Australian Government

Great Barrier Reef
Marine Park Authority

Coral Bleaching Response Plan 2009 - 2010

Great Barrier Reef Marine Park Authority

Executive Summary

Climate change is now recognised as the greatest long-term threat to the Great Barrier Reef. Climate-related events have already caused significant stress leading to severe mass coral bleaching events in 1998 and 2002, as well as a localised event in the southern Great Barrier Reef in 2006, all of which were caused by higher-than-normal sea temperatures. Future bleaching events are inevitable and reef managers have a responsibility to monitor, assess and respond to the socio-ecological impacts of coral bleaching.

Each year the GBRMPA updates the Coral Bleaching Response Plan to incorporate new technologies and key learnings from the previous summer. Summer 2008-09 provided a number of valuable insights into the future for the Great Barrier Reef under a changing climate. Whilst widespread bleaching did not occur the Reef was stressed by extreme sea surface temperatures, monsoonal rainfall and physical damage caused by Tropical Cyclone (TC) Hamish. Sea surface temperatures in December 2008 were consistent with patterns that preceded the 1998 and 2002 mass coral bleaching events; fortunately widespread bleaching did not occur primarily because sea temperatures decreased rapidly with the arrival of the monsoon in early 2009. However whilst the monsoon was beneficial from a Reef wide perspective, record levels of monsoonal rainfall and flooding caused substantial property damage in a number of coastal communities and localised bleaching, disease and coral mortality on shallow inshore reefs between Cairns and Townsville. In the southern section of the Great Barrier Reef analysis of pre and post TC Hamish aerial imagery and surveys conducted by scientists from the Australian Institute of Marine Science (AIMS) indicate that many coral cays and up to 70 per cent of reefs were severely damaged. Substantial social and economic consequences of TC Hamish were also revealed through interviews with commercial fishers that rely upon the affected area.

Whilst the Great Barrier Reef has a long history of exposure to, and recovery from, major disturbances such as cyclones and floods, the recovery capacity of the ecosystem is likely to diminish as summer conditions like those of 2008-09 become the norm. Consequently the risk of coral bleaching each summer cannot be viewed in isolation, as the legacy of impacts from previous years may render corals more susceptible to bleaching and disease.

As sea temperatures and the occurrence of severe weather events continue to increase, understanding how coral reefs in the Great Barrier Reef Marine Park will respond and which species, regions, and industries are most likely to be affected is critical for management to maintain the health of the ecosystem. This document outlines a strategic approach for monitoring risk and responding to coral bleaching events when they occur. The four main components are:

1. Early Warning System
2. Incident Response
3. Management Actions
4. Communication Strategy.

The Early Warning System uses state-of-the-art technology and a volunteer monitoring network to monitor the risk and onset of impacts each summer. If significant damage is reported, the Climate Change Incident Response Framework (CCIRF) provides a common organisational structure that coordinates the governance, finance, planning and reporting procedures required to measure the extent and severity of the impact and implement an effective response to a coral bleaching event. Management actions can support the resilience of affected coral reefs and promote recovery after bleaching disturbance. Each of the first four components is complemented by effective communication to senior decision-makers, the media, and stakeholders about bleaching risk, habitat condition, and plans for the implementation of management actions.

This Response Plan is intended as a practical guide for coral reef managers to respond to the threat of climate-induced coral bleaching. It provides the detailed protocols and describes the decision-support tools that the Great Barrier Reef Marine Park Authority uses to monitor and understand coral bleaching. This updated version of the Coral Bleaching Response Plan also outlines a framework to guide implementation of management actions that can help build the resilience of coral reefs to coral bleaching events.

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Introduction

Climate change has a range of direct and indirect impacts on coral reefs, and in combination with other human-induced stressors is leading to unprecedented pressure on coral reefs. Climate change poses a multitude of threats to reefs but the increased frequency and severity of coral bleaching events is among the most pressing. Spatially extensive or 'mass' coral bleaching events, driven by unusually warm sea temperatures, have now affected every major coral reef ecosystem in the world (Wilkinson 2004). Coral bleaching is caused by a disruption in the symbiosis between the coral animal host and the single-celled algae that reside within its tissues, the zooxanthellae. These symbiotic algae provide the coral with nutrients through photosynthesis, and are pigmented, giving corals their rich colours. The symbiotic relationship breaks down when high sea temperatures alter the chemical photosynthetic pathways in the zooxanthellae, producing toxic by-products. Ultimately the zooxanthellae are expelled from the coral and the transparent coral tissue remains, clearly revealing the white limestone skeleton beneath – hence the name 'bleaching'. Corals can regain their zooxanthellae and survive bleaching if conditions abate. However, if the thermal stress persists, corals can and have died in great numbers (Wilkinson 2004). Corals provide structure, habitat and food for the rich biological diversity for which reefs are renowned. These interdependencies mean that the effects of coral bleaching are potentially devastating to ecosystems and the communities and industries that depend upon them. Consequently, understanding the effects and implications of coral bleaching, and identifying strategies to reduce stress and mitigate impacts, are urgent challenges for the conservation and management of coral reefs worldwide.

The Great Barrier Reef (the Reef) has experienced two widespread coral bleaching events in recent years, 1998 and 2002 and a severe localised coral bleaching in 2006. During the 1998 and 2002 events at least half of the reefs within the Great Barrier Reef Marine Park were affected by bleaching, with up to five per cent of reefs suffering serious damage (>50 per cent corals killed). The spatial extent of these events, combined with the high level of mortality seen at severely affected sites, has lead to widespread concern about the future of the Reef in the face of global climate change. In 2006 extreme sea surface temperatures around the Keppel Islands in the southern section of the Reef resulted in around 40 per cent coral mortality on the fringing reefs around the islands. Whilst extreme sea surface temperature affected the Reef in November and December 2008 the heat stress was alleviated and a widespread bleaching event was avoided by the arrival of the monsoon in January 2009. The monsoonal rainfall rapidly cooled the majority of the Reef with the exception reefs in the far northern (Port Douglas – Lizard Island) and southern (Swains Reefs) sections of the Marine Park. Moderately severe local bleaching was reported from those locations. In addition the heavy rainfall resulted in significant flooding of coastal catchments between Townsville and Cairns and associated localised mortality of fringing coral reefs around several inshore islands primarily as a result of low salinity stress (Figure 1). On a Reef wide scale these two sets of impacts did not cause major damage however the category five Tropical Cyclone (TC) Hamish which tracked through the central and southern regions of the Reef in March 2009 did cause substantial damage to approximately seventy percent of reefs located within its path (Figure 1). The cumulative impact of these extreme events is uncertain, however the legacy of last summer coupled with sea temperatures remaining 1-2 degrees centigrade above average throughout winter 2009 highlights the need to consider bleaching risk within the context of residual stress from previous impacts. Research findings indicate stressed reefs may be more susceptible to coral bleaching and disease outbreaks (Harvell et al., 2002; Fitt et al., 2001; Bruno et al., 2007). Consequently the legacy of impacts from last summer, coupled with this mild winter may increase the susceptibility of corals to coral bleaching over the coming summer.

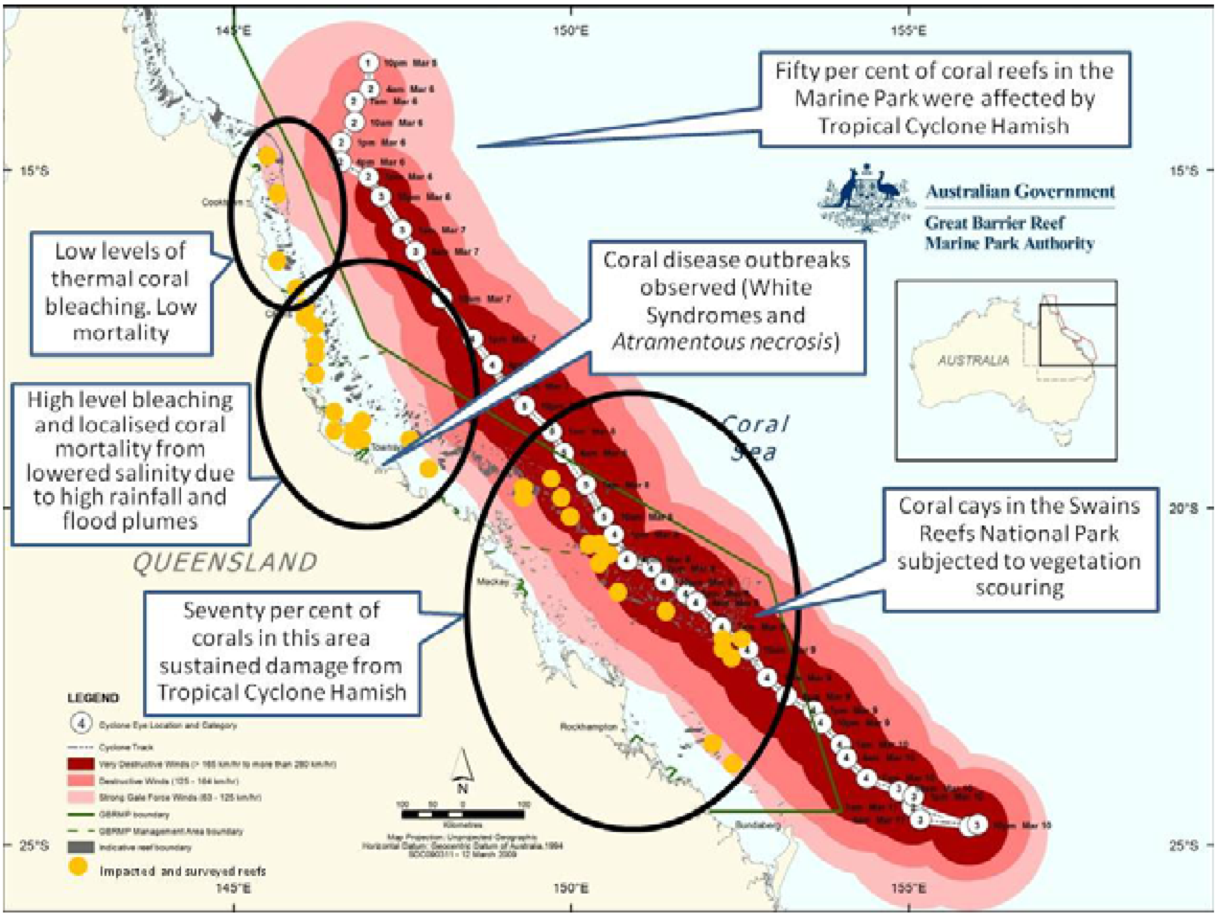


Figure 1. Extent and severity of extreme weather impacts affecting the Great Barrier Reef during the summer of 2008-09.

To meet the challenge of responding to coral bleaching events, the Climate Change Group at the Great Barrier Reef Marine Park Authority (GBRMPA) developed a Coral Bleaching Response Plan (the Response Plan) in 2002, as part of a response to the bleaching event that occurred in the late summer (February and March) of that year. Since then, the Climate Change Group has coordinated implementation of the Response Plan each summer – December to March – and has reviewed and refined it annually. The Response Plan has four primary components: 1) Early Warning System, 2) Climate Change Incident Response, 3) Management Actions, and a 4) Communication Strategy (Figure 2). Monitoring of the Early Warning System and some aspects of the communication strategy occur annually while components 2 and 3 only apply if a spatially extensive and/or severe bleaching event occurs. During each summer season an effective management response to bleaching depends on clear and transparent communication between managers and senior decision-makers, stakeholders and the public. Communication is, therefore, an overarching theme. Within this document, the objectives of each of the four primary components are outlined and the components described in detail.

Importantly, the Response Plan has been developed in conjunction with *A Global Protocol for Assessment and Monitoring of Coral Bleaching* (prepared by WWF, World Fish Center and GBRMPA) and *A Reef Manager's Guide to Coral Bleaching* (an international collaborative effort led by the GBRMPA, National Oceanic and Atmospheric Administration (NOAA) and the International Union for Conservation of Nature (IUCN)) to maximise comparability and consistency with bleaching responses in other regions.

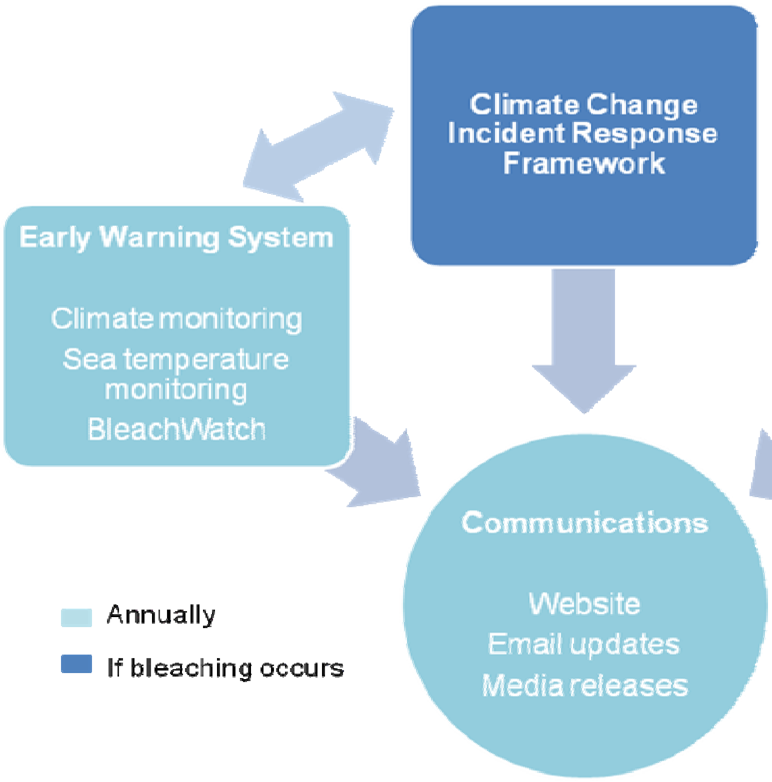


Figure 2. Four components of the Coral Bleaching Response Plan. The Early Warning System, Climate Change Incident Response Framework, and Management Actions are all connected by the need to clearly and effectively communicate about bleaching risk, ecosystem condition, and management strategies following bleaching events.

