

# A pause in recent coral recovery across most of the Great Barrier Reef

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AIMS acknowledges the Traditional Owners of all the land and sea Countries in which we work, and pay our respect to their elders past, present and emerging. We honour their continuing culture, knowledge, beliefs and spiritual relationship and connection to Country. We also recognise Aboriginal and Torres Strait Islander peoples as the Traditional Owners of the land and sea Country on which the Australian Institute of Marine Science works, and as Australia's first scientists.

## AIMS LONG-TERM MONITORING PROGRAM GREAT BARRIER REEF 2022-2023 RESULTS



Total number of reefs surveyed in 2022 - 2023 **111**

Region	Survey period	Hard Coral Cover	Crown-of-Thorns Starfish Outbreaks	In-Water Bleaching Prevalence	
<b>NORTHERN GREAT BARRIER REEF</b>	October to December 2022	HARD CORAL COVER PER REEF Each square represents the current hard coral cover category on each survey reef  Number of reefs surveyed <b>38</b>	Status & Trend ↓ Coral cover decreased from 36.5% in 2022 to <b>35.7%</b>	Status & Trend ↓ No outbreaks	Status & Trend ↑ <b>33</b> Low <b>5</b> None Number of reefs with bleaching
<b>CENTRAL GREAT BARRIER REEF</b>	October 2022 to May 2023	HARD CORAL COVER PER REEF Each square represents the current hard coral cover category on each survey reef  Number of reefs surveyed <b>42</b>	Status & Trend ↓ Coral cover decreased from 32.6% in 2022 to <b>30.8%</b>	Status & Trend — No outbreaks	Status & Trend ↓ <b>28</b> Low <b>14</b> None Number of reefs with bleaching
<b>SOUTHERN GREAT BARRIER REEF</b>	August 2022 to May 2023	HARD CORAL COVER PER REEF Each square represents the current hard coral cover category on each survey reef  Number of reefs surveyed <b>31</b>	Status & Trend ↓ Coral cover decreased from 33.9% in 2022 to <b>33.8%</b>	Status & Trend — Active outbreaks <b>2</b> reefs Incipient outbreaks <b>3</b> reefs No outbreaks <b>6</b> reefs	Status & Trend — <b>15</b> Low <b>16</b> None Number of reefs with bleaching



**LEGEND**

○ Survey Site Locations	<b>HARD CORAL COVER:</b>	<span style="color: red;">■</span> >0% - 10% <span style="color: orange;">■</span> >10% - 30% <span style="color: yellow;">■</span> >30% - 50% <span style="color: lightgreen;">■</span> >50% - 75% <span style="color: green;">■</span> >75% - 100%
	<b>CROWN-OF-THORNS STARFISH (COTS):</b>	<b>No Outbreak</b> >0 - 0.1 COTS <b>Potential Outbreak</b> >0.1 - 0.22 COTS <b>Incipient Outbreak</b> >0.22 - 1 COTS <b>Active Outbreak</b> >1 COTS (Number of COTS divided by tow numbers)
	<b>BLEACHING PREVALENCE:</b>	<b>None</b> 0% <b>Low</b> >0% - 10% <b>Moderate</b> >10% - 30% <b>High</b> >30% - 60% <b>Very High</b> >60% - 90% <b>Extreme</b> >90%

### SUMMARY

In 2023, regional average hard coral cover was similar to last year. The observed small decreases in all three regions were within the 95% Credible Intervals. Most reefs underwent little change in 2023, however coral cover losses from the 2022 mass coral bleaching event, a cyclone, coral disease and crown-of-thorns starfish on some reefs offset increases on other reefs less (or not) affected by such disturbances. Importantly, the trends of coral cover on individual reefs are highly variable across the Great Barrier Reef (GBR), and most reefs had between 10% and 50% hard coral cover.

Above-average water temperatures led to a mass coral bleaching in 2021/22, the fourth event since 2016 and the first recorded during a La Niña year, when conditions are typically cooler. This event caused some coral mortality and has contributed to a pause in recent hard coral recovery across the Northern and Central GBR. In-water surveys in 2023 recorded no bleaching to low bleaching across all of the GBR.

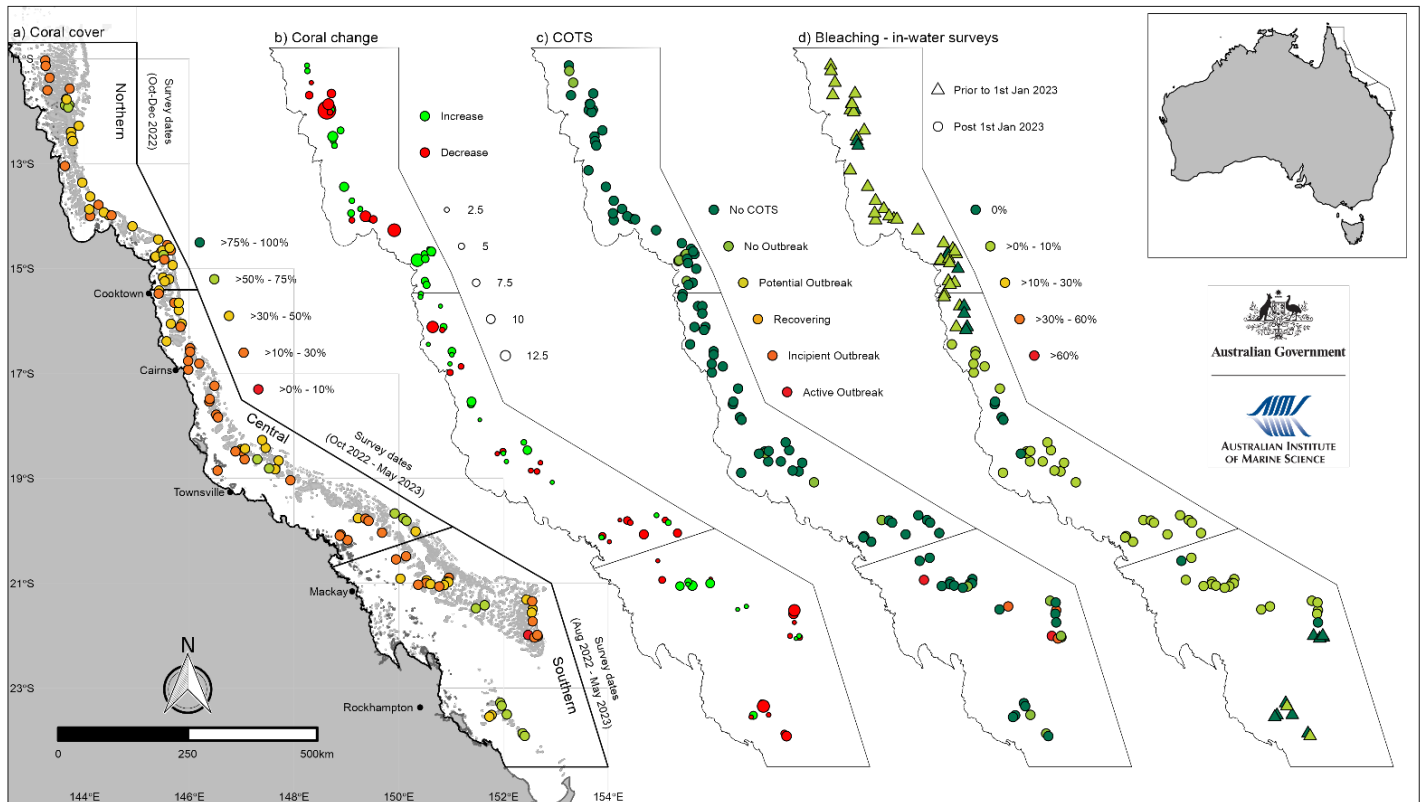
The GBR remains exposed to the predicted consequences of climate change, particularly more frequent and intense marine heatwaves, as well as the ongoing risk of outbreaks of the crown-of-thorns starfish and tropical cyclones. The increasing frequency and spatial extent of mass bleaching events in recent years poses a significant risk to the state of the reefs in the GBR.

