

# Marine Climate Change in Australia

## *Impacts and Adaptation Responses*

## 2012 REPORT CARD



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

Australia's oceans generate considerable economic wealth through fisheries, aquaculture, tourism and mining. Marine ecosystems provide irreplaceable services including coastal defence, oxygen production, nutrient recycling and climate regulation. Unless we adapt and mitigate, climate change will threaten our economic prosperity and social well-being.

### **Key findings:**

- Climate change is already happening: Widespread physical changes include rapid warming of the southeast and increasing flow of the East Australia Current. Increasing biological impacts include reduced calcification in Southern Ocean plankton and Great Barrier Reef corals from both warming and acidification
- Scientists, managers and resource users are working to design adaptation strategies that reduce the vulnerability of marine species, systems and industries to climate change
- We are observing and monitoring key physical and biological variables in the ocean, which is critical to evaluating effective adaptation strategies.
- Preparation for climate change also involves changes in management or policy arrangements that currently limit adaptation responses.

## Marine heat wave

In early 2011, sea temperatures along most of the west coast were 2–4°C warmer than usual. Changes in the local abundance and distribution of seaweeds, sessile invertebrates such as abalone, demersal and pelagic fish were reported, with a shift towards a more tropical fish community. Such extreme climate events are key drivers of change and provide insight into future long-term change. (*Leeuwin, ENSO, Temperature, Pelagic fish, Seaweeds chapters*)



**Observing:** Collecting information on changes in the marine environment is needed for developing adaptation responses. National programs for observing the marine environment, such as the Integrated Marine Observing System, help to identify regions and systems most at risk. Biological monitoring is challenging, but where we have time series, dramatic changes are being detected.

## The south

Australia has one of the richest and endemic temperate algal floras in the world. In response to warming, macroalgae have retreated 10–50 km per decade south on both sides of the continent. Further, the east-west orientation of Australia's temperate coastline predisposes flora and fauna there to potential species extinctions from southward shifting isotherms. As macroalgae are foundation species that support a myriad of unique marine life, the decline in temperate macroalgae in response to climate change is likely to resonate across entire temperate marine ecosystems. (*Macroalgae chapter*).



## Great Barrier Reef

Warming temperatures have been associated with reduced foraging success and chick growth in seabirds, changes in sex ratios of sea turtles, more frequent bleaching of corals because of climate variability superimposed on a warming trend, some increases in abundance of large herbivorous reef fish, and decreases in abundance of coral-dependent fishes. Ocean acidification has led to a potential reduction in coral calcification and thinning of shells and increase porosity of winged snails. (*Coral reefs, Zooplankton, Marine reptiles and Seabirds chapters*).



**Adaptation** is the process of responding to changing ocean environments. Both animals and humans can adapt – either autonomously (on their own) or in a directed manner (with human assistance). Scientists, managers and resource users are designing adaptation strategies that reduce the vulnerability of marine species, systems and industries to climate change.

**Sea level rise**, currently increasing at 3 mm per year, will threaten coastal systems. Most at risk are low-lying estuaries and tidal flats, and beaches where there is insufficient sand for replenishment. In locations where human settlements or structures such as seawalls prevent landward retreat of coastal habitats, 'coastal squeeze' may lead to loss of habitats. (*Mangroves and tidal wetlands chapter*).

## Marine mammals and seabirds

Increasing water temperatures are likely to have an impact on the distribution of marine mammals and seabirds; ranges of both tropical and temperate species are likely to move southwards. Adaptation options at bird breeding colonies, such as shading of burrows and reducing fire risk, may offset declining breeding performance as temperatures rise, while reducing non-climate stressors can also increase resilience of marine mammals to climate change. (*Marine mammals and Seabird chapters*).



**South-east Australia** is a global warming hotspot. The warm East Australia Current is extending southward, leading to fast warming. Southward range extensions have been documented for seaweeds, phytoplankton, zooplankton, and demersal and pelagic fishes. Declining recruitment for rock lobster has been observed. Fisheries and aquaculture businesses are already adapting to these changes. (*EAC, Temperature, Phytoplankton, Zooplankton and Temperate fish chapters*).



## Marine Climate

### What is happening (Confidence = ●)

### What we are doing about it

#### TEMPERATURE

##### Confidence



Ocean temperatures around Australia have warmed by 0.68°C since 1910-1929, with south-west and south-eastern waters warming fastest. The rate of temperature rise in Australian waters has accelerated since the mid-20th century; from 0.08°C/decade in 1910-2011 to 0.11°C/decade from 1950-2011.