1. Early Warning System

Mass coral bleaching is preceded by a series of conditions that can be used to assess the probability of an event occurring. The Early Warning System uses climate forecasts, remote sensing data, *BleachWatch* reports and site inspections to monitor conditions that are conducive to coral bleaching and any early signs of bleaching. These elements are described below.

Prior to the summer season, calm, clear ENSO-like climatic conditions can develop that are known to warm sea temperatures. Above-average water temperatures often follow, which can lead to patchy bleaching or bleaching of more vulnerable coral species (Figure 3). Widespread bleaching can ensue, resulting in a mass bleaching event. Recent advances in science and technology allow for monitoring of these climatic conditions that lead to bleaching as well as near real-time monitoring of sea temperatures throughout the Marine Park and Coral Sea. A volunteer monitoring network – *BleachWatch* – also provides localised sea temperature and habitat information to ensure managers are notified of early signs of bleaching. The *BleachWatch* network is spatially extensive and provides an information exchange that makes monitoring cost-effective and educational. If bleaching is reported then quantitative site inspections are undertaken to confirm the severity of bleaching and form the final step in the early warning process. If bleaching impacts are spatially extensive and/or severe, the Incident Response component is implemented.
The following sections describe each element of the Early Warning System in more detail.

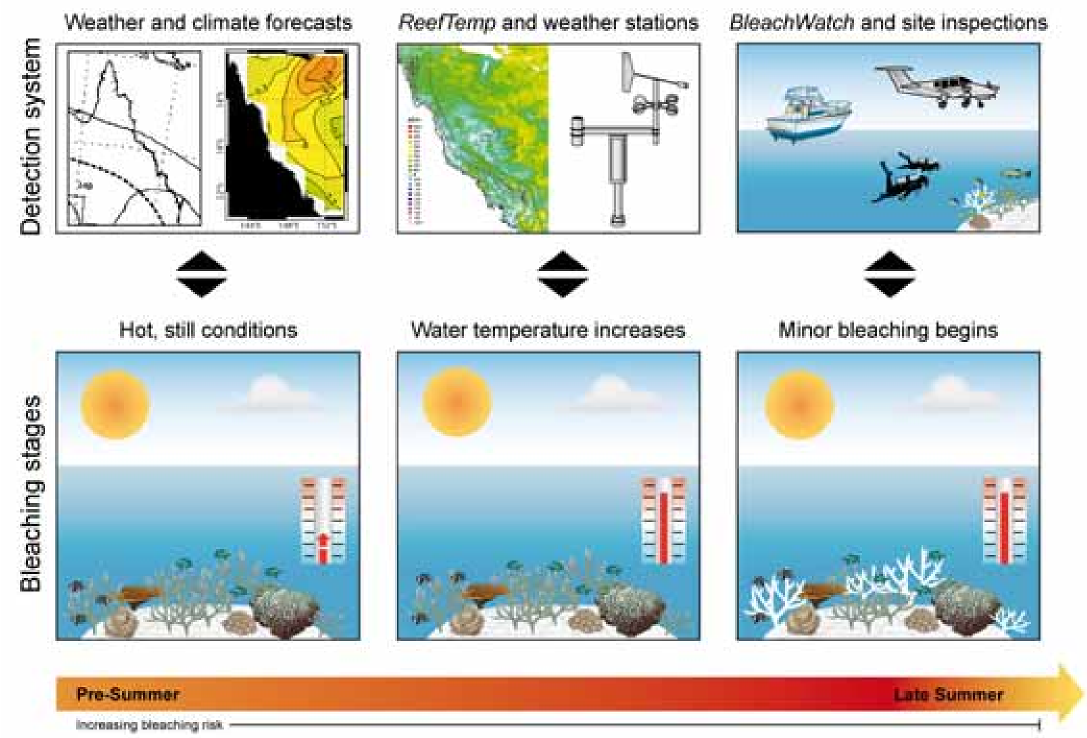


Figure 3. Detection of early signs of coral bleaching can occur at a number of stages including (a) forecasts of hot, calm conditions, (b) mapping by *ReefTemp* or weather stations of anomalous high water temperatures, (c) reports by reef users of the initial stages of coral bleaching, which is followed by site inspections.

Climate monitoring and prediction

A number of factors are known to cause high sea temperatures in the Great Barrier Reef. In particular, delayed or weak development of the monsoonal trough over northern Australia during summer appears to be a strong precursor to the anomalously warm conditions that, if severe or prolonged, can cause coral bleaching. Based on an emerging understanding of the relationship between weather and sea temperatures for the Great Barrier Reef, current and forecast weather conditions can indicate whether conditions conducive to bleaching are likely. 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 Incident Response component of the Response Plan should begin.

The probability of above average summer sea temperatures, and hence the likelihood of a mass bleaching event occurring, can now be predicted using the coupled ocean-atmosphere seasonal prediction system POAMA (Predictive Ocean Atmosphere Model Australia), developed by the Centre for Australian Weather and Climate Research (CAWCR). POAMA sea surface temperature (SST) forecasts for the Great Barrier Reef[1] are produced for up to six months into the future, with significant skill in predictions up to three months ahead (Spillman and Alves 2008; Figure 4). It is expected that future improvements in the model will lead to increased skill with longer lead times. Seasonal climate predictions reviewed in the early stages of summer can help indicate the potential for the development of anomalous sea temperatures in coming months. In particular, above average sea temperatures on the Great Barrier Reef and western Pacific are often associated with El Niño events, forecasts of which have been operationally produced by POAMA since 2002. The presence and/or prediction of strong El Niño conditions or the forecasting of above average temperatures by POAMA will trigger logistical preparations for bleaching assessment and monitoring (see Figure 15).

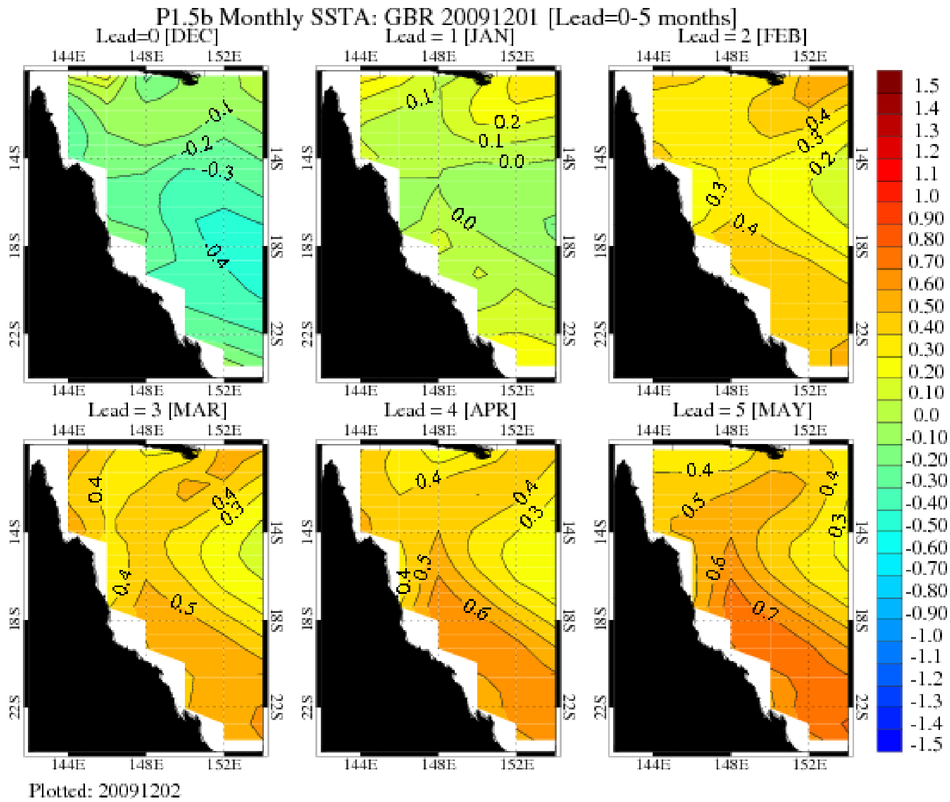


Figure 4. POAMA forecasts of sea surface temperature anomalies in the Great Barrier Reef region for the 2009/2010 summer (current as of 1st December 2009). The forecasts show that temperatures throughout the Great Barrier Reef Marine Park are likely to be at or below average for December 2009 and January 2010 and 0.3 to 0.5 °C above the long-term averages for the region for rest of the summer period.

[1] http://poama.bom.gov.au/experimental/poama15/sp_gbr.htm

In 2009 BOM formally released the operational version of POAMA v1.5 (POAMA) and introduced a further range of experimental predictive tools that expand upon the existing POAMA model. The new experimental tools include A) a second sea surface temperature anomaly (SSTA) forecast based on the ensemble of daily forecasts from the past 10 days to highlight the influence of any recent events in the region e.g. the onset of the monsoon or tropical cyclones (Figure 5). B) a probabilistic forecast of the likelihood of sea surface temperature anomalies of 0.6 degree Celsius or greater affecting the Reef in the coming months (potential coral bleaching conditions) (Figure 6) and C) a measure of the skill (accuracy) of the forecasts. These new tools provide enhanced early warning capacity and are a useful addition for Reef managers.

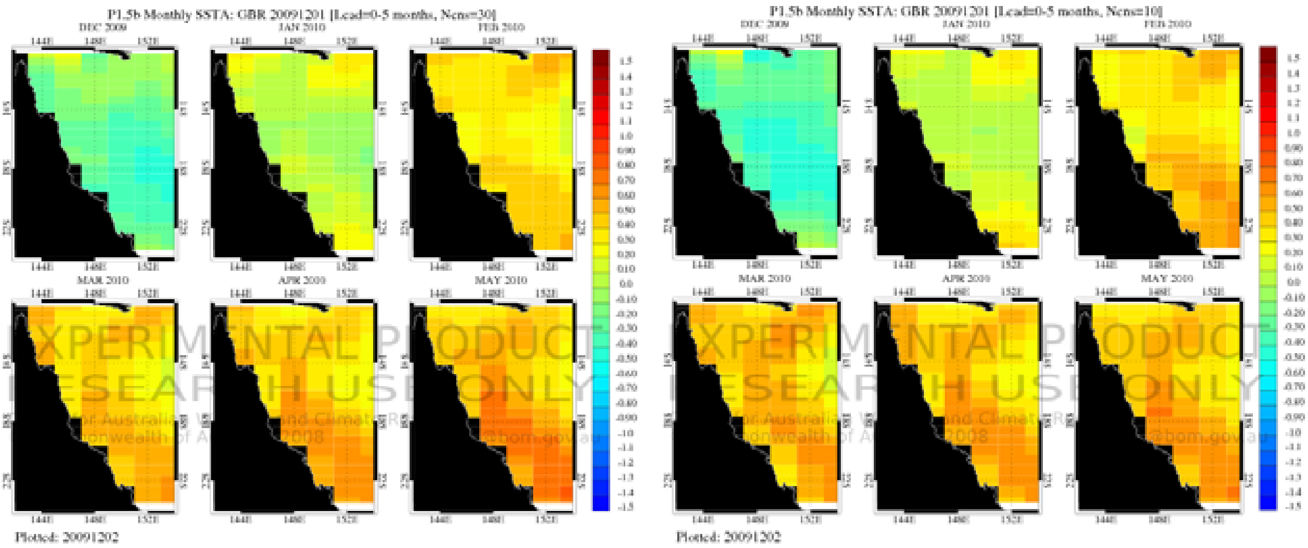


Figure 5. Experimental 30 and 10 member ensemble POAMA forecasts of sea surface temperature anomalies in the Great Barrier Reef region for the 2009/2010 summer (current as of 1st December 2009). Comparison of the 30 and 10 member ensemble forecasts can highlight the influence of recent events such the onset of the monsoon or tropical cyclones on future forecasts.

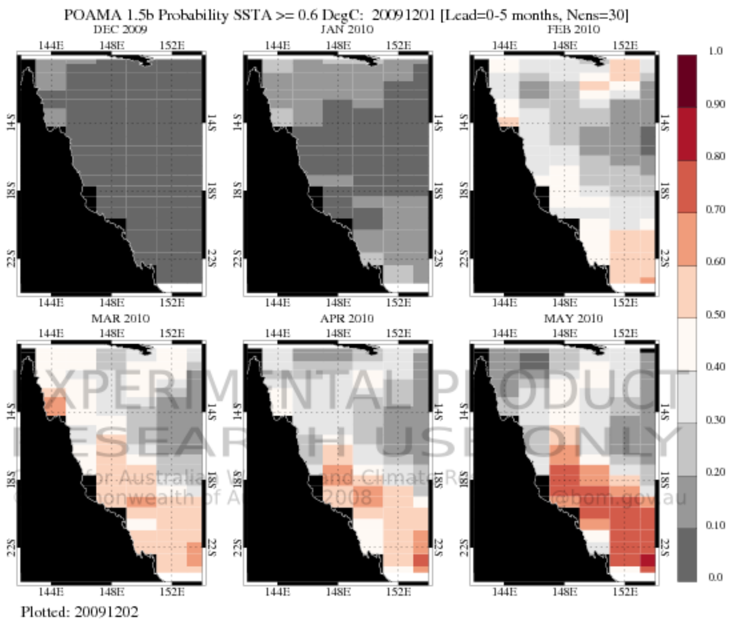


Figure 6. Experimental probabilistic forecast of the likelihood of sea surface temperature anomalies of 0.6 degree Celsius or greater (potential coral bleaching conditions) affecting the Reef in the following six months.

