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Tropical Water Quality Hub impacts

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Tropical Water Quality Hub

About this hub

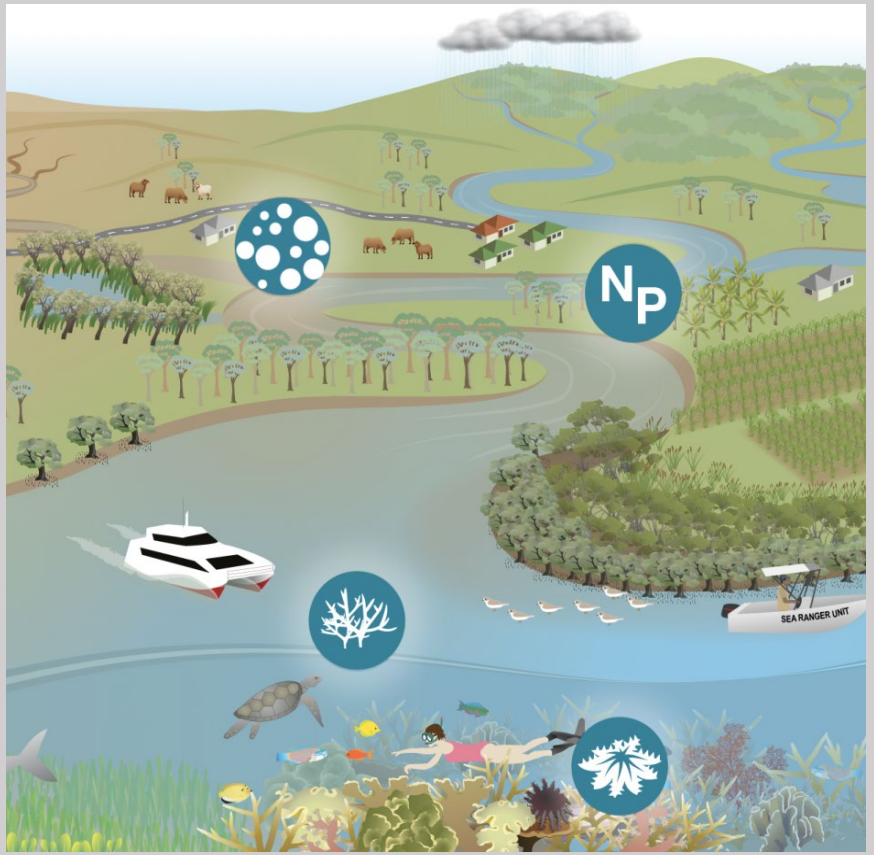
The Tropical Water Quality Hub is 1 of 6 hubs from the first phase of the National Environmental Science Program. It conducted research to help guide decisions about managing the Great Barrier Reef. This hub provided innovative research for practical solutions to maintain and improve tropical water quality from catchment to coast.

NESP funding: $31.98 million

Host organisation: Reef and Rainforest Research Centre Inc.

Hub leader: Professor Damien Burrows

Hub partners: James Cook University, Australian Institute of Marine Science, CSIRO, University of Queensland, Griffith University, Central Queensland University



Key themes

- Responding to coral bleaching on the Great Barrier Reef
- Ecosystem restoration is key to improved water quality
- Indigenous engagement for improved water quality
- Blueprint for Crown-of-thorns Starfish control on the Great Barrier Reef
- Achieving change in farming practices

A suite of products prepared in the final year of the hub bring together the learnings of multiple research projects and initiatives, to provide a more complete picture of Australia's tropical water quality, coastal management and the Great Barrier Reef.

Find out more about the Tropical Water Quality Hub's projects.

Responding to coral bleaching on the Great Barrier Reef

There is concern that the relative contribution of bleaching on coral decline and mortality in the Great Barrier Reef has increased. The years 2016 and 2017 saw significant mass bleaching across the reef, with further bleaching occurring in 2020.

Understanding the relative contribution of bleaching to coral loss was an important step in developing appropriate strategies for ongoing protection of coral on the Great Barrier Reef, as heat wave bleaching conditions present an existential threat to the reef's future.

