RESILIENCE BASED MANAGEMENT CASE STUDY

Crown-of-Thorns Starfish Control Program

GREAT BARRIER REEF, AUSTRALIA

A COTS Control Program on the Great Barrier Reef, working towards greater reef resilience.

The Issue

Crown-of-Thorns Starfish (COTS, *Acanthaster planci*) are a naturally occurring coral predator throughout the Indo-Pacific region. COTS periodically reach 'outbreak' (pest-level) densities that dramatically reduce live coral cover and erode reef resilience to other stressors.[1] Reef damaging COTS outbreaks have been recorded throughout the Indo-Pacific region. The Great Barrier Reef Marine Park (GBR Marine Park) is currently experiencing its fourth major outbreak since the 1960s.

COTS exist naturally on reefs in densities of 6-20 starfish per km^2 (less than 1 per hectare). On a healthy reef, low densities of COTS can help maintain a diverse reef ecosystem by consuming faster growing corals and allowing slower growing corals to establish. However, a COTS outbreak, defined as the density at which starfish consume coral tissue faster than the corals can grow (generally 30 or more adult starfish per hectare of reef), can rapidly degrade coral reef health, live coral cover and habitat structural complexity.[2]

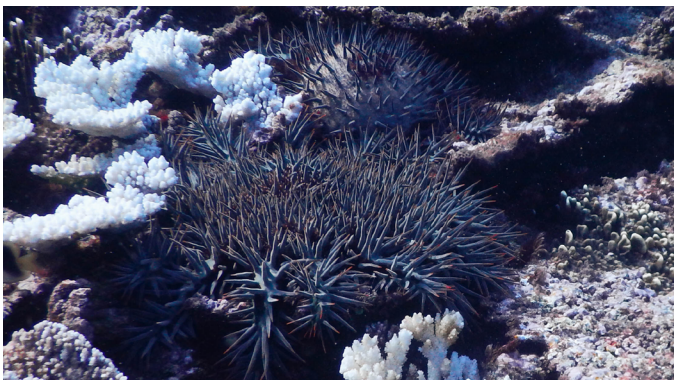

Figure 2. COTS feeding on coral

Several factors contribute to the initiation of COTS outbreaks, including anthropogenic influences and the life history characteristics of the starfish themselves. Natural predators of COTS include a diverse range of reef fishes and invertebrates. Diminished abundance of natural COTS predators on fished reefs may result in

How the Program Addresses Resilience Based Management?

Figure 1: The COTS Control Program contributes to the community, governance and ecosystem components of resilience based management.

Removal of COTS from coral reefs decreases the prevalence of a major coral predator, supporting coral growth and recovery that in turn will underpin reef resilience to stressors such as bleaching, poor water quality, cyclone damage, and other coral predators. By focusing COTS removal on reefs with high ecological value, these efforts can support the growth and dispersal of coral throughout the Reef. The Integrated Pest Management decision support framework at the heart of the Program will allow adaptive management and the integration of climate change forecasts into plans and policies. The successful delivery of the COTS Control Program has involved the collaboration of government, research organisations, Traditional Owners, and citizens, and has built enduring relationships. The Program has also provided demonstrable, and tangible coral protection outcomes which can be very powerful for building public support and political will to protect the Reef.

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higher survivorship, and in turn, higher numbers, of juvenile and adult COTS.[3] Elevated nutrient and phytoplankton levels may also contribute to increased survivorship of COTS larvae and subsequently higher rates of settlement and recruitment rates.[1] In addition, COTS are highly fecund, reach reproductive maturity within 2 years, and have a long pelagic larval duration, enabling them to disperse widely and rapidly.[1] When COTS are present at high densities, their fertilisation success rate increases, leading to increased larval supply and further propagation of outbreaks on downstream reefs.[4] Once initiated on individual reefs, COTS outbreaks tend to continue until live coral food sources are depleted or until they are actively suppressed.

Remedying the systemic conditions that lead to COTS outbreaks, through the protection of COTS predators and improved water quality, may assist in reducing the frequency of future outbreaks, but these benefits will take time to accrue and are unlikely to influence current COTS outbreak dynamics.[5] Proactive surveillance and targeted manual culling of COTS has been shown to be an effective, efficient, and scalable action to suppress outbreaks and provide immediate coral protection.[5]

Actions Taken

The current Great Barrier Reef COTS Control Program was established in 2012 following the initiation of the current COTS outbreak in 2010. Although there have been previous control efforts on the Reef, they have been limited to site specific scale. The current Program has expanded to Reef scale and regional suppression, with the key objective to protect coral on high-value reefs via suppression of COTS numbers to ecologically sustainable levels. Given the vast size of the GBR Marine Park, it is not possible to manage COTS populations on every reef. To deliver effective COTS control with the available resources, the Program draws upon the best available science, monitoring data, and field intelligence to inform the deployment of COTS control effort.

The development of an Integrated Pest Management (IPM) decision support framework has greatly improved the effectiveness of the Program. The IPM framework was implemented in 2018 to systematically guide the order of operations at each actioned reef. The process to prioritise specific reefs for COTS control is led by the Great Barrier Reef Marine Park Authority and is conducted annually in collaboration with research partners, Program contractors and Reef stakeholders. Priority reefs have significant ecological value (i.e. important coral larval source, important COTS larval source, high COTS risk, high resilience potential) and/or economic value (tourism). COTS outbreaks and coral condition are spatially and temporally dynamic and not all reefs are vulnerable to COTS at the same time. It is essential that the reef prioritisation process accounts for these dynamics to effectively direct Program effort for optimal effectiveness and efficiency.