A number of environmental stresses can lead to coral bleaching. It is, however, well established that spatially extensive or mass bleaching events are caused by anomalously high sea temperatures (Hoegh-Guldberg 1999). Excessive and persistent sea temperature anomalies are, therefore, a good indication that conditions are approaching levels known to be stressful to corals. *ReefTemp* has been developed to monitor summer sea temperatures in near real-time using temperature data collected by environmental monitoring satellites, and provides early warning of potential bleaching on the Great Barrier Reef.

The *ReefTemp* suite of products monitors sea temperatures, as well as several novel measures of temperature stress known to be strongly correlated with past observations of bleaching impacts, for coral reefs in all Australian waters[2]. *ReefTemp* was developed by the GBRMPA in collaboration with the Bureau of Meteorology and the remote sensing group of the CSIRO and was first trialled on the Great Barrier Reef in late 2005. The *ReefTemp* suite of products is a locally developed equivalent of the National Oceanic and Atmospheric Administration's (NOAA) HotSpot program[3], but with a 1-km resolution and with daily updates.

ReefTemp produces images that display the current sea surface temperatures around Australia as well as sea surface temperature anomalies, accumulated heat stress (degree heating days), and heating rate (Figure 7). The sea surface temperature anomaly is the temperature above the long-term average for that month, while the degree heating days is an index that incorporates both the intensity and duration of heat stress. A degree heating day is equivalent to one day in which a temperature of 1°C above the long-term average is observed. The heating rate indicates the intensity of the temperature anomaly, and is calculated as degree heating days divided by the number of days temperatures have exceeded the long-term average (see Maynard et al. 2008 for more detail).

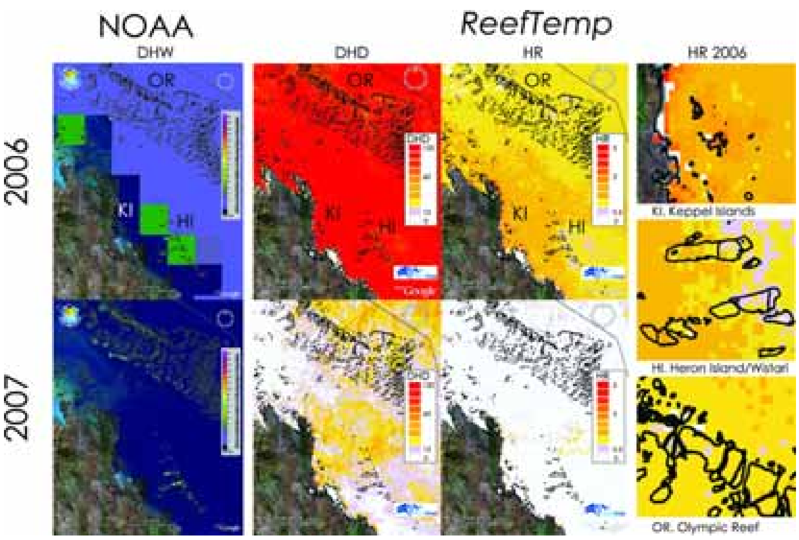


Figure 7. NOAA degree heating week (DHW), and *ReefTemp* images of degree heating days (DHD) and heating rate (HR) for the end of the summer, February 27, 2006 and 2007. The heating rate index used in *ReefTemp* performed the best, accurately predicting that bleaching responses in the southern Great Barrier Reef in 2006 (HR 2006) would be severe at the Keppel Islands (KI) and extremely mild at Heron Island (HI) and Olympic Reef (OR). The site images highlight the usefulness of high-resolution SST data in the *ReefTemp* application as all of the temperature information shown at each site (under HR 2006) is summarized with the colouring of just one pixel in the NOAA DHW product (sourced from Maynard et al. 2008).

[2] http://www.cmar.csiro.au/remotesensing/reeftemp/web/ReefTemp.htm).
[3] Available at: http://www.osdpd.noaa.gov/PSB/EPS/SST/climohot.html

In addition, *in situ* measurements of local sea temperatures are available from a network of weather stations installed on the Great Barrier Reef and maintained through collaboration between the GBRMPA and the Australian Institute of Marine Science[4] (Figure 8). These weather stations record water temperature at the surface and at 6m depth providing important information about depth-related variability, and a mechanism to ground truth *ReefTemp* outputs. *ReefTemp* and the weather stations are monitored regularly throughout the summer season. When reefs or reef regions within the Marine Park experience prolonged periods of excessively high temperatures, managers maintain close contact with a volunteer network of observers – *BleachWatch* – to ensure regular reports of reef condition are submitted and managers are alerted to early signs of bleaching.

Figure 8. Weather station operated by AIMS at Myrmidon Reef, an outer-shelf reef offshore of Townsville.

BleachWatch

Detecting the early signs of a mass bleaching event requires a wide network of observers on the Great Barrier Reef due to its size and because the initial onset of mass coral bleaching can range from gradual and patchy to rapid and uniform. *BleachWatch* is a community monitoring network that has been designed to provide reliable reports of reef condition throughout the summer season. *BleachWatch* was established in 2002 and is built on a network of regular reef users, including professionals, researchers, fishers and other recreational users who voluntarily monitor and report on conditions at reefs that they visit. Participation in *BleachWatch* spans the Great Barrier Reef from Port Douglas in the north to Bundaberg in the south. The broad base of participation is supported by the close coordination and linkages between *BleachWatch* and related programs such as the Reef Health Impact Survey (RHIS) deployed by Queensland Parks and Wildlife Service and the GBRMPA Eye on the Reef program developed for the tourism industry to monitor broad indicators of ecosystem health.

BleachWatch participation is greatest in areas of the Great Barrier Reef that are tourism hubs, such as Cairns, Port Douglas and the Whitsundays. Other regions are not regularly visited and represent a gap in the spatial coverage of the monitoring network. Collaborations with Coastwatch, RHIS, researchers and other monitoring programs such as Reef Check help capture reports of bleaching from areas that are not regularly visited by other participants. Reports of severe bleaching from either *BleachWatch* or affiliated efforts are verified by the Climate Change Group in partnership with trained staff from Queensland Parks and Wildlife Service who undertake detailed site inspections (Figure 9).

[4] http://data.aims.gov.au/awsqaqc/do/start.do

In 2009 the *BleachWatch* program was enhanced with the development of a revised monitoring protocol that is common to both *BleachWatch* and RHIS. These changes were adopted for two main reasons 1) to increase the accuracy and comparability of data collected by these two programs and 2) to enable *BleachWatch* participants to monitor a range of reef health indicators throughout the year. The revised protocol can be completed by snorkelers or divers using a repeated Global Positioning System (GPS) tagged five metre radius point survey method. This method is used to assess a range of reef health indicators including coral and algal cover and the extent and severity of impacts such as coral bleaching, disease, predation and damage (Figure 9). Prior to these revisions, surveys were completed during a 20 minute timed swim; whilst this method continues to be valuable in detecting the presence or absence of impacts the data cannot be directly compared between sites as the size of the survey area is not consistent.

The new protocol also recognises the limited time that many *BleachWatch* participants have to complete survey forms. One form will be completed for each point survey thus reducing the time taken to evaluate benthic cover and allowing ample time to accurately evaluate the presence or absence of the increased range of impacts included in the new form. Ideally observers will complete at least three point surveys at each site whilst remaining within one habitat type e.g. reef slope or lagoon. Repeated surveys are conducted to enable statistical analysis of the data; however these surveys do not have to occur on the same day if time is limited. In addition to data accuracy and comparability benefits these revisions also address the need to evaluate bleaching impacts in the context of cumulative stresses on reef health such as those that were experienced during the 2008-09 summer (Figure 1).

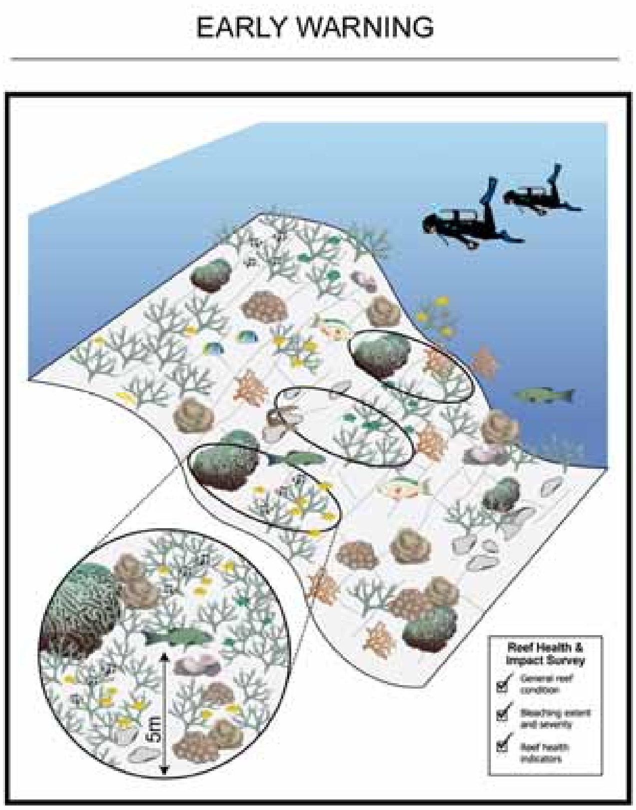


Figure 9. ***BleachWatch* protocol:** Under the Early Warning System *BleachWatch* observers use the new protocol to assess reef condition and to detect impacts including coral bleaching. *BleachWatch* surveys can be completed by snorkelers or scuba divers. Observers select a central point for the survey from the surface and record the GPS coordinates on the data sheet. A 360 degree panorama of photographs of the survey area should then be taken from the GPS waypoint. The survey area is defined using a 5m tape measure to mark the radius of the circular survey area. Experienced observers may chose to eliminate the tape measure once they are familiar with estimating a 5m radius area underwater. If significant bleaching is detected, the Climate Change Incident Response Framework will be triggered and either localised or Reef wide Assessment and Monitoring site inspections will be conducted by experienced observers.

The success of the *BleachWatch* program depends on the ability of participants to, correctly identify and submit robust information on reef health impacts and distinguish between the different degrees of bleaching extent, severity and mortality, and judge percentage cover of live, bleached and dead coral at a site. Participants also need to be able to recognise different coral life forms, as well as the signs of other impacts on corals such as diseases or predation by Crown of Thorns Starfish or *Drupella* snails. Many *BleachWatch* participants have no prior marine biology knowledge, hence the *BleachWatch* training program and participant resource kits have also been revised to bridge this knowledge gap and ensure that reports are as consistent as possible. Training sessions are held in each of the four different regions of the Marine Park at the beginning of each summer and information and distance learning materials are available for download via the GBRMPA website.

Participants are asked to complete their *BleachWatch* reports whenever they are out of the Reef and have spare time, and on a weekly or fortnightly basis during summer (see Appendix A). To fill out the form, participants are asked to provide information about: the reef location, general habitat condition, observations of any impacts and environmental conditions at the time of their visit such as water temperature and visibility. The information from *BleachWatch* reports is collated into a database and loaded into a spatial mapping tool. These results are reviewed weekly during the summer months (see Table 3) to identify where coral bleaching has been sighted, whether it is spatially or locally significant, and whether the Incident Response component of the Response Plan should be implemented. The reports submitted by *BleachWatch* participants are compiled and synthesised into monthly summary regional reports of reef condition between December and March each year. The reports are sent to participants to update them on reef condition at the sites they visit, to alert them of current and/or changes in bleaching risk, and as a way of reinforcing the value of the information they collect. In addition, synthesis reports inform participants of any differences between what they have observed in their region and what other visitors in their region have observed. At the end of the high bleaching-risk season, a summary report describing *BleachWatch* participation, bleaching observations and recommendations for future years is prepared and posted on the GBRMPA website.

Site inspections

Site inspections are conducted on an as-needed basis at sites where *BleachWatch* participants, Queensland Parks and Wildlife Service or Coastwatch have reported widespread and/or moderate to severe impacts (see Table 1). Site inspections are conducted by experienced observers to validate the impact reports from the *BleachWatch* network. Site inspections involve the completion of with a series surveys on scuba at two depths using either the *BleachWatch* 5m point survey or Rapid Assessment Monitoring Protocol (see Appendix D). Ideally, these site inspections are completed with the involvement of *BleachWatch* participants who provided the initial bleaching reports. If site inspections confirm moderate to severe localised impacts or widespread minor bleaching then the Climate Change Incident Response Framework is activated.

Table 1. Levels of bleaching severity and extent. Stressful conditions or reports of localised minor impacts trigger preparations for the Climate Change Incident Response Framework. If moderate to severe or widespread bleaching is confirmed by site inspections then the Climate Change Incident Response Framework is activated and the response level is determined in accordance with the situation analysis.