The hub was deliberately structured to be flexible and responsive to changes in end-user needs during the hub's lifetime. It was able to rapidly pivot to broker and fund about $2.7 million of new projects to address the threat of climate change during 2017 and 2018. This involved significant collaborations between lead researchers from partner institutions.

This research laid the foundation for an applied research response into both bleaching recovery, and potential opportunities for intervention under the subsequent $100m Reef Restoration and Adaptation Program.

Impact snapshots: Responding to coral bleaching on the Great Barrier Reef

What makes a coral species more tolerant to heat?

Some corals are more resilient than others when exposed to heat stress. A hub project looked at the distribution of 3 coral species populations across the reef and how they respond to these stressors.

This involved assessing both the genes and respective coral symbionts' response to heat stress. Knowing the distribution and abundance of stress-tolerant coral genes and their symbionts is enabling identification of key coral populations for protection, key reefs for resilience management, and potential breeding stock for use in the subsequent Reef Restoration and Adaptation Program.

Acropora millepora was found to be both homogenous across the reef ecosystem and the most resilient to heat stress, suggesting increased emphasis should be placed on protection or restoration of this species, potentially after mass bleaching events.

Understanding links between water quality and coral bleaching

Results from a hub project suggest heat stress was the primary significant driver for bleaching across recent events, with inshore corals showing greater recovery following bleaching compared to those in the mid-shelf.

Contrary to some expectations, the bleaching response across inshore and mid-shore corals was not exacerbated by higher levels of nitrate and phosphate, the land-based nutrients that run off from coastal river catchments.

Although it is now suggested that improvements to water quality alone are unlikely to mitigate the severe bleaching that occurs as a result of heat stress, those improvements are crucial to assisting in reef recovery.

Resilience-based management tool begins to illuminate pathways for reef recovery

The hub developed and applied an algorithm that uses present-day coral cover and a reef-scale connectivity model to identify important larval source reefs for supporting recovery of the reef from its present-day state.

This work led to the creation of a resilience-based management tool that has laid the groundwork for further decision-support software development under the Reef Restoration and Adaptation Program.

The tool has since provided a structured method to explore strategy options for restoring and protecting the reef. The decision-support software was recognised in a report from the American National Academies of Science, Engineering and Medicine.

Improved predictive modelling to shift messaging and management

In a Crown-of-thorns Starfish project, the hub applied a data-driven modelling approach to improve the scale of modelling for predicting both coral bleaching and subsequent mortality, following widespread heat stress events on the Great Barrier Reef.

A hub report suggested that initial estimates of mortality following the 2016 to 2017 bleaching events were high, and that predicted mortality across multiple bleaching events was varied and may be influenced by several factors.

Data from surveys undertaken under the Crown-of-thorns Starfish Control Program allowed for finer-scale estimation of mortality, putting reef managers and reef users in a better position to respond to these events by assisting in reef recovery efforts.

Ecosystem restoration is key to improved water quality

Healthy coastal ecosystems are critical for the long-term health of the Great Barrier Reef. Protecting, maintaining and restoring coastal ecosystems is critical to supporting reef recovery. An integrated whole-of-catchment approach is needed to protect and restore the ecological functioning of coastal ecosystems and improve the quality of water flowing to the reef.

Although only a small portion of the fine sediment from catchments and waterways reaches coral reefs and seagrass meadows, it can still have a significant impact by reducing light and water quality, especially during wet season flooding events. Understanding the sources of this sediment, its effects, and how future discharges can be reduced has been a key focus of the hub.

Erosion from alluvial gullies is a major source of sediment pollution on the Great Barrier Reef. Watch this video to discover how research supported by the hub shows that reshaping and stabilisation works (such as these carried out at Crocodile Station in Queensland) can effectively mitigate sediment sourcing from individual gullies.

From ridge to reef, hub research focused on ecosystem restoration, including gully restoration, coastal wetland restoration and innovative coral restoration techniques.

A resilience-based management approach was subsequently developed to assist reef managers in decision-making. Fine sediment reduction is now a priority under the Queensland Government's Reef 2050 water quality improvement plan.

Impact snapshots: Ecosystem restoration is key to improved water quality

Wetland restoration across various Great Barrier Reef catchments

Hub research involved working with land managers and using advanced scientific hydrological and ecological techniques to generate data to evaluate wetland repair efforts. This provided surety to government funding agencies.

