Australian Government

Department of the Environment, Water, Heritage and the Arts
Office of the Secretary

Our Reference: 2009/

The Chair
Standing Committee on Industry, Science and Innovation
House of Representatives
PO Box 6021
Parliament House
Canberra ACT 2600

Dear Ms Vamvakinou,

Thank you for your letter of 19 March 2009 to the Minister for the Environment, Heritage and Arts, the Hon Peter Garrett AM MP, inviting submissions to the inquiry into long-term meteorological forecasting in Australia.

I am pleased to offer the attached submission outlining the role of the portfolio in current climate modelling and forecasting methods and systems, and the impact of accurate forecasting on various decision-making processes.

Yours sincerely

Robyn Kruk AM
Secretary

29 June 2009

Australian Government

Department of the Environment, Water, Heritage and the Arts

Submission to the Inquiry into Meteorological Forecasting

The Australian Government Department of the Environment, Water, Heritage and the Arts welcomes the opportunity to provide a submission to the House of Representatives Standing Committee on Industry, Science and Innovation inquiry into long-term meteorological forecasting.

The Portfolio develops and implements national policy, programs and legislation to protect and conserve Australia's environment, water resources and heritage and to promote Australian arts and culture. Meteorological forecasting is a key input to a number of the portfolio's policy and program functions. In particular it is critical to fulfilling our obligations in relation to ozone protection and the management of the Great Barrier Reef Marine Park. The Bureau of Meteorology (BOM) is also a part of the portfolio and has provided a separate submission.

The department is responsible for ensuring that Australia meets its Montreal Protocol phase-out obligations. Under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*, the department controls the manufacture, import and export of all ozone-depleting substances and their synthetic greenhouse gas replacements. It also regulates end-uses to minimise emissions to the atmosphere. The department works with industry and the community to implement programs to phase-out ozone-depleting substances and to minimise emissions of these substances and their synthetic greenhouse gas replacements.

The Bureau of Meteorology (BoM) monitors atmospheric ozone concentrations and investigates emerging intra-seasonal linkages between ozone and climate change. This work is important to maintaining stratospheric ozone concentration records to support and advance Australia's domestic and international objectives.

The Great Barrier Reef Marine Park Authority (GBRMPA) is the principal adviser to the Australian Government on the control, care and development of the Great Barrier Reef Marine Park.

The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems

Ozone

The Department particularly values the research undertaken by the BoM into ozone and its links to climate change and long term meteorological forecasting. The BoM balances the allocation of funding it receives between the maintenance of basic weather systems and applied and strategic research. Both areas of operation, particularly as it relates to ozone monitoring and forecasting, need to be supported well into the future.

The BoM's extensive monitoring network covers approximately 12 per cent of the earth's surface. There is a limited number of ozone monitoring platforms internationally; there are fewer platforms in the southern hemisphere compared to the northern hemisphere. The BoM maintains half of the World Ozone and Ultraviolet Data Center ozonesonde platforms and a quarter of the Dobson spectrometers in the southern hemisphere. Such coverage ensures that data provided by the BoM forms a significant part of the ozone data from the southern hemisphere. The BoM's data sets have long been, and still are, used to inform the work of the Scientific Assessment Panel of the Montreal Protocol.

Nationally, the BoM's ozone monitoring platforms support the UV and Ozone Forecasting System. This system in turn supports the Australian UV index, the UV Alerts and Ozone forecasts which are published daily as part of the weather report. Forecasts and data are used in Australia's SunSmart promotional and educational campaigns.

The Great Barrier Reef Marine Park Authority

The increasing severity and frequency of mass coral bleaching events due to climate change is currently one of the most pressing threats on the Great Barrier Reef. Mass coral bleaching is preceded by a series of conditions that can be used to assess the probability of an event occurring. The Great Barrier Reef Marine Park Authority's (GBRMPA) Coral Bleaching Response Plan (Figure 1) includes an Early Warning System that uses meteorological forecasts, remote sensing technology and in-water monitoring amongst other tools to monitor any early signs of coral bleaching and conditions that are conducive to coral bleaching.