Severity	Description
Stressful conditions	POAMA predicts SST anomalies >0.6 ^{o}C for > 2 months Degree heating days index >50 at multiple sites Heating rate index >2 at multiple sites Major flooding of coastal catchment imminent Major cyclone passed over reef
Minor impacts	Severe bleaching of many (10-50 per cent) colonies from highly-sensitive indicator species (Pocilloporidae) Severe bleaching of some (<10 per cent) colonies of moderately-sensitive indicator species (Acropora) Paling of low-sensitivity indicator species (Porites) Severe bleaching of moderate or low-sensitivity indicator species but confined to reef flat
Moderate impacts	Bleaching extends deeper than reef flat and: Severe bleaching of most (>50 per cent) colonies of highly-sensitive indicator species (Pocilloporidae) Severe bleaching of many (10-50 per cent) colonies of moderately-sensitive indicator species (Acropora) below reef crest Severe bleaching of some (<10 per cent) colonies of low-sensitivity indicator species (Porites) Some mortality of high-sensitivity species but confined to reef flat
Major impacts	Bleaching extends deeper than upper reef slope and: Mortality of many (>50 per cent) colonies of highly-sensitive indicator species (Pocilloporidae) Severe bleaching of most (>50 per cent) colonies of moderately sensitive indicator species (Acropora) Severe bleaching of many (10-50 per cent) colonies of low sensitivity indicator species (Porites)
Severe impacts	Many to most (10-100 per cent) of colonies of moderate to low-sensitivity indicators species (Acropora and Porites) killed

Extent	Description
Localised	Impacts present in less than 10 sites within one region
Regional	Impacts present in more than 10 sites but confined to one region
Widespread	Impacts present in more than 10 sites in each of multiple regions

2. Incident Response

The Australian Standards based Climate Change Incident Response Framework (CCIRF) provides a common organisational structure that identifies the governance, planning, operations, logistics, financial and inter-agency liaison arrangements required to respond in an efficient and effective manner to a climate change incident (Figure 10.). The CCIRF sets out the coordination and control mechanisms for mobilising resources to deal with climate change incidents such as coral bleaching, severe rainfall events, coral disease outbreaks and cyclone impacts.

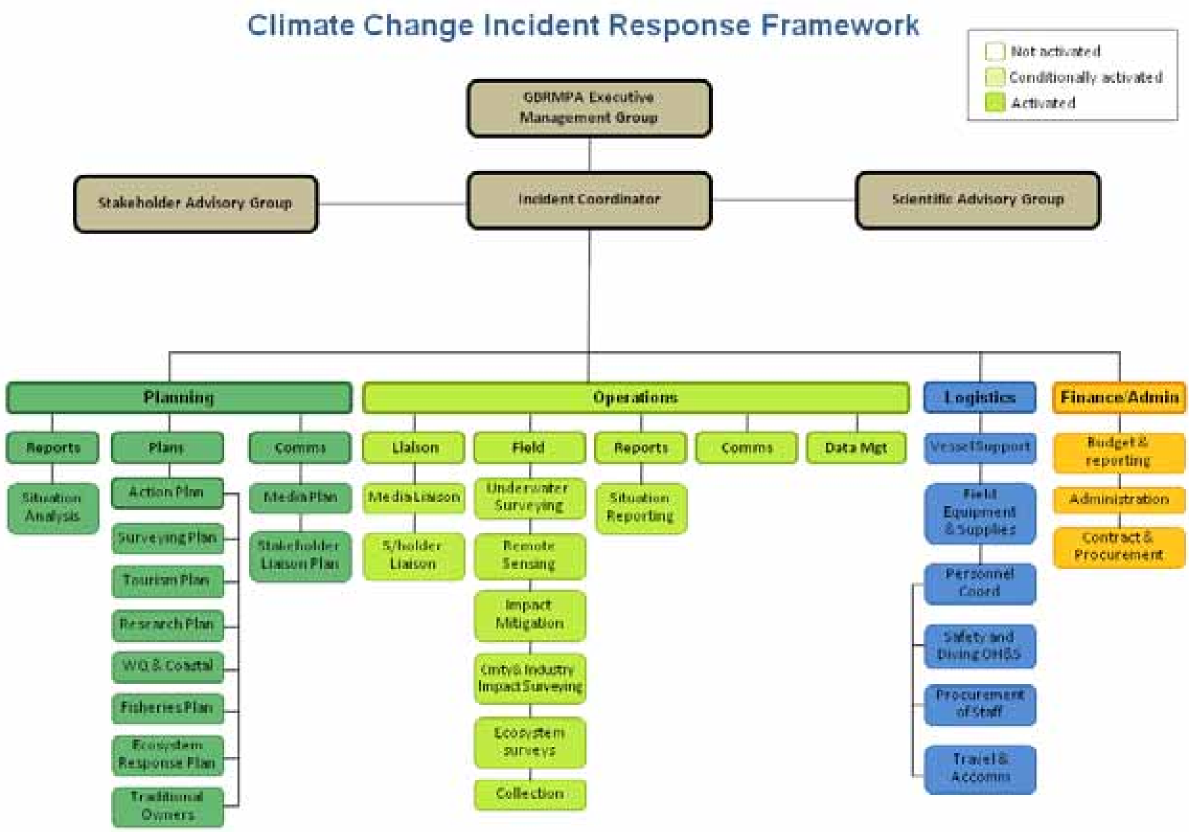
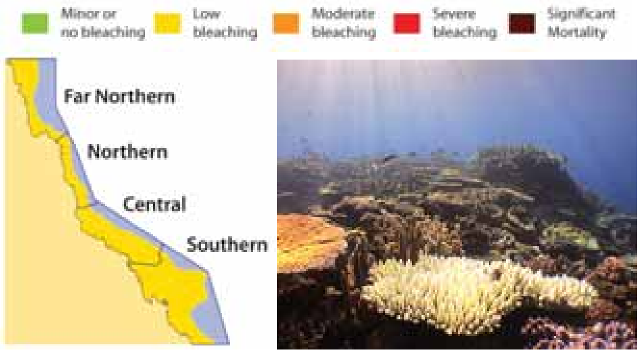


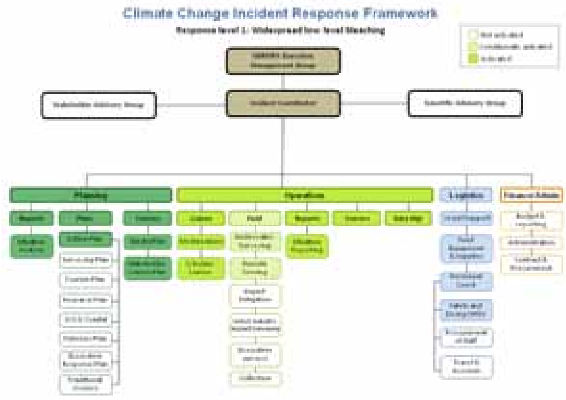
Figure 10. The Climate Change Incident Response Framework. Framework components are conditionally activated dependent upon the nature, extent and severity of the incident.

The CCIRF provides detailed plans for coordinating the incident response. Preparation and coordination commences with monitoring of the Early Warning System (Figures 2 and 13). Information gathered through the monitoring of the Early Warning System is used to develop the situation analysis. The information presented within the situation analysis is assessed by the governance group; (the GBRMPA executive management group, the incident controller and the scientific and stakeholder advisory groups) to determine the required level of response (Figure 11). Once the appropriate response level has been determined the corresponding conditional planning and resource provisions of the CCIRF are activated. The CCIRF is only intended to direct and coordinate management actions relating to the incident. Post incident management options including those designed to support or enhance resilience and recovery are detailed in section 3.

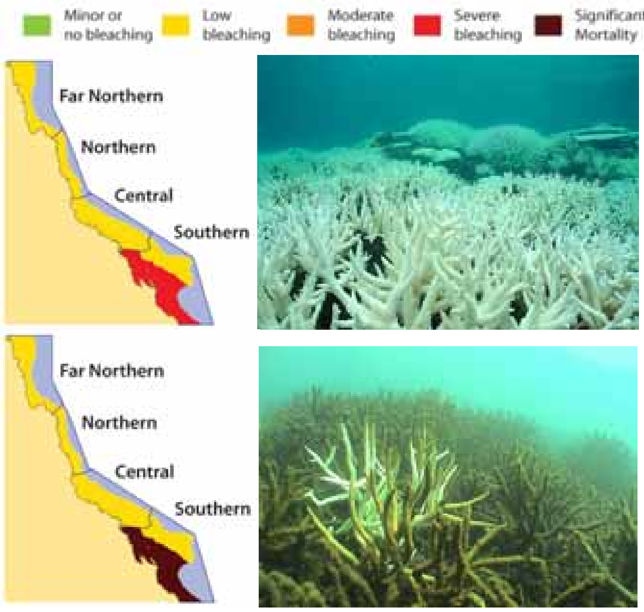
Response Level 1: Widespread low level bleaching



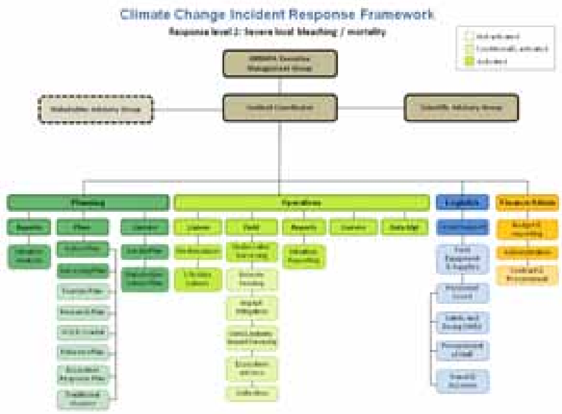
Low to moderate coral bleaching at multiple sites.



Response Level 2: Severe local bleaching and/or local mortality

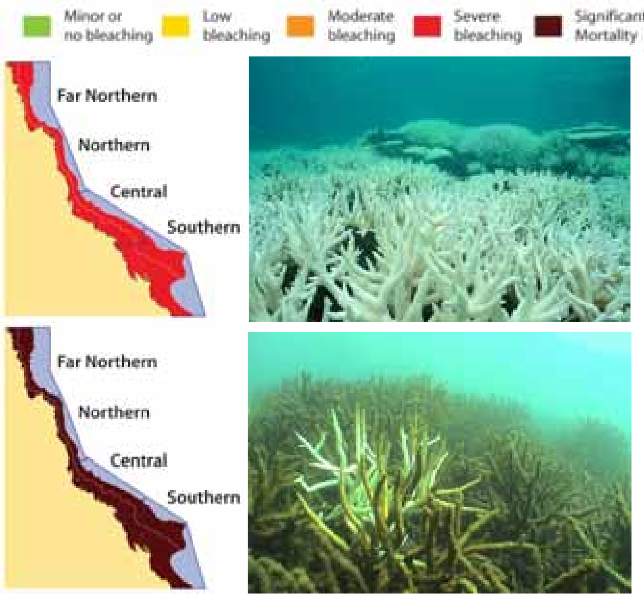


Severe coral bleaching at multiple sites within one region.

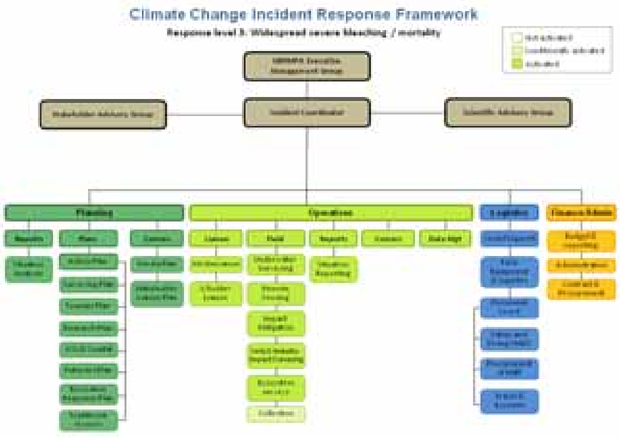


Significant coral mortality at multiple sites within one region.

Response Level 3: Severe widespread bleaching



Severe coral bleaching throughout the Marine Park.



Significant coral mortality throughout the Marine Park.

Figure 11. CCIRF coral bleaching response levels. Activation of each response level is based upon an assessment of the current field conditions by the Incident controller. Conditional activation of CCIRF components is illustrated by the intensity of colour of each box within the CCIRF diagrams above.

Assessment and Monitoring is conducted to assess the spatial extent and severity of coral bleaching events and determine the ecological implications of mass bleaching. The implications of mass bleaching include but are not limited to: coral mortality, shifts in coral community structure, altered habitat composition, ecosystem flow-on effects, and reduced social or economic value.

A two-tiered approach of intensive in-water surveys at routine sites (surveyed during each event) and targeted sites (those most affected by bleaching), combined with aerial surveys provides the best possible combination of spatial coverage and continuity (Oliver et al. 2004). Such an approach is a pragmatic yet defensible way to collect data quickly during a bleaching event while creating a long-term record. While there have been recent developments in the use of satellites to measure spatially extensive bleaching (Elvidge et al. 2004), this approach is still experimental and relatively expensive. Since 2008 GBRMPA has received free of charge satellite imagery through the Planet Action initiative developed by Spot Image. This partnership greatly enhances GBRMPA's capacity to task and obtain relevant satellite images. In 2009 high resolution satellite imagery was used to assess the extent of flood plumes associated with monsoonal rainfall and to complement aerial surveys and images of localised bleaching. GBRMPA is currently working in partnership with researchers from CSIRO and the University of Queensland (UQ) to develop remote sensing techniques for assessing climate change impacts on the Marine Park utilising the imagery provided through the Planet Action initiative.

