.

Limiting warming to 1.5°C means giving our coral reefs a fighting chance.

DECLINING SEA ICE

Less sea ice is forming in the Earth's polar regions - with serious implications for global climate and weather.

Sea ice in the Earth's polar regions in 2023 was lower than for any other year on record - by June Antarctica was missing an area of ice 20 times the size of Tasmania.

Declining sea ice can accelerate global warming. When sunlight heats the open water instead of ice, more solar radiation is absorbed into the ocean.

Far stronger action is needed now if we're to avoid crossing dangerous and irreversible tipping points for sea ice.

SLOWING OCEAN CURRENTS

Global warming is slowing down ocean currents that regulate the Earth's climate and distribute carbon, oxygen and nutrients around the world.

Australian scientists have found that deep ocean currents around Antarctica have slowed by almost 30 percent since the early 1990s.

Some of the world's major ocean currents are slowing faster than expected, and could be headed for collapse altogether - with potentially disastrous worldwide impacts.

Given the potential for catastrophic outcomes, the collapse of ocean currents must be avoided at all costs. The only way to do this is to rapidly end the use of fossil fuels.

SEA LEVEL RISE

Global sea levels have risen by 20cm since the start of the 20th Century. The rate of sea level rise has accelerated in recent decades.

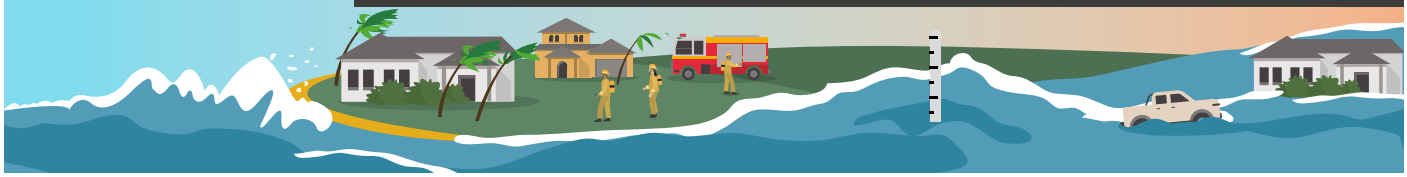
Australia's sandy shorelines are projected to retreat by around 100 metres by the end of the century.

Sea level rise threatens infrastructure worth hundreds of billions of dollars.

More than a billion people live less than 10m above today's high-tide lines.

By the end of the century 630 million people could face annual coastal flooding.

By getting our emissions plummeting this decade, we can limit the future rate and extent of sea level rise, meaning fewer communities are displaced from their land and homes.



OCEAN ACIDIFICATION

Thirty percent of the carbon emitted by burning fossil fuels has been absorbed into the ocean, which has in turn made the entire ocean more acidic.

Ocean acidification makes it more difficult for organisms like corals, mussels and oysters to form shells and skeletons.

Ocean acidification is already reducing the size of Sydney rock oysters.

In coming decades acidification will have widespread consequences for ocean biodiversity, and for fisheries and aquaculture - threatening food security for millions of people.

Every action that we take to limit carbon emissions will help to slow ocean acidification.

OCEAN TIPPING POINTS

Perhaps most worryingly of all, as the oceans continue to warm we risk crossing 'tipping points' in the Earth's climate system. These represent thresholds which, when crossed, will trigger abrupt, irreversible and self-perpetuating changes to the world's climate and oceans. Tipping points include the loss of polar ice sheets and associated sea-level rise and the collapse of major ocean currents that distribute heat around the globe.

The consequences of crossing these tipping points would be widespread and catastrophic. For example, the collapse of major ice sheets on Greenland, West Antarctica and East Antarctica would commit the world to 10 metres of irreversible sea level rise.

Most tipping points were once considered likely only if the world exceeded 5°C of warming. However we now know that tipping points can be crossed at much lower levels of warming. It is possible that even at today's level of warming - around 1.2°C above the long-term average - we have *already* crossed tipping points for the Greenland and West Antarctic ice sheets, and for tropical coral reefs (Armstrong, McKay et al. 2022). A recent review paper setting out the state of the science on tipping points finds that warming of between 1.5°C and 2°C - that is, within the Paris Agreement temperature goal - makes the crossing of these and other tipping points not only possible, but *likely* (Armstrong, McKay et al. 2022). Furthermore, we know that crossing climate tipping points can generate self reinforcing 'feedback loops' that increase the likelihood of crossing other tipping points.

If we fail to dramatically and urgently curb greenhouse gas emissions this decade, we risk crossing multiple tipping points in the Earth's climate system in coming decades - raising the risk of destabilising yet other tipping point elements. If such a 'tipping cascade' scenario were to be set in motion, the Earth would continue to warm until it reaches a new stable state (Steffen et al. 2018; Lenton et al. 2019). Transition to such a 'Hothouse Earth' would lead to the extinction of many species, and would make life for humans difficult and dangerous.

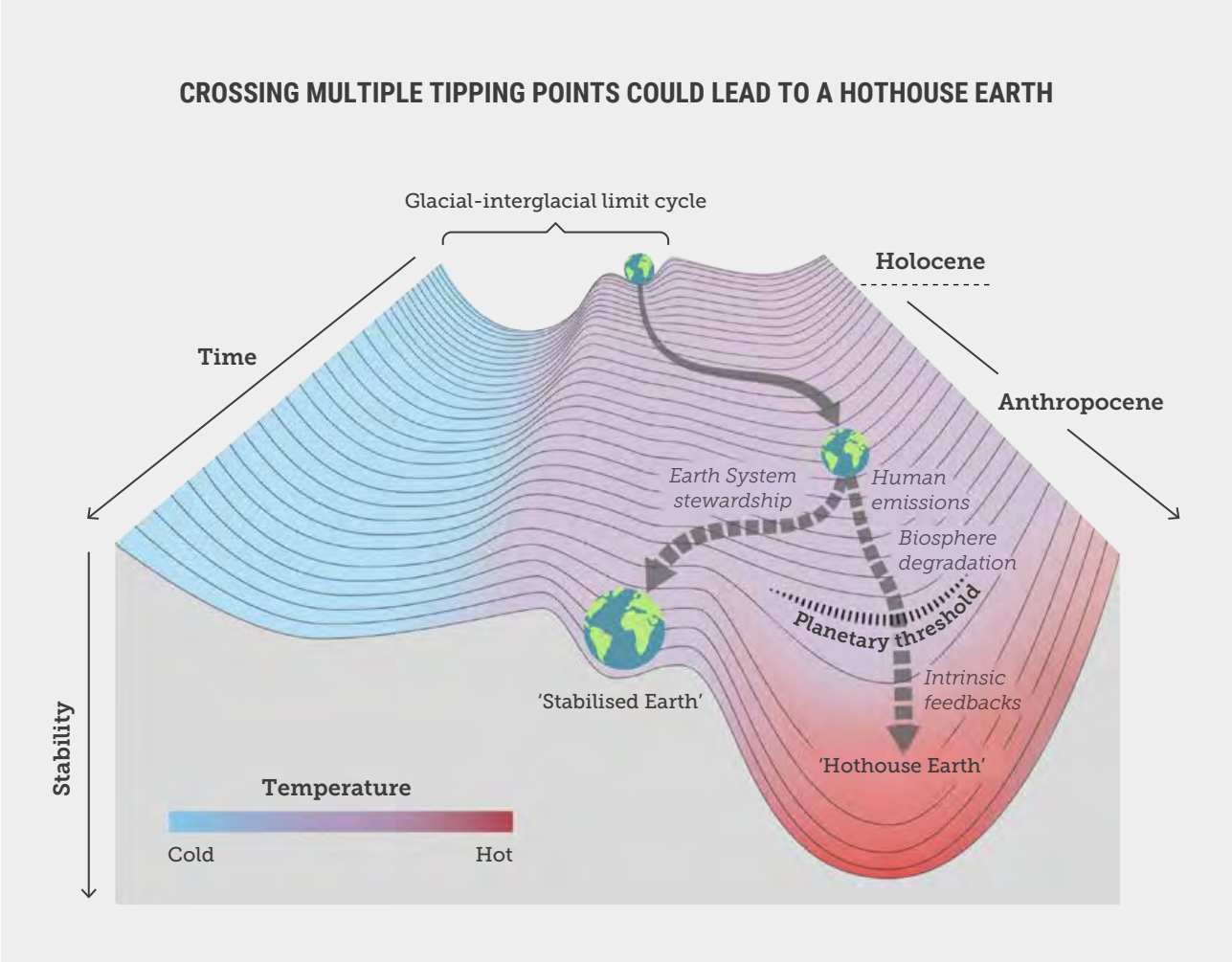


Figure 24: A 'stability landscape' showing two potential pathways for the Earth System. Beyond the 'planetary threshold', a potential tipping cascade could take the trajectory of the system beyond human control and irreversibly towards 'Hothouse Earth'. **Source:** Steffen et al. 2018.