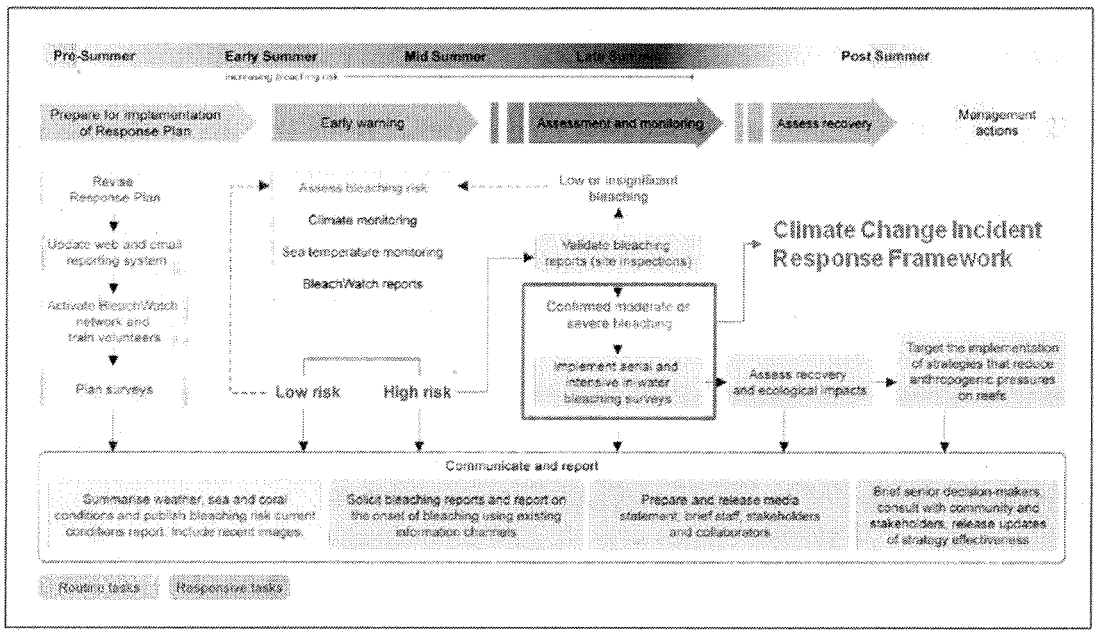


Figure 1: GBRMPA Coral Bleaching Response Plan schedule of routine and responsive tasks before, during, and after the coral bleaching season

These tools include long-term predictive modelling tools such as the Predictive Oceans and Atmosphere Model Australia (POAMA), daily near real-time monitoring tools such as *ReefTemp* and real-time in-water monitoring networks such as that run by the Australian Institute of Marine Science (AIMS).

The efficacy of these modelling methods and techniques has been maximised by running the models against historical Great Barrier Reef sea temperature datasets in the case of POAMA and comparison with in-situ monitoring information in the case of *ReefTemp*.

Repeated evaluation has shown that POAMA is a useful climate forecasting tool to inform management decisions relating to coral bleaching events. While this type of tool may have limitations in its ability to predict or take into account related climatic events such as cyclones or monsoons, it has proven useful in accurately predicting patterns in sea surface temperatures up to 3 months in advance on the Great Barrier Reef.

Innovation in long-term meteorological forecasting methods and technology

Ozone

The BoM undertakes innovative and unique research in Australia, particularly in the field of ozone science. Both climate and weather patterns in the Southern Hemisphere

are influenced by the Southern Hemisphere annular mode (SAM). Studies of SAM have established a link between seasonal stratospheric ozone concentrations fluctuations and the movement of the southern storm track. The variation in pressure between latitudes caused by seasonal ozone fluctuations causes the storm track to shift towards the pole, drawing rainfall south and away from southern Australia. This linkage requires further investigation especially from an Australian standpoint given the impact that the formation of the annual Antarctic Ozone hole appears to have on Australian climate and weather patterns. The BoM is already moving to investigate this emerging area of research.

Both the ozone monitoring and research functions of the BoM place it well to inform strategic policy directions and improve Australia's understanding of the science at both national and international levels. The BoM maintains key partnerships with several universities and the CSIRO, including linkages with Centre for Australian Weather and Climate Research, to effectively stimulate research in key areas of interest for Australia. These partnerships place the BoM in a unique position to bring together the work of these agencies and direct research efforts in a way that enhances the quality of the science and as a result, global understanding of climate systems.

With its successful strategic partnerships and unique research focus and capabilities, the BoM is well positioned to continue to support the work of the Department as it relates to ozone and climate forecasting and to ensure Australia maintains its position as a leader in ozone and climate forecasting in the southern hemisphere.