- This report summarises the condition of coral reefs of the Great Barrier Reef (GBR) from the Long-Term Monitoring Program (LTMP) surveys of 111 reefs conducted between August 2022 and May 2023 (reported as '2023').
- Over the past 37 years of monitoring by the Australian Institute of Marine Science (AIMS), coral reefs of the GBR have shown dynamic responses to cycles of disturbance and recovery.
- Despite small declines in 2023, regional hard coral cover was similar to that reported in 2022.
- Above-average water temperatures occurred from October to December 2022; however, an active monsoon trough stopped further heat accumulation of waters of the GBR from January to March 2023 and no to low coral bleaching was recorded during the 2023 summer.
- Over the past 12 months, survey reefs were exposed to minimal other stressors, i.e., there were no severe cyclones impacting the GBR and despite crown-of-thorns starfish outbreaks persisting on some Southern GBR reefs, the number of outbreaks on the surveyed reefs has largely decreased.
- Only one reef had hard coral cover <10%, while nearly half of the surveyed reefs (49 out of 111) had [hard coral cover](#) levels between 10% and 30%, and over a third of the surveyed reefs (43 out of 111) had hard coral cover levels between 30% and 50%. Eighteen reefs had hard coral cover between 50% and 75%.
- On the [Northern GBR](#), region-wide mean hard coral cover declined slightly to **35.7%** (32.1% - 39.6% 95% Credible Intervals [C.I.s]) compared with 36.5% (32.2% - 40.9% C.I.s) in 2022 but remained within the C.I.s.
- On the [Central GBR](#) region-wide mean coral cover declined slightly to **30.8%** (27.6% - 34.2% C.I.s) from 32.6% (28.8% - 36.5% C.I.s) in 2022 but remained within the C.I.s.
- Region-wide mean hard coral cover on reefs in the [Southern GBR](#) declined slightly in 2023 to **33.8%** (29.0% to 38.9% C.I.s) from 33.9% (28.6% - 39.3% C.I.s) in 2022 but remained within the C.I.s, despite ongoing crown-of-thorns starfish outbreaks that led to loss of coral cover on some reefs in this region.
- The accumulation of thermal stress during the 2022 mass coral bleaching event caused low levels of coral mortality, but this, coupled with likely sub-lethal effects (e.g., reduced growth) plus some mortality from crown-of-thorns starfish outbreaks, coral disease and [Tropical Cyclone Tiffany](#) in January 2022, has paused the recovery of hard coral cover on many reefs.
- Most coral reefs of the GBR demonstrate resilience in the absence of acute disturbances showing the ability to recover from events causing widespread mortality. However, as the 2022 mass bleaching event highlighted, and crown-of-thorns starfish outbreaks, coral disease and [Tropical Cyclone Tiffany](#) further emphasise, the reefs of the GBR continue to face cumulative stressors. Even without causing mass mortality, bleaching events can hinder hard coral growth. The future is forecasted to bring more frequent, intense and enduring marine heatwaves, alongside the persistent threat of crown-of-thorns starfish outbreaks and tropical cyclones.



Photo Credit: AIMS LTMP





**Figure 1:** Summary of the results from the 111 reefs surveyed by manta tows between August 2022 and May 2023, along with the boundaries of the Northern, Central and Southern GBR reporting regions (see details of the long-term regional coral cover trends below). a) Average reef-level percent hard coral cover. b) The coral change metric displays the magnitude and direction of the absolute annual change in reef-level percent of hard coral cover between 2023 and the previous survey within the last two years. c) The COTS outbreak status of each reef is defined by the number of COTS per 2-minute manta tow: No COTS (0 COTS), No Outbreak ( $>0 - 0.1$  COTS), Potential Outbreak ( $>0.1 - 0.22$  COTS), Incipient Outbreak ( $>0.22 - 1$  COTS) and Active Outbreak (more than 1 COTS). Reefs are defined as Recovering when they were previously classified with an Incipient or Active Outbreak but currently have COTS numbers below outbreak thresholds. d) The coral bleaching severity recorded during in-water LTMP manta tow surveys.



Photo Credit: AIMS LTMP

With reef surveys extending over 37 years, the Australian Institute of Marine Science ([AIMS Long-Term Monitoring Program](#)) (LTMP) provides a unique and invaluable record of change by repeatedly surveying coral reef communities across the entire span of the Great Barrier Reef (GBR).

This annual summary of the status and trends in hard coral cover is based on manta tow surveys of coral reefs, mainly on the mid- and outer shelf (Figure 1).

Additionally, the LTMP collects more detailed information on coral and fish assemblages on 73 reefs across the GBR.

A newly developed [dashboard](#) now presents a synthesis of all AIMS' coral reef monitoring data across the surveyed reefs and at various spatial aggregations (including Natural Resources Management regions and latitudinal sectors).