New results based on a relatively high scenario for greenhouse gas emissions (RCP8.5) indicate greatest warming in south-east (>3°C) and north-west waters (~2.5°C) by the end of this century.

Investing in regional monitoring as part of the Integrated Marine Ocean Observing System (IMOS) to measure changes in ocean temperatures. Developing ocean models to project changes in coming decades. Ongoing development of seasonal forecasting models and applications to support timely adaptation responses by marine users.

#### SEA LEVEL

##### Confidence



Sea levels are rising around Australia, with fastest rates currently in northern Australia. New analyses of sedimentary records from the east coast of Tasmania confirm slow sea-level change over 1000s of years until the early 20th century, when there was a significant acceleration in the rate of sea-level rise. High sea-level events on annual to decadal timescales have increased by a factor of three during the 20th century.

Sea level will continue to rise during the 21st century and beyond, and result in inundation of low-lying coastal regions and coastal recession.

Satellite altimeters and the Australian Baseline Sea Level Monitoring Array have provided a comprehensive picture of sea level around the Australian coastline since the early 1990s. Adaptation planning will be informed by national and regional assessments of coastal inundation and recession due to future changes in sea level and wave climate.

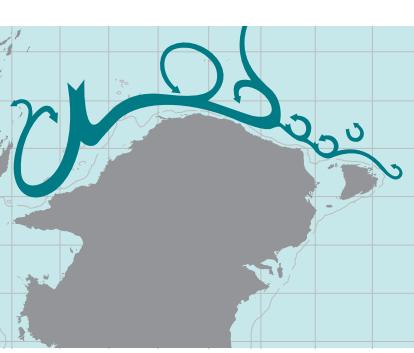
#### EAST AUSTRALIAN CURRENT

##### Confidence



The intensification of flow and accelerated warming observed in the EAC is also seen in other Southern Hemisphere western boundary current systems, driven by the strengthening and contraction south of Southern Hemisphere westerlies (wind), although regional responses mean rates of warming differ among systems. A range of species, including plankton, fish and invertebrates, are now found further south because of enhanced transport of larvae and juveniles in the stronger EAC and the high rate of regional warming.

EAC flow will increase off south-east Australia with a compensating decrease off north-east Australia.



#### LEEWIN CURRENT

##### Confidence



Since the mid 1970s, the Leeuwin Current has weakened due to more frequent El Niño events. However, in the past two decades, a strengthening is observed, linked to natural decadal variability not long-term change. Associated with this, there has been a southward range shift in marine biota.

IMOS is monitoring the Leeuwin Current. National Reference Stations at Darwin, Exmouth, Rottnest and Esperance and are providing physical and water quality data. Coastal water temperatures are monitored along the Western Australian coastline by the Department of Fisheries as part of a rock lobster program.



## EL NIÑO-SOUTHERN OSCILLATION

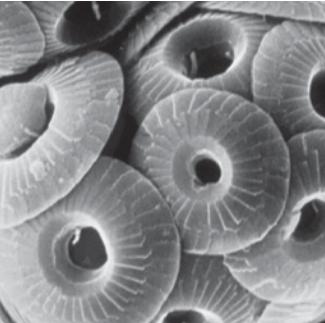
Investing in Pacific region climate change programs, high quality data collection and monitoring, improving pre-instrumental ENSO reconstructions, process studies to understand mechanisms of variability, and enhancing modelling capabilities.

While observed El Niño-Southern Oscillation (ENSO) variability is within the broad range of natural variability, the possibility that anthropogenic forcing has influenced ENSO cannot be ruled out.



**OCEAN ACIDIFICATION**  
**Confidence**  
○ ○  
Low Med High  
  
**MANGROVES AND TIDAL WETLANDS**  
**Confidence**  
○ ○  
Low Med High

Most conclusions about biological responses to ocean acidification in Australian waters come from laboratory manipulations rather than observations. However, reduced calcification observed in Southern Ocean zooplankton suggest ocean acidification is already impacting biological systems.



## Impacts on marine biodiversity

**MANGROVES AND TIDAL WETLANDS**  
**Confidence**  
○ ○  
Low Med High  
  
**SEAGRASS**  
**Confidence**  
○ ○  
Low Med High

The red mangrove *Rhizophora stylosa* is expanding within its range at its southern limits; the expansion is still to be attributed to climate change however knowledge of thermal limits suggests warming plays a role.



