

Australia's coral reefs in a changing ocean

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Cover image

Coral of the Great Barrier Reef, QLD
Photo by Paradise Ink & DSEWPaC

Preface

This report was developed for the Department of Sustainability, Environment, Water, Population and Communities to help inform the Australia State of the Environment (SoE) 2011 report.

The Minister for Environment is required, under the *Environment Protection and Biodiversity Conservation Act 1999*, to table a report in Parliament every five years on the State of the Environment.

The Australia State of the Environment (SoE) 2011 report is a substantive, hardcopy report compiled by an independent committee appointed by the Minister for Environment. The report is an assessment of the current condition of the Australian environment, the pressures on it and the drivers of those pressures. It details management initiatives in place to address environmental concerns and the effectiveness of those initiatives.

The main purpose of SoE 2011 is to provide relevant and useful information on environmental issues to the public and decision-makers, in order to raise awareness and support more informed environmental management decisions that lead to more sustainable use and effective conservation of environmental assets.

The 2011 SoE report, commissioned technical reports and other supplementary products are available online at www.environment.gov.au/soe.

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The World's tropical coral reefs are increasingly threatened by climate change and ocean acidification. Ocean warming leads to increased risk of mass coral bleaching events, coral disease outbreaks and the formation of stronger storms. Ocean acidification is the insidious change in ocean carbon chemistry which, by lowering the saturation state of aragonite (the chemical building block of corals), reduces the capacity of marine calcifying organisms, such as corals, to build calcium carbonate skeletons and maintain reef structures. Australia has some of the World's most spectacular coral reefs: the Great Barrier Reef (GBR) to the east and Ningaloo Reef in the west. They are an important part of Australia's and the World's natural heritage and add significant revenue to the national economy, the GBR alone contributing over \$5 billion per year. Australia also has significant coral reefs at high latitudes, including Lord Howe Island in the southeast and the Houtman Abrolhos in the southwest. Severe coral bleaching on Australian reefs has in the past two decades been confined mainly to the GBR and other reefs at low latitudes (e.g. Scott Reef), however the first extensive bleaching events have now also been recorded around Ningaloo, Lord Howe Island, Houtman Abrolhos and Rottneest Island (Fig 1). These bleaching records, in conjunction with projections for ocean acidification, raise important questions about whether high-latitude reefs could become refuges or high-risk sites in a changing ocean.