Strategic reconnaissance, surveillance and monitoring activities inform the deployment of COTS Control Program resources. The Program conducts systematic reef surveys at all actioned reefs and routinely draws upon information collected via the “Eye on the Reef” sightings network, and surveys conducted by the Reef Joint Field Management Program (RJFMP), the Australian Institute of Marine Science (AIMS) and other research institutions.

Figure 3: Manta tow snorkel surveys are used to provide information on COTS and coral cover across large areas.
Photo Credit: D. Schultz, Reef Authority

Dedicated Program vessels with teams of professionally trained divers are deployed to manually cull COTS by injecting starfish with a single shot of either ox-bile salts or household vinegar. Injecting COTS with these solutions quickly and humanely kills them without negative effects to the reef ecosystem. The single shot injection method is more effective, efficient and less expensive than previously deployed methods, greatly enhancing the feasibility of large-scale COTS control.

The size of the Program has grown and developed over the past decade and currently actions approximately 200 reefs each year for

Figure 4: A scientific innovation in 2014 enabled COTS to be killed with a single shot injection of bile salts, significantly improving the efficiency of manual culling.
Photo credit: Reef Resilience Network

surveillance and targeted culling. Approximately 20,000 diver hours are deployed annually across the Program's fleet, with about 10% used to conduct surveillance and 90% used to cull COTS. Additionally, the Association of Marine Park Tourism Operators (AMPTO) works with Marine Park Reef tourism operators to coordinate culling of COTS at important tourism sites.

How Successful Has it Been?

Since 2012, the Program has invested over **100,000 diver hours** in reef surveys and targeted culling of almost **1.2 million COTS**. As of November 2023, culling has directly reduced COTS numbers to sustainable levels across **103,990 hectares of reef** and delivered coral protection outcomes across **379 reefs**, collectively covering more than **700,000 hectares of coral habitat**. Given their conspicuous nature, initial voyages to a site remove predominantly larger, more fecund, and more damaging COTS, achieving significant management benefits.[3] Repeat voyages to a site are generally required to reduce COTS densities to ecologically sustainable levels.[5]

The primary goal of the COTS Control Program is to reduce COTS numbers to sustainable levels and minimise impact on coral cover rather than to cull large numbers of starfish or eradicate COTS altogether. Success is thus seen in the survival and regrowth of live coral cover. Given the variability of live coral cover between reefs and regions, and the impact other stressors have on coral cover, the COTS Control Program doesn't have explicit coral cover targets. However, where removal efforts have been targeted, coral cover has remained high, and in some cases increased, despite broad scale coral bleaching events and a trend towards declining coral cover in other areas.[6] This evidence suggests that the Program is delivering effective coral protection across thousands of hectares of high value reef habitat[5].

With the development of innovative injection techniques and the IPM decision framework, the Program has successfully progressed the efficacy of manual control programs and demonstrated their value in building reef resilience.

Key Challenges and Lessons Learnt

Close collaboration between management, research and other partners is critical:

Ongoing partnerships between national and international research partners have been critical to the evolution of the Program and the development of critical advances that have increased efficacy and efficiency of COTS control. The collaborative annual reef prioritisation process, application of the IPM framework, sophisticated connectivity studies, and COTS risk and coral resilience modelling means that the culling effort is precision-guided, which greatly amplifies program outcomes.

Engage in ongoing monitoring:
Ongoing monitoring is essential to the implementation of the IPM and hence the success of the control efforts. Monitoring results inform management strategies, guide the strategic planning, and help measure the relative success of the program. Investment of resources in research and innovation at the beginning of the Program helped to significantly increase efficiency of the current Program.

Early warning monitoring:
Development of early warning monitoring, that enables pre-emptive culling to occur in the early stages of an outbreak, will greatly improve the success of mitigating future outbreaks, and prevent the COTS larvae from spreading to larger areas. Early identification of an outbreak and rapid deployment of resources can significantly reduce the amount of resources needed to suppress an outbreak.

Utilise modelling and large-scale data:
Since the onset of the current outbreak, considerable improvements in modelling and mapping have been achieved. GBR wide connectivity modelling and satellite-based reef mapping tools (also deployed in the Allen Coral Atlas) have helped managers target actions on the reefs with the greatest likelihood of intervention success.

The case for sufficient, sustained resourcing:
The COTS Control Program on the Great Barrier Reef has evolved considerably over the years. While it is now a well-funded, large-scale project, it was difficult to secure initial funding and GBR Marine Park managers had to overcome public opinions that questioned the feasibility of manual COTS control. A decade on from the start of the current outbreak, the program has matured, its benefits to Reef health and resilience are strongly backed by long-term datasets, and public and political support for the effort has strengthened.

Lead Organisation
Great Barrier Reef Marine Park Authority

Partners
Great Barrier Reef Foundation
Reef and Rainforest Research Centre
Australian Institute of Marine Science
Eye on the Reef

Additional Resources
Crown-of-thorns starfish Strategic Management Framework

Crown-of-thorns starfish control guidelines: second edition

Reef 2050 Integrated Monitoring and Reporting Program: Strategy Update 2018

References

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