**SEAGRASS**  
**Confidence**  
○ ○  
Low Med High  
  
**MACROALGAE**  
**Confidence**  
○ ○  
Low Med High



A southern range extension of 300 km into Moreton Bay (Qld), of the tropical seagrass *Halophila minor* consistent with a warming and a strengthening East Australian Current.



**MACROALGAE**  
**Confidence**  
○ ○  
Low Med High  
  
**OCEAN ACIDIFICATION**  
**Confidence**  
○ ○  
Low Med High  
  
**MANGROVES AND TIDAL WETLANDS**  
**Confidence**  
○ ○  
Low Med High  
  
**SEAGRASS**  
**Confidence**  
○ ○  
Low Med High  
  
**MARINE BIODIVERSITY**  
**Confidence**  
○ ○  
Low Med High  
  
**IMOS AUTONOMOUS UNDERWATER VEHICLE**  
**Confidence**  
○ ○  
Low Med High

Warming will reduce the resilience of macroalgal habitats to other stressors such as pollution. Temperate species will contract their ranges southwards and tropical species expand their ranges further south. Many temperate species, found only in Australia, are at risk of extinction in the next 50–100 years. Extreme events (storms, heat

Research is underway to improve the methods and equipment used for high-precision carbonate chemistry measurements. Monitoring of carbon chemistry in the open ocean and some shallow coastal systems, including the Great Barrier Reef, has already commenced. Research is underway to investigate effects of ocean acidification on whole coral ecosystems in the Great Barrier Reef.

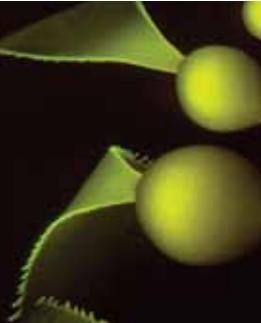


Systems to monitor surface height have been deployed in Moreton Bay, south-east Qld and in tidal wetlands in southern Australia. The network will provide greater knowledge of possible thresholds of sea-level rise that exceed the adaptive capacity of coastal mangrove and saltmarsh ecosystems to keep pace.



Ongoing monitoring and research into the impacts of climate change on seagrass beds, including quantitative modelling at local scales. Investigations into the role of seagrass beds as carbon sinks for CO<sub>2</sub> mitigation.

IMOS Autonomous Underwater Vehicle Facility will provide long-term monitoring of water properties and temperate reefs at key locations in Qld, NSW, Tas and WA. Several research projects focusing on climate change and temperate macroalgae are under way. These focus both on establishing the range of impacts as well as the mechanistic relationships



forming species. In eastern Tasmania, a substantial decline in algal habitat is associated with southward expansion of a grazing sea urchin aided by the strengthening of the East Australian Current and warmer temperatures.

The reporting frequency of microbial-mediated disease outbreaks affecting marine organisms is increasing and could contain a climate change signal. However, disease events (or breakdown in microbial symbioses) in corals, sponges and some other species have been linked with warmer seawater temperatures.

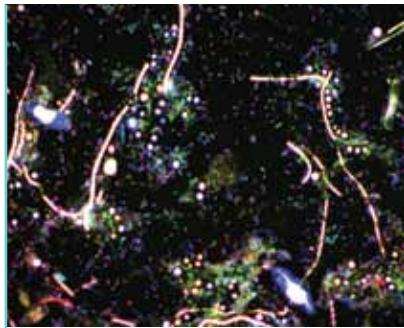
## MARINE MICROBES

Confidence



With warmer temperatures in the future, microbial-mediated disease outbreaks or disruptions to symbiosis are likely to become more frequent and wide-spread.

Initiatives are underway for monitoring long-term changes in microbial biodiversity through genomic analysis of water samples. This will allow us to investigate environmental stress thresholds of microbial symbioses of key marine species. Construction of national infrastructure including the SEASim aquarium at AIMS and state-of-the-art facilities at SIMS will increase capacity to investigate changes in community structure and function of marine microorganisms under climate scenarios.



## PHOTOPLANKTON

Confidence



Changes in timing of seasonal phytoplankton blooms may impact marine food webs.

Establishment of IMOS National Reference Stations and AusCPR (Australian Continuous Plankton Recorder) tows are enhancing Australia-wide phytoplankton and biogeochemical data collections for monitoring responses.