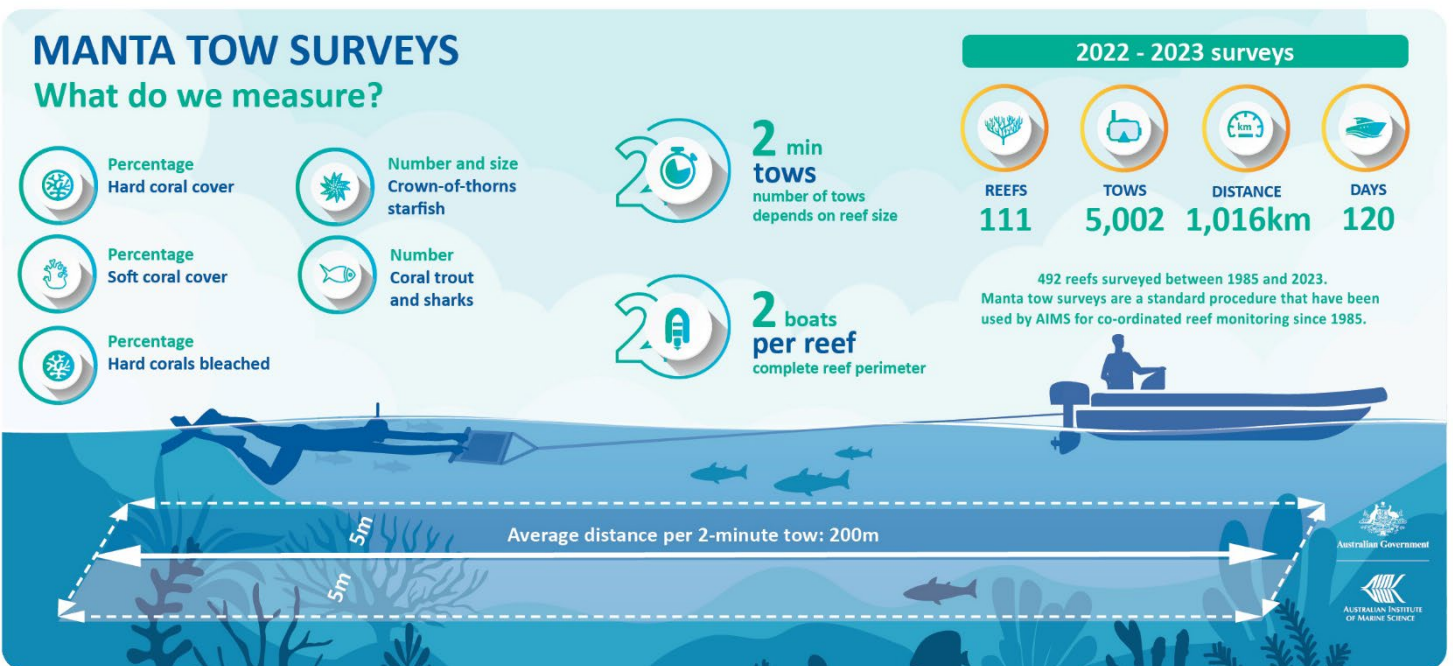
For this annual summary, the GBR Marine Park is divided into three regions (Figure 1), with each showing different trajectories of change in hard coral cover over time, mostly in response to the cumulative impacts of the main disturbances: severe tropical cyclones, outbreaks of crown-of-thorns starfish and coral bleaching.

A total of 111 reefs were surveyed from August 2022 to May 2023 (reported as '2023'). [Detailed online reports](#) on the state and trends of reefs grouped by latitudinal sectors and individual reefs, including their disturbance history, are available shortly after the completion of each survey trip. Data summaries are [available for download](#).

The reefs of the GBR are dynamic and there is considerable variation among regions in the decline and recovery rates of hard coral cover and community composition in response to disturbances. Understanding the dynamics in the context of the disturbance regimes is critical for the interpretation of the long-term monitoring data.

The LTMP provides the longest running, most spatially extensive dataset collected by standard methods on the GBR (see [Box 1](#)). The number of reefs able to be surveyed each year is a small portion of the number of reefs found on the GBR (~100 vs 3000). However, the LTMP survey reefs provide a [representative sample](#) across the length and breadth of the GBR that captures multiple geographical and ecological gradients (e.g. latitude and position across the continental shelf) and encapsulates many of the [bioregions](#) and all the [management zones](#) defined in the 2004 rezoning of the Great Barrier Reef Marine Park.

AIMS is committed to continuous improvement in the analysis of LTMP data, and recent statistical advances have permitted a refinement of analytical approaches for the type of ecological time series data used in this report.





### Condition Summary to May 2023

Surveyed October to December 2022

There was substantial variation in the condition of individual reefs in the Northern GBR (Figure 1a, Image 1). Fourteen of 38 reefs had coral cover >10% – 30%, 19 reefs had >30% – 50% cover and five reefs had >50% – 75% cover (Figure 1a).

Region-wide recovery has halted on the Northern GBR. Fourteen out of 33 reefs previously surveyed in the last two years had lower hard coral cover than in the previous surveys (Figure 1b), however only eight showed substantial statistical evidence for decline. These declines were likely due to the mass coral bleaching and the passage of [Tropical Cyclone Tiffany](#) in early 2022, and low numbers of crown-of-thorns starfish.

Region-wide hard coral cover was relatively stable from 1985 to 2010, then declined to the lowest recorded levels in 2017 following cumulative impacts from crown-of-thorns starfish outbreaks, severe tropical cyclones (TCs Ita and Nathan), and back-to-back severe mass coral bleaching events in 2016/17. There was a period of strong recovery from 2017 to 2022. Hard coral cover has declined slightly from 36.5% (32.2% - 40.9% C.I.s) in 2022 to 35.7% (32.1% - 39.96% C.I.s) in 2023 but remains within the credible intervals (Figure 2).

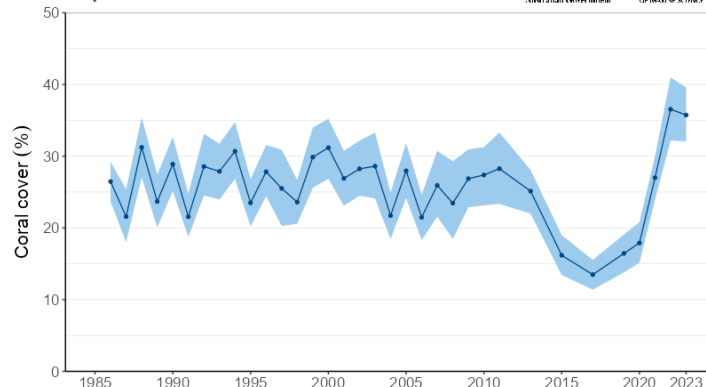
Surveys in 2023 found low crown-of-thorns starfish numbers at some reefs in the region (Image 1C), however all reefs were classified as No COTS or No Outbreak (Figure 1c). The Great Barrier Reef Marine Park Authority's [Crown-of-thorns Starfish Control Program](#) has been actively removing starfish in this area.

This field season, LTMP in-water surveys were conducted from October to December 2022, prior to peak summer temperatures. Northern GBR reefs experienced accumulated heat stress between 0.28 and 4.64 DHW<sup>1</sup> during this period and low coral bleaching (<10% of corals) was observed on 29 out of 38 reefs, despite being surveyed before the height of summer (Figure 1d).