The Great Barrier Reef Marine Park Authority

Tools used by the GBRMPA include long-term predictive modelling tools such as the Predictive Oceans and Atmosphere Model Australia (POAMA), daily near real-time monitoring tools such as *ReefTemp* and real-time in-water monitoring networks such as that run by AIMS.

1) Predictive Oceans and Atmosphere Model Australia (POAMA) – Climate monitoring and prediction

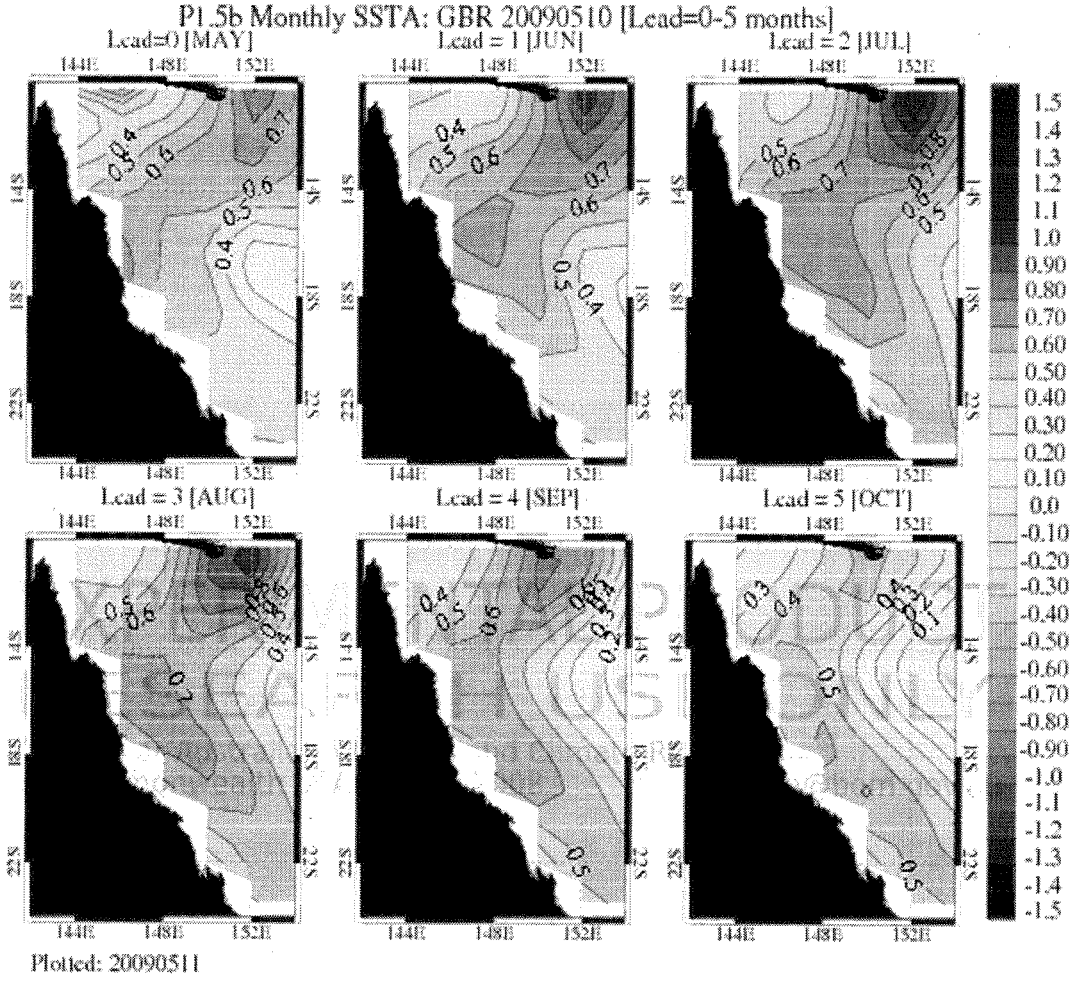
The GBRMPA uses sea temperature forecasts provided by the Predictive Ocean Atmosphere Model for Australia (POAMA) group at the Centre for Australian Weather and Climate Research (Bureau of Meteorology and CSIRO), and the National Oceanic and Atmospheric Administration (NOAA) in the US, to determine the risk of coral bleaching on the Reef. The POAMA is a coupled oceans-atmosphere seasonal prediction tool that uses current and forecasted weather conditions to indicate whether conditions conducive to bleaching are likely. Global weather patterns drive sea temperatures and can increase or decrease the likelihood of coral bleaching.

