

Controlling of the Crown of Thorns Starfish in the Great Barrier Reef

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Politics of the Great Barrier Reef

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Introduction

Climate change is the greatest threat to the Great Barrier Reef (GBR), leading to the common knowledge that the reef is suffering, approached with an attitude of hopelessness that there is no way to fix such a large-scale global phenomenon. Conservation, however, is not a lost cause. There are factors heavily contributing to the reef's destruction that are more manageable than others, and when the policy behind controlling these issues is executed properly, huge conservation improvements are made. A major contribution to the unhealthy state of GBR is the Crown-of-Thorns Starfish (COTS), a naturally occurring species found in the GBR, responsible for 42% of the reef's 3.38% per year coral cover decline.¹ The starfish preys on species of coral, reproducing rapidly when conditions are right, creating cycles of outbreaks that severely damage the state of the reef when not controlled.

While reef conservation may seem impossible due to the seemingly irreversible factors such as global warming, through approaching specific issues facing the GBR such as controlling the COTS, reef conservation is made feasible for all those whose livelihoods depend on the reef along with the general public. To control this invasive species and make a positive impact on the GBR, it is crucial to have a specific adaptable policy that can be improved with future technology that addresses both its political, economic, and societal impacts. Through looking at what the government is currently doing to manage the issue, the factors that have contributed to the creation of this policy, and brainstorming alternative methods, marine scientists, coastal farmers, and the general public can work together to make a monumental difference in the state of the GBR.

¹ Scott Bainbridge, "Technology and the Great Barrier Reef," Lecture, July 3, 2022.

Background



Image 1: COTS outbreak completely covering the surface of a reef in the GBR

COTS, or *Acanthaster planci*, are a naturally occurring species of starfish that feed on live coral tissue. They are native to the Indo-Pacific oceans and play a role in their ecosystem; therefore, it is not ethical to completely remove them from the ocean, as they do serve a purpose in the marine circle of life. Mature COTS have up to 21 arms and hundreds of 4 cm-long toxin-tipped thorns.² Consequently, adult COTS are prey for just a few marine species, although still a source of food for the giant triton snail, the humphead Maori wrasse, starry pufferfish, and titan triggerfish.³ Juveniles and larvae are more largely preyed upon by different types of shrimp, crabs, and polychaete worms.⁴ Additionally, because they tend to feed on faster-growing species of corals, they can create space on the reef for slower-growing corals which provide different habitats, sequentially increasing the biodiversity of the reef.

² Australian Institute of Marine Science, “Crown-of-Thorns Starfish,” n.d., <https://www.aims.gov.au/sites/default/files/cots-revised.pdf>.

³ Great Barrier Reef Foundation, “Crown of Thorns Starfish,” Great Barrier Reef Foundation, 2020, <https://www.barrierreef.org/the-reef/threats/Crown-of-thorns%20starfish>.

⁴ Australian Institute of Marine Science, “Crown-of-Thorns Starfish”

COTS are a nocturnal species and can travel up to 20 meters per hour.⁵ Being able to regrow limbs, withstanding hunger for up to 9 months, and their protective thorns make COTS a very durable creature which is one of the reasons they can take over and destroy reefs.⁶