A whole-of-catchment approach, through various wetland sites along the Queensland coast, has documented the benefits of restoring coastal wetlands through applied practical solutions and monitoring.

Various methods were trialled and monitored, including removing historical tidal bund walls (enabling fish movement between fresh and saltwater); constructing wetlands on agricultural properties; erecting feral pig exclusion fencing; and identifying and removing aquatic weeds in wetlands. These methods have proven to benefit native species, reduce nitrogen on farms entering waterways, and improve water quality entering the reef.

Gully remediation to reduce sediment and nutrient loss

The hub developed a method for identifying priority gullies for rehabilitation that is vastly more accurate and efficient than previously used mapping. The results demonstrated not only that the gully rehabilitation techniques are effective, but when, where and how to best apply them for maximum effect.

This research indicates that Australia can get halfway to the Australian Government's Reef 2050 plan sediment targets by identifying and treating just the most sediment-intensive and cost-effective 2% of gullies.

The team's contributions to water quality improvements for the Great Barrier Reef were recognised in 2017 with the awarding of a Eureka Prize.

Rehabilitation of alluvial gullies

Hub research trialled various rehabilitation options across small and large alluvial gullies. The results found that applied treatments reduced fine sediment losses by 80 to 90%, and provided detailed cost estimates for various forms of treatment.

This research constitutes some of the first control and treatment field experiments to measure actual changes in water quality on the ground as a result of gully rehabilitation efforts, with results critical in constraining scenario analysis in future paddock-to-reef modelling.

Coral restoration for reef resilience

The Great Barrier Reef is suffering from the combined effects of many threats and disturbances, including mass coral bleaching, pollution, storm damage and outbreaks of Crown-of-thorns Starfish. Although some of these threats are caused or exacerbated by global issues such as climate change, others may be amenable to local- or regional-scale intervention, restoration and management.

Collaboration with tourism operators and reef managers allowed the hub to trial and evaluate innovative coral restoration techniques.

A coral restoration database created by the hub is now informing the Reef Restoration and Adaptation Program and the upcoming Great Barrier Reef Marine Park Authority's (GBRMPA's) coral restoration and adaptation policy. These initiatives are being used to better assess and guide future restoration project applications for the Great Barrier Reef.

Indigenous partnerships for improved water quality

Close collaboration between Traditional Owners and hub researchers has resulted in better co-management of Country and improved water quality. The hub led the way in the foundational development of a meaningful engagement strategy with Aboriginal and Torres Strait Islander peoples in the sustainable cultural and environmental management of the Great Barrier Reef and its catchments.

In addressing targets of the Reef 2050 plan, Traditional Owners' aspirations and building capacity have been fundamental to land and sea Country management and governance.

The Orpheus Island reef restoration and leadership workshop 2020 focused on developing leadership skills and emphasising the role everyone must play in preserving precious and unique natural ecosystems.

Working with Indigenous ranger groups throughout the life of the hub, researchers passed on valuable skills that can be carried forward in land and sea monitoring for healthy Country. Together with scientists, Traditional Owners have actioned cultural site clearance and preliminary assessments.

They also gained new skills in wetland rehabilitation, feral pest management, land and sea Country mapping, grass seed collection, gully remediation construction, estuary and mangrove management, salinity monitoring, water quality sampling, equipment maintenance, weed management and general site management. Training in jellyfish stinger collection and identification, shoreline video assessment, coral identification and restoration techniques are additional skills that have been passed on for future management activity.

Impact snapshots: Indigenous partnerships for improved water quality

Workshops pass on reef monitoring and restoration skills to sea Country Traditional Owners

The hub supported sea Country Traditional Owners to attend the 2019 and 2020 Orpheus Island reef restoration and leadership workshops. The Traditional Owners gained skills and knowledge to begin planning or commence activities on their Country, engaging in Indigenous tourism and inshore coral monitoring.

Saranne Giudice, who leads the Gidarjil Sea Rangers, has thoroughly appreciated the upskilling within her team: ‘The Gidarjil Sea Rangers who attended the workshop found it beneficial in a number of ways. The workshop definitely contributed to the sea rangers’ coral species, fish and macroinvertebrate identification skills, and also their experience and confidence in the water. The planning and restoration techniques they learnt have set us in good stead to identify any of our inshore reefs that could benefit from restoration.’

