

The Effect of Crown of Thorns Starfish on the Great Barrier Reef

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Abstract. Invasive species are normally defined as creatures with high reproduction rates and few natural predators. Their existence in an ecosystem can destroy an entire food chain by overconsumption of a particular population due to their vast numbers. This paper explores the effects the crown of thorns starfish has had on the great barrier reef in the past and the present such as its effects on the ecosystem and impact on human lives. The paper also explores patterns regarding climate change and other human impacts and how that may affect the growth of the crown of thorns. Finally, this paper covers and evaluates the proposed solutions to combat the starfish by weighing their feasibility and how well they could work if they were put into practice. The purpose of this paper is to understand how the crown of thorns is a threat to the great barrier reef and possible methods to combat it.

Keywords: Crown of Thorns (COT), Great Barrier Reef (GBR), Outbreak.

1. Introduction

The sea is home to a plethora of creatures and ecosystems. One of the most prominent is coral reefs, home to a wide range of creatures. Records of coral fossils have been dated up to 500 million years ago making it some of the oldest habitats on the planet. In recent years however coral reefs have seen a significant decline in health. Many corals have experienced bleaching as a result of global warming and thus cannot photosynthesize therefore killing the corals. A similar effect occurs for ocean acidification where corals grow at slower rates thus decreasing the speed at which they can repopulate. Finally, there's the effect of invasive species which can harm the ecosystem of the reef by either consuming large amounts of reef inhabitants or destroying the reef itself.

An existing invasive species that will be discussed is the Crown of Thorns starfish. Also known as *A. Planci*, the crown of thorns, is named after its most distinct feature the many venomous spikes that cover its backside offering protection from possible predators. These spines can grow up to 4 cm long and the venom they contain is a neurotoxin that causes high amounts of pain to anyone who touches it [1, 2]. The starfish itself has an average of 21 arms which it uses to move around, the creature itself is flexible, being able to bend around to fit into tight spaces. The crown of thorns is a threat to reefs as it feeds on hard corals leaving white feeding marks after consumption of the coral, it is noted to be able to consume around 5-6m² of coral on average per year [3]. Alongside comes its exceptionally high rate of reproduction with a large adult female being able to produce 200 million offspring in a year [4]. The female releases these eggs simultaneously with the male releasing its sperm in large groups to achieve high levels of egg fertilization. Larval crowns of thorns have a low survival rate, often being eaten by crabs or other predators; however, due to their numbers, there will always be those that survive until adulthood. As of now, the attention to the crown of thorns stems from their effect on the Great Barrier Reef, one of the largest reefs in the world which is situated in Australia. The reef itself spans around 348,000 square kilometers housing more than 600 types of hard and soft corals alongside 10% of the world's fish species [5]. The reef is an extremely important ecosystem on the earth due to its massive scale and the amount of creatures it houses thus why the current threats it faces are incredibly dangerous. Recently the reef has suffered from 4 mass bleaching events, decrease in water quality and attacks from waves of crown of thorns starfish which have damaged large amounts of coral and the ecosystem. This will not only affect the lives of creatures which depend on the reef for survival and protection but also affect the livelihood of humans nearby. Continued

destruction of reefs could amplify the effects of tropical storms on coastal land thus causing more property damage and injuries overall.

The subsequent effects of these combined issues raises the need for certain levels of protection and countermeasures against both crown of thorns and climate change. Although climate change is a much more global issue which requires a combined effort from many nations to solve, the starfish are a much more local problem to places such as Australia. Currently there are a high number of NGOs in Australia which rely on funding and sometimes collaborate with the Australian government in order to combat issues surrounding Crown of Thorns. These could include research on better methods of combating them, daily surveys and culling of the starfish and likely reconstruction or care for the great barrier reef as well.

2. Problematic causes of the Crown of Thorns invasion

2.1. Current effect the Crown of Thorns has on the reef

The crown of thorns poses a massive problem to not just the great barrier reef but reefs around the world mainly due to their diet. As they eat corals, continuous exposure to a reef breaks the previously established ecosystem, robbing away the homes of many animals. Without the protection that was previously present, animals that hid in these corals are more susceptible to predators. Should this happen more consumption of smaller creatures would lead them to lower numbers thus resulting in nothing for the larger animals to eat. This leads to the collapse of the ecosystem due to the predators starving to death. Apart from that crown of thorns starfish also have an extremely fast reproduction speed thus leading to invasions of massive numbers. The exterior of the crown of thorns starfish is also spiky, greatly discouraging most animals from attempting to consume it. This is its primary defence mechanism and is also partly why it's so difficult to deal with in the case of both humans and animals.