BOX 3: OUR OCEAN PLAYGROUND IS AT RISK

For many Australians, the ocean is not only a source of security and sustenance, but a place for play and recreation. Unfortunately, climate change threatens to disrupt one of Australia's most iconic pastimes, surfing, as sea level rise and changing wind and swell patterns undermine treasured surf spots around the country.

Around half a million Australians are surfers, regularly drawn to the ocean by the sheer joy of riding the energy of waves (Sport Australia 2019). Climate change is creating a warmer and more energetic ocean-atmosphere system, which means more energy for wind and waves. At first blush this might sound like good news for surfers - bigger waves! However, while there could be an increase in the incidence of very large waves in some places, many locations will see surf conditions deteriorate (Climate Council 2021).

Observed increases in wave heights have occurred mostly at higher latitudes away from the Australian coastline, in particular in the Southern Ocean (Young and Ribal 2019). In fact, an analysis of trends in wave heights at 16 international surfing locations since the 1970s has found that in most cases wave heights are actually trending downwards (Willis 2018).

Figure 25: Many surfers are passionate about tackling climate change. Surfers for Climate Action is an Australian organisation that brings surfers together to campaign against coastal and offshore fossil fuel development.

BOX 3: CONTINUED

Shifts in large-scale wind and swell patterns due to climate change are also driving changes in wave direction and the angle at which waves hit the coast (Hemer et al. 2013, Erikson et al. 2015). Combined with sea level rise, these changes are dramatically reshaping coastlines, changing some much-loved Aussie surf locations. Loss of coral reefs, impacts on sandbars, and other factors is also altering where and how waves break.

As some breaks are lost to sea-level rise and coastal erosion, some new ones will also form. However, with so much of our coastline rimmed with houses, sea walls and other structures, in many instances beaches will simply disappear and these existing coastal developments will create a hard barrier that prevents new spots from forming.

Surfing could also be impacted by the southward migration of tropical marine species as Australian waters warm. The deadly irukandji jellyfish is spreading further south and their season is lengthening (Carette and Seymour 2013). Irukandji have been observed as far south as Hervey Bay and Fraser Island and could eventually be found as far south as the Gold Coast, presenting a real threat to surfers (Climate Council 2018a).

Climate-fueleld extreme weather events may mean that at times it is not safe to catch waves at all. In March 2022, major flooding in Northern New South Wales Southern Queensland led to pollution in the ocean, as flood and storm water - and even raw sewage - flowed into the sea. For weeks after the floods, dozens of people presented to health services with ear, eye and skin infections after surfing at iconic beaches at Byron Bay and the Gold Coast (ABC 2022).Overall, when it comes to the future of surfing, the one silver lining - the chance of chasing even bigger waves - is likely to be overshadowed by the loss of much-loved surf breaks, new dangers, and damage to coastal communities and to marine ecosystems.

Whether you are an elite surfer or one of the millions who enjoy a lazy Sunday afternoon at the beach, climate change is harming the ocean playground we love, and must now fight to protect.

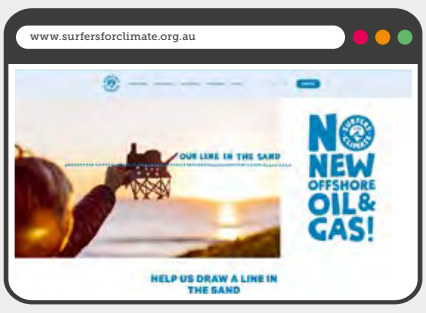
5 ways that climate change affects surfing:

1. Beaches lost to coastal erosion
2. Dangerous pollution from flood events
3. Treasured surf breaks changing
4. Migrating species - including deadly jellyfish - present new risks
5. Damage to marine ecosystems and coastal communities we love.

SURFERS FOR CLIMATE

Surfers for Climate Action is an Australian organisation that brings surfers together to campaign against coastal and offshore fossil fuel development.

Visit surfersforclimate.org.au



5. Ocean solutions to the climate crisis

The ocean is at the centre of the climate change story. Climate change, driven by the burning of fossil fuels, is causing major changes to our ocean, with profound implications for communities worldwide. Our first priority is to limit these harms by breaking our addiction to coal, oil and gas.

There is a less commonly explored side to the story, however, and that is the critical role of the ocean in climate solutions. The ocean holds vast quantities of carbon, helping regulate atmospheric concentration of carbon dioxide. While climate change is the greatest threat to our ocean, ocean ecosystems continue to suffer from over-fishing, destructive coastal developments, and plastic pollution.

Damage to marine ecosystems reduces the ocean's ability to absorb and store carbon, and its ability to protect us. Preserving and actively restoring marine ecosystems is a critical part of global efforts to tackle the climate crisis.

Supporting sustainable fisheries throughout our oceans is also an important part of the climate solution, as seafood is a low carbon source of protein.

In this section we explore a range of ocean-based climate solutions, and ways we must protect our ocean so that it can continue to protect us.

BLUE CARBON

Like great forests on land, coastal ecosystems like seagrass beds, saltmarshes, and mangroves absorb and store large amounts of carbon. They also provide a nursery for many fish species, filter pollutants from the water, and provide a protective barrier for the coast that reduces erosion and flooding. Protecting and regrowing these 'forests of the sea' is essential to tackle the climate crisis, and to adapt to its impacts.

The term 'blue carbon' describes the carbon stored in marine ecosystems - in particular the vegetation and sediments of coastal ecosystems (Pendleton et al. 2012; Christianson et al. 2022). Seagrass beds, mangroves and saltmarshes, cover around 49 million hectares globally (Pendleton et al. 2012). These are some of the most carbon-rich ecosystems on the planet, and incredibly efficient at absorbing and storing carbon. It is estimated that mangroves and coastal wetlands absorb carbon at a rate two to four times greater than mature tropical forests (McLeod et al. 2011), and store three to five times more carbon than tropical forests covering the same area (Donato et al. 2011; Pendleton et al. 2012). They store carbon accumulated over hundreds to thousands of years in deep, organic rich sediments.

Tragically, around two-thirds of the world's mangroves have been lost or degraded (IUCN 2017). When these and other ecosystems are disturbed or destroyed, the stored carbon can be released, contributing to the atmospheric concentration of greenhouse gases. While recent conservation efforts have been effective in slowing the rate of loss, we continue to lose vast areas of mangroves to human activities every year (Leal and Spalding 2022).

Halting and reversing the loss of mangroves, seagrass beds and saltmarshes is an urgent global priority. Besides their value as an essential 'carbon sink', mangroves are an important coastal defence for many low-lying communities, and in many cases are critical for food security livelihoods.

Efforts to protect and restore ocean and land-based ecosystems - while vital - are no substitute for accelerating the phase out of fossil fuels. They cannot be used to 'offset' emissions from the burning of fossil fuels. This is because the processes that eventually return carbon to long-term storage underground take a very long time (Climate Council 2023b). There is also considerable imprecision and uncertainty in accounting methods for blue carbon (Climate Analytics 2017). With climate change itself posing a growing threat to coastal ecosystems, restored mangroves, seagrass beds and other ecosystems may again be lost to rising ocean temperatures and other impacts of our changing climate (Chatting et al. 2022).

