

# Marine Climate Change in Australia

## Impacts and Adaptation Responses **2009 REPORT CARD**



This report card summarises our current knowledge of marine climate change impacts for Australia, highlighting key knowledge gaps and adaptation responses

*"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"*

Intergovernmental Panel on Climate Change  
(IPCC) Fourth Assessment Report 2007

### Key findings:

- > Australian ocean temperatures have warmed, with south-west and south-eastern waters warming fastest
- > The flow of the East Australian Current has strengthened, and is likely to strengthen by a further 20% by 2100
- > Marine biodiversity is changing in south-east Australia in response to warming temperatures and a stronger East Australian Current
- > Declines of over 10% in growth rates of massive corals on the Great Barrier Reef are likely due to ocean acidification and thermal stress

## What is happening?

## What is likely to happen this century?

## Addressing knowledge gaps

## Key adaptation options

### Marine climate

<b>Temperature</b>	<ul style="list-style-type: none"> <li>Ocean temperatures around Australia have warmed 0.7°C since 1910-1929, with south-west and south-eastern waters warming fastest (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Australian ocean temperatures will be 1°C warmer by 2030 and 2.5°C warmer by 2100 (<b>HIGH confidence</b>), with the greatest warming in south-eastern waters (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Expand ocean climate observations to validate other datasets, ground truth satellite observations, verify models and improve understanding of ocean processes and heat fluxes</li> </ul>	<ul style="list-style-type: none"> <li>Climate change requires immediate and vigorous international diplomacy to reduce greenhouse gas emissions. According to the 2007 Intergovernmental Panel on Climate Change Fourth Assessment Report, global greenhouse gas emissions have increased by 70% between 1970 and 2004. Some level of future climate change is already certain (e.g. 2°C of warming) because of the greenhouse gases already in the atmosphere. A delay in reducing human-related emissions will result in even greater levels of climate change and subsequent impacts on marine species and habitats.</li> </ul> <p>Adaptation options for marine climate change need to focus on conservation responses to increase resilience of our marine biodiversity as well as adapting our businesses and practices.</p>
<b>Sea Level</b>	<ul style="list-style-type: none"> <li>Global sea levels have risen by 20 cm over 1870-2004 (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Global sea levels will continue to rise 5-15 cm by 2030 and 18-82 cm by 2100 (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Improve estimates of regional sea level rise through better observed and modelled regional changes over the 20th century</li> </ul>	
<b>East Australian Current</b>	<ul style="list-style-type: none"> <li>Southward flow has strengthened so warmer, saltier water is now found 350 km further south compared to 60 years ago (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Likely to strengthen by a further 20% by 2100 (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Regional downscaling to increase resolution of boundary current, shelf circulation and mesoscale dynamics in climate projections. Establish time series of current volumes and heat transport using observation programs such as the Integrated Marine Observing System</li> </ul>	
<b>Leeuwin Current</b>	<ul style="list-style-type: none"> <li>Southward flow has slightly weakened since the 1970s (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Weakening will continue over the coming century (<b>LOW confidence</b>)</li> </ul>		
<b>El Niño-Southern Oscillation</b>	<ul style="list-style-type: none"> <li>Little evidence of change in ENSO variability due to global warming (<b>LOW-MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>A background "El Niño-like" pattern is projected this century (<b>MEDIUM confidence</b>), with no change in ENSO event amplitude or frequency (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Improve understanding of the nature and timing of causes that trigger the different 'flavours' of El Niño</li> </ul>	
<b>Ocean Acidification</b>	<ul style="list-style-type: none"> <li>Carbon dioxide dissolving in the oceans has lowered pH by 0.1 units since 1750, representing a 30% increase in hydrogen ion (acid) concentration (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Ocean pH will decrease by a further 0.2-0.3 units by 2100 (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Improve projections of the spatial and temporal variability in the progress of acidification and impacts of acidification on marine biodiversity; establish and commit to long-term measurements of ocean chemistry</li> </ul>	