Tracking aesthetic values provides new engagement for Traditional Owners along the Great Barrier Reef

A hub project provided an insightful example of how social sciences research is complementary in designing, interpreting and improving the artificial intelligence system for monitoring the aesthetic value of the Great Barrier Reef. Throughout the project, these results were communicated to more than 30 Indigenous communities along the reef’s coastline.

This impactful cross-cultural exchange was achieved by incorporating the knowledge into the project’s Indigenous engagement strategy, a key element of every hub project design.

Indigenous partnerships lead to ongoing capacity for Cape York Traditional Owners

A partnership between hub scientists, Cape York Natural Resource Management staff and Indigenous graziers has reduced sediment run-off from one of the Indigenous Land and Sea Corporation's (ILSC) Crocodile-Welcome Station gullies by 85%.

This success has spurred on the expansion of gully remediation activities. With the support of the Australian Government's Reef Trust, the ILSC has now purchased an excavator and employed a crew of local Traditional Owners to continue the works, providing ongoing social and ecological outcomes.

New skills and greater capacity for ranger groups thanks to hub engagement

Since 2006, MangroveWatch, co-developed by hub researcher Professor Norm Duke, has been used to make mangrove monitoring more accessible to groups and communities.

NESP research assessing the recent dieback of mangroves across the Gulf of Carpentaria led to the upskilling of several Indigenous ranger groups in these monitoring techniques, following engagement across the span of the project.

Various Northern Territory and Queensland gulf rangers, and sea rangers from Gidarjil Aboriginal Corporation are now trained in the Shoreline video assessment methodology, which allows local rangers to efficiently monitor mangrove health from boat or shore.

Blueprint for Crown-of-thorns Starfish control on the Great Barrier Reef

Crown-of-thorns Starfish (CoTS) are voracious coral predators and cause significant coral loss on Australia's Great Barrier Reef. For reasons that are unclear, CoTS populations go through periodic cycles of abundance and can reach densities of hundreds of individuals per hectare. During these periods of high density, CoTS can consume most of the hard coral cover at a site.

CoTS outbreaks are one of the few threats amenable to direct intervention, emphasising the importance of ensuring that control efforts are as effective as possible at defending live hard coral cover. Although there is a long history of research into CoTS biology, ecology and causes of outbreaks on the Great Barrier Reef, there were few significant advances in how control activities are implemented and how to maximise effectiveness.

Watch this video to learn why the CoTS Control Program is a vital part of supporting the Great Barrier Reef.

The hub's adaptation of a world-first integrated pest management (IPM) approach to the marine environment has delivered a strategic response to CoTS control on the Great Barrier Reef, and is effectively reducing outbreak incidents and ecosystem impacts.

The applied CoTS IPM approach filled critical ecological knowledge gaps, developed and delivered new tools and methods for surveillance and control, and has demonstrably improved the capacity for manual CoTS control to defend coral cover on the Great Barrier Reef.