Mangroves and coastal wetlands absorb carbon at a rate two to four times greater than mature tropical forests. Halting and reversing the loss of these 'blue carbon' ecosystems should be an urgent global priority.

30 X 30

The good news is, significant efforts are already underway worldwide to protect our oceans. These include creating or expanding marine protected areas, implementing sustainable coastal development practices, and promoting international agreements.

In 2022, at the UN Biodiversity Summit (COP15), the global community committed to conserving 30 percent of coastal and marine ecosystems by 2030. Expanding marine protected areas, including Indigenous protected areas, can play a vital role in protecting and restoring blue carbon.

PROTECT THE OCEAN SO IT CAN PROTECT US

Patagonia Australia is calling on the Australian government to fully protect 30 percent of Australia's oceans by 2030 and prioritise First Nations custodianship of Sea Country.

Visit www.patagonia.com.au for more information and to sign the petition.

BOX 4: FARMING SEAWEED TO CUT EMISSIONS

The ocean has some surprising possible solutions for tackling the climate crisis, like growing seaweed to cut methane emissions from the burps and farts of cows and sheep!

Grazing animals are a significant source of emissions in Australia's agriculture sector because cattle and sheep produce methane during digestion which is 'burped' into the atmosphere. This is problematic because, measured over a 100 year period, methane is about 28 times more powerful than carbon dioxide when it comes to its role in driving global warming (IPCC 2013, Ch.8).

Australian researchers at the CSIRO have found that a certain type of seaweed - *asparagopsis* - can reduce cow burps and farts when added in small amounts to cattle feed. Trials are continuing, as scientists assess the consequences of adding seaweed to feed and the potential to cut methane emissions. With the agricultural industry moving to cut emissions, seaweed farming to feed cows could become a booming business. The Australian Seaweed Institute forecasts that the Australian *asparagopsis* market could be worth $100 million by 2025 and $1.5 billion by 2040 (Kelly 2020).

Figure 26: Seaweed farmer Sam Elsom is growing seaweed at Triabunna, north of Hobart. His business *Sea Forest* is backed by some of Australia's biggest investors and is a nominee for the prestigious global 2022 Earthshot Prize, set up in 2020 by Prince William and nature documentarian Sir David Attenborough.

OCEAN-BASED RENEWABLE ENERGY

The amount of energy carried by ocean currents, waves and winds is colossal. Ocean-based renewable energy sources offer tremendous potential when it comes to replacing fossil fuels and reducing global greenhouse gas emissions.

There are several ways to harness energy from the ocean:

- Energy from waves can be captured by devices that move with the motion of the waves, converting the kinetic energy into electricity.
- Underwater turbines can capture energy from the predictable flow of tides.
- Ocean Thermal Energy Conversion (OTEC) utilises the temperature difference between warm waters at the surface and cold deeper waters to generate electricity.
- Offshore wind farms capture the energy from strong and consistent winds available at sea.

Most of these technologies are yet to be widely utilised. However, offshore wind is the exception, and has already been deployed at scale by countries including China, the UK, Germany and the Netherlands. Australia's offshore wind industry remains in its infancy but has great potential. Our offshore wind resources are some of the world's best, with the theoretical potential to meet all our energy needs many times over (Climate Council 2021b).

6. El Niño, extreme heat and fires: How oceans are driving our weather

The ocean has a major influence on weather around the world. Variations in ocean currents, changes to ocean wind patterns, and shifts in ocean heat content have a big impact on the rainfall and temperatures we experience everyday.

Most people know Australia is a sunburnt country, a land of drought and flooding rains. What is less well known is how Australia's weather patterns are shaped by the ocean.

Life in the outback, even thousands of kilometres from the sea, is profoundly influenced by major climate drivers in the Pacific and Indian Oceans, and in the Southern Ocean.

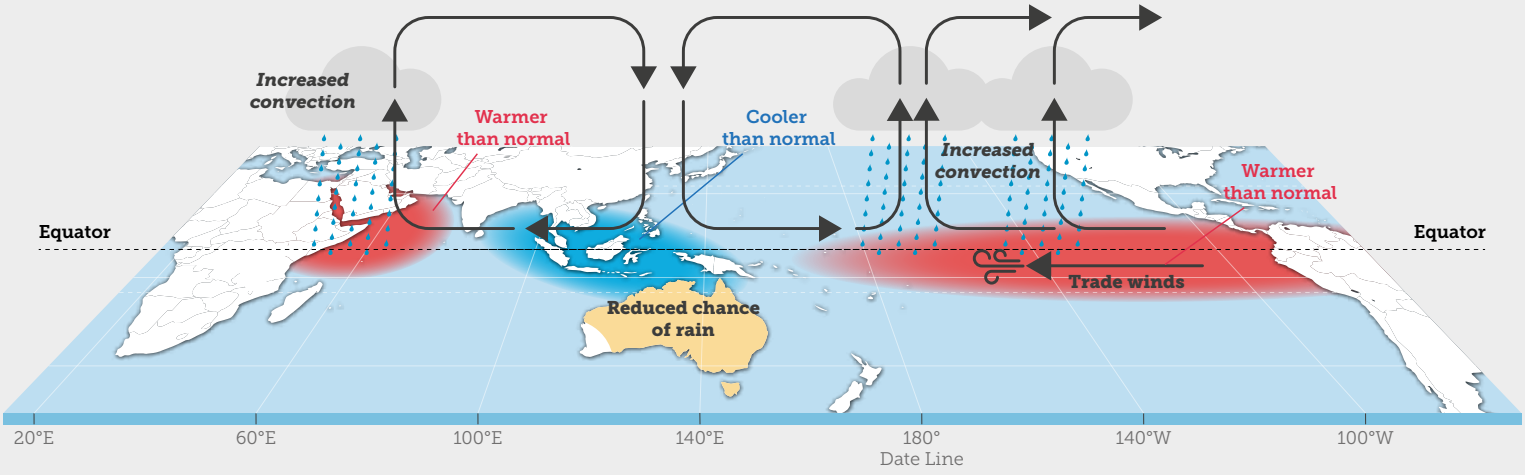
In the Pacific Ocean, the El Niño-Southern Oscillation (ENSO) is a recurring climate pattern that involves changes to the temperature of surface waters in the central and eastern tropical Pacific Ocean. ENSO is the oscillation between El Niño and La Niña states in the Pacific. El Niño events in the Pacific Ocean typically produce warmer and drier conditions for Australia, especially for the eastern half of the continent, while La Niña drives cooler and wetter years.

In the Indian Ocean, differences in sea surface temperatures between the tropical western and eastern Indian Ocean is known as the Indian Ocean Dipole (IOD). The Indian Ocean Dipole oscillates between positive and negative states. A positive IOD typically produces drier conditions over parts of Australia - especially in Spring and Summer - while a negative IOD drives wetter conditions.

In the Southern Ocean, the Southern Annular Mode (SAM) is a recurring pattern that sees a band of prevailing westerly winds move southward away from Australia during a positive SAM phase and northward during a negative SAM phase, with impacts on rainfall in southeast Australia especially.

The 2023-24 summer will be influenced by major climate drivers in the Pacific and Indian Oceans. In spring of 2023, the Pacific Ocean swung from a protracted La Niña phase to an El Niño phase. The Indian Ocean shifted to a positive IOD phase at the same time. The co-occurrence of these climate drivers means that Australians can expect a hotter and drier spring and summer, with greater risk of extreme heatwaves, flash drought and deadly bushfires. There is also a significant risk of marine heatwaves and mass bleaching of the Great Barrier Reef.

Figure 27: When an El Niño event and a positive Indian Ocean Dipole occur at the same time, this can mean reduced rainfall is expected for most of the continent. In September 2023 the Bureau of Meteorology formally declared an El Niño and a positive IOD event.



Indian Ocean Dipole (IOD): **Positive phase**

El Niño-Southern Oscillation (ENSO): **El Niño**

BOX 5: HOW THE OCEAN CONTRIBUTED TO AUSTRALIA'S BLACK SUMMER

When warmer-than-normal water accumulates in the ocean further away from the Australian continent - as happens off Australia's west coast during a positive phase of the Indian Ocean Dipole and off the east coast during a El Niño event - there is a decreased chance of rainfall across much of the continent, and an increased chance of heatwaves, droughts and bushfires.

