Controlling Crown-of-thorns Starfish

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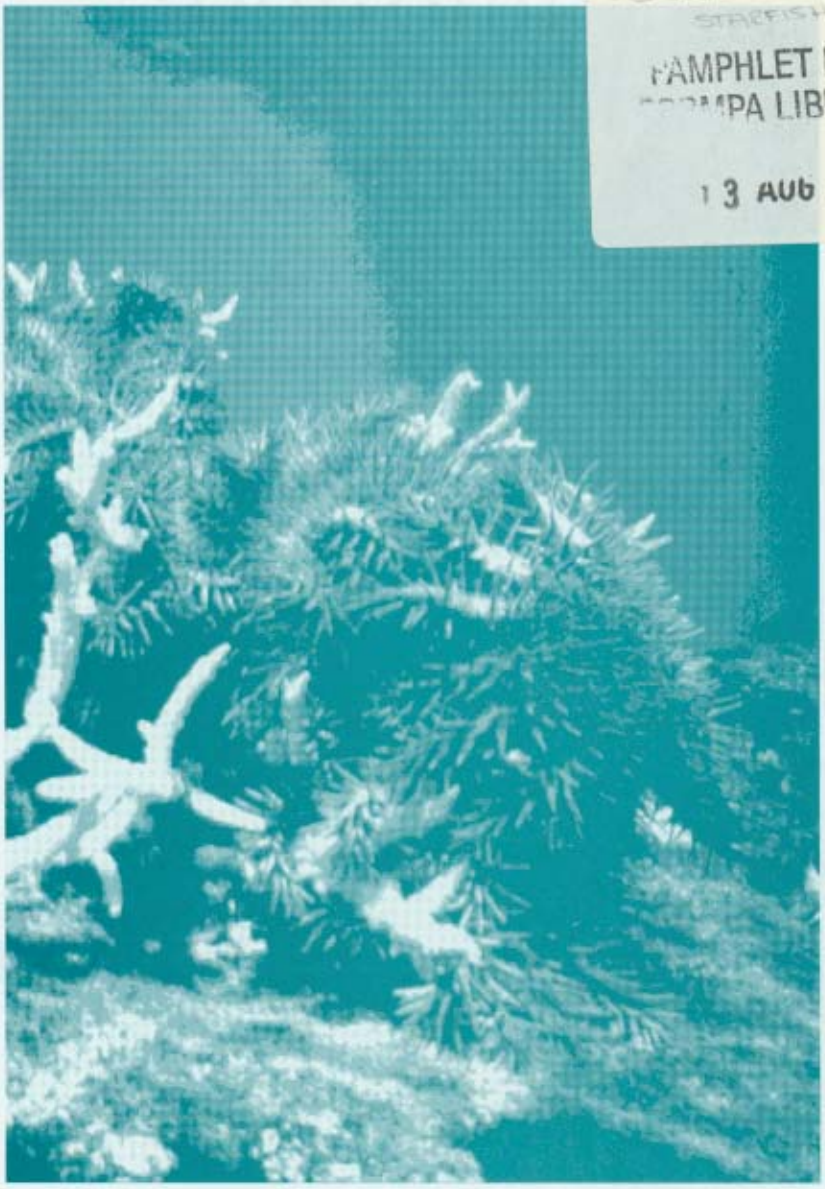

Great Barrier Reef Marine Park Authority

CRC Reef Research Centre

Controlling Crown-of-thorns Starfish

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When are Controls Necessary?

The crown-of-thorns starfish *(Acanthaster planci)* is a natural inhabitant of coral reefs throughout the Indo-Pacific Region. 'Normal' (non-outbreaking) densities of starfish range from about 1 per hectare (an area 100 m x 100 m) to 15 per hectare depending on the amount of coral cover (food) available. When in low densities the damage to corals as a result of the starfish's feeding can be sustained with no apparent long-term damage to the reefs. While individual starfish consume between 5 m^2 and 13 m^2 of coral a year, they prefer the faster growing *Acropora* coral species. This means that damaged corals are fairly quickly replaced.

According to some theories the feeding starfish may help to maintain high diversity on coral reefs by allowing other species to colonise space created when corals are killed. Because this is a natural process the Great Barrier Reef Marine Park Authority (GBRMPA) does not recommend that starfish be killed when their numbers are low.

When the numbers of *A. planci* exceed the capacity of the reef to cope with feeding by the starfish, the damage can be dramatic and recovery can take a long time. The 'flip' from non-outbreaking to outbreaking populations is usually very obvious, involving perhaps a 10-fold (or more) increase in starfish numbers. In severe outbreaks the starfish will eat most corals, including massive forms such as brain corals which can take decades to centuries to recover because of their slow growth rates.