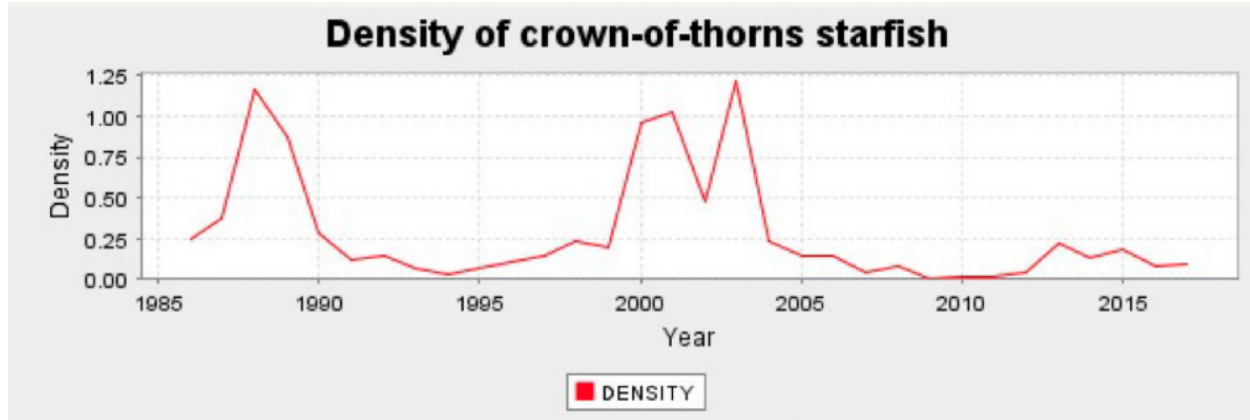


Figure 1: Time-series plot of the mean relative abundance (density*) of COTS on reefs across the GBR. (AIMS LTMP manta tow data 1986-2017; * density = mean number of COTS per 2 min. manta tow)

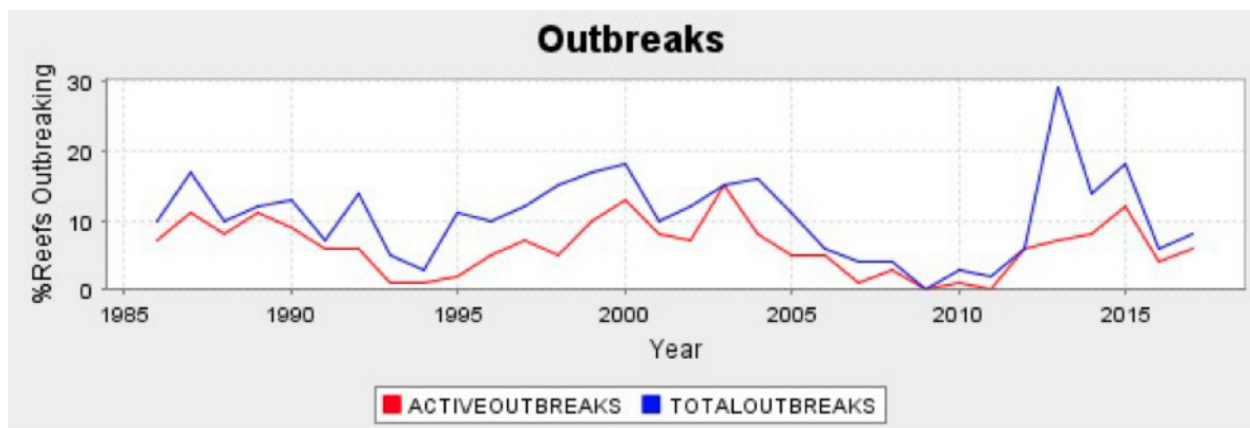


Figure 2: Time-series plot of the percentage of reefs with COTS outbreaks across the GBR. (AIMS LTMP manta tow data 1986–2017)

There have been four occurrences of outbreaks of COTS since 1960: 1962, 1979, 1993, and 2010. The naturally occurring density of COTS is just one per hectare, thus, a COTS outbreak is defined as more than 15 individuals in a 1-hectare area, or when they are consuming

⁵ Ibid.

⁶ Great Barrier Reef Foundation, “Crown of Thorns Starfish”

coral at a faster rate than the coral is growing.⁷⁸ During an outbreak, COTS consume their body size (1 meter) of live coral tissue per day and have been proven to strip up to 90% of a reef's coral cover.⁹ In addition to eating any and all kinds of coral, COTS also eat sponges, soft corals, algae, and encrusting organisms. Notwithstanding, they prefer the faster-growing table and branching corals, as they are more fragile and fleshy species of coral. This causes a greater issue, as table and branching corals are also the most susceptible to bleaching, therefore the combination of COTS and bleaching can be detrimental to reef regrowth.¹⁰ COTS can spawn up to 50 million eggs when reproducing resulting in a surplus of planktonic larvae.¹¹ Due to their planktonic nature, they can spread up to 200 km from their original location, making them exceptionally hard to contain.¹²