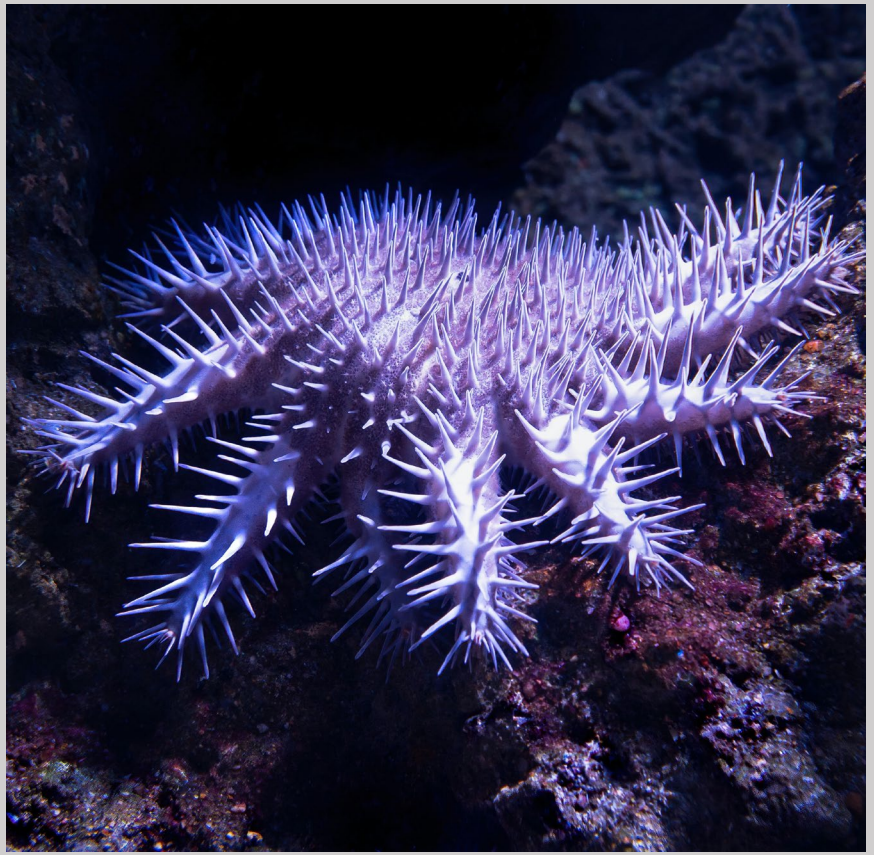
Impact snapshots: Blueprint for Crown-of-thorns starfish control on the Great Barrier Reef

Advancing understanding of CoTS ecological processes

Hub researchers and industry partners used a systems understanding of CoTS outbreaks and control logistics to develop an IPM strategy that demonstrably protected more hard coral than any other action. Collaborative and strategically targeted research projects were conducted to address gaps in knowledge.

A continuous assessment of control performance and operations in place enabled continuous improvement in the CoTS IPM Control Program. It ensured the program effectively achieved the protection of coral at local, reef and regional scales.

These approaches are now being expanded to meet the program's new potential under the CoTS Control Innovation Program, including the future development of new tools and technologies not reliant on manual control, such as environmental DNA detection, predation and chemical cues.



Protecting hard coral cover on the reef

CoTS predation is identified as a major cause of coral loss at the scale of the reef, contributing as much as 42% of coral loss between 1985 and 2012. This poses long-term risks to overall reef health and resilience.

The CoTS IPM Control Program is now successfully ensuring that CoTS densities are kept below the critical densities that allow CoTS predation to outpace coral growth. It is now twice as likely that a CoTS-infested site will have CoTS numbers reduced to below the ecological threshold where net coral loss occurs. Under the previous approach, it took 60% longer to achieve this outcome at site, meaning that more coral was lost before control was successful. And the previous approach was successful at just 53% of sites and 0% of reefs. Where implemented, the CoTS IPM Control Program achieves these outcomes at 88% of sites and 92% of reefs.

The program has greatly reduced the number of reefs considered to be in active outbreak mode. There are even indications it has also reduced the starfish's overall geographic spread.

New decision-support tool app improves control efficiency and effectiveness

The CoTS Control Centre Decision Support System (CCC-DSS), developed by CSIRO under the hub, is used daily on CoTS control vessels.

The CCC-DSS is installed on 32 ruggedised Android tablets, along with a suite of 3 data collection apps developed for GBRMPA, and 3 decision-support components developed under the hub's CoTS IPM Control Program. The tablets have also been managed remotely, including locating hardware and updating software.

Data is then shared between the apps that make up the CCC-DSS within a tablet, between tablets on a vessel independent of cellular connectivity, and with GBRMPA's Eye on the Reef database, when cellular networking is available.

The CCC-DSS is now used by GBRMPA for control operations, identifying priority reefs for control and maintenance, and thus boosting the program's impact in protecting hard coral cover.

Training and employment of Indigenous and non-Indigenous youth

The CoTS control youth training program, funded by the Queensland Government's Skilling Queenslanders for Work Program, has operated since 2010 and produced several hundred graduates.

The training program had a substantial and significant positive impact on the self-reported life satisfaction of the CoTS program graduates, with many reported having greater confidence in their skills and vastly improved employment opportunities.