The causes of outbreaks are still unknown despite considerable research into the problem. Outbreaks almost certainly occur naturally, but they may be made more frequent or more intense by human activities (most likely through effects on water quality and perhaps overfishing of their natural predators).

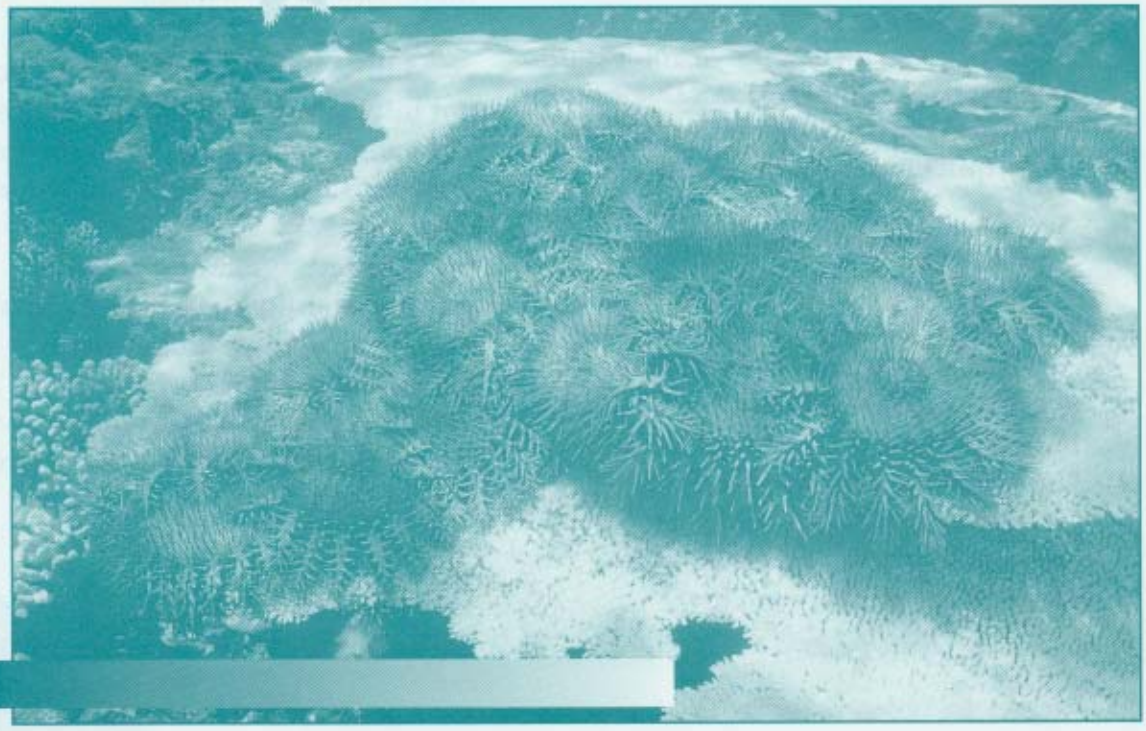
GBRMPA has a general policy of not interfering with natural processes. The policy regarding crown-of-thorns starfish is that, unless it can be proven that outbreaks are caused or exacerbated by human activity, controls should be limited to small-scale tactical measures in areas important to tourism or science. A permit is needed to conduct crown-of-thorns starfish controls on the Great Barrier Reef.

Success of Controls

Despite numerous attempts throughout the Pacific Region, no large-scale control programs (involving more than 20,000 *A. planci*) have successfully protected corals or eradicated the starfish. The main reasons why large scale control programs failed included the high cost; long delays in getting the programs underway; inefficiency of currently available control methods which involve treatment of individual starfish; movement of starfish into cleared areas; and early termination of programs.

To give control programs the best chance of success the following points need to be considered:

- The program needs to be of a realistic scale - about 2 to 4 hectares is the maximum reef area that can be protected using the available manual control techniques (the size of the area that could be protected will depend on the resources available);
- Adequate funding and resources must be allocated for the task;
- The program needs to be initiated as soon as possible after an outbreak has been detected;
- Areas should be surveyed before controls are started to gauge the extent of the problem and the likelihood of other starfish moving into cleared areas (GBRMPA can