For example, strong El Niño conditions and delayed or weak development of the monsoonal trough over northern Australia during the summer are often responsible for unusually warm sea temperatures which, if severe or prolonged, lead to widespread coral bleaching. Forecasts for El Niño conditions and other broad-scale weather patterns are used to predict sea temperatures and indicate bleaching risk.

Specifically, forecasts of calm clear conditions, above average summer temperatures, below average rainfall or combinations of these will provide advanced warning that logistical preparations for the Assessment and Monitoring component of the Coral Bleaching Response Plan should begin.

Prolonged above average Sea surface temperature (SST) is now recognised as the primary cause of mass coral bleaching events (Hoegh-Guldberg 1999). The POAMA is used experimentally by the GBRMPA to forecast sea surface temperature (SST) anomalies with significant skill in predictions up to three months ahead. It is expected that future improvements in the model will lead to increased prediction skill up to six months in advance.

The following plots show examples of the experimental sea surface temperature (SST) anomaly forecasts in the Great Barrier Reef for six months of 2009.

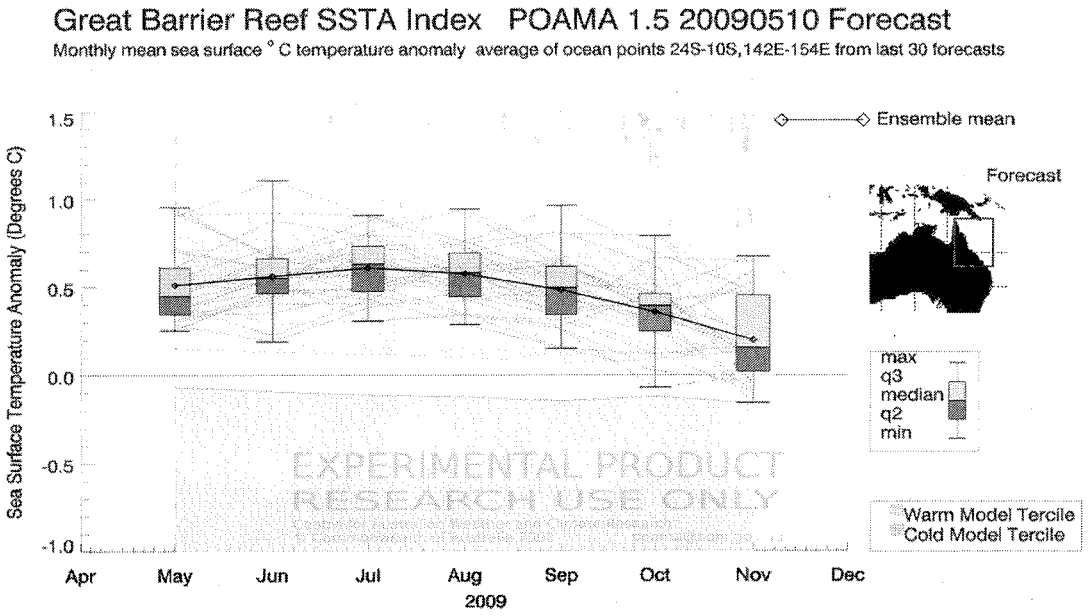


Forecasts are generated from POAMA V1.5 at lead times of 0-5 months for the region. Plots are updated daily and are based on the ensemble mean of the last 30 forecasts. SST anomalies are calculated as the difference between SST values and the climatology, the monthly long term mean SST. To evaluate the accuracy of model forecasts and provide a measure of the skill of the model, hindcasts of SST anomalies are compared to observed SST anomalies for the same period. Skill is calculated by

correlating model anomalies with observed anomalies in both space and time. For further details see Spillman and Alves (2008).

Great Barrier Reef Index Ensemble Distribution

The following plot shows the distribution by quartiles of the ensemble composed of the last 30 forecasts for SST anomalies averaged over the Great Barrier Reef region. The ensemble distribution gives a sense of the certainty of the forecast, and of the relative probabilities of various outcomes. The shading indicates upper and lower climatological terciles from the POAMA 1.5 hindcasts.