# Impacts on marine biodiversity

<b>Tidal wetlands</b>	<ul style="list-style-type: none"> <li>&gt; Expansion of mangroves into salt marsh habitat in south-east Australia and into freshwater wetlands in northern Australia driven by sea-level rise and soil subsidence associated with reduced rainfall (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Mangrove areas are likely to expand further landward, driven by sea-level rise and soil subsidence due to reduced rainfall (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Assess the state of tidal wetlands in poorly sampled areas of Australia (e.g. Kimberly), measure wetland accretion and subsidence rates in tropical Australia and improve research into how tidal wetland fauna will respond to climate change</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Remove artificial barriers such as seawalls, ditches and buildings to allow tidal wetlands to adapt naturally and allow landward migration of these habitats</li> </ul>
<b>Seagrass</b>	<ul style="list-style-type: none"> <li>&gt; A southern range extension of 300 km into Moreton Bay, Qld, of the tropical seagrass <i>Halophila minor</i> consistent with a warming and a strengthening East Australian Current (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Declines in seagrass abundance and extent due to sea-level rise, increased storminess and warmer temperatures (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Improve understanding of thermal tolerances, coastal catchment runoff under changing climate and responses to increasing rates of habitat fragmentation</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Reduce non-climate related human impacts and maintain seagrass genetic diversity via planting or habitat protection to increase resilience</li> </ul>
<b>Macroalgae</b>	<ul style="list-style-type: none"> <li>&gt; Loss of algal habitat off eastern Tasmania associated with a southward range expansion of a sea urchin assisted by the strengthening of the East Australian Current and warmer temperatures (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Range shifts and local extinctions of cool-temperate species will occur along Australia's temperate coastline (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Improve knowledge of the distribution and abundance of indicator species, and consider experimental transplants to recover depleted habitats</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Improve and maintain coastal water quality to increase the resilience of macroalgae to climate change</li> </ul>
<b>Phytoplankton</b>	<ul style="list-style-type: none"> <li>&gt; Expansion of sub-tropical species, including harmful species, into south-eastern waters is driven by warming and a strengthening of the East Australian Current (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Increased episodes of harmful algal blooms in south-eastern waters in response to extreme rainfall events and warming temperatures (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Maintain and increase monitoring efforts to detect change in indicator species, and provide information to ocean users on bloom species; maintain and utilise ocean colour satellite derived chlorophyll products</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Increase vigilance of harmful algal blooms to allow businesses (such as fish farms) and local agencies to respond rapidly</li> </ul>
<b>Zooplankton</b>	<ul style="list-style-type: none"> <li>&gt; Although there are no long-term data in Australia, species elsewhere are shifting distributions polewards (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Changes in community structure resulting from modified productivity regimes, as well as range extensions with warming, such as the potential for venomous jellyfish to extend southward, particularly on the east coast (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Monitor zooplankton within the Integrated Marine Observing System and conduct targeted experimental and modelling studies to predict changes in zooplankton dynamics</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Improve and maintain coastal water quality to increase the resilience of coastal Australian zooplankton communities to climate change; alter beach management practices (e.g. closing beaches) in regions newly colonised by venomous jellyfish</li> </ul>
<b>Coral reefs</b>	<ul style="list-style-type: none"> <li>&gt; Sea surface warming has led to extensive coral bleaching events and declines in coral condition on the Great Barrier Reef and on north-western reefs (<b>HIGH confidence</b>). Ocean acidification and increased thermal stress are the likely causes of a &gt;10% reduction in the growth rates of massive Porites corals on the Great Barrier Reef (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Frequency and severity of mass coral-bleaching events will increase as temperatures warm, leading to declines in coral reef health (<b>HIGH confidence</b>). Ocean acidification will reduce coral growth rates making reefs more susceptible to erosion and disturbance from storms (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Undertake experimental studies to strengthen predictions of thresholds for coral-algal phase shifts and loss of ecosystem function under climate change</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Improve and maintain coastal water quality and healthy populations of herbivorous reef fishes to help sustain the resilience of coral reefs</li> </ul>