Australia has recently experienced similar ocean conditions. In 2019, the Indian Ocean underwent the strongest positive IOD event this century (Ratna et al 2020; Shi 2021). At the same time conditions in the Pacific Ocean were very close to the threshold for an El Niño event. The United States declared an El Niño while the Australian Bureau of Meteorology, which uses different criteria, did not. These trends in the Indian and Pacific Oceans were a key reason why 2019 was the hottest and driest year on record in Australia (BoM and CSIRO 2020). In 2019, the southeast of the continent experienced severe and protracted drought conditions, while warm and windy conditions during spring and early summer led to repeated periods of severe fire weather (Climate Council 2020). This led to the catastrophic 'Black Summer' bushfires that burned 186,000 square kilometres (an area larger than South Korea). Nearly three billion animals - including 60,000 koalas - were caught up in the devastating bushfires (van Eeden et al 2020). The economic costs of the Black Summer fires were estimated at close to $100 billion, making them Australia's costliest disasters on record (Read and Dennis 2020).

Conditions across Australia, even thousands of kilometres from the coast, are heavily influenced by what's happening in our oceans.

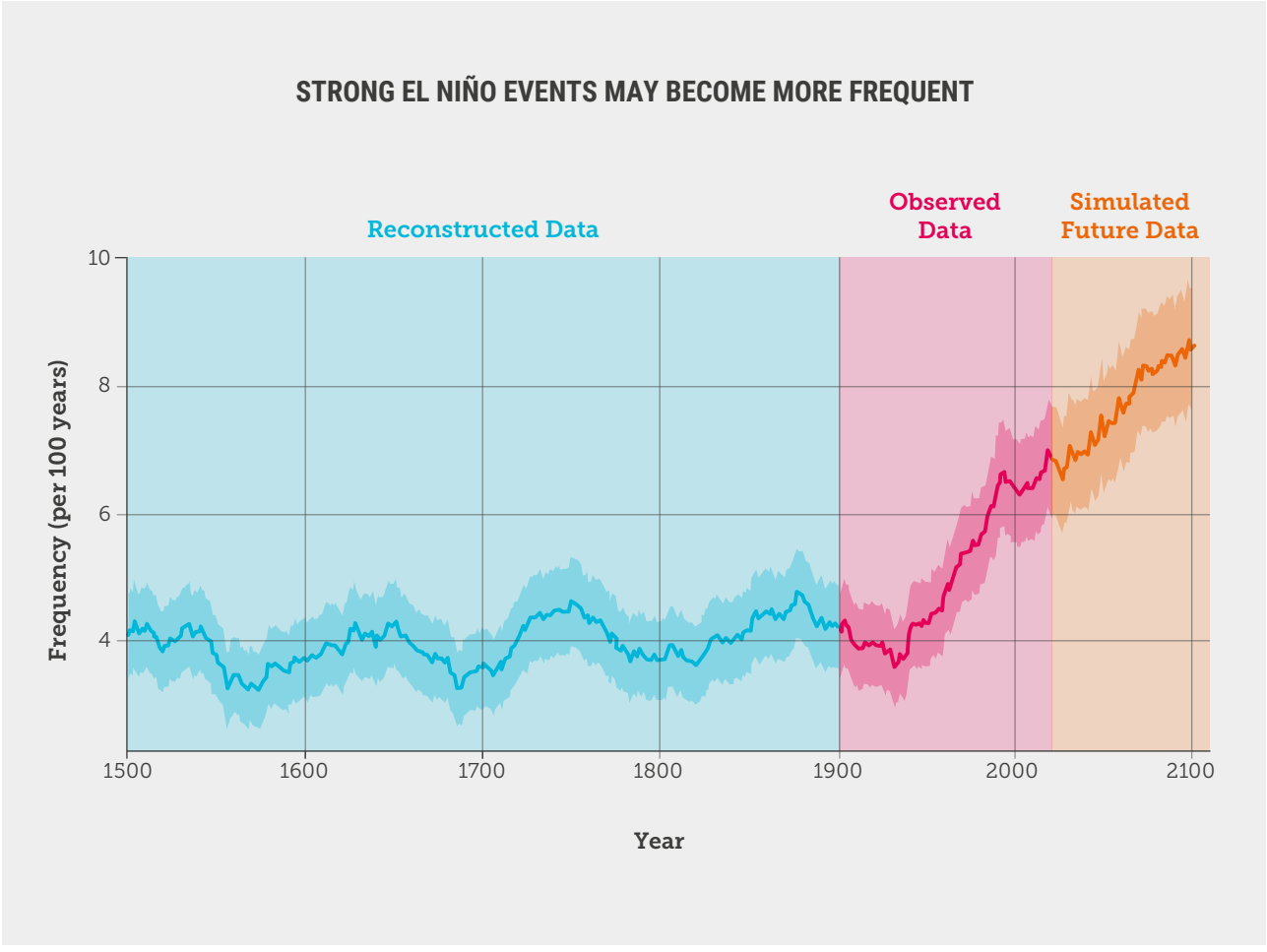
Figure 28: Climate drivers in the Indian and Pacific Oceans have a major influence on Australia. When the Pacific is in an El Niño phase and the Indian Ocean Dipole is in a positive phase, hotter and drier conditions are more likely, which in turn can lead to catastrophic bushfires.

CLIMATE CHANGE MAKES STRONG EL NIÑO EVENTS MORE FREQUENT

Climate change is heating the world's oceans and atmosphere. This means year-on-year variability in ocean climate patterns is occurring against a backdrop of an underlying warming trend that exacerbates natural variability, making swings - between La Niña and El Niño states, or positive and negative IOD events - both more frequent and more extreme. Recent research led by Australian scientists has found that extreme El Niño events may happen twice as often this century as they did during the 1900s (Cai et al. 2023).

An increase in the frequency of strong El Niño and La Niña events means more pronounced swings between periods that are wetter than average and those that are drier. This increases the chances of devastating floods, following shortly after or before deadly heatwaves, and extreme fire conditions. In 2023, Australia is already facing this reality, as we switch from a protracted La Niña event to the return of El Niño conditions (Climate Council 2023b).

Figure 29: Recent research by Australian scientists estimates extreme El Niño events may happen twice as often in the 21st Century. (Adapted from Cai et al 2023; Newton et al 2023.)



Climate change is also increasing the frequency and intensity of climate drivers in the Indian Ocean. Positive IOD events - linked with drier conditions - have already become more common over the 20th Century (Abram et al 2020; Abram et al 2008). Positive IOD events have also become stronger and more frequent, especially since the 1960s.

As the oceans continue to warm, strong positive IOD events - like the one Australia experienced in 2019 ahead of the Black Summer bushfires - are also projected to occur more frequently (Abram et al 2020; Cai et al 2021). The current 2023 positive IOD event has been strengthening over spring and is contributing to Australia's hot and dry outlook for summer (Domensino 2023a).

Figure 30: Climate change is increasing the frequency and intensity of El Nino events in the Pacific Ocean. This has huge consequences for Australia. We will see hotter and drier summers, with greater risk of bushfires and deadly heatwaves.

7. Sea Country: First Nations perspectives

> *"The ocean is what connects us all."*
>
> - Tishiko King (Tish) is a proud Kulkalaig woman from Masig in Zenadth Kes (Torres Strait Islands), a marine scientist, prominent climate justice activist, and co-author of this report.

In this edited conversation, Tish describes how climate and ocean change is impacting her community, discusses some of the barriers facing First Nations peoples, and highlights the importance of working together to safeguard our common future.

Reflecting on a recent expedition to Antarctica, Tish reveals how we are all connected by the ocean, dependent upon it for our survival, and profoundly affected by recent changes. Finally, Tish explores the common bond that First Nations, Pacific Island communities, and non-Indigenous Australians have with the ocean, and the opportunities to all work together through this make-or-break decade for climate action.