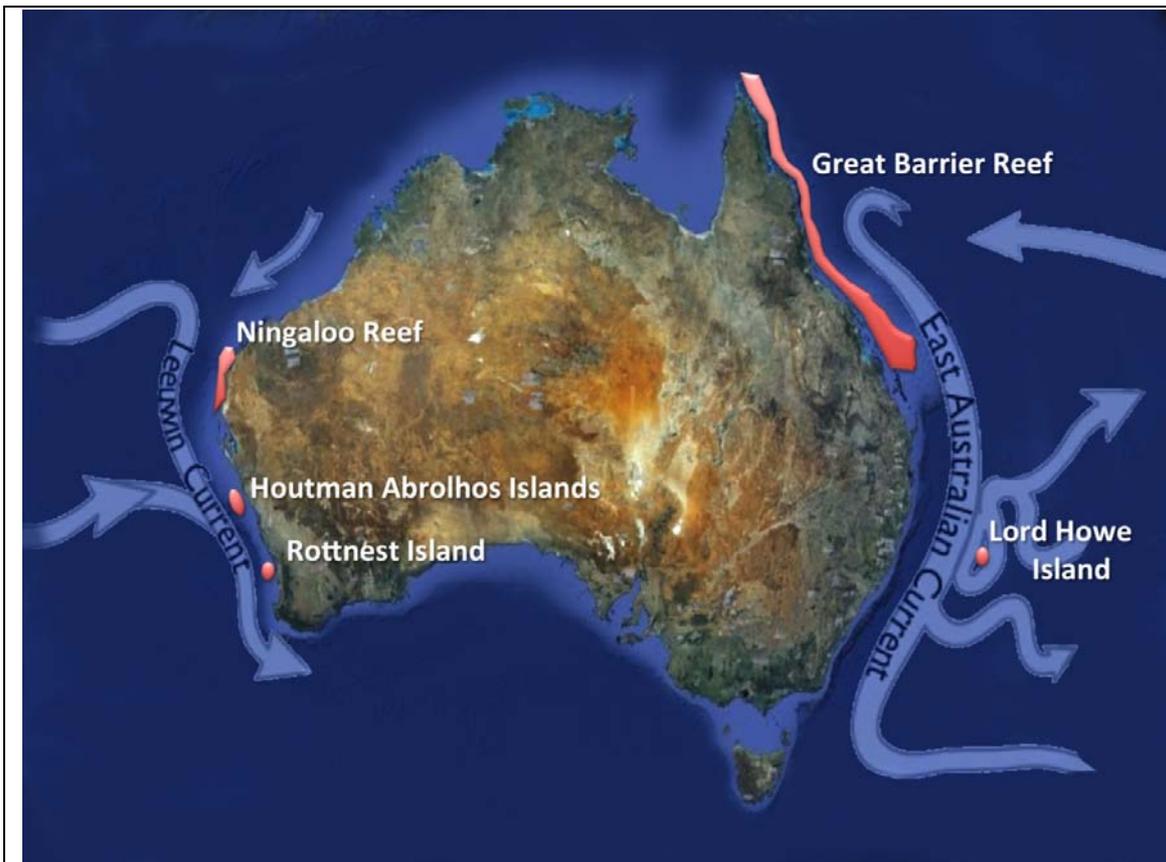


Figure 1 Locations of recent coral bleaching events observed in Australian waters

The scientific evidence supporting a causal relationship between concentrations of greenhouse gasses (mainly carbon dioxide) in the atmosphere and declining health of the World's coral reef ecosystems is growing stronger. Since 1998, which saw more than 16% of the World's coral reefs devastated by coral bleaching, several extensive bleaching events of varying severity have occurred on Australia's coral reefs. An expanding body of experimental research indicates that interactions of thermal stress with ocean acidification and other stressors, such as declining water quality, are likely to increase the risk to reef ecosystems. For example, mortality risk from thermal bleaching is exacerbated under acidification and potentially under high nutrient concentrations. Further, the increased fragility of coral skeletons and accelerated rates of reef erosion under ocean acidification will increase the susceptibility of reefs to storm damage. The decreased calcification rate of corals in a low pH ocean will also reduce the speed at which corals and coral reefs can recover from events such as tropical cyclones and mass bleaching, further diminishing the resilience of the ecosystem.

As Australia moves into a high-CO₂ era, ocean warming and acidification are predicted to continue from low to high latitudes. Regional-scale processes that vary between east and west, however, complicate projections for coral bleaching and ocean acidification risks at high-latitude reefs. The East Australian Current is strengthening, delivering more warm water to southeastern reefs including Lord Howe Island, whereas the Leeuwin current is predicted to slow down, enhancing the potential for wind-driven upwelling of cool water along the southwest Australian coast. The implications of these large-scale changes in ocean currents for the impacts of ocean acidification on Australia's reefs are unclear. Ocean acidification is expected to progress faster at high-latitude reefs, as atmospheric CO₂ dissolves more readily in cold water, and the rate of ocean warming will also be greater at these higher latitudes. Two key questions therefore remain: Firstly, to what extent will the increased thermal bleaching risk at high-latitude reefs to the east (e.g. Lord Howe Island) be offset by the reduced ocean acidification risk as a function of warming? Preliminary models suggest that any positive effect of warming ameliorating risks from ocean acidification will be overwhelmed by the negative

warming effects on coral bleaching. In other words, the beneficial warming effects on ocean carbon chemistry conducive to high rates of calcification are likely to be lost as corals bleach more frequently. Secondly, what are the consequences of a predicted slowing of the Leeuwin Current for temperature and carbon chemistry in southwest Australian waters? Reefs at Houtman Abrolhos and Rottneest Island may have relatively lower bleaching risks but may become more exposed to ocean acidification.

Under a business-as-usual carbon emission path (i.e. A1B or A1FI scenarios of the IPCC-AR4), Australia's coral reefs face a challenging future, and are highly unlikely to sustain the ecosystem goods and services on which people rely, particularly in the tourism and fishing sectors. Although physical and chemical oceanography and terrestrial influences vary between regions, influencing susceptibility to bleaching and ocean acidification, the medium to long-term projections are clear: the frequency and severity of coral bleaching events will continue to increase, accompanied by progressive ocean acidification. Studies of gene flow between northern and southern reefs suggest that there is only limited scope for warm-adapted/acclimated genotypes to populate southern reefs. While experimental and observational studies indicate that some level of local adaptation and/or acclimatization to ocean warming and ocean acidification is possible, the rate of projected warming and acidification is likely to outpace most species' capacity for adaptation and/or acclimatization. Improving the outlook for Australia's coral reefs requires immediate and rapid reduction in greenhouse gas emissions, and enhancing the resilience of coral reefs by reducing local pressures through improving water quality and the sustainability of fishing practices.

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