More detailed information on POAMA can be viewed at: //poama.bom.gov.au/experimental/poama15/r_gen.htm

2) Reef Temp – Near real-time sea temperature monitoring

The use of the POAMA is complemented by *ReefTemp,* which is a collaborative project between the GBRMPA, CSIRO Marine Research and the Bureau of Meteorology. *ReefTemp* is the first sea-surface temperature monitoring and mapping product in Australia tailored specifically for coral bleaching and builds on pioneering work done by the National Oceanic and Atmospheric Administration (NOAA). The system uses temperature data collected by environmental monitoring satellites.

At the broader scale, sea temperatures are monitored using the Hotspot and Accumulated Heat Indices products available from the National Oceanographic and Atmospheric Administration (NOAA), along with local weather station data. *ReefTemp* has been tailored specifically to the Great Barrier Reef to provide 'now-casting' of bleaching risk at a much finer spatial scale, enabling temperatures to be monitored at the scale of an individual reef.

Maps of coral bleaching risk are produced in *ReefTemp* by presenting thermal stress indices (SST, SST anomaly, Degree Heating Days, and the Heating Rate). These

indices are calculated by comparing remotely sensed daily temperatures to long-term averages. The SSTA, Degree Heating Days and Heating Rate indices provide managers with an indication of the likely extent and severity of mass coral bleaching. For each stress index, estimates of bleaching severity are presented in the *ReefTemp* interface as a colour gradation of light blue to dark red.

A more detailed project description of *ReefTemp*, technical reports, and contact information for project managers can be viewed at http://www.cmar.csiro.au/remotesensing/reeftemp/web/ReefTemp_application.htm

3) In-water monitoring network – real-time

The risk of sea temperatures increasing to levels that are stressful to corals also depends on a complex interaction of local weather patterns. For example, regional water temperature, local air temperature, cloud cover, wind, rainfall, and fine-scale ocean circulation patterns may all increase or decrease the risk of coral bleaching. Fine-scale temperature monitoring in the Great Barrier Reef occurs throughout the summer to ensure that localised bleaching predictions are accurate. Current in-water conditions are monitored closely using a system of remote weather stations maintained by the AIMS.

The Great Barrier Reef Ocean Observing System (GBROOS) is the Great Barrier Reef specific node of the nation-wide Integrated Marine Observing System (IMOS) and is coordinated by AIMS. GBROOS is a reef-based IP data network which assimilates data from instrument sensors located permanent moorings in the ocean and vessels out at sea along with remote sensing data from satellites. In this way the system currently collects information about the water column, water movement, temperature, water quality and nutrients throughout the northern Great Barrier Reef.

More information about the GBROOS is available at: www.aims.gov.au/docs/research/monitoring/gbroos/ocean-observing.html

The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism

The Great Barrier Reef Marine Park Authority

Climate-related events are likely to have a range of unavoidable impacts on industries such as fisheries and tourism that are directly reliant upon the ecosystem goods and services provided by the Great Barrier Reef. The goal of Objective 3 of the Great Barrier Reef Climate Change Action Plan is to work with industries and communities to increase their understanding and resilience to these changes and support strategies for adaptation. Hence, the ability to accurately predict inter-seasonal climate variability is very important to decision making processes for the GBRMPA, as this information enables GBRMPA to inform risk management and climate change adaptation strategies for these Reef-dependent industries. During the summer period when the risk of coral bleaching and cyclones is at its highest, the GBRMPA regularly assesses the risk and status of these events and provides this information to users of the Marine Park. Identification of areas of acute climate impact also provides the opportunity to test adaptive management programs.

In addition, accurate rain event forecasting is important for timing the application of fertilisers and pesticides to agricultural lands in the Great Barrier Reef catchment, so that concentrations in waterways that drain into to the Great Barrier Reef are reduced. Nutrients, sediments and pesticides that enter the waters of the Great Barrier Reef through catchment runoff, decrease water quality and compromise the health of the reef.

Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail, and tsunami, in Australia and in neighbouring countries

The Great Barrier Reef Marine Park Authority

Long term meteorological forecasting is an important element of the Early Warning System of the Coral Bleaching Response Plan. The information provided from these systems informs management of the potential level of risk that a coral bleaching event will occur at some point throughout the summer season. This knowledge aids the preparation and implementation of management responses to large scale rapidly developing climate-related events or incidents such as cyclones or mass coral bleaching events, as appropriate through the Climate Change Incident Response Framework (CCIRF) (Figure 2).