Currently the crown of thorns starfish is prominently seen in the Great Barrier Reef and other locations throughout the Indo-pacific region from coral reefs in the red sea to the west coast of America [4]. Outbreaks throughout these regions have been recorded prominently throughout recent years. Most notably in the Great Barrier Reef many recorded outbreaks have occurred since 1962 [6] which is a number that is expected to increase with the growing effects of overfishing and climate change. The effects of overfishing are also expected to further worsen the outbreak of the crown of thorns as a result of decreasing the number of natural predators. Besides the crown of thorns, there are also other factors that greatly increase the impact that the crown of thorns has on reefs around the world, these being climate change and ocean acidification. Climate change is the fluctuation of the earth's temperature due to increased amounts of greenhouse gasses trapping heat within our atmosphere. Ocean acidification on the other hand is the decrease of pH in seawater due to chemicals and increased amounts of carbon dioxide being absorbed by the sea. In both cases the effects are that corals are dying off as the polyps that normally help coral to feed and survive leave the coral which kills it over time. Overall these factors pose a problem for the health of the Great Barrier reef, its inhabitants and the places which the reef shields.

2.2. Past effects on the Great Barrier reef

In the past of the great barrier reef, there have been many documented major outbreaks. This is done by a long-term monitoring program devised by the Australian government [4]. Outbreaks last for varying lengths of time based on the number of COTs that invade. Outbreaks don't occur throughout the entire length of the Great Barrier Reef, but rather certain sections of it such as the years 1983-1986 where a large number of COT were documented off the coast of Townsville (see figure 1) before moving down towards Mackay in 1987. This wave didn't end until 1990 when the regions of high COT density dissipated, likely having been eaten or died off [4]. In recent years the Great Barrier reef has also been noted to have undergone 4 mass bleaching events which, when paired alongside the attacks from starfish, have caused considerably high amounts of damage to the reef.

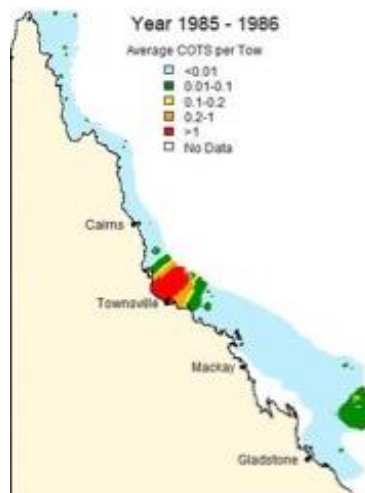


Figure 1. Documented average number of COT per Tow in the years 1985-1986[4]

As of 2012, the Great Barrier Reef is estimated to be around half dead from causes such as coral bleaching, global warming and others. However, it's estimated that 42% of the dead corals were caused by the crown of thorns starfish [7]. Alongside the great barrier reef, many others in the Indo-Pacific region have also been affected. Some locations include the Red Sea, the Indian Oceans and across the Pacific. Humans are partly to blame for this as overfishing has depleted the numbers of creatures that prey on the crown of thorns. An example would be the Giant Triton, a species of snail that preys on the crown of thorns with its "radula" which can be considered its tongue. The radula can pierce the hard exoskeleton of the COT reaching its actual body and consuming it. As this species of snail is faster than the COT it can catch up to it before it can run away. Similarly, there are fish like the Redthroat Emperor which can feed and control COT. Due to the intervention of humans, the previous population of these species of fish is being consumed by us at rapid speeds. This breaks the balance between the number of fish available that can consume COT.

Furthermore, nutrient availability within the ocean has also increased as a result of agricultural runoff. The increase of these nutrients results in a higher amount of food for larval COT thus increasing the number of adults in the future [4]. This is believed to occur in conjunction with overfishing which results in fewer fish consuming the larval crown of thorn starfish. Added to the absurdly high amount of eggs that are produced by a large female crown of thorns this causes problems with population. Additionally, juvenile COTs are nearly impossible to spot with the human eye especially underwater. This makes neutralizing them at their early juvenile stages difficult. As of now the only effective method against early-stage Crown of Thorns seems to be predators such as crabs which eat the juvenile starfish.

Another factor to consider alongside the current Crown of Thorns invasion is the lasting effects of climate change on the Great Barrier Reef. Although it has been confirmed that reefs do have the ability to regrow over time, the current effects of global warming and ocean acidification are impeding the ability the reefs to do so as either slowing the process of preventing it completely [8]. As global warming is expected to intensify in the future we can expect higher amounts of bleaching and faster declining coral health among the reef.

Currently methods are being used to combat the crown of thorns however they are still in a very early and arguably inefficient stage. Although there are methods that are being developed in different countries, the current ones rely heavily on manpower and manual eradication. As stated earlier the existence of natural predators does also act as a natural counterbalance to the starfish but may not be enough to fully stand up against the high numbers. According to the Great Barrier Reef foundation they currently send out 5 vessels and more than 100 divers a day in "high-value reefs" to investigate and remove crown of thorns in the area [5]. Accordingly they claim to have surveyed 16836 ha of high value reef area since 2018 and have been able to remove 355794 starfish in total [5].