Tell us a little about yourself, your community, and your work

I am a proud Kulkalaig woman from the Kulkalgal nation and the island of Masig in the Torres Strait Islands. I was raised on my mother's side, on Masig, which is in the central island group. Though through my father's side I also have strong blood connections to the Themu Clan and to Badu island, which is in the southern group.

The ocean has always given me a sense of connection and wholeness, and been at the heart of my work and my purpose in life. I studied ocean science at Griffith University, have worked with CSIRO, and in a number of other roles. Today I am focused on the opportunities we have to create a safer climate and more equitable future.

I did not foresee that this is what I would end up doing. But when you know what is happening to our climate, our ocean, and our communities, you have a sense of responsibility. We only have one life on this planet, and we have to fight for our families and for the people and places that we love.

As a marine scientist and Kulkalaig woman, what are some of the changes you are seeing in our ocean and how are these affecting your community?

I began my research in Western Australia on the Ningaloo Reef, before moving to Meanjin (Brisbane). There, my supervisor was focused on how the movement of species due to climate change would affect coastal populations dependent on their local marine resources, and looking at communities in the Pacific, parts of Asia, and the Torres Strait. This included my island of Masig.

Members of my family were working together with scientists, talking about the shifts they were seeing. I felt for the first time a strong family connection to what was happening. I learned that as the ocean was warming, the natural resources that we depend upon were moving or disappearing.

When I returned to Masig, my older brother Yessie Mosby showed me areas of seagrass that had been decimated by ocean warming. These seagrass beds were home to dugongs - our totem. At the same time, as the seas rise, it is eroding away our land. The impact on our communities is deeply confronting. We are seeing our burial grounds inundated, and grave sites washed away and desecrated. It is really hard and incredibly sad.

My family doesn't have a seawall to protect them. We are using wooden palettes, coconut husks, palm leaves, and whatever else we can find to protect our church. It is an old church, made from coral, and a special place that I hold in my heart from when I was a young kid.

We also see that fruits are not growing where they used to, that our seasons are changing, and that our land and ocean are no longer in sync. As a saltwater person, our way of life is in relationship and in harmony with the land and sea. With our oceans warming and rising, it is having a cascading effect, taking away our food sources, our security, and at a rate we cannot adapt to.

This is why negotiations over 'loss and damage' under the Paris Agreement, efforts to ensure greater access to climate finance, and our recent victory through the Our Islands, Our Home campaign are all so important.

Your work has also focussed on creating spaces for Indigenous women to share knowledge and play a bigger role in decision making. Why is this so important to climate justice?

Following my early years as a scientist, I worked for a brief time in the energy industry and with a company developing wind power on Cape York. This work meant spending a lot of time listening to communities and also exposed me to the operations of the big mining corporations.

I saw, for example, how communities who had lost many of their traditional food sources were left instead to pay ridiculous prices for basic food items. I saw that people faced enormous barriers to employment. Meeting with companies, I came to realise that First Nations and women were not a priority. After a very stressful time, I moved to Naarm (Melbourne) and began working with Seed Indigenous Youth Climate Network. This opened up my life to understanding the role I could play as a Torres Strait Islander person, to my cultural responsibility, and to how I can use my education as a weapon to help protect my island home.

More recently, I have been involved with a program called Sea Women of the Great Barrier Reef. Such initiatives create space for sea women to share their knowledge

and for First Nations people to play a leading role in vital efforts to protect our reefs. We are coming to understand not only the damage to our reefs, but also their natural resilience, and how working together we can ensure vibrant and diverse marine ecosystems. Ultimately, self-determination and women's rights become vital to protecting sea country and to building a more sustainable future. We have the solutions, and it is vital that we learn and work together, sharing knowledge across generations.

You have recently visited Antarctica. What did you learn?

Going to Antarctica is an experience I am very grateful for. Antarctica is like a root of our entire ocean and life support system. Invertebrates like krill that swim in Antarctic waters are a foundation of the marine food web. Ocean currents that begin in Antarctica shape weather patterns around the world, creating the conditions that we depend upon for our survival. It is a reminder of our connectedness. Everyone on Earth depends on what happens down there. It is incredibly beautiful. It is also the most vulnerable ecosystem on the planet and reaching a tipping point. When it changes, it impacts us all.

Everywhere we saw the signs of rapid change. Great chunks of ice calving off to expose ancient blue ice. Tonnes and tonnes of water being added. Constantly. On one occasion, as we had just entered a bay under beautiful blue skies, surrounded by waddling chinstrap penguins, I looked up and saw an enormous cliff of ice collapse in front of me. I had that heart crunching feeling again. At first I did not know what to do. I had to walk away and I cried a little. But it put a fire in my belly and made me really angry. As a developed nation, we have a responsibility to protect our Southern Ocean. We have to be leaders because we have so much at stake.

How do you feel when the Government approves a new coal mine?

Honestly, I am dumbfounded.

Our environment, climate change, biodiversity, culture, the wellbeing of communities... it is all fundamentally connected. And yet our decision making structures, our ministerial portfolios, are siloed and disconnected. We have environmental laws for assessing new projects that don't even factor in climate change. And so we end up approving new coal mines, in full knowledge that they are putting our future even more at risk.

Every new mine we approve is setting us back decades. And we do not have time. My people don't have time. Our brothers and sisters in the Pacific don't have time. Our oceans are rising.

You will shortly be heading to Fiji. How are First Nations and Pacific Island communities working together to protect our climate and our ocean?

Connections and collaborations are so important to this work. First Nations come together with Indigenous communities of other islands because we are in this shared struggle together, and it is global in scale.

I have had the honour of working with and learning from a group called the Pacific Climate Warriors, who have inspired me in how we can tell our stories and use what is in us to keep our fire burning and bring people along with us. I say this with great respect, as we have received tremendous love and kindness from our Pacific brothers and sisters. It has taught us about the power of our stories, how we can talk about climate change within our communities, and the power of working across borders and across cultures.

There is an important opportunity right now to strengthen not only relationships between First Nations and non-Indigenous Australians, but between First Nations and Pacific Island communities. We are going to continue to sit down together, learn together, support our young people, and support each other to lead.

What can the Australian Government do to protect our oceans and tackle the climate crisis?

We know what is needed to protect our futures: leaving fossil fuels in the ground, having the resources to adapt to our changing climate and ocean, being able to access funds to address loss and damage. The Australian Government can champion these priorities on the world stage. It can also fund grassroots and community organisations who are working to protect their communities and to bring their knowledge and solutions to the table. And it can provide basic practical support, such as adequate funding for the construction of seawalls, for communities in the Torres Strait who are struggling to protect their homes, food and water sources, and sacred sites from the rising ocean.

Right now, the Australian Government has rejected our recommendations - refusing to pay for losses and damages, and continuing to approve new fossil fuel projects. It has failed to support the priorities of Pacific Island countries. We saw recently during New York Climate Week, Australia being put in the spotlight and challenged to do better. It has the opportunity to do so much better.

Limit warming to 1.5°C means giving us a fighting chance. 2°C could mean the end. Australia holds the weapons that can make us or sell us out.

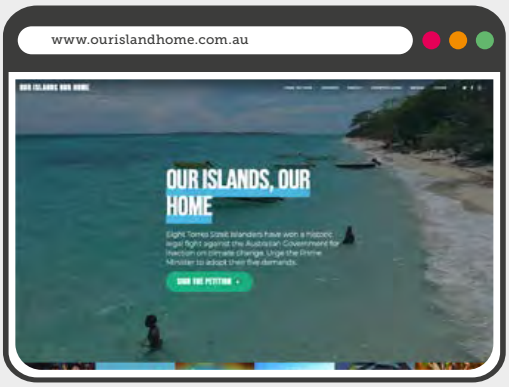
We have the opportunity to work together: First Nations, Pacific Island nations, non-Indigenous Australians. It starts by listening, and understanding what we all have in common. The ocean is what connects us all together.

OUR ISLANDS, OUR HOME

Our Islands, Our Home is a campaign led by Torres Strait Islanders to protect their island homes.