There are many hypotheses regarding why COTS outbreaks occur, such as their reproductive capacity, natural causes, and lack of distinct predators.¹³ However, most research points back to two main causes: overfishing and elevated sediment and nutrient levels.¹⁴ The Predator Removal Hypothesis, or overfishing, has been one of the more successful in determining why COTS have waves of abundance. Commercial fishing removes thousands of creatures from the ocean every day, and some of these are active regulators of the COTS. Reefs that are no-take reserves are three times less likely to have outbreaks when compared to reefs

⁷ Great Barrier Reef Foundation, "Crown of Thorns Starfish"

⁸ "Crown of Thorns Starfish | Reef Resilience," Reef Resilience Network, accessed June 26, 2022, <https://reefresilience.org/stressors/predator-outbreaks/crown-of-thorns-starfish/#:~:text=However%2C%20when%20branching%20coral%20cover>.

⁹ Great Barrier Reef Foundation, "Crown of Thorns Starfish"

¹⁰ "Crown of Thorns Starfish | Reef Resilience,"

¹¹ Australian Institute of Marine Science, "Crown-of-Thorns Starfish"

¹² Eric Lawrey, "Crown of Thorns Starfish (COTS) Outbreaks on the Great Barrier Reef," Eatlas.org.au, 2013, <https://eatlas.org.au/content/crown-thorns-starfish-outbreaks-animation>.

¹³ Russell C. Babcock et al., "Assessing Different Causes of Crown-of-Thorns Starfish Outbreaks and Appropriate Responses for Management on the Great Barrier Reef," ed. Carlo Nike Bianchi, *PLOS ONE* 11, no. 12 (December 30, 2016): e0169048, <https://doi.org/10.1371/journal.pone.0169048>.

¹⁴ Ibid.

that are subject to fishing.¹⁵ Through studies, predation has been proven to control COTS populations with a high level of certainty.¹⁶ This remains the case when overfishing is the focal point of the experiment AND when it is combined with other factors (water quality). However, even with high levels of certainty, there remain holes in this hypothesis. The main experimental error is that there is no evidence regarding the interactions between COTS and its individual predators. Therefore, it is unknown which of their predators play the largest role in controlling the population at an adult, and more especially, larval level. Even with this uncertainty, coral reefs can improve rather rapidly (within 15 years) with the management of predatory species.¹⁷

According to the Australian Institute of Marine Science (AIMS), the most important influence on COTS is water quality.¹⁸ The “Smoking Gun” theory, presented by Scott Bainbridge, states that 3-4 years after a flood, there is a COTS outbreak, especially in Cairns and Cooktown. Flood events bring many types of nutrients from inland to the ocean. Due to Australia’s reliance on agriculture, many pesticides, nitrogen, and phosphorus get washed into the ocean over time. Reefs exposed to elevated nutrient concentrations show significant increases in macroalgal cover and reduced coral species richness and recruitment.¹⁹ These macroalgal plankton are the primary source of food for COTS larvae. The plankton has population booms after major flooding, thus survival of COTS larvae increases exponentially.²⁰ However, since there is no evidence regarding the predator-prey relationship, it is still uncertain whether the elevated nutrients play a role in COTS outbreaks. Notwithstanding, it would be ignorant to

¹⁵ Ibid.

¹⁶ Ibid.

¹⁷ Ibid.

¹⁸ Scott Bainbridge, “Technology and the Great Barrier Reef”

¹⁹ G. De’ath et al., “The 27-Year Decline of Coral Cover on the Great Barrier Reef and Its Causes,” *Proceedings of the National Academy of Sciences* 109, no. 44 (October 1, 2012): 17995–99, <https://doi.org/10.1073/pnas.1208909109>.

²⁰ “Looking to the Larvae: What Causes Crown-of-Thorns Starfish Outbreaks on the Great Barrier Reef?,” [www.youtube.com](https://www.youtube.com/watch?v=HVFhjX0otUc), accessed June 26, 2022, <https://www.youtube.com/watch?v=HVFhjX0otUc>.

completely disregard it as a factor, as water quality plays a clear role in the health of a marine ecosystem.