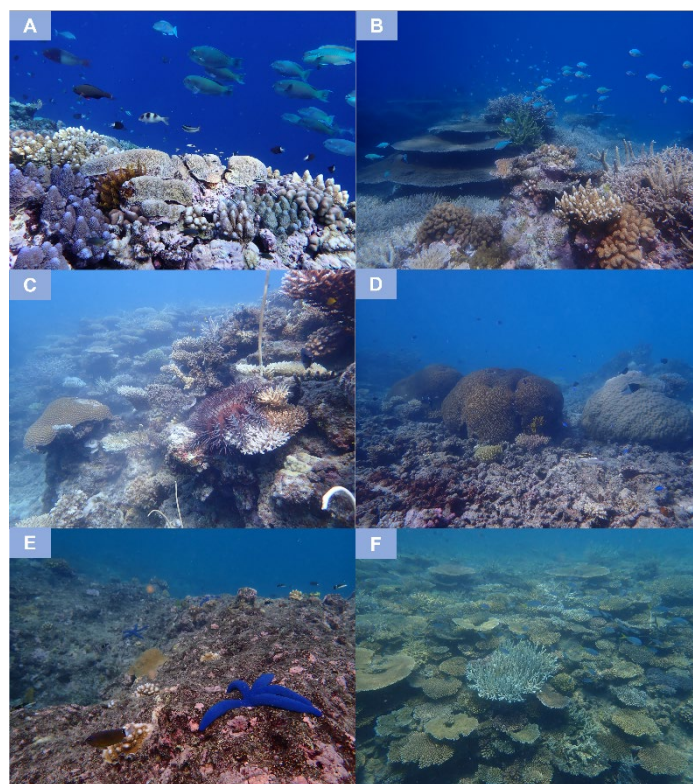
The fourth mass coral bleaching event since 2016 occurred over the austral summer of 2021/22 and Northern GBR reefs were variously affected. With the 2023 surveys complete, we are now able to assess the impacts of the 2022 mass coral bleaching event, which are discussed in more detail below.

### Northern Great Barrier Reef

#### Cape York to Cooktown



**Figure 2:** Trends in average hard coral cover (blue line) for the Northern GBR based on manta tow surveys. Survey data from 129 reefs contributed to the 37-year time series; blue shading represents 95% Credible Intervals. A total of 38 reefs were surveyed in 2023. Note that many reefs in this region do not have a regular survey history and in recent years fewer inshore reefs have been surveyed due to the risk of crocodile encounters.



**Image 1:** Photos showing the variable state of reefs in the Northern GBR in 2023. **A.** Parrotfishes swim over a coral-rich reef slope on [Reef 12-071](#). **B.** High coral cover abounds on some reefs throughout the Northern GBR, like [Creach Reef](#) north of Princess Charlotte Bay. **C.** Low numbers of crown-of-thorns starfish were found on some reefs in the Northern GBR, like [Martin Reef](#) inshore from Lizard Island. **D.** In some places there has been little recovery from the 2016/17 bleaching events but heat resistant corals such as these *Porites* colonies at [South Direction Island](#) still survive. **E.** Signs of recovery with abundant juvenile corals on [Pearson Reef](#). **F.** Flourishing coral assemblages at [Linnet Reef](#). More information on individual survey reefs can be found [here](#).

<sup>1</sup> DHW expresses the accumulated heat stress over the previous three months by adding up the time when temperature exceeds the bleaching threshold (Degree Heating Week). Significant coral bleaching is predicted above 4 DHW and coral mortality is expected above 8 DHW. Further information available from [NOAA](#).



## Condition Summary to May 2023

Surveyed October 2022 to May 2023

Since regular surveys by AIMS began in 1985, hard coral cover on reefs in the Central GBR has generally been lower than that in the Northern and Southern GBR.

Region-wide hard coral cover in the Central GBR decreased to the lowest level in LTMP records in 2012, following the impact of severe TC Yasi in 2011. Hard coral cover then recovered rapidly to 29.1% (25.4% - 33.2% C.I.s) in 2016. From 2016 to 2019, region-wide hard coral cover decreased continuously to 14.2% (12.0% - 16.7% C.I.s), largely due to repeated mass coral bleaching in 2016 and 2017 and outbreaks of crown-of-thorns starfish. From 2017 to 2022, hard coral cover underwent strong recovery to 32.6% (28.8% - 36.5% C.I.s). In 2023 it declined slightly to 30.8% (27.6.0% - 34.2% C.I.s) but remained within the margin of error (Figure 3).

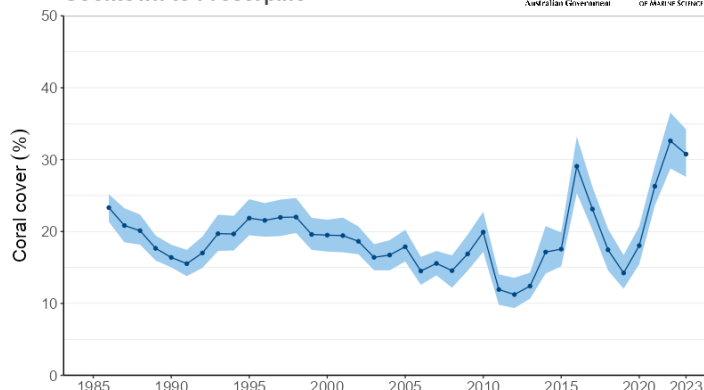
The status of the reefs in the Central GBR was variable in 2023; 24 of the 42 reefs surveyed had hard coral cover >10% – 30% while 13 reefs had hard coral cover >30% – 50%. Five of the surveyed reefs had hard coral cover >50% – 75% (Figure 1a, Image 2). A total of 35 of the 42 Central GBR reefs surveyed in 2023 had been previously surveyed within the last two years. Sixteen of these reefs had lower hard coral cover than in the previous surveys (Figure 1b), but only five showed substantial statistical evidence for decline. Hard coral cover was higher on 19 reefs (Figure 1b), with substantial statistical evidence for increases on nine.

Many reefs offshore from [Cairns](#), [Innisfail](#) and [Townsville](#) have had outbreaks of crown-of-thorns starfish in recent years. However, there were no [Potential](#), [Incipient](#) or [Active Outbreaks](#) of crown-of-thorns starfish recorded on Central GBR reefs in 2023 (Figure 1c).