On 23 September 2022, the Torres Strait 8 made international legal history after the United Nations Human Rights Committee found that the Australian Government is violating its human rights obligations to Torres Strait Islanders by failing to act on climate change.

Our Islands, Our Home is calling on the Australian Government to resource Torres Strait Islander peoples to protect their island homes from climate damage; to transition rapidly away from fossil fuels; and to do everything possible to help limit warming to 1.5°C.



Visit www.ourislandsourhome.com.au for more information and to sign the petition.

8. Climate change in the *Blue Pacific*

Many people think of Pacific island countries as tiny and remote. But Pacific islanders see themselves as part of a broader maritime world, shaped by deep cultural ties that span across the vast ocean.

Before Europeans arrived in the region, island societies were disconnected from the large continents for centuries. During this time Pacific islanders developed an oceanic identity, as people of the ocean (Hau'ofa 1998).

Today, Pacific countries draw on cultural and economic connections with the sea to assert a contemporary identity as 'large ocean states' with sovereign rights and exclusive economic zones (EEZs) across a large part of the Earth. Pacific island countries have also developed a shared narrative for their ocean region, which they have labelled the *Blue Pacific*. Drawing on pre-colonial relations across the ocean, island leaders have committed to work together as a joined up 'maritime continent' (Pacific Islands Forum 2017) and have developed a shared '2050 Strategy for the Blue Pacific' (Pacific Islands Forum 2022).

As the ocean warms, however, the people of the Pacific are increasingly vulnerable. Fish stocks are declining and their distributions are changing, marine ecosystems face widespread losses, coral reefs are bleaching, sea levels are rising and flooding coastal areas, and warmer waters are fuelling more severe cyclones.

Figure 31: As our oceans warm, many fish species are on the move. Tuna - a mainstay of many Pacific economies - are migrating away from Pacific Island countries' territorial waters.

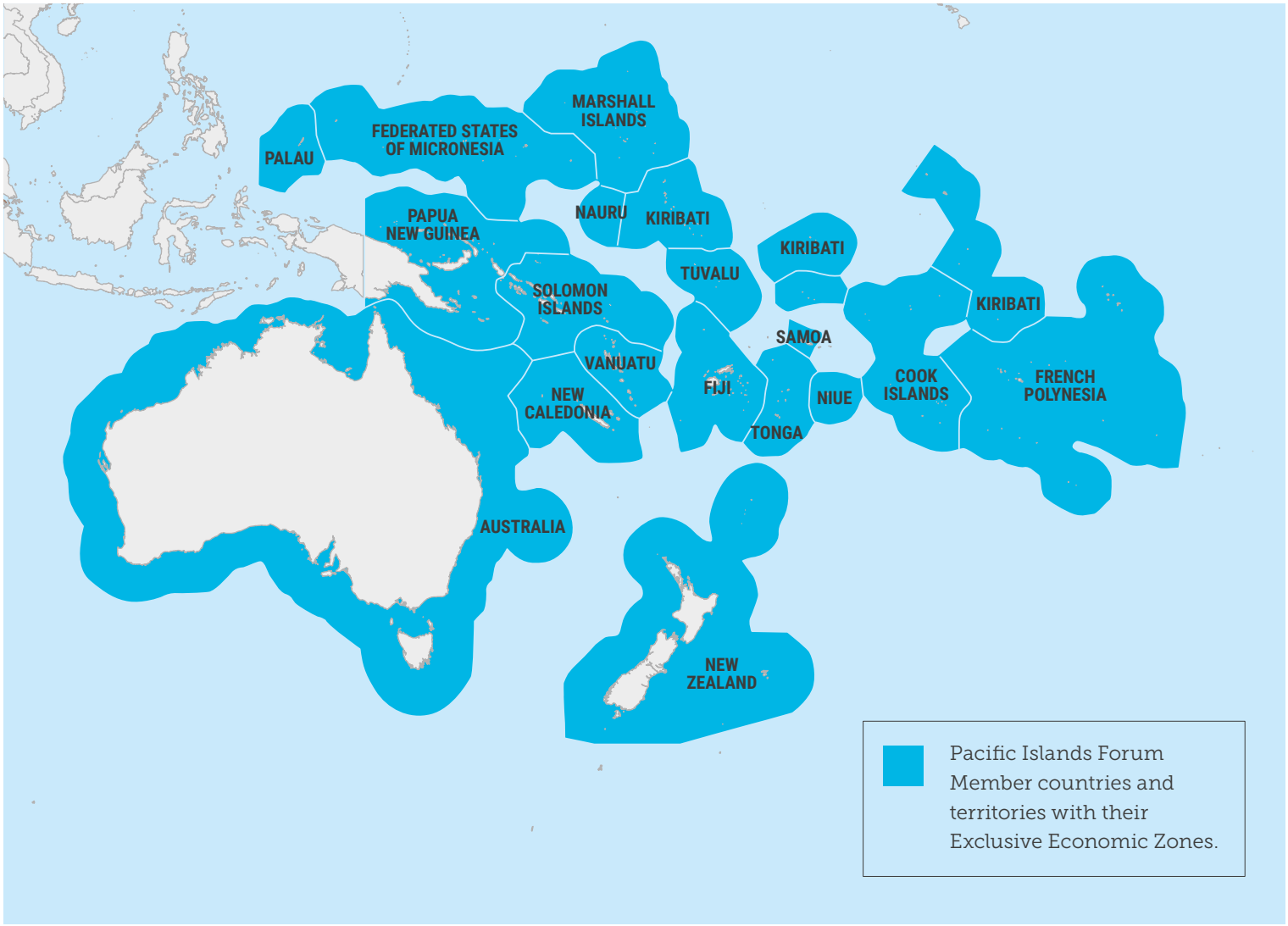


Figure 32: Pacific Island countries are custodians of vast areas of the world's ocean.

FISHERIES ON THE MOVE

Climate change is changing the distribution of tuna in the Pacific Ocean, with devastating consequences for Pacific economies. More than 50 percent of the world's tuna catch comes from the Pacific and the region's fishery is worth around US$6 billion (Hanich et al 2021). Ten Pacific nations rely on fisheries for a substantial proportion of national income, with fishing access fees comprising up to 70 percent of government revenue for some nations (Bell et al 2021).

As the Pacific Ocean warms, key tuna species are shifting away from national waters into the high seas. For the ten Pacific nations most dependent on income from fisheries, this means a potential 13 percent decline in those species by 2050, a yearly loss of around $90 million in access fees and an average drop in government revenue of 13 percent (Bell et al. 2021; Goodman et al. 2022).