Policy Background

The constant battle of seeking out and controlling the removal of the starfish has led to the “war” to manage them.²¹ The management of the COTS is representative of the complicated nature of managing the GBR due to its intersecting policies between the Australian federal and state governments. In response to the COTS outbreaks starting in 1962, the Parliament of the Commonwealth of Australia officially addressed how to deal with the problem in 1985. Within this document, the Australian House of Representatives Standing Committees on Environment and Planning began by recognizing the importance of the Great Barrier Reef Park under the Great Barrier Reef Marine Park Act 1975, which outlined the region controlled by the Marine Park Authority. They state that they had previously trusted the Marine Park Authority to protect the reef from potential threats, however with further research about the problems the COTS had been causing since 1962, the 1985 committee decided it was time to intervene for the sake of protecting the future state of the reef.

The first investigation into the COTS problem was conducted on the state government level in Queensland by Professor Endean at the University of Queensland in 1965.²² From there, a joint committee between the Commonwealth and Queensland was formulated in 1970, exemplifying the growing fear of COTS outbreaks during this time.²³ Despite the many

²¹ Scott Bainbridge, “Technology and the Great Barrier Reef”

²² House of Representatives Standing Committee on Environment and Conservation (34th Parliament), “Protection of the Great Barrier Reef,” 1985, <http://www.austlii.edu.au/cgi-bin/sinodisp/au/other/AUHRStaCEP/1985/4.html?stem=0&synonyms=0&query=crown%20of%20thorns%20starfish>.

²³ Ibid.

committees on state and federal levels during the early 70s, the verdict continued to be that more research was required to figure out if the outbreaks were something to be worried about, and if it was worth intervening. As previously mentioned, the cyclical nature of the COTS outbreaks led to the problem seemingly dying down and causing policymakers to wrongfully assume that the issue was no longer something to worry about. When the outbreaks picked up again in the early 80s, the Crown of Thorns Starfish Advisory Committee (COTSAC) was appointed in 1984 to start new research.²⁴ Throughout the research process, the controversy between the Advisory and the Standing Committee continued, with the Committee asserting that the problem was manipulating data to make the problem seem less serious.²⁵ As coral regeneration and reinfestation were debated, the coral's variability in response to outbreaks became a cause for concern.

Current Policy

The GBRMPA created its Crown of Thorns Starfish Control Program in 2012, following the GBRMPA Crown-of-thorns Starfish Strategic Management Framework, which is still in place today. In partnership with the Queensland Government, the Marine Park Authority builds off of previously conducted research to continuously improve research on the starfish problem.²⁶ Within the document, the issue is explained and the COTS place in the Reef 2050 Sustainability Plan is introduced. The GBRMPA also introduces its Eye on the Reef Program where reef visitors can report COTS sightings, as well as log the state of the coral's health. We intend to suggest continuing the promotion of this program, as citizen scientists locating and tagging the

²⁴ Ibid.

²⁵ Ibid.

²⁶ "Crown-of-Thorns Starfish Strategic Management Framework," n.d., https://www.gbrmpa.gov.au/_data/assets/pdf_file/0005/267656/GBRMPA-crown-of-thorns-starfish-strategic-management-document-July-2020.pdf.

starfish could not only help with gathering data but also support the professionals seeking to remove them. Further preventative actions are outlined in the framework, most regarding water quality improvement and preventative action against climate change which is a main cause of flooding. Along with prevention, there are also designated actions to take during the case of an outbreak. This includes allowing the reef to recover in its non-outbreak phase, suppressing and containing COTS during the primary outbreak phase, and protecting the reef in the secondary outbreak phase.²⁷ As of now, it is the trained professionals within the Control Program that can take tactical measures in the case of an outbreak, doing so by using lethal injections with salts or vinegar. Looking forward, we ask whether or not these removal techniques can be improved safety-wise to build on citizen science and give those who want to be involved hands-on opportunities.

Notable programs within the Australian Government currently working hard to control the starfish include the Australian Institute of Marine Science (AIMS) and the Australian Department of Agriculture, Water and the Environment (DAWE). The crucial role of AIMS is to conduct and publish scientific research about COTS. In an educational lecture, Scott Bainbridge, a leader in the AIMS Technology Department, explained in depth the methods used. During the notable outbreaks in the 80s, rapid surveys were conducted to understand what was happening below the ocean surface, which laid the foundation for the methods still used today. Within the first surveys, hundreds of thousands of starfish could be found covering the entirety of the ocean floor, completely hiding the bottom. These surveys were conducted by trained observers towed behind a small boat, giving the reef's health a score on a scale from 1-5 by looking at the percent coral cover. The perk of this method is speed, however, speed sacrifices the depth of data being