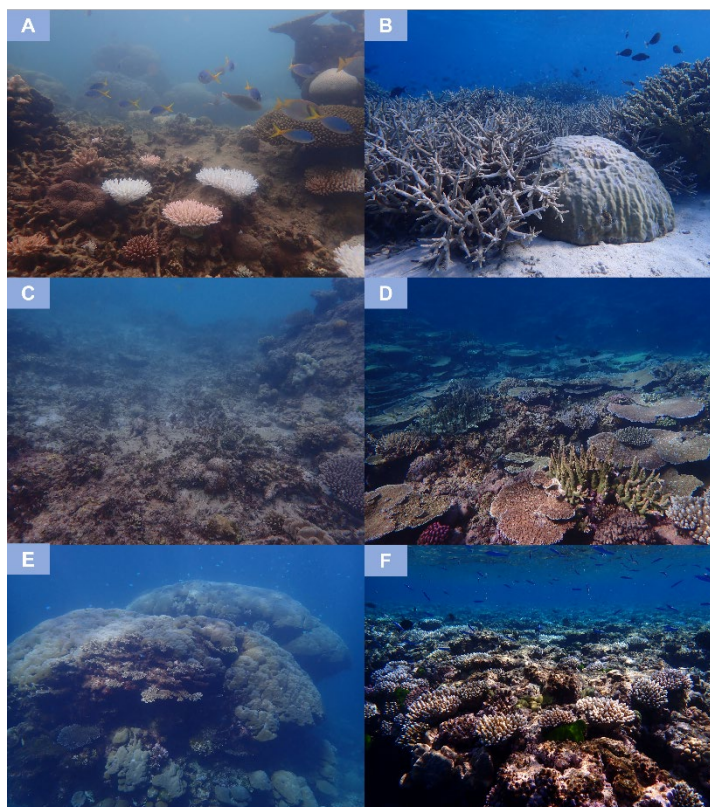
The Great Barrier Reef Marine Park Authority's [Crown-of-thorns Starfish Control Program](#) has been actively removing substantial numbers of starfish in this area, which has likely contributed to the low numbers of crown-of-thorns starfish recorded during these surveys.

Reefs of the Central GBR were exposed to accumulated heat stress between 0 and 1.85 DHW over the summer. This resulted in low coral bleaching (<10% of corals) being recorded on two-thirds of survey reefs (28 out of 42) in the Central GBR during 2023 (Figure 1d), with no bleaching recorded on the remainder of reefs. With the 2023 surveys complete, we are now able to assess the impacts of the 2022 mass coral bleaching event, which are discussed in more detail below.

## Central Great Barrier Reef Cooktown to Proserpine



**Figure 3:** Trends in average hard coral cover (blue line) for the Central GBR based on manta tow surveys. Survey data from 226 reefs contributed to the 37-year time series; blue shading represents 95% Credible Intervals. A total of 42 reefs were surveyed in 2023.



**Image 2:** Heat stress accumulation was relatively low this summer, although there was still some minor bleaching across reefs of the Central GBR. **A.** bleached corals at [Low Isles](#) offshore from Port Douglas. **B.** Coral assemblages flourish in the sheltered waters of the back reef of [Agincourt Reef \(No. 1\)](#). **C.** Recent crown-of-thorns outbreaks have reduced coral cover on a number of mid-shelf reefs of the Innisfail sector like [Peart Reef](#). **D.** [Chicken Reef](#), on the outer shelf off Townsville has recovered well from recent disturbances. **E.** Large *Porites* colonies at [Rib Reef](#) have survived a wave of crown-of-thorns starfish outbreaks and a number of mass coral bleaching events. **F.** Patchy minor bleaching on the reef flat at [Myrmidon Reef](#). More information on individual survey reefs can be found [here](#).



### Condition Summary to May 2023

Surveyed August 2022 to May 2023

The Southern GBR has generally had higher coral cover than the Northern or Central GBR, but it has also been the most dynamic over the 37-year survey history. TC Hamish in 2009 reduced coral cover to the lowest levels recorded by the LTMP in 2011 (Figure 4). A rapid and substantial increase in hard coral cover occurred from 2011 to 2017, reaching 36.8% (30.3% - 44.0% C.I.s). However, outbreaks of crown-of-thorns starfish began in 2018 and regional coral cover decreased to 29.0% (23.0% - 36.8% C.I.s) in 2019. In 2021, coral cover had increased to 37.8% (31.8% - 44.2% C.I.s) but declined again in 2022 to 33.9% (28.6% - 39.3% C.I.s) (Figure 4). In 2023, coral cover remained similar at 33.8% (29.0% - 38.9% C.I.s).

The state of individual Southern GBR reefs was variable (Image 3) with one reef having cover of <10%, 11 reefs having cover >10% – 30%, 11 reefs with cover >30% – 50% and eight reefs with cover >50% – 75% (Figure 1a). Of the 31 reefs surveyed in 2023, 25 reefs have been surveyed in the last two years. Hard coral cover was lower than previous surveys on 15 of these, with substantial statistical evidence for decline on six (Figure 1b). Ten reefs had higher hard coral cover than previously surveyed, but only two with substantial statistical evidence for an increase (Figure 1b).

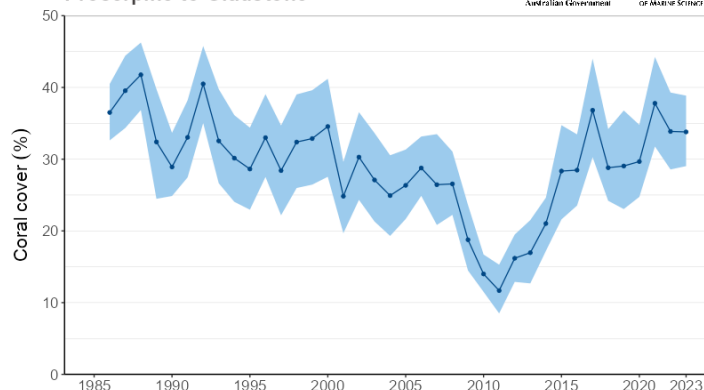
The Southern GBR has been the epicentre of crown-of-thorns starfish outbreaks in recent years, and remained so in 2023, with the focus in the Swain reefs. Two of the 31 reefs were classified as having *Active Outbreaks*, three reefs had *Incipient Outbreaks* (Figure 1c). Low numbers of crown-of-thorns starfish were recorded on six reefs classified as *No Outbreak* and the remainder had *No COTS*. The Great Barrier Reef Marine Park Authority's [Crown-of-thorns Starfish Control Program](#) has been actively removing substantial numbers of starfish in this area.

Southern GBR reefs were exposed to low levels of accumulated heat stress (0 to 2.55 DHW) over 2023. LTMP in-water surveys recorded low bleaching (<10% of colonies) of sensitive species on 15 of 31 reefs; however, no instances of more severe bleaching were observed on the remaining 16 survey reefs (Figure 1d). With the 2023 surveys complete, we are now able to assess the impacts of the 2022 mass coral bleaching event, which are discussed in more detail below.