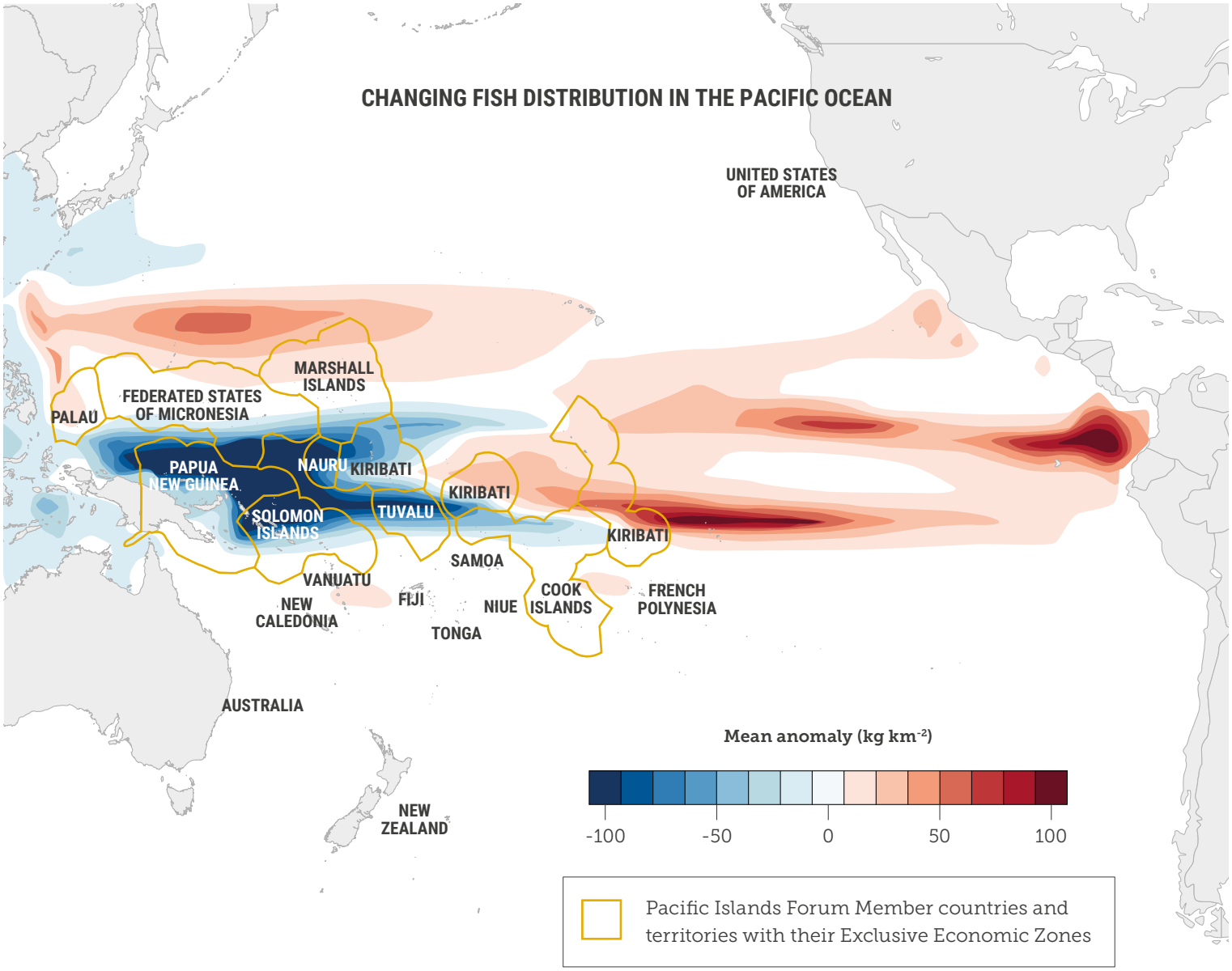


Figure 33: This map shows the projected change in the biomass distribution of skipjack tuna by mid-century, under a high emissions scenario. By 2050 areas in dark blue will have up to 100kg *less* skipjack tuna per km^2 while areas in dark red will have up to 100kg more. (Adapted from Bell et al 2021.)

UNDERMINING FOOD SECURITY

A warming ocean also impacts the food security of Pacific island communities. Changes in ocean temperatures, pH, dissolved oxygen, storms and waves are already affecting marine ecosystems, leading to widespread loss of marine habitats such as coral reefs, seagrass beds and mangroves - and subsequent declines in important fish species that depend on these habitats and are a crucial source of food for island communities.

Warming waters pose a particular threat to the coral reefs that have been a key source of food for Pacific islanders for countless generations. The IPCC is clear that even with 1.5°C of warming, between 70 and 90 percent of tropical coral reefs will likely not survive due to repeated bleaching events (IPCC 2018). That number rises to 99 percent with 2°C of warming. Impacts for marine life and island communities that rely on reef ecosystems will be devastating.

Figure 34: Pacific communities rely on healthy oceans for their food security. Rising oceans temperatures, ocean acidification and other impacts of climate change are leading to loss of critical marine habitats and declines in important fish species.

RISING SEAS: AN EXISTENTIAL THREAT

For Pacific atoll nations - which are almost wholly made up of reef and sand and rise only metres above the waves - the warming ocean presents a profound threat. They now face a challenge to their very existence as sea levels rise, flooding drinking water and steadily undermining the territorial integrity of their island homes.

Almost all of the islands of low-lying atoll nations like Kiribati, Tuvalu and Marshall Islands are less than five metres above sea level at their highest point. The global mean sea level rose by around 20 centimetres between 1901 and 2018 (IPCC 2021). The rate of sea level rise has been accelerating since the 1990s, with almost half (8cm) of the rise in global average sea levels occurring since 1993 (IPCC 2021). A recent study commissioned by the US military found that sea level rise will make dozens of atoll islands uninhabitable from the middle of this century, as salt-water intrusion undermines access to drinking water (Storlazzi et al. 2018).

Sea level rise also threatens the maritime boundaries of Pacific nations. The outer edges of maritime Exclusive Economic Zones (EEZs) are measured 200 nautical miles from coastal baselines. As coastal areas become inundated, those baselines are eroded and EEZs could shrink or disappear altogether. To avoid this, Pacific nations are measuring their maritime zones using GPS coordinates instead, and are demanding other nations recognise their existing rights in perpetuity. In 2021 Pacific leaders issued a regional declaration proclaiming their existing maritime sovereign rights "shall continue to apply, without reduction, notwithstanding any physical changes connected to climate change-related sea-level rise" (Pacific Islands Forum 2021).

Figure 35: A number of Pacific countries are made up of atoll islands that are just metres above the waves. In 2021 Tuvalu Foreign Minister Simon Kofe addressed the UN climate talks from knee-deep in water to highlight the threat posed by sea level rise.

MORE DESTRUCTIVE STORMS

A warming ocean is 'supercharging' destructive cyclones in the Blue Pacific. While Pacific island countries are no strangers to cyclones, hotter oceans are fuelling more severe tropical cyclones. In the past 10 years, Pacific nations have been struck by a string of severe Category 5 cyclones that have killed dozens, left tens of thousands of people in emergency shelters, decimated food crops, and crippled sorely needed infrastructure.

El Niño years herald a longer cyclone season that threatens a greater area. The last El Niño in the Pacific was in 2015-2016. In February 2015 Vanuatu was devastated by Cyclone Pam, the strongest recorded storm at that time to make landfall in the Pacific, with economic losses equivalent to 64% of Vanuatu's GDP (Asian Development Bank 2015). In March 2016 Fiji was hit by an even stronger storm, Cyclone Winston, which was the most powerful storm recorded in the southern hemisphere. Winston left 32,000 homes damaged or destroyed (Red Cross 2017). These storms provide a terrifying window to our warmer future, when severe storms become more frequent. As the Pacific Ocean warms, Category 5 storms could occur four times more often by the end of this century (Thomas et al. 2016).

Figure 36: A warming ocean provides more energy for tropical storms. Over the past decade Pacific island nations have been struck by a string of Category 5 Severe Tropical Cyclones, including the strongest storms ever recorded in the region.

TOWARD A *FOSSIL FUEL FREE PACIFIC*

Pacific island nations have been global leaders for climate action for decades. Pacific diplomats played an important role helping to secure the 2015 Paris Agreement, which is the key means we have to cooperate to cut global emissions. Pacific negotiators were central to securing the Paris temperature goal of limiting warming to 1.5°C, and have put oceans on the agenda for UN climate talks.

Today, Pacific island countries are spearheading a campaign to phase out fossil fuels. Pacific leaders have set out an agenda for a *Fossil Fuel Free Pacific* that is intended to accelerate the clean energy transition in Pacific nations and speed up a global phase out of coal, oil and gas. At the regional level, Pacific nations have called for the establishment of a new Pacific Energy Commissioner to help drive the clean energy transition in the Pacific.

At the global level, Pacific countries are leading a diplomatic campaign for a Fossil Fuel Non-Proliferation Treaty. This would help to govern the end of fossil fuel expansion and facilitate an equitable phase out of fossil fuels.

Last year, Pacific leaders formally declared a Pacific climate emergency. Pacific nations, including Australia and New Zealand, also committed to achieving net zero emissions as part of a 2050 Strategy for the Blue Pacific. Since then, Pacific ministers have held a series of dialogues on 'Pathways for the Global Transition Away from Fossil Fuels'.

In March 2023, a grouping of Pacific island ministers issued a *Port Vila Call for a Just Transition to a Fossil Fuel Free Pacific*. The goals of the Port Vila Call have since been endorsed at a series of Pacific regional ministerial meetings.