²⁷ Ibid.

as all that is conducted is a subjective score that cannot be further analyzed. Other problems with the current system in place include the ability to only travel to a small number of reefs due to zoning laws, only surveying the perimeter of reefs, and coral cover being a poor indicator of actual reef health. While the methods prove to have been an important start for collecting data on the COTS, issues are apparent, and organizations should continue to brainstorm ways how to build on data collection. AIMS promotes education on the issue, as seen by their website on which they have created an easily accessible color-coded map where the public can view coral cover estimates and COTS survey results. Different than AIMS, DAWE focuses on implementing the removal of the starfish. While they recognize that the COTS maintain diversity within the reef, it is their job to control outbreaks so that coral can regenerate.²⁸ They have two teams of 10-12 divers that survey reefs year-round removing the starfish, which has already made a noticeable difference in the regeneration of the coral.²⁹

Political, Economic, Societal Impacts

Politically, it is difficult to manage COTS as they are regarded as both a scientific and public policy issue. The Standing Committee of 1985 justified their interference in the controlling of COTS as they saw it as their job to solve the public policy issue.³⁰ This ultimately caused controversy due to the common goal of reef protection, but a different understanding of the severity of the COTS problem. The starfish are dealt with separately on a scientific and political basis, which makes combining the research for a comprehensive view of their potential effects tricky. Scientifically, the argument can be made that this is a naturally occurring species, therefore there should not be human interference. The Australian Coral Reef Society for example

²⁸ “Crown-of-Thorns Starfish Management Programme: Case Study - DAWE,” www.awe.gov.au, n.d., <https://www.awe.gov.au/parks-heritage/great-barrier-reef/case-studies/crown-of-thorns>.

²⁹ Ibid.

³⁰ “Crown-of-Thorns Starfish Management Programme: Case Study - DAWE”

asserts that “the outbreaks of Crown of Thorns Starfish are a natural and a periodic phenomenon... given no substantive evidence to the contrary.”³¹ These viewpoints continue to be debated as if they are a naturally occurring species achieving success, is it our responsibility as humans to step in? This has led to the narrative surrounding the COTS maintenance to be controlled instead of irradiating, as it is much more of a monitoring process than removal, except for within an outbreak when removal is necessary.

When it comes to the politics of conserving the Great Barrier Reef, there is a crucial balance between environmental and economic concerns. A large sum of money and effort has gone into the research and development of policy for controlling COTS. Preserving the GBR is a priority for all levels of the Australian government due to the marine park’s monumental economic roles, for example through the reef’s top money maker of tourism. Without its world-renowned reputation for its reef full of coral and marine life, Australian tourism would face detrimental consequences. This proved to be a motivating factor for policymakers to invest in protecting the reef from COTS to ensure the safety of the Australian economy. The 1895 Parliament address acknowledges how “in November 1984 the Australian Institute of Marine Science was allocated \$1.1 million under the Commonwealth Community Employment Program to carry out a survey of the occurrence of Crown of Thorns starfish over the entire Reef”, despite the Crown of Thorns Starfish Committee recommending a 3 million dollar fund for research over the subsequent five years.³²

Along with tourism, the reef’s economy is connected to major Australian industries such as farming and fishing. With the COTS outbreaks being newly found to be connected to runoff, major amounts of money and effort have gone into remediating catchments, reducing fertilizers,

³¹ Ibid.

³² Ibid.

and regulating farming practices.³³ Societal disagreement regarding the policy of controlling COTS stems mainly from certain groups feeling targeted as the cause of the issue. With data pointing towards runoff being a factor in the outbreaks due to its perfect conditions for COTS growth with the abundance of phytoplankton, terrestrial workers surrounding the GBR may feel as though they are being unfairly blamed. Tourism and the human contribution to global warming could also be a factor in the over-survival rates of the larvae as its predators cannot survive in the reef's condition to naturally remove them. It is therefore important to educate those living around the reef on the effects of conservation practices near the reef so they can understand that their actions can make an positive impact. The fishing industry on the other hand is very easy on the side of starfish removal being as their economic success relies on the health of the reef. If the COTS takes over the coral, fish species are unable to survive and be caught. This phenomenon is ultimately representative of how outbreaks destroy the reef and fish populations, which in turn hurts the holistic economic value of the GBR.