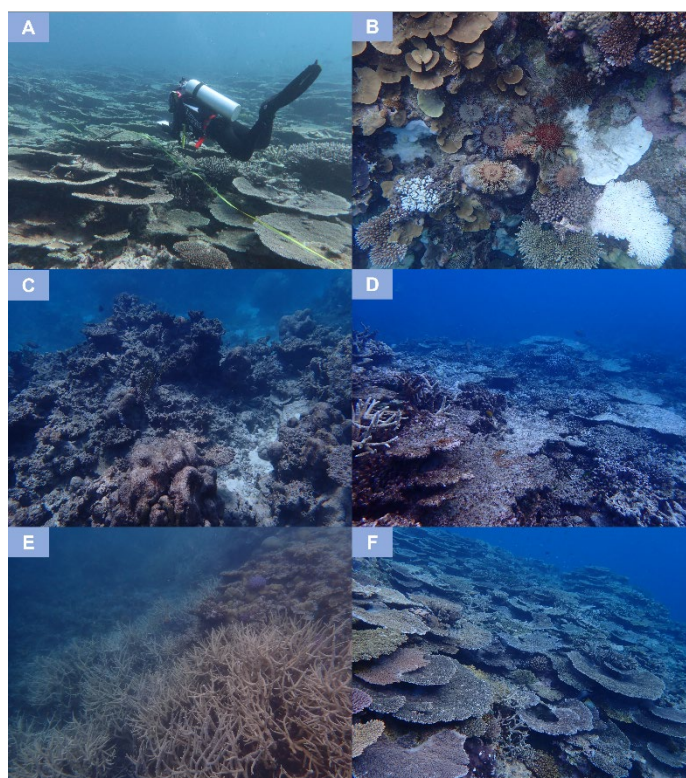
All reefs of the Capricorn-Bunker group had notable occurrence of coral disease.

### Southern Great Barrier Reef

#### Proserpine to Gladstone



**Figure 4:** Trends in average hard coral cover (blue line) for the Southern GBR based on manta tow surveys. Survey data from 137 reefs contributed to the 37-year time series; blue shading represents 95% Credible Intervals. A total of 31 reefs were surveyed in 2023.



**Image 3:** A. A diver surveying the coral community at [One Tree Island](#) in the Capricorn-Bunker sector. B. A large outbreak of crown-of-thorns starfish was found at [Tern Islet](#) in the Pompeys. Elsewhere in the Southern GBR, crown-of-thorns starfish infestations have run their course and reduced coral cover to very low levels, particularly in the Swains, like C. [Chinaman Reef](#) and D. [Gannet Cay](#). E. High coral cover is still found at many reefs in the Southern GBR, like [Reef 21-187](#) in the Pompeys and F. [Lady Musgrave Island](#) in the Capricorn-Bunkers. More information on individual survey reefs can be found [here](#).

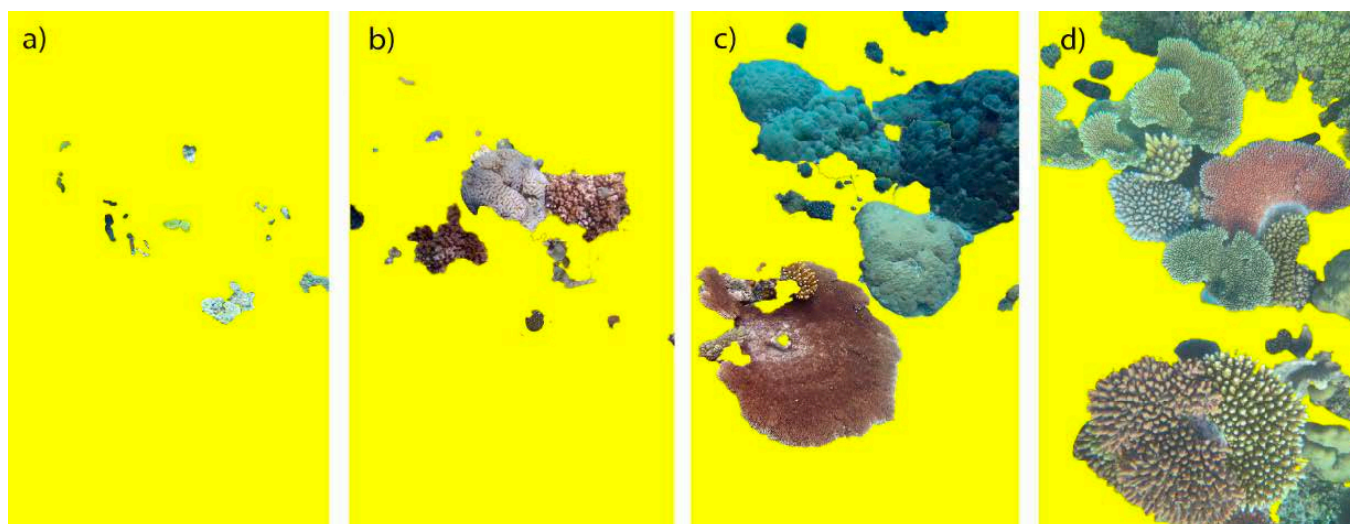
## BOX 1: What does ‘percent hard coral cover’ mean?

There are many ways to measure the status of coral reefs. One of the most common is to use percent hard coral cover as an ‘indicator’ of reef condition because it describes the abundance of a critical ecosystem engineer on coral reefs. This measure describes the proportion of the seafloor that is covered in live hard coral. Percent hard coral cover is widely used by scientists worldwide and is a standard measure that applies to all locations. While it does not tell us anything about the diversity or composition of coral assemblages, it provides a simple and robust measure of reef health.

Percent hard coral cover can be estimated using various techniques. The technique used for this report is [manta tow surveys](#), which are visual estimates of percent hard coral cover over the area covered by an observer during one 2-minute tow (~2000 m<sup>2</sup>). The percent hard coral cover for a reef is then estimated as the average of the estimates from all tows around a reef and reported as broad categories (e.g., 0 = 0%, >0% – 10%, >10% – 30%, >30% – 50%, >50% – 75% and >75% – 100%; Box 1 Image).

A coral reef consists of more than just hard coral and contains a diverse array of other corals, sponges, algae, sand, rock and invertebrates. It is relatively rare for GBR reefs to have 75% – 100% hard coral cover and AIMS defines >30% – 50% hard coral cover as a high value, based on historical surveys across the GBR.

[Other techniques](#) for determining percent hard coral cover involve counting the number of points within sampling units (quadrats and photos), as used by the LTMP during fixed site surveys, or the linear distance along a tape measure (line-intercept) that intersect live hard coral colonies. Adding up the total number of points of live hard coral cover and then expressing this as a percentage of the total number of points within a sample yields the estimates of hard coral cover. Data from both the fixed site and manta tow surveys conducted by the LTMP are highly correlated and show the same trends in hard coral cover estimates. However, manta tow estimates are generally lower than those obtained from fixed site surveys as they encompass the entire reef, including sandy back reef habitats that have low coral cover.