<b>Tropical fish</b>	<ul style="list-style-type: none"> <li>&gt; Numbers of tropical species at sub-tropical and temperate latitudes are increasing as temperatures warm indicating that some species are shifting their ranges southward (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Loss of diversity and widespread changes in the composition of coral reef fish communities following degradation of coral reefs (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Understand the effects that changes in temperature, pH and ocean currents have on the physiology and population dynamics of tropical marine fishes, and the capacity for acclimation and genetic adaptation to these rapid environmental changes</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Reduce overfishing and maintain, restore and protect essential fish habitats such as seagrass beds, salt marshes, coral reefs, mangroves and macrolagal beds</li> </ul>
<b>Temperate fish</b>	<ul style="list-style-type: none"> <li>&gt; Southward range expansions in south-eastern waters are linked to warming temperatures and a strengthening of the East Australian Current; estuarine fish abundances are linked to annual fluctuations in freshwater discharge (rainfall), which is declining (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Breeding populations of tropical species establish in southern waters; reduction in the abundance of estuarine species as rainfall, therefore riverflow, is reduced (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Provide baseline information (ecology, physiology, reproduction, early life history) on many fished stocks, and in particular non-commercial fish, and experiments to test survival in changing habitats</li> </ul>	
<b>Pelagic fish</b>	<ul style="list-style-type: none"> <li>&gt; Replacement of small cool-temperate species in southern waters by sub-tropical and tropical species driven by warmer temperatures (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Increased occurrence of tropical species in southern waters (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Downscale climate models to investigate the impact of changing prey fields under climate change scenarios on pelagic fish distribution and abundance, and how fishers might respond</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Include climate change projections in fishery management plans to conserve stocks and assist fishers in adapting to changes in species' abundances and distributions</li> </ul>
<b>Marine reptiles</b>	<ul style="list-style-type: none"> <li>&gt; Warmer sand temperatures, from increased air temperature, has increased mortality of sea turtle eggs and hatchlings at the Mon Repos rookery in south-east Qld (<b>HIGH confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Declines of reef-associated sea snakes as temperatures warm and coral reefs degrade (<b>LOW confidence</b>); some tropical sea turtle nesting beaches will produce 100% females (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Identify areas in Australia that have the potential to serve as functional habitats for marine reptiles under projected climate forecasts and investigate potential for artificial beach modification to reduce impacts</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Reduce non-climate threats, protect turtle nesting beaches particularly beaches which are important for producing males, improve and maintain coral reefs and inter-reef habitat to protect sea-snake populations</li> </ul>
<b>Seabirds</b>	<ul style="list-style-type: none"> <li>&gt; Little penguins are altering their breeding time in response to warmer temperatures, and chick growth of tropical and sub-tropical seabirds has slowed in response to less food availability as temperatures warm (<b>LOW confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Warmer temperatures and an El Niño-like future climate are expected to reduce food availability for breeding seabirds leading to a reduction in breeding success (<b>MEDIUM confidence</b>)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Maintain and expand monitoring to improve understanding of drivers of change in seabird populations, and investigate the potential of alternative land-use strategies to increase the ability of nesting birds to cope</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Manage breeding habitats and reduce or eliminate non-climate threats to increase resilience and improve the likelihood of natural adaptation; reduce competition from humans for food e.g. through fishery management</li> </ul>