Societally, it is imperative to continue educating both those directly impacting the reef and the general public about the conservation of the reef. The reef's reputation is what brings most of its economic value, meaning that along with the maintenance of the coral itself, we must maintain its societal value. There must be a drive to support reef conservation to continue its beauty into the future. To do so, it is crucial to create a well-worded policy that outlines specific goals, such as the Reef 2050 plan that define concrete plans with a sense of positivity. By approaching smaller issues within the reef such as the COTS with concrete principles with tangible results, optimism is brought back to the state of the reef, which brings momentum to continue thoughtfully enjoying its resources. Creating successful policy surrounding COTS will

³³ Scott Bainbridge, "Technology and the Great Barrier Reef"

spark the domino effect of positivity surrounding GBR conservation, along with restoring its reputation worldwide.

Final Considerations

Since the 1980s, COTS outbreaks have continued to occur, however, due to the many policies and efforts put forth by AIMS, GBRMPA, and COTSAC, they have become less of a threat to the reef. Due to this fact, independent groups who previously relied on external government funding, such as AIMS, have transitioned to primarily internal funding within the organization which limits their abilities to prevent COTS outbreaks. Over 500,000 COTS have been neutralized by authorized divers (6). That number could be much higher, for only certified divers are permitted to inject them. A potential way to involve the public could be tagging. When an ordinary citizen sees a COTS, they could report it to a database, such as the Eye On the Reef app, in which the authorized divers will already know the location of the COTS instead of having to find them themselves. The app's COTS section could be elaborated upon through a map feature where divers could tag outbreak areas by dropping a location pin. The more people identifying and helping the cause, the more efficient the process of removal will be. To incentivize this process, there could be some kind of points earning feature within the app where tagging COTS areas and the state of the coral could result in some sort of certificate or reward. This process would not only help with the tagging of COTS-infested areas but also promote education and awareness about the issue, along with giving the public the satisfaction of supporting the reef which adds to its positive reputation.

Another way to entice the public to help would be if there were a market for COTS. While the removal process is currently most commonly through lethal injection, one could look

at the measures taken to control the invasive lionfish. Through finding other uses for lionfish such as fishing and art, there strategically became an incentive to control their species within the ocean. There have been studies in Japan that are looking into potential uses for COTS, such as using it in fertilizer or as a natural aphrodisiac. COTS can be used as natural fertilizer if buried in soil, however, this method may come with more risk than reward.³⁴ Since they spawn in stressful situations along with their dangerous spines, if people want to use the COTS, safer removal processes must be developed. If the public can profit off of COTS removal, there would be much more incentive to learn about and support the cause. Through continued education and research surrounding COTS removal, more methods for their potential use will arise, providing further motivation to get the situation under control.

While there has been a successful effort in the past decades to get the COTS problem under control, it does not mean the problem will not come back, as removal efforts are not the solution to why the outbreaks transpire. It is important to recognize that the outbreaks may seem to be improving due to the zoning practices that make the data biasedly portray this issue as under control. Divers cannot go everywhere, meaning COTS are likely still thriving in deeper waters and territories where diving is illegal. Data continues to be collected about the starfish every day, and as we learn more about the unique lifespan of COTS, we have a greater ability to ensure the health of the reef. Even with the current policies in place to manage them, there are still many questions to be asked. While programs continue to develop goals for reef conservation with political, economic, and societal motivation, ultimately the root of the problem which goes back to runoff pollutants must be solved to consider the starfish management a success. Thus, COTS will remain a threat to the Great Barrier Reef until we improve COTS larvae monitoring

³⁴ “Managing a COTS Outbreak - Living Oceans Foundation,” Living Oceans Foundation, 2015, <https://www.livingoceansfoundation.org/science/crown-of-thorns-starfish/managing-cots-outbreak/>.

to catch outbreaks before they begin. Controlling the COTS problem remains to be a metaphor for all the reef's major problems in that we each must do whatever small actions possible to make a long-lasting difference while maintaining the positive reputation of the GBR.

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