**Box 1 Image:** Examples of categories of percent hard coral cover a) >0% – 10%, b) >10% – 30%, c) >30% – 50% and d) >50% – 75%. The yellow areas show non-hard coral reef surfaces, and the categorisation is based on the proportion of the substrate covered in live hard coral colonies.



# Impacts of the 2022 Mass Coral Bleaching Event

In the austral summer of 2021/22, much of the GBR was subjected to a level of accumulated heat stress that caused mass coral bleaching to occur in the Northern and Central regions (Image 4). This was the fourth such event since 2016 and the first to ever occur in a La Niña year; more frequent mass coral bleaching is a sign that the GBR is experiencing the consequences of climate change. [In-water and aerial surveys in 2022](#) found that widespread coral bleaching occurred across the GBR in the austral summer, with the severity and prevalence of bleaching variable among reefs.

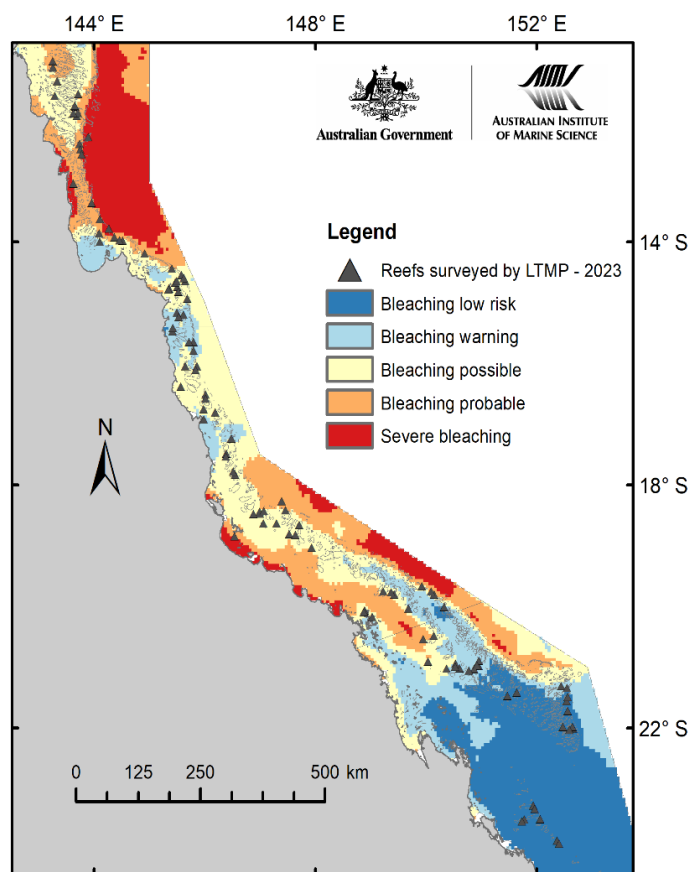
Due to the nature of the LTMP field season, which occurs from July to June the next year, it was not possible to assess the impacts of the 2022 bleaching event until after the 2023 season was completed. Of the 111 reefs surveyed in 2023, 93 reefs had been surveyed in the previous two years, which allowed an examination of the impacts of the 2022 bleaching event.

Of the 93 reefs, there was substantial statistical evidence of annual declines in percent hard coral cover on 19 reefs. Of these, 10 had declines likely due to direct mortality from the 2022 bleaching event, while the remainder were due to a mix of bleaching, crown-of-thorns starfish, [Tropical Cyclone Tiffany](#) and/or coral disease.

Fifty-one reefs had small annual changes in hard coral cover, either positive or negative. These are within the credible intervals with little substantial statistical evidence for change and are considered stable.

The impacts of the 2022 mass coral bleaching event agree well with levels of accumulated heat stress observed across the GBR in 2022. Of the 93 LTMP reefs surveyed in 2023 available for an assessment of the 2022 mass bleaching event, 16 had thermal stress accumulation representing bleaching low risk (0 – 2 DHW), 14 were at bleaching warning levels (2 – 4 DHW), 48 reached levels where bleaching was possible (4 – 6 DHW), 12 were categorised as bleaching probable (6 – 8 DHW) and three exceeded levels of heat stress where severe bleaching was likely (>8 DHW). Widespread mass coral bleaching is expected between [4 and 8 DHW](#), with a greater risk of severe bleaching and mortality above 8 DHW (Figure 5).

Heat stress accumulation between 4 and 8 DHW can cause some mortality but is more likely to produce sub-lethal effects like [reduced growth](#), [reproductive output](#) and [larval settlement](#) following moderate bleaching. These sub-lethal effects can have long-lasting impacts on the recovery dynamics of coral reefs.

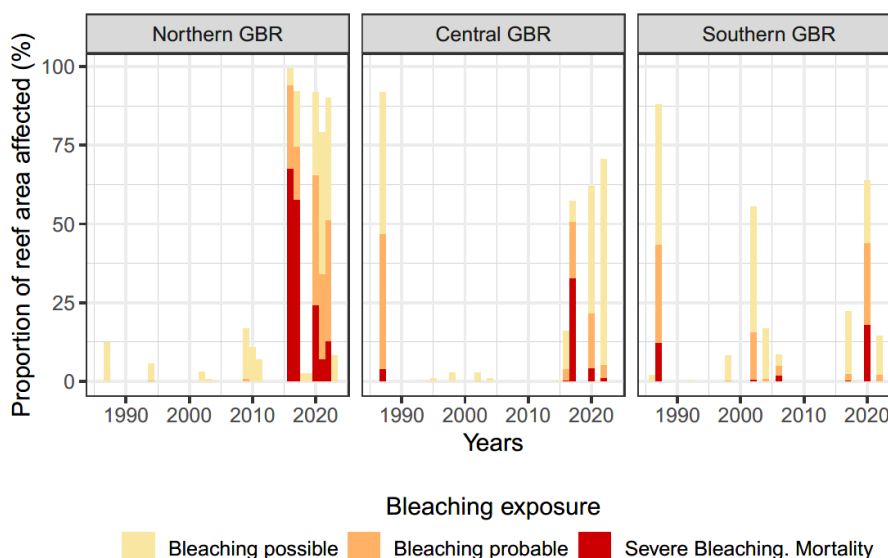


**Figure 5:** Exposure level of the 111 LTMP reefs surveyed in 2023 to accumulated heat stress during the austral summer of 2021/2022. Bleaching low risk = 0 – 2 DHW, Bleaching warning = 2 – 4 DHW, Bleaching possible = 4 – 6 DHW, Bleaching probable = 6 – 8 DHW and Severe bleaching >8 DHW. Source: [NOAA/NESDIS/STAR Coral Reef Watch program](#)



**Image 4:** Bleached hard coral colonies on the reef flat at Davies Reef during the mass coral bleaching event in March 2022. Photo credit: Marta Panero, AIMS.