2.3. Effects in the future

Crown of Thorns attacks in the future are relatively difficult to predict. Patterns suggest that many of the starfish attack in massive groups, whether this is coordinated or by coincidence is uncertain. However, it is stated that juvenile crowns of thorns are able to lie in wait until a reef that is heavily damaged regenerates where they then proceed to attack. This is often classified as an outbreak due to their large numbers and difficulty to stop. Furthermore, coral reefs are not always able to regenerate and regrow. Although it has been seen that certain corals are able to regrow this has become increasingly more difficult with time. Namely, global warming and ocean acidification becoming factors that disrupt the regeneration speed of coral reefs. This of course presents issues as coral reefs act as natural barriers for the shoreline against waves and storms and without them, we could be up against stronger storms in the future.

Currently, prevention measures against the crown of thorns exist and are being put into practice. According to the Australian Institute of Marine Science, current methods include using a camera/robot that is towed behind a boat to identify starfish that are on the reef [4]. The system is controlled and identified by AI and will detect the number/density of COT starfish in different areas so higher populated ones can be marked and investigated sooner. Problems regarding this method arise, however, especially surrounding the problem of AI. Questions such as if AI can actually identify crowns of thorns would appear or if AI may mistake certain objects for COT starfish. This method is stated to be still under development.

Another method is a more manual approach which takes advantage of vinegar's effect on the COT. By injecting them with these substances the COT can be euthanized, this is a tactic that is currently being employed by divers around the world and the Great Barrier Reef [9]. This can make up for the fact that predator creatures may not always be able to consume COT due to the amount of food they can intake. This tactic can also be altered if crown of thorns are to be investigated, by using long sticks to catch them and bring them to the surface scientists can study the starfish to find better methods to euthanise them [10]. However this solution is inefficient when it comes to large-scale control, humans need to dive underwater to administer the vinegar or salt. This thus requires both oxygen and skill to be able to perform. Humans also can't stay underwater for extensive periods and will need to resurface to receive another supply of oxygen and take rests. Thus, this method is not the most efficient however it works when it comes to accuracy.

A third method suggested by the Australian Government is the use of lures. The COT is stated to have a response to certain proteins that are released into the water attracting the creatures. If a lure is employed, starfish can be attracted to a single location where they can then be neutralized. This works well in conjunction with administering vinegar and salt as it saves the divers the effort of finding the starfish in the first place. This method however is still in development and might take more time for it to be completed [4]. Another problem arises when it comes to the range of the bait as it necessitates the use of a high number of lures given the size of the Great Barrier Reef.

3. Conclusion

The crown of thorns invasions aren't something that can easily be stopped, due to their high numbers and appearance exterminating them is not only difficult but time consuming and costly. Major outbreaks of crown of thorns is also one of the highest contributors to the destruction of coral reefs, as crown of thorns consume reef building corals their existence is highly harmful to the environment. The resilience of crown of thorns is what makes it so difficult to deal with, not only do they group up in extremely high numbers, their toxic spines make it hard for predators to consume them and humans to combat them safely.

Climate change and ocean acidification are 2 of the many factors which further prevent coral reefs from properly recovering from crown of thorns outbreaks. Although coral reefs are able to naturally generate, human intervention has greatly decreased the speed at which it occurs, rendering the habitats of many creatures at risk and coastal areas more susceptible to strong storms. This is one of the main

reasons why the control of the crown of thorns is such an important matter. Current weather conditions are already worsening as a result of climate change and if coral reefs are unable to serve as a natural barrier many people will likely get injured as a result. Furthermore, lack of coral reefs could also influence the availability of fish in certain regions which impacts the ecosystem of the area along with the livelihood of people such as fishermen.

Solutions to fight against the crown of thorns starfish exist however most of the time require trained personnel such as the ability to dive. Although usage of AI and machines are also being employed most of the time it's only used to identify and measure the amount of the starfish in a certain area so humans can go in and euthanize them. There are also the predators of the crown of thorns which naturally consume the starfish as their diet however over time humans have caused their numbers to fall such as the giant triton snail which is one of the top predators for crown of thorns. One way to handle this could be to introduce artificial breeding programs then release more of the snails into the sea to further combat the starfish.

Overall the condition of which the crown of thorns starfish has left the great barrier reef in is not the best. Alongside climate change and ocean acidification a good chunk of the reef is dead. However part of the reef still remains alive, in the future we should aim to further mitigate the damage that would be dealt by the crown of thorns and protect reefs from further possible harm and, if possible, aim to rebuild the reef so it can still sustain life.

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