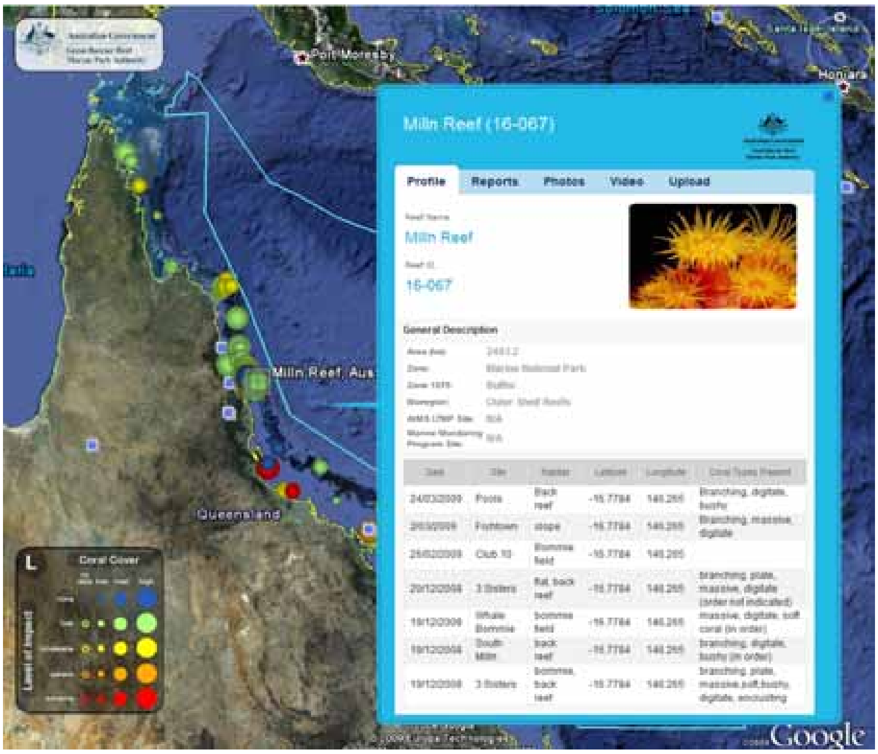


Figure 12. Reef health and status Google Earth layer for 2008-09. The layer includes a symbology system to represent each reef in the Great Barrier Reef ecosystem where the size of the marker dot represents the amount of coral cover and the colour of the dot represents the degree of impact. The dots scale as the viewer zooms in or out of the layer and providing an instant snapshot of impact extent and severity across the Reef. Clicking an individual dot reveals a tabbed information balloon that contains reef level background and impact report information. In the future the layer will also provide access to photos and video from that site an upload facility for data forms.

Historically the peak of previous bleaching events on the Reef has occurred around February to March. Bleaching events progress quickly once visible signs of stress are prevalent, with only four to six weeks required for bleached corals to either recover or die. If surveys are delayed they can provide an underestimate of bleaching impact severity as many corals may have died or recovered, making it difficult to confidently attribute any coral mortality to bleaching-related stress. To accurately characterise the extent and severity of bleaching, bleaching-induced mortality and associated longer-term ecological implications requires three temporal surveys are undertaken: baseline, event and survival/mortality. By surveying sites that are also surveyed as part of the bi-annual AIMS Long Term Monitoring Program, additional surveys are not required to gather baseline condition data and long term trends in reef condition.

Survey sites

The Response Plan surveys 45 routine sites for intense in-water assessments (Appendix C). These sites are surveyed bi-annually by the AIMS Long-term Monitoring Program, which works to provide long-term data on baseline condition. This means surveys need only be completed during a bleaching event (to assess extent and severity of bleaching) and post-event (to assess extent of bleaching-induced mortality). The sites represent cross-shelf as well as latitudinal gradients along the Great Barrier Reef. The site groupings are located at latitudes centred on Lizard Island, Cairns, Townsville, Whitsunday Islands and the Capricorn Bunker Group (Figure 13 and Appendix B). Three inshore, three mid-shelf and three outer shelf reefs are surveyed in each transect.

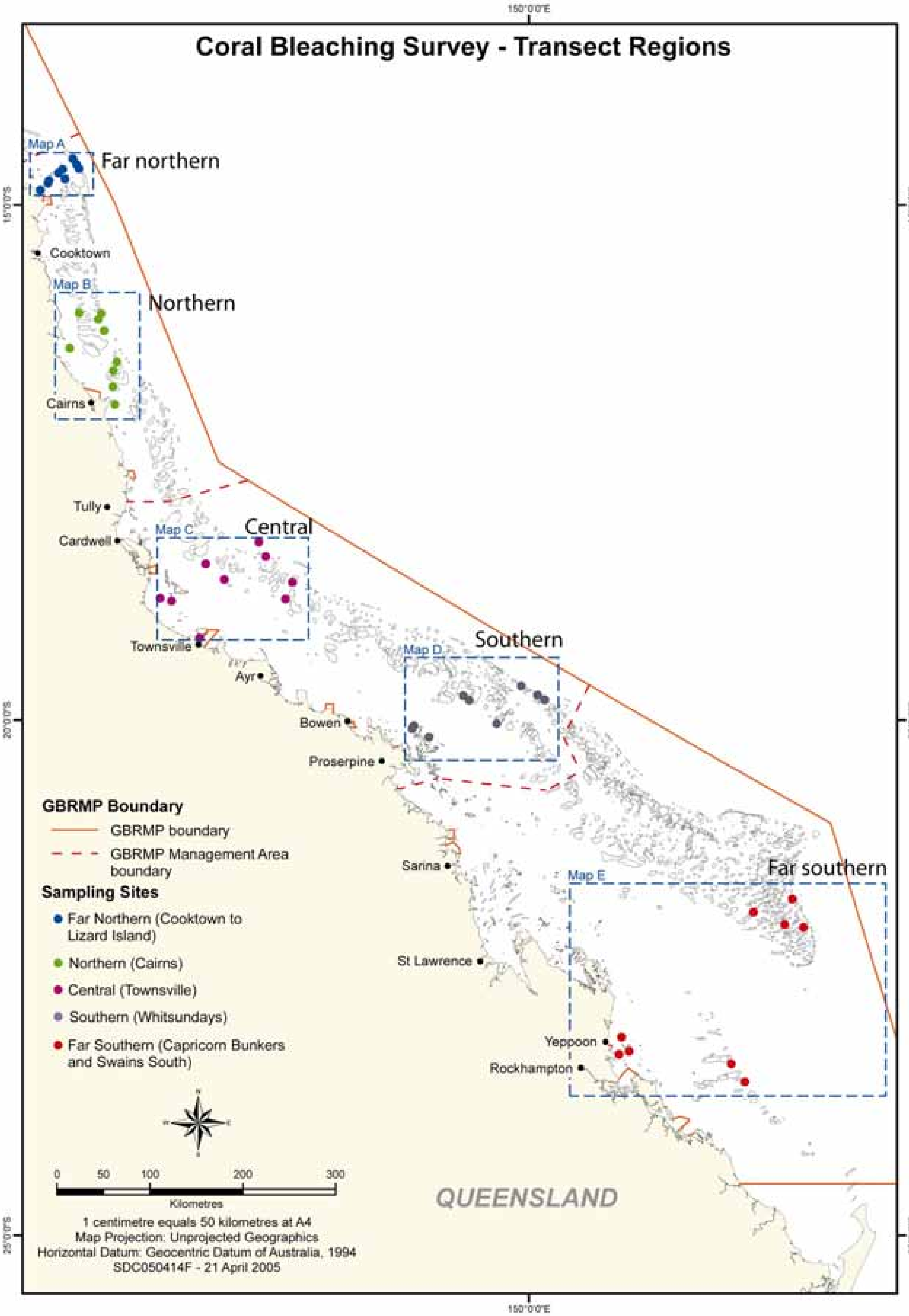


Figure 13. Response Plan monitoring sites routinely surveyed during a mass bleaching event. High-resolution maps of each cross-shelf transect (Maps A – E) can be found at Appendix C.

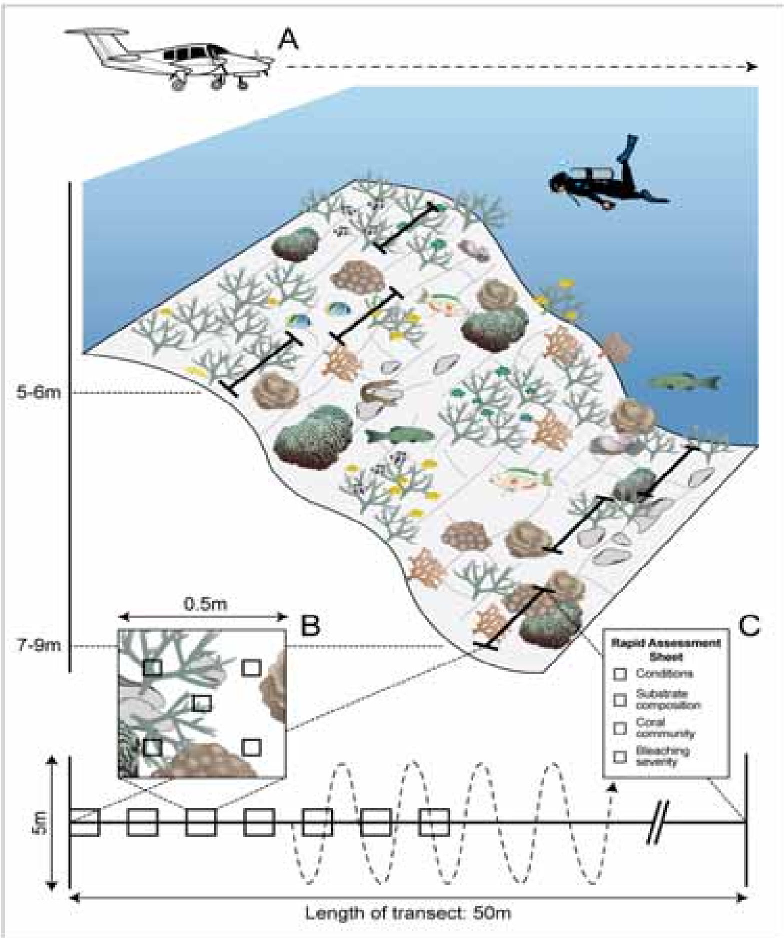


Figure 14. Schematic representation of the Assessment and Monitoring protocol. A) spatially extensive aerial surveys provide reef-wide information that is verified by B) intense in-water surveys at 45 sites using C) the rapid assessment monitoring datasheets (see Appendix D).

At each site, three 50m transects are surveyed on the reef crest (1 – 4 m) and lower reef slope (6 – 9 m), by a two-diver team that conduct a rapid assessment datasheet (see Hill and Wilkinson 2004; Figure 14, and Appendix D for survey datasheet) and complete photo transects (see English et al. 2004; Appendix D for survey datasheet). Photo transects are systematically carried out by holding the camera 40 – 60 cm above the substrate and the observer taking a photo every 0.5 m. In this way, each photo frame documents 0.5 x 0.5 m of substrate (English *et al.* 2004). The photos are later analysed by identifying the substrate, and bleaching severity, at five points within the photo frame (see Figure 14 inset B). The rapid assessment provides information about the extent and severity of the bleaching event in near real-time, which can be immediately communicated to senior management, government and the public (see Marshall and Schuttenberg 2006). In contrast, the photo transects, whilst requiring a more lengthy analysis, provide a long-term record, more detailed information and increased data resolution, which is useful for understanding the patterns and specificity of bleaching events. In addition, since the photos are discontinuous, either each photo or each transect could be an independent statistical sample, ensuring the data can be used to help answer a variety of research questions. This monitoring protocol is rigorous but also easy to teach and implement, with surveys at each site completed in less than two hours.

Reef sites reported through *BleachWatch* to be severely affected by bleaching may also be targeted for completion of the survey protocol described here.