# Impacts of the 2022 Mass Coral Bleaching Event



**Figure 6:** Comparison of accumulated heat stress from 1990 to 2023. Data are the proportion of reefs in each reporting region (Northern, Central and Southern GBR) exposed to heat stress where bleaching is possible (4 – 6 DHW), bleaching is probable (6 – 8 DHW) and severe bleaching and coral mortality are likely (>8 DHW).

Heat stress has recently been measured from satellite estimates of sea surface temperature in relation to the local climatological maximum monthly mean temperature (1985–2012), indicating the upper limit of ‘usual’ maximum summer temperatures.

The GBR has experienced a notable increase in the magnitude and extent of marine heatwaves in the past seven years, with about 60% of the reefs in the Northern GBR experiencing high levels of thermal stress and severe bleaching and mortality in 2016 and 2017, and moderate stress in 2020 and 2022 (Figure 6).

While the GBR experienced large-scale bleaching in 2020 and 2022, the extent of reefs affected by severe thermal anomalies has been consistently lower than in 2016 and 2017 (Figure 6). Therefore, the observed mortality due to thermal stress over the last two years was much lower than what was observed after the 2016, 2017 and even the 2020 bleaching events.

The 2022 bleaching event resulted in low direct coral mortality, however indirect sub-lethal effects on growth, together with mortality from COTS, [Tropical Cyclone Tiffany](#) and coral disease have been enough to pause the recent coral recovery seen in the Northern and Central GBR and keep coral cover close to levels reported in 2022 in the Southern GBR.

A point of concern, however, is the increasing frequency and spatial extent of bleaching events. Mass bleaching events are predicted to occur almost annually as Australian waters rapidly warm and pose significant risks to the future condition of the coral reefs in the GBR.



**Image 5:** The AIMS LTMP team spends 120 days a year surveying coral reefs from Cape York in the north to the Capricorn-Bunkers in the south. Much of their time is spent in small tenders from which they conduct diver-based operations. Photo credit: Kate Osborne AIMS



# Assessing the Long-term Health of the Great Barrier Reef

Determining the status of the GBR requires robust long-term datasets collected using standard methods. Long-term data are particularly important to avoid the 'shifting baseline' syndrome, as the results each year are always considered in the context of the long-term trends.

The last few years have revealed recovery across much of the GBR. We reported in 2022 the highest recorded coral cover in the Northern and Central GBR since the LTMP began monitoring in the 1980s.

Such recovery occurred despite the latest two mass coral bleaching events in 2020 and 2022, which underlines that widespread coral bleaching does not necessarily lead to extensive coral mortality. The 2020 and 2022 events saw accumulated heat stress at the survey reefs to a level where widespread bleaching occurred (4 – 8 DHW), but not to the level where widespread coral mortality was expected (>8 DHW). An assessment of the 2022 mass coral bleaching event revealed some coral mortality, which coupled with sub-lethal effects on coral physiology (growth and reproduction) was enough to arrest recent increases in regional hard coral cover. Nonetheless, the increased frequency and extent of bleaching events of the past seven years remains concerning.

Crown-of-thorns starfish are coral predators, and their outbreaks represent a major cyclic disturbance on the GBR. The Great Barrier Reef Marine Park Authority's [Crown-of-thorns Starfish Control Program](#) has been active on the GBR during the current outbreak and seeks to decrease starfish numbers at key reefs to reduce the amount of coral lost and diminish the crown-of-thorns starfish brood stock that propagates the outbreak 'wave' southward through most of the GBR.

In 2023, the number of *Active Outbreaks* has continued to decrease from previous years, although outbreaks were still recorded in the [Swain](#) sector of the Southern GBR. The LTMP provides data to routinely assist in the prioritisation and analyses of the effectiveness of the [Crown-of-thorns Starfish Control Program](#).

Most of the recent recovery was driven by increases in the fast-growing *Acropora* corals, which have proliferated across many GBR reefs. Once established, these corals enter an exponential growth phase that rapidly increases percent hard coral cover, as documented in last year's results. However, fast-growing corals are particularly susceptible to wave damage, like that generated by strong winds and tropical cyclones. They are also highly susceptible to heat stress and are the preferred prey for crown-of-thorns starfish. Therefore, large increases in hard coral cover can quickly be overturned by disturbances on reefs where *Acropora* predominate.

This year's surveys showed that even a minor bleaching event and ongoing crown-of-thorns starfish outbreaks were enough

to lead to loss of coral cover on many reefs, which offset the continued increases on other reefs and caused region-wide mean hard coral cover to remain unchanged.

The prognosis for the future disturbance regime under climate change is one of increasingly frequent and longer lasting marine heatwaves, with the ongoing risk of crown-of-thorns starfish outbreaks and tropical cyclones. The consequences of climate change are evidenced by multiple mass coral bleaching events over the past seven years in the three GBR regions. Simultaneously, the continuing risk of crown-of-thorns starfish outbreaks and chronic stressors such as high turbidity, increasing ocean temperatures and changing ocean chemistry can all negatively affect recovery rates, while more frequent acute disturbances mean that the intervals for recovery are becoming shorter. Enabling coral reefs to survive these stressful conditions requires a combination of a reduction in global greenhouse emissions to stabilise temperatures, best practice management of local pressures, and the development of interventions to help reefs adapt to and recover from the effects of climate change.

Measuring and understanding the process of, and limitations to, coral reef recovery will be a continued focus of AIMS' research and monitoring.

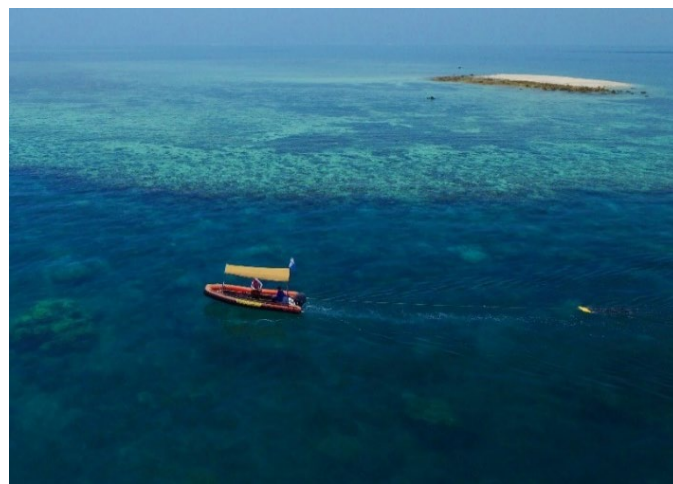


Photo Credit: AIMS LTMP

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