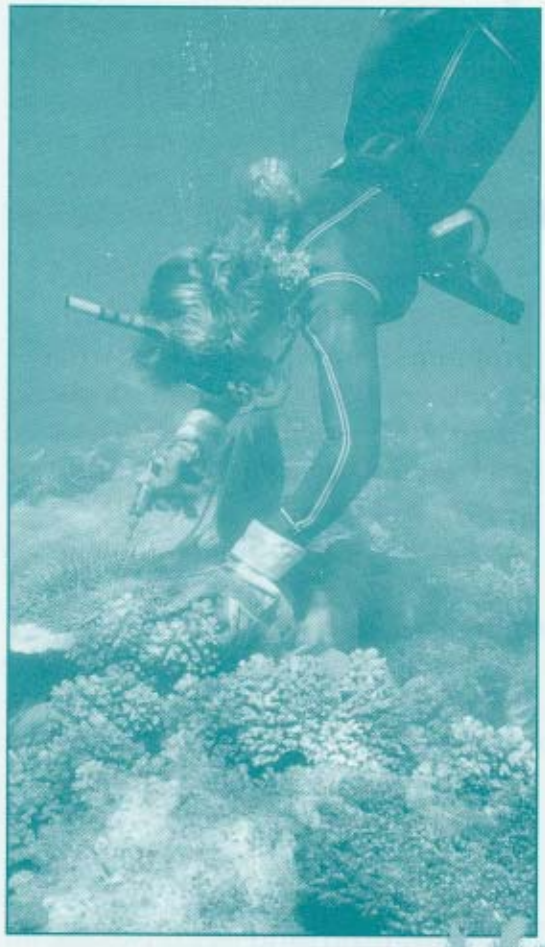
provide advice on survey techniques and we may also be able to organise for surveys in your area);

- Surveys should be conducted regularly to monitor the success of the program;
- Cleared areas must be visited regularly (initially every 4-5 days) to 'mop up' starfish that were missed and immigrants to the area; and
- There must be a commitment to continue the program until starfish densities are reduced to below the area's capacity to cope with the numbers present.

The Cost of Controls

Costs of control programs vary enormously, depending on the situation (area to be protected; distance from provincial centres; land- or shore-based; vessel availability and requirements; number of divers involved; labour costs; depth, number and dispersion of the starfish etc.).

On the Great Barrier Reef costs of controls ranged from about A$0.5 to A$40 per starfish. A survey of the area to estimate the number of starfish and to assess their extent of aggregation and location will help to establish the likely cost of the program.



Diver injecting starfish

Control programs are rarely once-off operations. Because starfish will move into cleared areas and new individuals will settle on the reef over time the effort must be sustained, in some cases for several years. Preservation of a limited area (2-4 hectares) of reef on the Great Barrier Reef might cost between A$20,000 to A$200,000 over 3 years.

Labour and Organisation

Three categories of personnel have been used to conduct control programs: bounty collectors (where people are paid an amount for each starfish collected), volunteers and paid staff. Generally the bounty system has been the most efficient method for large outbreaks but it has not worked well for smaller outbreaks. It has been most successful when the area is accessible by road (or transportation is provided) and the starfish are close to shore in shallow water where they can be collected by wading or snorkelling. Bounty collectors are usually not thorough and they concentrate on large aggregations which provide the quickest return. When starfish numbers are lower or the starfish are dispersed, collection becomes an uneconomical proposition for the collectors even though there may be enough starfish to continue to damage the reef.

Volunteers have been successfully used in a number of situations but they tend not to be particularly efficient or thorough. Inexperienced divers typically don't have the necessary discipline and long-term commitment and their 'kill rates' are usually much lower than professional divers. Trained Armed Services personnel have been involved in control programs on the Great Barrier Reef to overcome these problems. Although volunteers may be less costly than paid staff in the short term, they still require substantial support and, because they are less efficient, there is a greater risk of the program failing.

For local controls, paid divers are likely to be the most efficient and effective option. The biggest problem is recruiting a sufficiently large team quickly to eliminate the starfish before they cause significant damage. Someone must take responsibility for organising and supervising controls. This may be the operator, a dive master, boat skipper or a contracted diver. In all cases it is extremely important to maintain continuity of the supervision (and keep accurate records) to avoid duplication of effort or missing large numbers of starfish.

Control Techniques

A variety of techniques have been used to kill crown-of-thorns starfish. All involve treatment of individual starfish. Injection with poison is the most cost-effective.

Injection of Poison

This is the most efficient technique, taking just a few seconds to inject each starfish. Rates of treatment

of up to 120 starfish per diver hour have been recorded during trial control operations.

Until recently, the recommended poison was copper sulphate ($CuSO_4$), also called 'blue stone'. It was recommended because it was effective, inexpensive, widely available and safe when handled correctly.

Other poisons that have been used include formalin; concentrated aqua ammonia solution and hydrochloric acid. These aren't as effective as copper sulphate, they tend to damage the injection guns and they are usually more hazardous to use (particularly in a rocking boat). Getting the dose right was critical - using less or more than the recommended doses resulted in fewer starfish dying from the treatment.