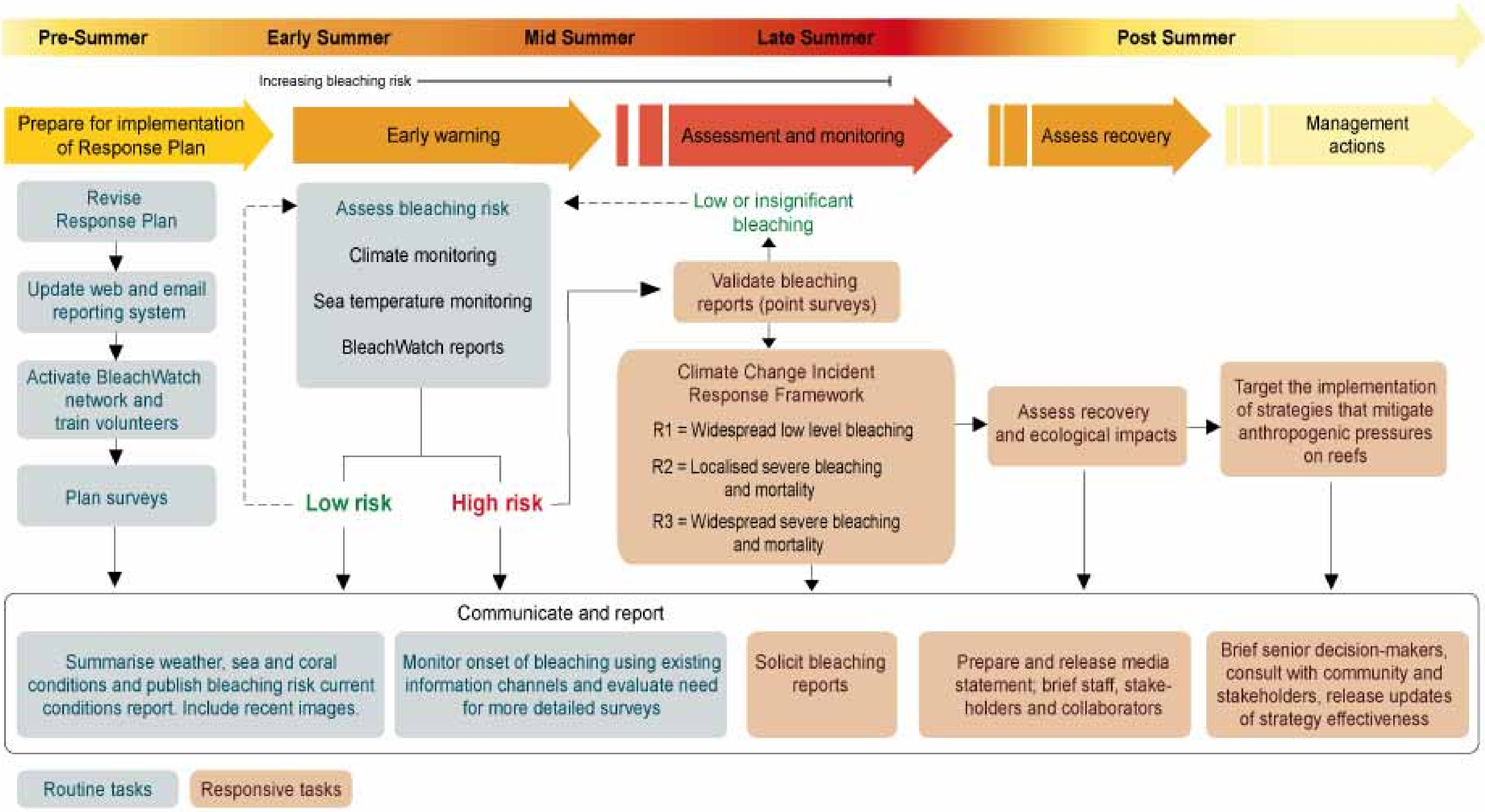


Figure 15. Response Plan schedule of routine and responsive tasks before, during, and after the coral bleaching season

3. Management Actions

The long-term implications of coral bleaching depend on the spatial extent of bleaching impacts and on the amount of coral mortality resulting from bleaching events. Coral mortality rates will strongly influence recovery times as availability of coral larvae from surviving corals are a key factor in successful recolonisation of a damaged site. Bleaching events are expected to increase in frequency and severity as a result of climate change, making recovery processes increasingly important in the ability of reefs to persist as coral-dominated systems. Significantly, many human activities impose stresses on coral reefs that compound the risks imposed by coral bleaching. Through reducing these compounding pressures, management actions can help reefs cope with or recover from coral bleaching events, and thereby build the resilience of reefs to climate change.

This Response Plan outlines a suite of potential management actions that can support the resilience of the Great Barrier Reef to coral bleaching events. The extent and severity of bleaching will determine which actions are most appropriate and where they should be implemented (Figure 16, and Table 2).

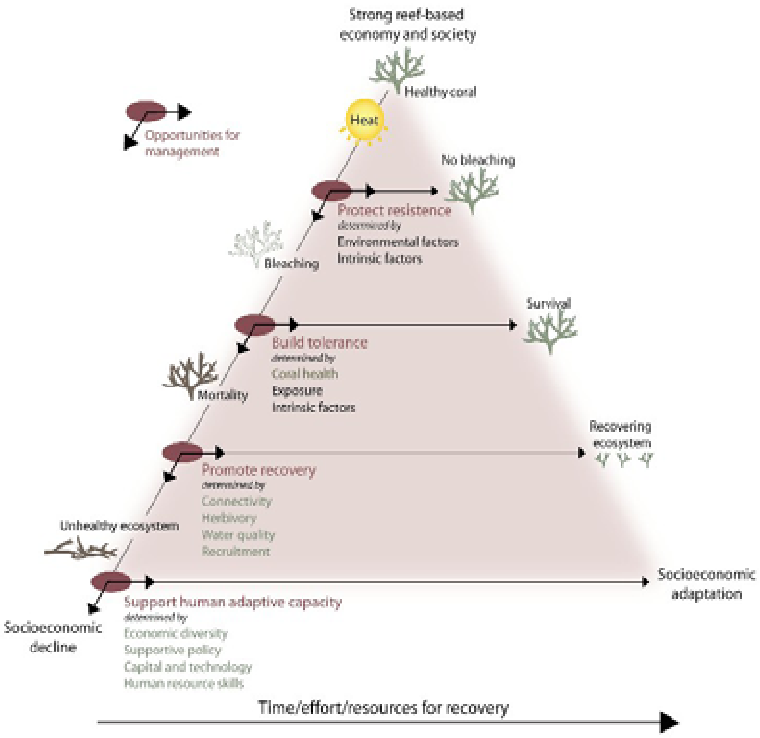


Figure 16. Opportunities for management action to reduce the impacts of stressful sea temperatures on coral communities (from Marshall and Schuttenberg 2006)

Potential management actions involve reducing the anthropogenic pressures so as to: protect resistance to thermal stress, build tolerance to bleaching and promote recover after a bleaching event. For example, corals exposed to stressors such as pollutants, excessive turbidity, sedimentation, decreased salinity or pathogens, are likely to have compromised health, increasing their susceptibility to bleaching and reducing survivorship. Furthermore, chronic local stresses, such as poor water quality, can affect the recovery potential of reef communities as reproduction and larval recruitment in corals are processes that are particularly sensitive to environmental conditions. In addition, growth rates of macroalgae increase in nutrient-rich waters, leading to risk of overgrowth of substrate that would otherwise be suitable for coral recruits (Hoegh-Guldberg et al. 2007).

In addition to measures to build ecosystem resilience, the Response Plan can help build social and economic resilience to coral bleaching events. Resource users that are well-informed of risks, involved in efforts to understand problems and included in decision-making processes about strategies to address resource issues can be expected to much more resilient to resource impacts (Marshall & Marshall, 2007). The Response Plan, especially through the BleachWatch program, provides opportunities for strong involvement by resource users who might be affected by coral bleaching. These relationships also assist GBRMPA to identify management actions that might enhance the resilience of reef users to bleaching events (eg. through provision of targeted educational materials, flexible permitting arrangements, etc). By working closely with stakeholders to understand and respond to coral bleaching events, the Response Plan also enables GBRMPA to support the adaptive capacity of reef users in the context of future damage from bleaching events.

Table 3. Options for management actions that can reduce the severity of bleaching impacts on coral reef ecosystems

Goal	Scale	Management action
Protect resistance	Local to regional	• Identify and protect refugia with resistant populations (eg resistant coral species, previous history of bleaching resistance) • Protect areas with environmental factors that facilitate resistance (e.g. high water mixing, upwelling, shading)
Build tolerance	Local and regional	• Minimise pressures associated with human activities that compromise coral health (e.g. physical damage, pollution, resource extraction/fishing pressure and introduced species or disease) • Protect areas with intrinsic and environmental factors that facilitate tolerance (e.g. tolerant species, upwelling, topographic complexity)
Promote recovery	Local and regional	• Minimise pressures associated with human activities that compromise coral recovery, in particular poor water quality (coastal development, catchment uses) • Minimise pressures associated with human activities that compromise recruitment (eg damage or removal of 'sources' of coral recruits)
Support adaptive capacity	Local, regional and national	• Flexible planning to allow for targeted protection of reef areas • Supportive policy to allow for immediate and temporary management actions to be implemented • Social and economic diversity to facilitate changes in resource use • High level communication with senior decision-makers and stakeholders

Managers can invest their resources to mitigate impacts at local scales and/or more broadly at regional levels. Local actions will be particularly important when severe bleaching impacts are highly localised and the severe bleaching event that occurred on reefs in the Keppel Bay in 2006 provides an example. In contrast, however, spatially extensive and severe bleaching events will require broader actions. Importantly, post-bleaching survey data on survival and recovery is needed to identify key areas for action and to assess the resilience of the reef to bleaching. This information will determine the appropriate actions required to reduce human-related stressors. In most cases, local actions, like temporary closures, that work to protect extremely unique resources will be complemented with actions that influence larger areas, such as improving water quality.

4. Communication Strategy

As described here, responding to coral bleaching events strategically and effectively involves a combination of routine and responsive tasks implemented through an Early Warning System and, if a bleaching event occurs, Assessment and Monitoring as well as Management Actions (see Figure 16). All routine and responsive tasks rely on effective communication, particularly since bleaching events attract significant interest from the public, media and senior decision-makers (see Table 4). The Response Plan ensures timely and credible information on coral bleaching in the Great Barrier Reef Marine Park is available during and in the months and years that follow bleaching events.

Table 4. The frequency and timing of tasks associated with collating current bleaching information and effectively communicating during the bleaching season.

Frequency	Timing/Trigger	Task
Weekly	Monday	• Check GBRMPA *ReefTemp* and NOAA HotSpot maps on web • Receive updated Great Barrier Reef sea temperature graphs from AIMS • Review weekly weather summary, for example air temp, cloud cover and wind from Bureau of Meteorology • Review *BleachWatch* (including Coastwatch) reports and update maps • Prepare briefing for internal meetings
Weekly/ fortnightly	Constant	• Monitor extent of bleaching using existing information and evaluate for trends (ie change in bleaching extent) • Advise GBRMPA senior management and the Minister if worsening of conditions • Announce web update and send brief report to senior management
Event-based	High bleaching risk*	• Actively solicit confirmatory bleaching reports from reliable sources, including *BleachWatch* participants, Day-to-Day Management field officers, AIMS, other researchers, etc. • Alert relevant project coordinators and managers • Brief GBRMPA senior management
	Moderate or severe bleaching event observed*	• Brief GBRMPA executive and the Minister • Prepare media position, draft statement and consult with GBRMPA media coordinator and executive • Brief all GBRMPA staff, stakeholders and collaborators • Release media statement • Actively promote and solicit submissions to online bleaching reports to provide broad spatial coverage

* See Table 1

In addition to the task and reporting schedule outlined in Table 4, a briefing schedule for GBRMPA senior management, the Minister, and stakeholders is outlined in Table 5. This schedule ensures these groups are aware of when delivery of reports can be expected.

Table 5. Targeted briefing schedule to communicate onset of bleaching season (predetermined dates) and bleaching risk and occurrence throughout the bleaching season (date determined by when trigger level is reached).

Approx. date	Trigger[1]	Briefings			
		Senior Management	**Minister**	**Stakeholders**	**Message**
1 Dec	Annually	^	^	^	Summer approaching; bleaching risk period; Response Plan being implemented
20 Dec	Annually	^			Temperature trends for December; plans for Christmas break
	High bleaching risk	^	^		Temperatures unusually high; coral bleaching event probable
	Moderate bleaching	^	^	^	High temperatures recorded; moderate bleaching observed; areas most affected
	Severe bleaching	^	^	^	Very high temperatures recorded; severe bleaching observed; areas worst affected; mortality likely
15 Feb[3]	Annually	^			Temperature trends for first half of summer; summary of any observed coral bleaching
31 March	*No bleaching*	^	^	^	Summer concluding; bleaching risk period over; no significant bleaching observed
	*Moderate, major or severe bleaching impact**	^	^	^	High water temperatures recorded; bleaching observed; preliminary assessment of extent and severity; detailed surveys underway
30 May	*Moderate, major or severe impact**	^	^	^	Summary of full extent and severity of bleaching; implications for Great Barrier Reef

* See Table 1

Conclusion

This Response Plan outlines the strategic approach that GBRMPA is employing to tackle the challenge of climate-induced coral bleaching and provides practical tools for monitoring, assessing and reducing bleaching risk and impacts. The Response Plan will continue to be implemented prior to and during each summer season and in the months and years that follow bleaching events. As bleaching events become more frequent and severe, impacts on the reef ecosystem and on reef users will become increasingly acute and apparent. Accordingly, there will be escalating expectations for management actions that can build the resilience of the reef, and those who depend on it for cultural connection, recreation and income. While coral bleaching is only one aspect of the challenge presented by a changing climate, this Response Plan lays the foundations for an informed and adaptive approach to building the Reef's resilience to climate change.

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Appendix A – *BleachWatch* reporting form

BleachWatch
observe to conserve

Reef Health and Impact Survey

20 min swim [S]
Point survey [P]
▷ [ ]

Australian Government
Great Barrier Reef Marine Park Authority
Queensland Government

OBSERVER DETAILS

Observer name: .... Date: ....
Vessel / organisation: .... Phone: ....
Email: .... Sheet: ...... of ......

SITE INFORMATION

Reef ID /name: .... Marine Park zone: ....
Position at start : Lat: ....S Long: ....E
Check one: Decimal Degrees (preferred) ☐ Degrees + Decimal Mins ☐ Deg Min Sec ☐

Snorkel [S]
Dive [D] ▶ [ ]

Depth (m): ....