With an average age of 22, over 80% of graduates found employment following the program, maintaining a strong personal connection with, and motivation to protect the Great Barrier Reef. With youth graduates nearly 27 times more likely than other local youth to be fully employed, it is no exaggeration to say that this program has changed lives for the better in far north Queensland, especially in Indigenous communities.

Achieving change in farming practices

One of the biggest challenges in meeting the water quality targets under the *Reef 2050 plan* – and restoring trust − has been the ability to determine with confidence, the sources and amounts of dissolved inorganic nitrogen, sediment and other pollutants in river systems that flow into the Great Barrier Reef.

The Russell-Mulgrave catchment in the Wet Tropics just south of Cairns was facing many challenges for farmer engagement and uptake of improved farming practices for water quality. These challenges included a lack of credible data to overcome pre-existing mistrust in the science, technology to provide real-time runoff sensing, and the ability to identify nutrient hot spots.

In meeting these challenges, the hub engaged water quality scientists with established experience and rapport with the sugar industry because it was acknowledged that the provision of complex messages is best done by trusted, highly credible sources.

More efficient irrigation results in both improved water quality outcomes for the Great Barrier Reef and improved return on investment for farmers. To make this possible, researchers used advanced Internet of Things approaches to enable 2 separate but vital software systems to exchange information with minimal human input, freeing up time for farmers to spend on other tasks on their properties.

‘We are sometimes told that we are the worst polluting catchment and at other times that title goes to [another catchment]. We are told that the information comes from the end-of-catchment water quality modelling. I can tell you that very few farmers believe that modelling.’

– Barry Stubbs, second-generation cane grower in the Russell-Mulgrave catchment

Impact snapshots: Achieving change in farming practices

Real-time water quality monitoring study builds trust

Technological advances allowed accurate and real-time measurements of nitrate concentrations in local waterways to be gathered throughout the year and immediately fed back to canegrowers via a mobile phone app developed by CSIRO.

Hub analysis of wet season data from the study showed that the first big flushes of rain were responsible for approximately 40% of the contaminants that end up flowing onto the reef from that catchment.

The integration of relatively traditional monitoring approaches (discrete sample collection for subsequent laboratory analysis) with emerging technology enabling real-time, high-frequency, sensor-based monitoring allowed the data to be available to farmers in real-time. Through a series of “shed workshops”, a safe learning environment was also created in which farmer committee members could better interpret the real-time data and understand their context.

Internet of Things improves cane farming practice

Hub researchers developed an Internet of Things (IOT) platform that has vastly improved the efficiency of automated irrigation systems on 3 cane farms in the Burdekin catchment.

The platform combines information from weather forecasts and the grower’s own watering system to create a suggested model for irrigation for the day, saving the grower huge amounts of time and effort, and minimising wasted water and sediment runoff to the Great Barrier Reef.

As a pilot demonstration, this hub project has created a foundation around the IOT platform that can now adopt other automated functions in the cane farming space, and continue to improve water quality outcomes for catchments using them.

Farmer-built wetlands delivering multiple returns

Hub research centred around restoring wetlands within Great Barrier Reef coastal ecosystems for cultural, biodiversity and water quality values across catchments was an important action in achieving *Reef 2050 plan* targets. As a result, a number of farmers have constructed wetlands of their own, and are impressed with the results so far.

Farmer Garth Pernase, operating near the Johnstone River, said he had experienced multiple benefits from constructing a wetland on his cane property in 2010. 'We've seen a lot of native species – both fish and birds – in the wetland since we built it. I've also been able to raise a portion of other growing land above flood level and in that area the wetland's also been great for drainage where a lot of crop was being lost to grass.'

Making the switch to enhanced efficiency fertilisers

Hub researchers tested whether a number of inter-related strategies could maintain sugarcane productivity, improve efficiency and uptake of nutrients in particular cane, and minimise the loss of fertiliser via drainage.

Enhanced efficiency fertilisers (EEFs), which moderate the release of nutrients into the soil, have been applied and monitored on a number of sites, with promising results when used in certain conditions. Fertiliser producers are now working on improving their EEF fertilisers using some of this research.

Communication of their benefits for growers is now being sought, with hub research informing a series of upcoming workshops for growers seeking to adopt or adjust these practices and work towards the *Reef 2050 plan* targets within their catchments.

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