The main concern over using copper sulphate was the potential for heavy metal pollution in areas where control operations were conducted. Even relatively small doses of heavy metals can affect the health of reef animals and plants and with sufficient exposure result in death.

Trials of alternative poisons by GBRMPA staff resulted in the identification of a commonly available swimming pool chemical 'Dry Acid' (sodium bisulphate) as the poison of choice for killing crown-of-thorns starfish. It is widely available, inexpensive (about $4 per kilogram), considered to be safe to handle (when manufacturer's instructions are followed) and, most importantly, it eventually breaks down in seawater to completely benign components (it won't harm anything).

Details of the technique for injecting sodium bisulphate are described in appendix 1.

Starfish injection gun

Cutting Up

Cutting starfish into a number of pieces was one of the first methods tried, however its use was stopped because of concerns that the pieces would regenerate creating an even bigger problem. Some starfish (like the blue starfish *Linckia*) do regenerate entire bodies from substantial pieces but the survival of *A. planci* after having been cut into separate quarters in the field appears to be very low. Tests of the effectiveness of this method were conducted by GBRMPA staff. When starfish were cut into quarters or their central disk was removed, most of the pieces were still alive after 2 weeks. We don't know if these remains would have regenerated but it seems unlikely.

The biggest problem with this method is that the starfish have to be extracted from the coral to be treated. This will usually damage the corals as the starfish can be entwined securely around branching forms. The risk of a diver being spiked is quite high (see section on First Aid). Because poisons are not involved the method has the advantage of being environmentally 'friendly' (as long as coral is not damaged in extracting the starfish) and special equipment is not needed.

Trials conducted by GBRMPA showed that this method is 10 times slower than injecting poison and the diver doing the cutting up was spiked 3 times during the treatment of 20 starfish.

NOTE: Crown-of-thorns starfish may release their eggs and sperm when stressed during summer (their normal breeding season). Although the chances of this resulting in successful breeding are slight, it is best to avoid controls in December - January.

Removal and Burial Ashore

Strong sharpened sticks, barbeque tongs or a hooked steel rod are best for pulling starfish out from under corals. The collected starfish can then be taken to a strategically placed floating or sunken bin for transfer to a small boat. Long-handled barbeque tongs are best for carrying starfish (above- and under-water). Because of the multiple handling of each starfish removed, manual removal is highly inefficient and there is a high risk of serious spiking of the divers and people involved in the transfers in and out of the boat.

Underwater Fences

The need to continually remove starfish that move into cleared areas of reef adds significantly to the cost of control programs. Research conducted for GBRMPA found that the most effective barrier to crown-

of-thorns starfish was a fence made of rigid steel wire mesh (12.5 mm square), 1 metre in height and having a horizontal 60 cm overhang at the top. Materials for this fencing cost about A$10 per metre.

Fences have not been tested on a large scale but they could provide an answer to the problem of adult starfish moving into cleared areas. However, there are a number of problems with the fencing approach:

- They cannot stop immigration of the starfish's larvae or small juveniles;
- The cost is high, especially when maintenance is taken into account;
- They are difficult to construct in rugged areas as the bottom of the fences must be in close contact with the substrate;
- They are prone to damage in heavy seas and cyclones; and
- They are ugly.

Assessing the Situation: Survey Techniques

It is important that the area in which there is a problem, and the surrounding reef, are surveyed regularly during an outbreak to determine the scale of the problem and the success of control action.

Manta towing is the quickest way of seeing a large section of reef. A snorkel diver holds onto the grips of a manta board which is towed 5-10 m behind an outboard powered dinghy (rubber dinghies are best) at a speed of about 1-2 knots. Because of rapid ascents when manta towing, never use SCUBA. The diver can steer and dive by turning the manta board to carefully scan the bottom to note the number of crown-of-thorns starfish and the amount of white recently dead coral. The dinghy operator should stop after 2 minutes of towing (a distance of about 150-200 m) and record the path on an aerial photograph of the reef (laminated in plastic to make it waterproof). The diver should record (or tell the dinghy operator who then records) the number of starfish seen, and the amount of dead coral. Because of the speed of the diver's movement and the tendency of starfish to hide, probably less than 5% of the adult starfish in an area will be seen using this technique. Juvenile starfish (smaller than 15 cm diameter) are very rarely seen.

The manta tow technique works reasonably well for continuous areas of reef but not for patch reefs or bommie fields in back reef areas or where the water visibility is less than 10 m. Where the reef is very patchy, short (20 minute) spot SCUBA dives are best. The number of starfish and an estimate of the amount of recently dead coral should be recorded during or immediately following the dive.