Visibility
<5m [L]
5-10m [M] ▶ [ ]
>10m [H]

Secchi (m): ....

Air temp: ....
Water temp: 0-3m ....
5-10m ....

Tide at survey time
(Low/Mid/High): ....

Flood plume (Y/N) ▶ [ ]

Suspended algal bloom (Y/N) ▶ [ ]

Habitat
Lagoon [A]
Crest [B]
Slope [C] ▶ [ ]
Bommie field [D]
Reef flat [E]

Other: ....
....

Benthos (see Figure 1)

Hard coral:	.... %
Soft coral:	.... %
Dead coral (recently dead):	.... %
Macroalgae:	.... %
Sand:	.... %
Coral rock:	.... %
Coral rubble:	.... %
TOTAL:	100 %

CORAL OBSERVATIONS

Lifeforms

[ ] *Coral bleaching observed Y/N*

Lifeforms (see Figure 2)	Proportion (%) of total coral cover (see Figure 1)	Proportion (%) of those corals that are bleached (see Figure 1)		Severity of bleaching (see Table 1)
Soft coral:	%	%	Soft coral	[ ]
Branching:	%	%	Branching	[ ]
Plate:	%	%	Plate	[ ]
Massive:	%	%	Massive	[ ]
Encrusting:	%	%	Encrusting	[ ]
Bushy:	%	%	Bushy	[ ]
TOTAL:	100 %			

Depth range of bleaching: Min:.......... m Max:.......... m

Table 1: Most common level of bleaching severity

Bleached only on upper surface	1
Pale/fluoro (very light or yellowish)	2
Totally bleached white	3
Recently dead coral with algae	4

Figure 1: Estimating extent of coral cover

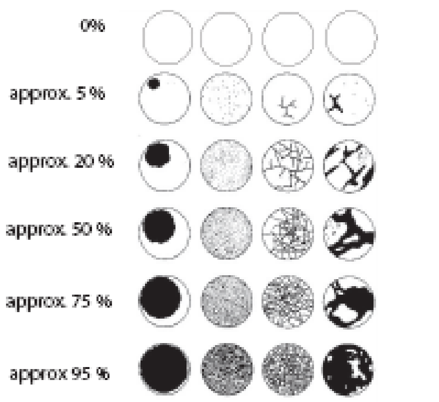
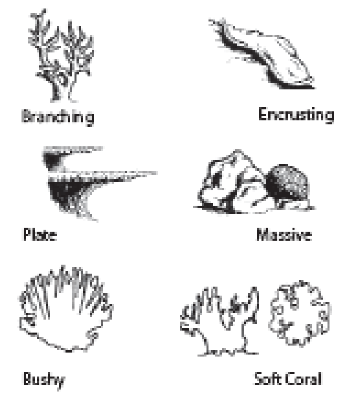


Figure 2: Coral lifeforms



[ ] *Have any reference photos been taken Y/N*

Coral bleaching	[ ]
Coral disease	[ ]
Coral breakage	[ ]
COTS and Drupella snails	[ ]
Other	[ ]

....
....
....
....

Reef Health and Impact Survey

ALGAE

☐ **Present Y/N** *(include algae growing on dead coral and rubble/rock)*

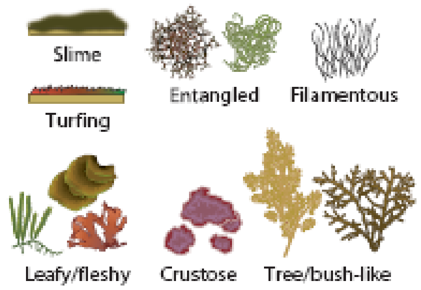
Proportion (%) of total algal cover (See Figure 1 and Figure 3)

Slime:	.... %
Turfing:	.... %
Leafy/fleshy:	.... %
Entangled:	.... %
Tree/bush-like:	.... %
Crustose:	.... %
Filamentous:	.... %
TOTAL:	100 %

Height (cm) — Insert code

	Insert code	Code	Height (cm)
Slime	☐	0	none
Turfing	☐	A	< 1
Leafy/fleshy	☐	B	1-3
Entangled	☐	C	4-10
Tree/bush-like	☐	D	10-25
Crustose	☐	E	25-100
Filamentous	☐	F	>1m

Figure 3: Algae



CORAL DISEASE

☐ **Present Y/N**

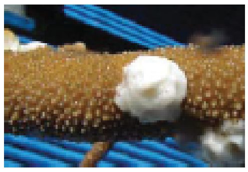
	White Syndromes (Insert code)	Black Band Disease (Insert code)	Brown Band Disease (Insert code)
Branching	☐	☐	☐
Plate	☐	☐	☐
Massive	☐	☐	☐
Bushy	☐	☐	☐
Encrusting	☐	☐	☐

Code	
0	none
A	≤5colonies
B	6-20 colonies
C	>20 colonies


White Syndromes


Black band disease


Brown band disease


Tumours

Other diseases/growth anomalies (tumours) observed: ....

RUBBISH

☐ **Present Y/N**

Code	
0	none
A	1 piece
B	2-5 pieces
C	>5 pieces

Fishing line	☐
Plastic	☐
Netting	☐
Rope	☐

Other: ....

PREDATION SCARS: Crown-of-thorns starfish (COTS) and *Drupella* snails

☐ **Present Y/N**

Number of juvenile COTS:
1) less than size of palm: ....
2) less than size of outstretched hand: ....

Number of adult COTS: ....

Number of *Drupella* snails: ....

	Colonies affected by COTS (Insert code)	Colonies affected by *Drupella* snails (Insert code)
Branching	☐	☐
Plate	☐	☐
Massive	☐	☐
Bushy	☐	☐
Encrusting	☐	☐

Code	
0	none
A	≤5colonies
B	6-20 colonies
C	>20 colonies

RECENT CORAL BREAKAGE

☐ **Present Y/N**

Amount		Cause: Primary	Cause: Secondary
☐	Branching	☐	☐
☐	Plate	☐	☐
☐	Massive	☐	☐
☐	Bushy	☐	☐
☐	Encrusting	☐	☐
☐	Soft Coral	☐	☐

Code	
0	none
A	≤5colonies
B	6-20 colonies
C	>20 colonies

A	Anchor
D	Divers
S	Snorkellers
W	Weather/storm
V	Vessel
C	Animal
X	Other

Comments:

....

....

....

....

....

Photocopy, photograph or scan your data sheet and submit by:

Email - bleachwatch@gbrmpa.gov.au

Fax - 07 4772 6093

Any questions, call - 07 4750 0722

Mail (no stamp required) -
Great Barrier Reef Marine Park Authoirty
Reply Paid 1379
TOWNSVILLE QLD 4810

11/2009

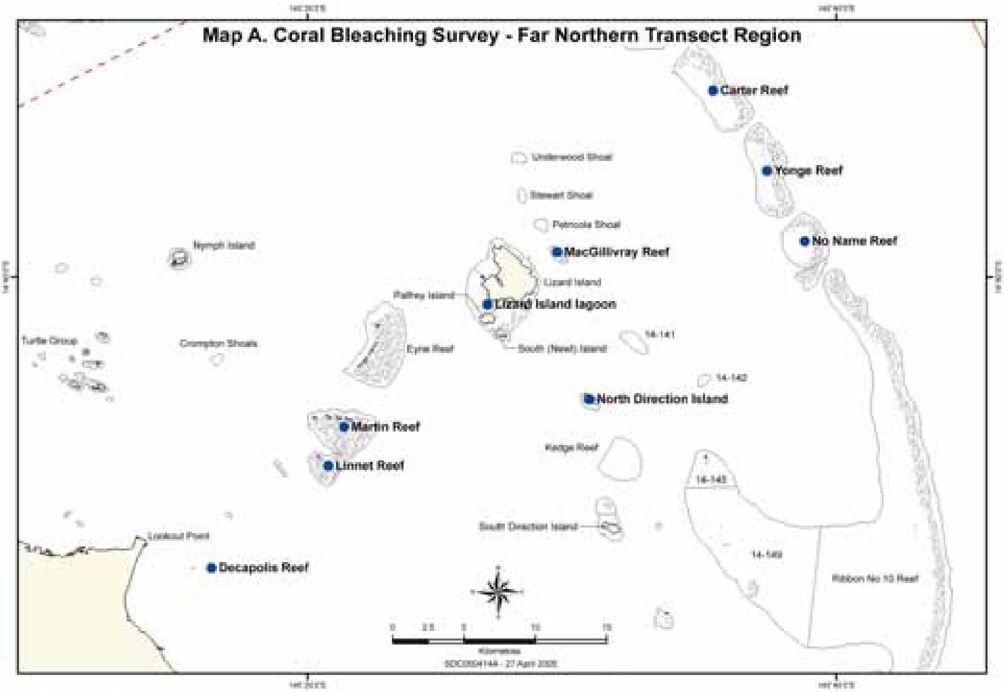
Appendix B —Locations of intensive survey sites

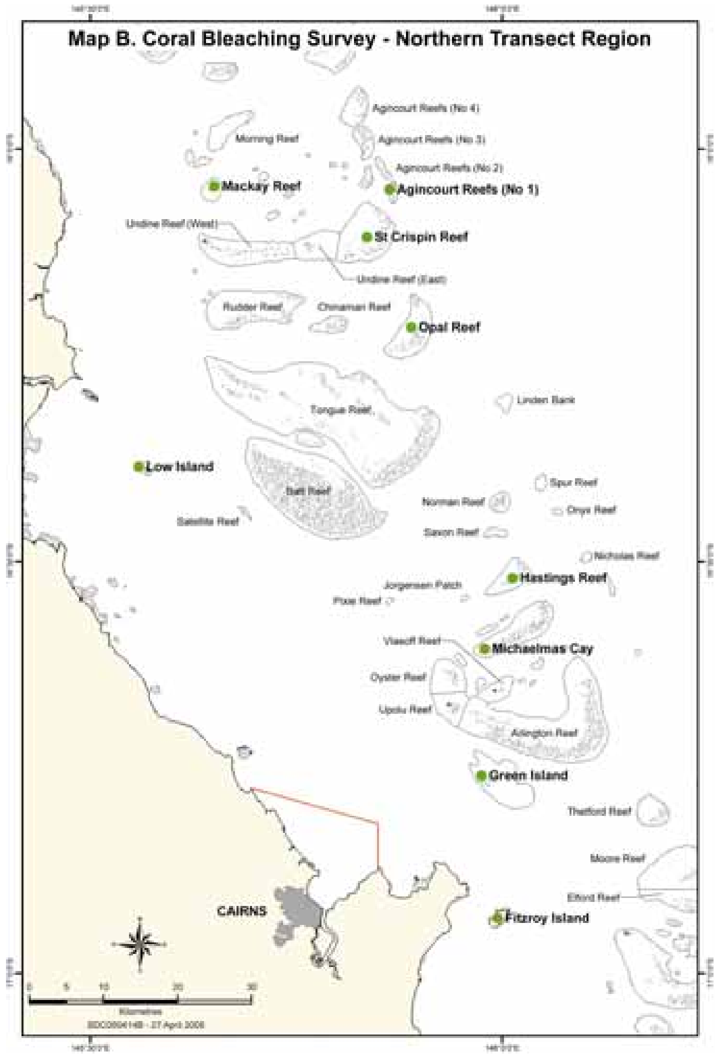
I = Inner-shelf reef, M = Mid-shelf reef, O = Outer-shelf reef