## ZOOPLANKTON

Confidence



Range shifts toward higher latitudes, earlier zooplankton blooms with warming, changes in nutrient enrichment and thus zooplankton abundance, and reduction in pteropod and foram abundance due to acidification will reorganize foodwebs in time and space and impact fish, seabirds and marine mammals.



## CORAL REEFS

Confidence



During the past three decades, coral reefs have been impacted by a growing number of thermal bleaching events although their occurrence and severity have varied substantially in space and time. Numerous experimental and observational studies have established a causative link between thermal anomalies (stress) and coral bleaching.



Formal adaptation plans are being implemented to help communities and industries that depend on Australia's coral reefs to deal with the serious impacts of climate change. The Great Barrier Reef Climate Change Adaptation Strategy and Action Plan outlines strategies and measures to support ecosystem resilience, support adaptation by reef-dependent communities and industries, and raise awareness of the importance of urgent action to mitigate climate change if we are to improve the outlook for coral reefs.

## TROPICAL FISH

New research suggests that some species have a greater capacity to acclimate to rising temperatures than previously thought; however whether such acclimation capacity is widespread in tropical marine fishes, and whether some critical processes (e.g. reproduction) remain significantly impaired, is unknown.



### TEMPERATE FISH

**Confidence**  
 2 High, 1 Med, 1 Low

In addition to effects of habitat degradation, warmer ocean temperatures will cause distribution shifts in some tropical fishes, increasing the geographic ranges of some species and decreasing the ranges of others, including some commercially important species.



### PELAGIC FISH

**Confidence**  
 2 High, 1 Med, 1 Low

Additional evidence and reviews confirm previous reports of southward range extensions for many coastal temperate fishes.

Reduced freshwater flows are likely to have negative effects on estuarine-dependent species, such as bream, and adaptation in relation to water flow management may be needed.



**Confidence**  
 2 High, 1 Med, 1 Low

There is ongoing experimental and observational work to understand the environmental tolerances and hence adaptive capacity of temperate fishes.

### MARINE MAMMALS

**Confidence**  
 2 High, 1 Med, 1 Low

Substantial evidence that sea surface temperature influences foraging locations and reproductive success of marine mammals. However, studies on long-term effects of warming are rare, with only one study providing evidence that dugongs extend their range in warm years.



Increased occurrence and persistence of tropical species in southern waters as waters warm.

There is increased modelling of distribution and abundance to refine understanding of impacts for tropical species, coastal small pelagic species, and large offshore species, and thus incorporate impacts of climate change into fisheries management.

### MARINE REPTILES

**Confidence**  
 2 High, 1 Med, 1 Low

Local declines of sea snakes on coral reefs may be the result of changing environmental conditions. Warming beaches are changing long-term sex ratios of hatchling turtles.



The Australian Animal Tracking and Monitoring System (AATAMS) is using acoustic technology, satellite tags and biologgers to monitor coastal and oceanic movements of marine mammals. This will elucidate links between climate change in Australia's coastal seas and the Southern Ocean, and responses of marine mammals.

### SEABIRDS

**Confidence**  
 2 High, 1 Med, 1 Low

Tropical and subtropical species breeding at Houtman Abrolhos, WA are now experiencing poor breeding success outside of El Niño years linked to warming. Large range extension reported for Bridled Tern in south-west Australia in response to ocean warming.



Implementation of fast-response fire action plans to reduce the risk of fire in seabird colonies close to human settlements or infrastructure. Investigating human adaptation options to increase resilience of conservation-dependent seabirds and marine mammals impacted by climate change



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This Report Card summarises present knowledge of marine climate change impacts and identifies knowledge gaps and adaptation responses in Australia. It was produced by an author team representing 34 universities and organisations, a project team from the CSIRO Climate Adaptation Flagship, and a steering group comprising representatives from the partner organisations [NCCARF Marine Biodiversity and Resources Adaptation Network, CSIRO Climate Adaptation Flagship; and the Fisheries Research and Development Corporation (FRDC)].



Australian Government  
Fisheries Research and Development Corporation

**Further information:** detailed assessments for each climate variable or species group, are 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)

E.S. Poloczanska, A.J. Hobday and A.J. Richardson (Eds) (2012). Marine Climate Change in Australia, Impacts and Adaptation Responses. 2012 Report Card. ISBN 978-0-643-10927-8