At the 2023 Pacific Islands Forum - which will be held in the Cook Islands from November 6-10 - Australian Prime Minister Anthony Albanese will be asked to endorse the Port Vila Call and join Pacific island leaders to issue a Declaration for a Just Transition to a Fossil Fuel Free Pacific.

Figure 37: Pacific Island countries including Vanuatu and Tuvalu are leading a global diplomatic push for the phase out of fossil fuels.

Pacific island nations have been global leaders for climate action for decades, securing the 1.5°C temperature goal, putting oceans on the climate agenda, and now championing a fossil fuel free Pacific.

BOX 6: HOSTING THE UN CLIMATE TALKS IN THE BLUE PACIFIC

Australia - the largest member country of the Pacific Islands Forum - is currently bidding to host the United Nations COP31 summit in partnership with Pacific island countries in 2026. If successful, it would be the first time the UN climate talks have been held in Australia or the Pacific. If Australia and the Pacific are successful in the COP31 bid, between 20,000 and 40,000 people can be expected to attend (Woodroofe 2022).

Hosting the UN climate talks with Pacific island countries could help to reaffirm Australia's place in the Pacific family, and as a security partner of choice for Pacific island countries. For their part, Pacific island countries see climate change as their single greatest threat (Pacific Islands Forum 2018; 2022). Hosting COP31 together is a chance for Australia to work with Pacific nations to address their key security challenge.

Australian climate minister Chris Bowen has told his Pacific counterparts he wants the UN climate summit to be "truly and genuinely a Pacific COP". He has told media in Fiji: "I want people to leave COP31, if Australia hosts it, saying, 'wow, that really was a Pacific COP'" (Bowen 2023). Pacific leaders have welcomed Australia's bid to host and have said they will advocate for the joint bid together (Pacific Islands Forum 2023). However, it is also clear that Pacific island countries expect Australia to do more to move away from fossil fuels (Morton 2023).

If COP31 is to be a 'Pacific COP' it will also need to be a summit that accelerates the *global* phase out of fossil fuels. This is key to the survival of Pacific island nations. Pacific leaders want all countries to set targets to cut emissions that are consistent with limiting warming to 1.5°C. This is seen as a key threshold to ensure low-lying atoll nations have a future. For more than a decade "1.5 to stay alive" has been the rallying cry for Pacific climate negotiators.

The COP31 summit will come in the middle of this make-or-break decade for global climate action. It is likely that Australia and the Pacific will need to shape an agenda for the summit that encourages a course correction for Nationally Determined Contributions that are currently not aligned with limiting warming to 1.5°C. Countries are expected to bring new 2035 targets to the COP30 negotiations in Brazil, but it is unlikely that these targets will collectively be ambitious enough. To be consistent with a reasonable chance of limiting warming to as close to 1.5°C as possible by the end of the century, Australia should be aiming to cut emissions by 75% by 2030 and achieve net-zero emissions by 2035 (Climate Council 2023b).

9. Conclusions and recommendations

Every community on Earth, from those who live on islands and river deltas to the highest mountain plateaus, is affected by changes in our ocean that are driven by climate change and the burning of coal, oil and gas.

The ocean's fate is our fate. It is the engine of the global climate system, the lifeblood of our economies, and a source of sustenance. For many communities, the ocean lies at the heart of their identity and culture. For all of us, our future is fundamentally tied to effective action to protect our climate and ocean.

For Australians, this dependency is particularly strong. We are an island continent, bordered by the Pacific, Indian and Southern Oceans. Our weather is strongly influenced by oceanic climate drivers including the El Niño-Southern Oscillation. Australia's climate, in particular our rainfall, is already characterised by big variations from year to year. A warming ocean and climate amplifies the swings from extreme wet to hot and dry - increasing the risks of floods, fire and extreme heat. Our population and infrastructure is highly concentrated along the coast and is vulnerable to rising seas and storm surges.

Beyond our shores, the large ocean states of the Pacific - custodians of vast tracts of the world's ocean - face a truly existential challenge from rising seas, migrating fisheries, and other climate and ocean impacts. Changes that are being driven mainly by the activities of heavy emitters, including Australia.

It is crucial that we understand ocean protection as a vital climate *solution*. Indeed, the ocean may be our greatest ally against climate change. Supporting vibrant and diverse marine ecosystems is essential to restoring balance to the Earth's carbon cycle. Mangroves and coral reefs provide much needed protection from coastal floods and storms. The ocean is also an incredible source of renewable energy from wind, waves and tides.

We are all connected by the ocean: Pacific Island nations, Aboriginal and Torres Strait Islander peoples, non-Indigenous Australians, and communities around the world.

Australia has an opportunity to lead; to accelerate the shift from fossil fuels to renewable energy and to support Indigenous stewardship of Sea Country, increase marine protected areas, and help champion climate and ocean solutions - long fought for by Pacific Island nations - on the world stage.

It is time to work together, drawing on our respective strengths and opportunities, to protect the very things on which all our lives depend. Doing so promises not only to safeguard the places, people, communities we love, but to heal divisions and to move forwards as a more united Pacific family.

Recommendation:

1. Plan to achieve net zero emissions by 2035

Our oceans and climate are in crisis. Australia and all countries must do everything possible to limit warming as close to 1.5°C as possible, recognising the enormous risks of further warming to our oceans, our climate and to communities worldwide. Australia's 2035 emissions reduction target and our next Nationally Determined Contribution (NDC) to the Paris Agreement must aim to limit warming as far as possible and with the highest probability of success. This means aligning as closely as possible with a budget that provides a 67 percent chance of limiting warming to 1.5°C, recognising the extreme and existential risks posed by tipping points in the climate system, and the need to do everything possible to eliminate the risk of catastrophic scenarios. Our target must represent a fair share of the global emissions reduction task, factoring in Australia's historical responsibility for climate change, our economic capability, and our natural advantages in renewable energy. The Climate Council assesses that Australia's 2035 target should be net zero. This must be based on genuine emissions reductions, with the use of offsets minimised and accounted for separately. It must be accompanied by a plan to rapidly phase out fossil fuel production and export.

Recommendation:

2. Reform our national environment law to prevent new fossil fuel developments

Every new coal, oil or gas development is further endangering our ocean and everything that depends on it. Australia and the world must phase out fossil fuels and accelerate the shift to renewable energy. Despite the stark warnings of scientists and the escalating climate crisis, the Australian Government has continued to approve new fossil fuel projects. In all, 740 fossil fuel projects have been given the green light since Australia's national environment law – the Environmental Protection and Biodiversity Conservation (EPBC Act) — came into effect in 2000. The Government must urgently update our national environment law, explicitly embedding climate change throughout, so that it puts a stop to dangerous new fossil fuel projects.

Recommendation:

3. Increase support for communities to adapt to climate and ocean change

Today, Australia continues to spend far more on subsidising fossil fuels and on cleaning up after disasters than it does on helping communities build their resilience in the face of climate change. Without funding to build proper seawalls and other coastal defences, many communities in the Torres Strait Islands are left to use old tyres, wooden palettes and other makeshift materials in desperate attempts to halt coastal erosion and protect sacred sites. It is vital that all levels of government increase support to communities around Australia to adapt to the impacts of climate change, including rising seas and coastal erosion, with particular attention to the most vulnerable communities.

Recommendation:

4. Protect the ocean as a climate solution

While climate change is the greatest threat to our ocean, ocean ecosystems are also being harmed by overfishing, plastic pollution, and other threats. These reduce the ocean's ability to absorb and store carbon and its ability to sustain and protect us. For example, mangroves and other coastal ecosystems are highly efficient at storing carbon, and also provide a protective barrier for the coast that reduces erosion and flooding. Preserving and actively restoring marine ecosystems is a critical part of global efforts to tackle the climate crisis. Expanding marine protected areas, including Indigenous protected areas, is an important part of these efforts. The Australian Government must ensure that 30 percent of Australia's oceans are fully and permanently protected by 2030, and should prioritise First Nations custodianship of Sea Country.

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Page 60, Figure 37: Pacific ministers meet in Port Vila, Vanuatu. Image by Voyager Pacific Studios. March 2023.

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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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