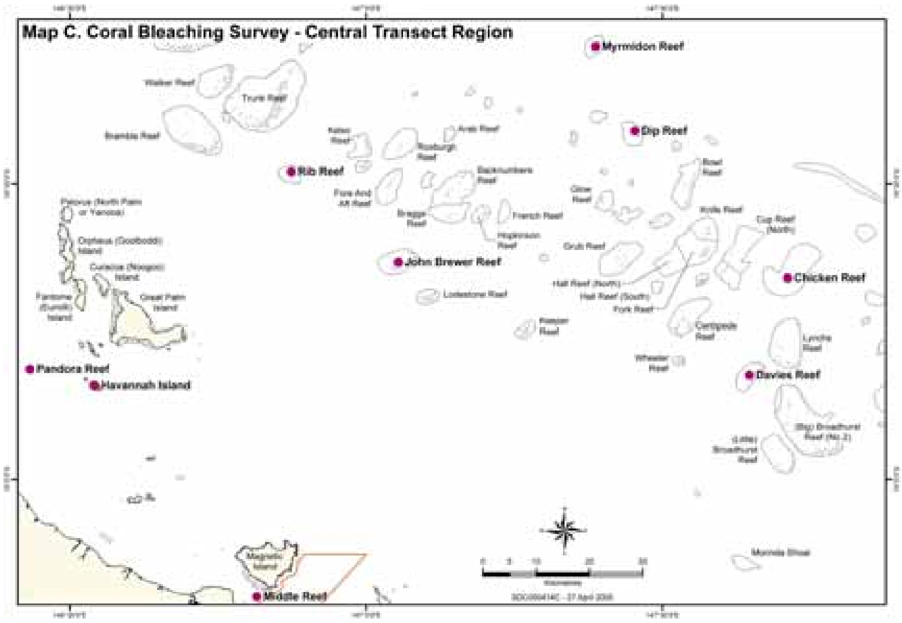
Coordinates

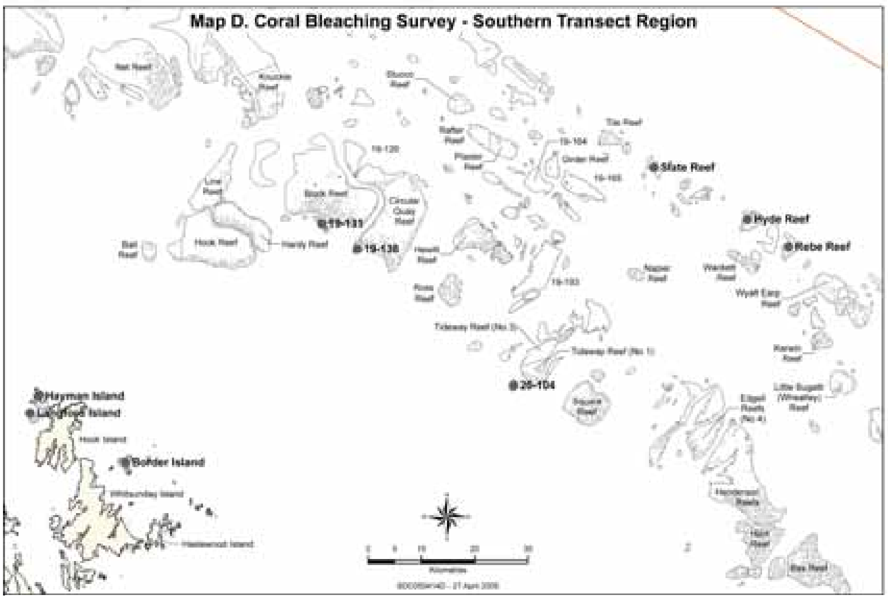
		Site coordinates (deg min)	
Transect and Region	**Reef Name**	**Latitude**	**Longitude**
Far Northern (Cooktown to Lizard Island)	Martin Reef (I)	14 45.566	145 22.586
	Linnet Reef (I)	14 47.33	145 21.21
	Decapolis Reef (I)	14 51.021	145 16.401
	MacGillivray Reef (M)	14 39.02	145 29.65
	Nth Direction Island (M)	14 44.784	145 31.02
	Lizard Island lagoon (M)	14 41.661	145 27.935
	Yonge Reef (O)	14 34.431	145 37.251
	Carter Reef (O)	14 31.584	145 35.1
	No Name Reef (O)	14 37.776	145 38.967
Northern (Cairns)	Green Island (I)	16 46.372	145 58.601
	Low Isles (I)	16 23.189	145 34.356
	Fitzroy Island (I)	16 55.384	145 59.765
	Mackay Reef (M)	16 2.697	145 39.147
	Michaelmas Cay (M)	16 33.09	146 3.241
	Hastings Reef (M)	16 30.182	146 1.594
	St Crispin Reef (O)	16 4.399	145 50.975
	Opal Reef (O)	16 12.451	145 54.452
	Agincourt No.1 Reef (O)	16 2.509	145 52.209
Central (Townsville)	Pandora Reef (I)	18 48.694	146 25.803
	Havannah Island (I)	18 50.04	146 32.482
	Middle Reef (I)	19 11.759	146 48.799
	Davies Reef (M)	18 48.679	147 40.231
	Rib Reef (M)	18 28.495	146 52.863
	John Brewer Reef (M)	18 37.358	147 5.045
	Chicken Reef (O)	18 39.348	147 43.43
	Dip Reef (O)	18 24.227	147 27.32
	Myrmidon Reef (O)	18 15.278	147 23.163
Southern (Whitsundays)	Hayman Island (I)	20 3.58	148 54.099
	Border Island (I)	20 10.517	149 2.098
	Langford & Bird Island (I)	20 4.78	148 52.614
	Reef 19131S (M)	19 46.162	149 22.719
	Reef 19138S (M)	19 48.5	149 25.58
	Reef 20104S (M)	20 2.007	149 41.686
	Slate Reef 19159 (O)	19 39.837	149 55.061
	Hyde Reef (O)	19 44.488	150 5.187
	Rebe Reef (O)	19 47.829	150 9.775
Far Southern (Capricorn Bunkers and Swains South)	Nth Keppel Island (I)	23 5.187	150 54.311
	Middle Island (I)	23 9.896	150 55.42
	Halfway Island (I)	23 12.193	150 58.187
	Gannet Cay (M)	21 58.743	152 28.955
	Chinaman Reef (M)	22 0.116	152 40.119
	Reef 21529S (M)	21 52.02	152 11.183
	Turner Cay (O)	21 42.204	152 33.807
	Wreck Island (O)	23 19.149	151 58.785
	One Tree Island (O)	23 29.261	152 5.554

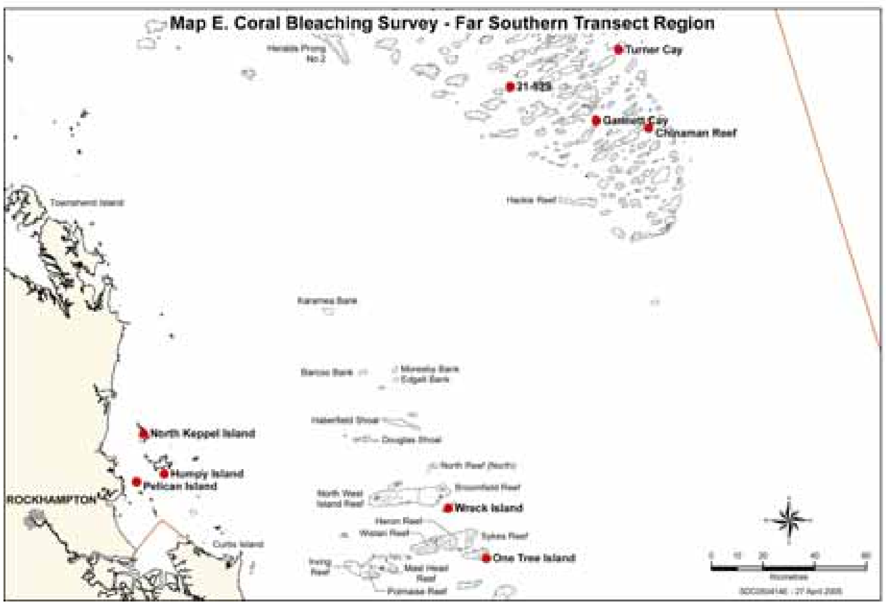
Appendix C – Detailed maps of survey site locations in each cross-shelf transect






Map C. Coral Bleaching Survey - Central Transect Region
Myrmidon Reef
Dip Reef
Rib Reef
John Brewer Reef
Chicken Reef
Davies Reef
Pandora Reef
Havannah Island
Middle Reef


Map D. Coral Bleaching Survey - Southern Transect Region
Slate Reef
Hyde Reef
Rebe Reef
19-131
19-138
20-104
Hayman Island
Langford Island
Border Island


Map E. Coral Bleaching Survey - Far Southern Transect Region
Turner Cay
Gannett Cay
Chinaman Reef
North Keppel Island
Humpy Island
Pelican Island
ROCKHAMPTON
Wreck Island
One Tree Island

Appendix D — Rapid assessment survey data sheet

GBRMPA Rapid Assessment Monitoring Sheet

Region:	**Reef Name:**	**Date:**	**Time:**
Observer:	**Dive Buddy:**	**Vessel:**	
Site Details		**Water Temp:**	
Waypoints/track starting number for photo transect GPS track		**Surface:**	**Depth:**
Notes:			

Benthos	**% cvr** (1)	**Transect 1**					**% cvr** (1)	**Transect 2**					**% cvr** (1)	**Transect 3**				
Abiotic		**Notes**						**Notes**						**Notes**				
Sand																		
Rubble		*																
Other																		
Other Live																		
Coral		**Bleaching severity (2)**						**Bleaching severity (2)**						**Bleaching severity (2)**				
		0	1	2	3	4		0	1	2	3	4		0	1	2	3	4
Soft																		
Hard																		
Acropora																		
Montipora																		
Pocilloporids																		
Porites																		
Faviids																		
Algae		**Notes**						**Notes**						**Notes**				
Fleshy/upright/macro																		
CCA																		
Filamentous (Turf)																		
Ephemeral/scuzzy																		
Total	**100%**						**100%**						**100%**					
Canopy height min/max/mode (cm)																		
Disease	% Cols Aff	**Notes**					% Cols Aff	**Notes**					% Cols Aff	**Notes**				
White Syndromes																		
Black Band Disease																		
Brown Band Disease																		
Tumours/Growth Anomalies																		
Total																		

Reef flat observations
Other notes and observations

* Bleaching severity levels 0 to 4 are described below and the blank boxes on the datasheet, just below the severity levels, are filled-in with the percentage of colonies in each taxa group bleached at each severity level.

Index	Bleaching level	Visual assessment
0	None	Colonies unaffected by bleaching
1	Low	Colonies are slightly pale
2	Moderate	Colonies are mostly pale and/or fluoro bleached
3	Severe	Colonies are mostly pale and partially bleached white
4	Extreme	Colonies are completely bleached white and/or recently died as a result of bleaching

Appendix E - Schedule of Coral Bleaching Response Plan routine and responsive tasks for before, during and after the coral bleaching season – including the Climate Change Incident Response Framework (CCIRF) 2009-2010.

TIMING/TRIGGER	TASK	EXPECTED OUTCOME	TICK UPON COMPLETION
Pre-summer preparations and training			
Oct-09	Seasonal outlook meeting	• Assessment of coral bleaching risk for the approaching summer • Preparations for coordinated response in the event of coral bleaching	
October 2009 – May 2010	Communications processes initiated (see Table 3)	Communications updated regularly on the status of coral bleaching	
Nov-09	CCIRF planning meeting	Preparations for CCIRF activation	
Nov-09	BleachWatch training coordinated with Eye on the Reef training – Cairns, Port Douglas and Airlie Beach	Training of volunteer network in coral bleaching assessment and reporting	
Nov-09	Field Management BleachWatch training	Training of field management staff in coral bleaching assessment and reporting	
Nov-09	GBRMPA internal staff BleachWatch training	Training of GBRMPA Townsville and regional staff in coral bleaching assessment and reporting	
Nov-09	Refresher training first aid, CPR and oxygen provider training; updates of AS2299 Diver medicals	Field staff suitably qualified and prepared in case response initiated	
Dec-09	Review of seasonal outlook, meeting convened if high likelihood of coral bleaching	Meeting convened to refine coordinated response if there is a risk of coral bleaching	
Dec-09	Brief Senior Management, Minister and Stakeholders	Senior management, Minister and stakeholders aware of approaching season bleaching risk	
Dec-09	Revise Coral Bleaching Response Plan (CBRP)	Revised CBRP published by December	
Dec-09	In water rescue refresher training	Staff proficient in in-water rescue and safety	
19-21 January 2010	Keppels scheduled monitoring	Support for ongoing resilience & RPM monitoring	
20-21 January 2010	BleachWatch training - southern region - Mackay, Yeppoon and Gladstone	Additional BW participants recruited	

Commencement of Early Warning System			
Dec-09	Commence web based updates for seasonal outlook and coral bleaching risk – current conditions reports	Communication of reef stressors to community through web on a monthly basis	
Dec-09	Planning for Christmas closure period	• Assignment of duties over Christmas closure period • Senior Management notified of arrangements • Minister advised if coral bleaching risk moderate-high	
December 2009 - April 2010	Assess bleaching risk weekly	• Check GBRMPA ReefTemp and NOAA hotspots on web • Review weekly weather summary reports • Review BleachWatch reports and update spatial layers • Review AIMS temperature graphs • Review QPWS RHIS reports and update spatial layers • Prepare briefings for internal meetings, round table • Advise senior management of changes	
15 February 2010	Assess temperature trends and bleaching for first half of summer	• Senior Management update on conditions • Contact made with BleachWatch participants in areas of interest	

Event reported - CCIRF initiation			
Bleaching reported	Situation analysis conducted	Climate Change Incident Response Framework (CCIRF) situation analysis	
Bleaching reported	Situation Analysis reviewed	Level of CCIRF response agreed (this includes nil response)	
CCIRF activated	Appointment of situation coordinator	Incident coordinator appointed to establish a response team	
CCIRF active	Notification of incident to relevant agencies		
CCIRF active	Action plan developed	• Action plan identifies roles and responsibilities for coral bleaching response • Action plan implemented and all sub plans including communications plan activated	
CCIRF active	Deploy operational teams	• Operational teams to manage incident deployed • Incident managed effectively • Emergency fast track permits authorised	
High risk season passed	Incident response terminated, CCIRF deactivated	Incident debrief convened	

CCIRF terminated & long-term management implemented			
Post event	Progress implementation of long-term impact management actions and adaptation plans	• Sectoral impact management plans implemented • Management actions (e.g. SMAs) implemented	
Post event April 2010	Preliminary report on the incident produced	Summary report of responses initiated for internal use	
Post event May 2010 - June 2010	Formal incident report produced	Summary report of the extent and severity of the impact	
Post event	CCIRF revision and update	Review CCIRF implementation and incorporate feedback	
Post event	Brief Senior Management, Minister and Stakeholders	Senior management, Minister and stakeholders aware of summer impacts and Reef recovery	
May 2010 - October 2010	End of season updates	• End of season reports posted onto the Web, including nil reports • BleachWatch end of season summary emailed to participants	
Post event ongoing	Impact recovery monitoring	Monitoring of recovery from severe coral bleaching impacts	