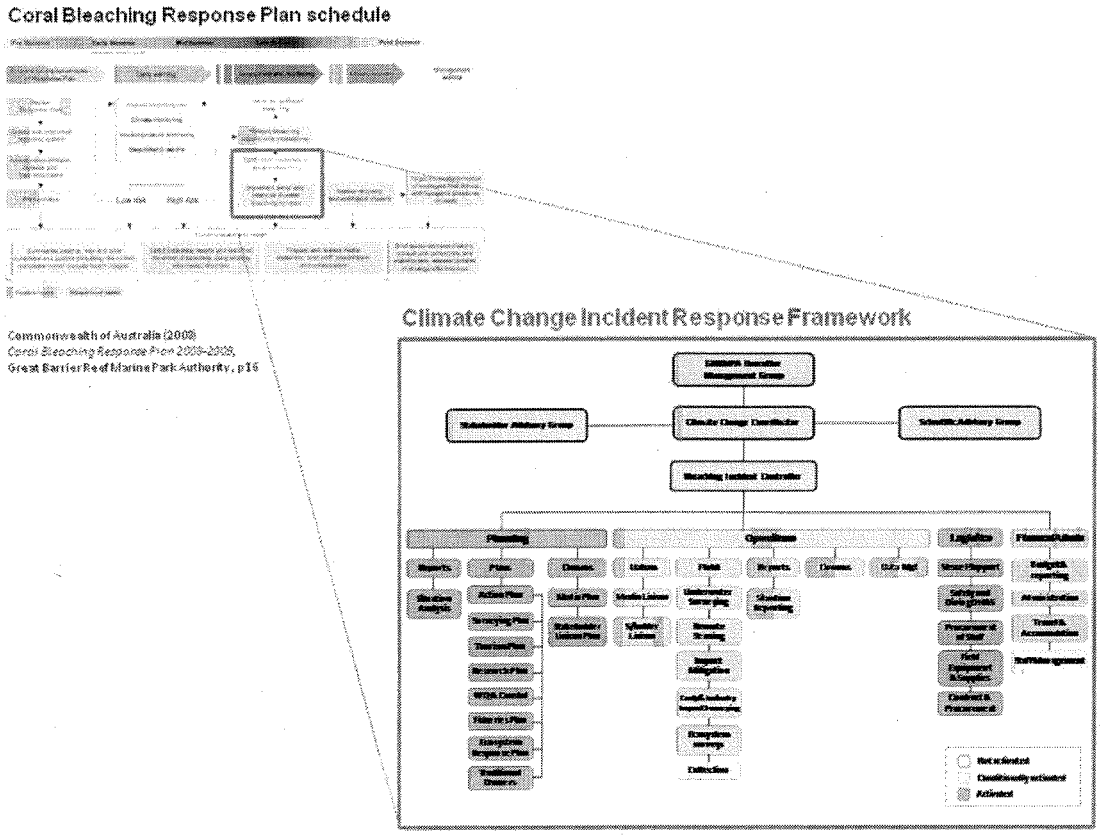


Figure 2: Climate Change Incident Response Framework

Strategies, systems and research overseas that could contribute to Australia's innovation in this area.

The Great Barrier Reef Marine Park Authority

Great Barrier Reef Marine Park Authority - Knowledge Management:
Access to the latest and most accurate meteorological information can greatly enhance the management capacity of government agencies. As the capacity of Australia's long-term meteorological forecasting continues to improve through the development of innovative modelling methods and techniques, it is particularly important that this information is disseminated as quickly and effectively as possible across agencies whose management capacity can benefit. Formal mechanisms may be necessary to ensure that this occurs as expediently as possible.

Overseas research:

Good examples of overseas programs that could substantially contribute to Australia's innovation in this area are those run by the United States' National Oceanographic and Atmospheric Administration (NOAA). NOAA Coral Reef Watch utilises remote sensing and in-situ tools for near real-time and long term monitoring, modelling and reporting of physical environmental conditions of coral reef ecosystems. Using this technique, NOAA maps "HotSpots," areas that are higher than the expected maximum. More information about these programs can be found at the following sites:

http://coralreefwatch.noaa.gov/
http://www.noaawatch.gov/themes/coral_bleaching.php

Whilst similar to the POAMA and *ReefTemp* initiatives used by the GBRMPA, the NOAA initiatives are designed for use on a global scale, whilst the tools used by the GBRMPA are tailored on the parameters necessary for use in the Great Barrier Reef region.