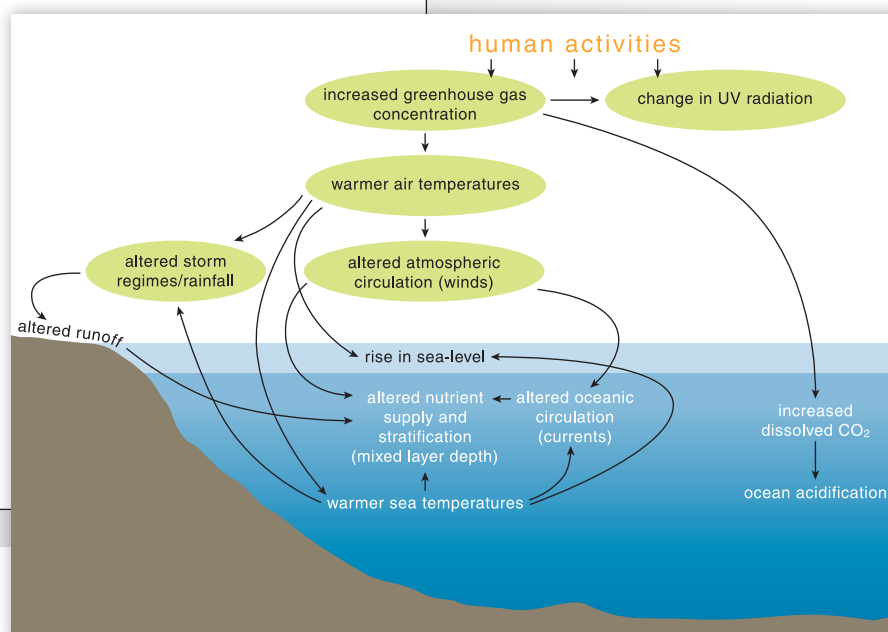
We are now observing changes in our marine climate and impacts on our marine biodiversity. We urgently need to reduce our greenhouse gas emissions to stabilise global warming and adopt strategies to allow our natural ecosystems and societies to adapt to unavoidable climate change.

## Climate Change

Increasing concentration of greenhouse gases in the atmosphere change the Earth's radiative balance (the balance between incoming solar radiation and outgoing radiated energy) and lead to global warming. Atmospheric concentrations of carbon dioxide have increased markedly since the Industrial Revolution (circa 1750) from 280 ppm to 387 ppm in 2009, as a result of human activities based on fossil fuel use.

Air and ocean warming observed since the 1950s, both globally and across Australia, are attributable to increases in atmospheric greenhouse gas concentrations. For marine ecosystems, rising atmospheric greenhouse gases warm the atmosphere and oceans altering circulation patterns and bringing

the additional threat of ocean acidification. Links between human activities and physical and chemical ocean processes are complex and widespread, affecting the coastal, deep and open oceans.



## Australia: a maritime country

Australia has a coastline of almost 60,000 km that spans tropical waters of northern Australia to the cool-temperate waters of Tasmania. Our mainland is bounded by the East Australian Current on the east coast and the Leeuwin Current on the west. These major currents carry warm water into southern regions and have considerable influence on our marine flora and fauna. Australia has sovereign rights over around 8.1 million km<sup>2</sup> of ocean (greater than its land area of around 7.7 million km<sup>2</sup>), which generate considerable wealth through economic sectors such as fisheries, tourism, and shipping and port industries.





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This Report Card summarises present knowledge on marine climate change impacts and identifies knowledge gaps and adaptation responses in Australia. It was produced by an author team representing 35 universities and organisations, a project team from the CSIRO Climate Adaptation National Research Flagship, and a steering group comprising representatives from the sponsor organisations [National Climate Change and Adaptation Research Facility (NCCARF); CSIRO Climate Adaptation National Research Flagship; and the Australian Climate Change Science Program (ACCSP)].

**Further information:** including detailed assessments for each climate variable or species group, is accessible at [www.oceanclimatechange.org.au](http://www.oceanclimatechange.org.au). Contact us via our website or [elvira.poloczanska@csiro.au](mailto:elvira.poloczanska@csiro.au)

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