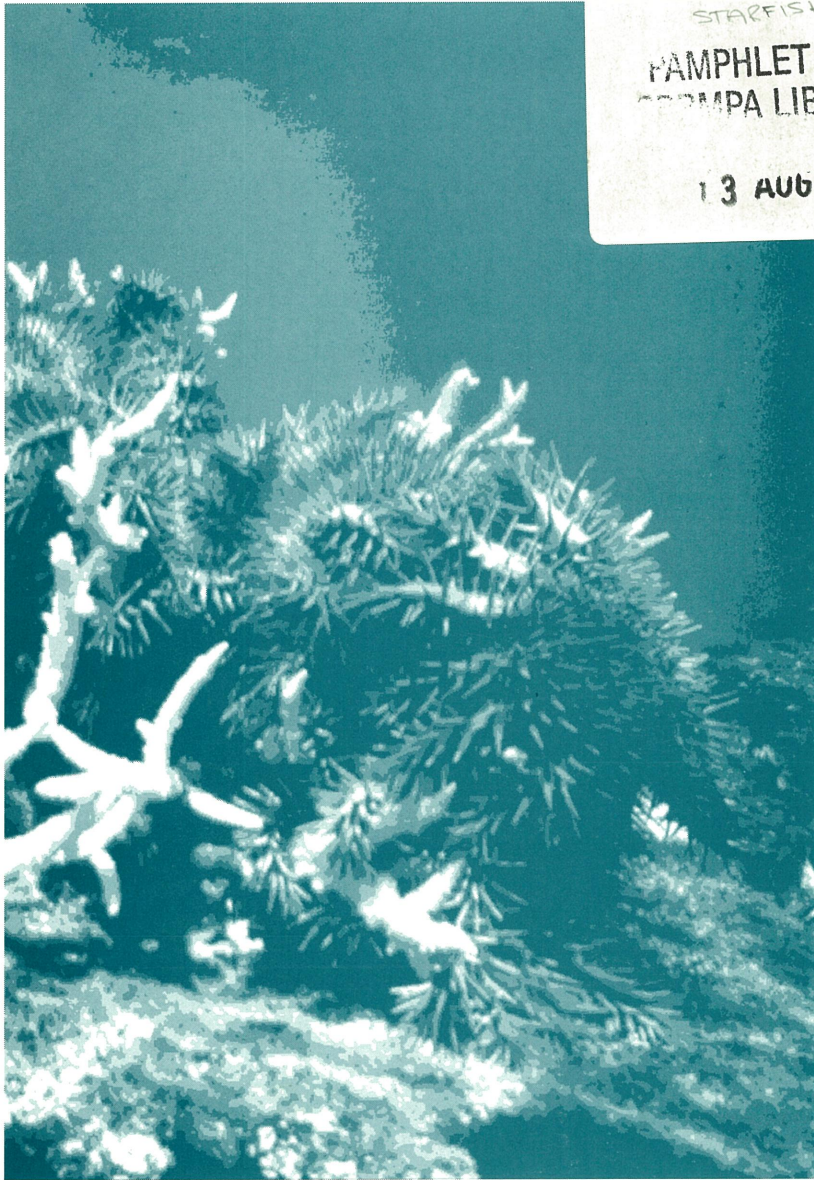


# Controlling Crown-of-thorns Starfish

"CROWN-OF-THORNS  
STARFISH"

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Marine Park  
Authority





# Controlling Crown-of-thorns Starfish

Brian Lassig  
Research and Monitoring Section  
Great Barrier Reef Marine Park Authority



Great Barrier Reef  
Marine Park  
Authority



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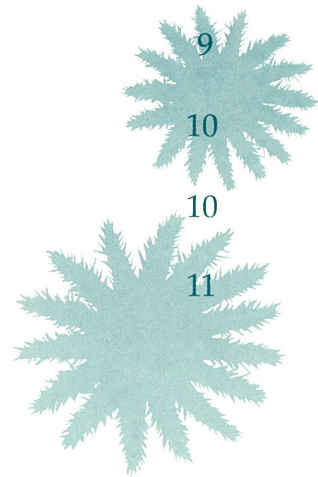
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# When are Controls Necessary?

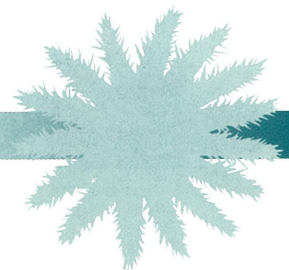
The crown-of-thorns starfish (*Acanthaster planci*) is a natural inhabitant of coral reefs throughout the Indo-Pacific Region. 'Normal' (non-outbreaking) densities of starfish range from about 1 per hectare (an area 100 m x 100 m) to 15 per hectare depending on the amount of coral cover (food) available. 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<sup>2</sup> and 13 m<sup>2</sup> 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.



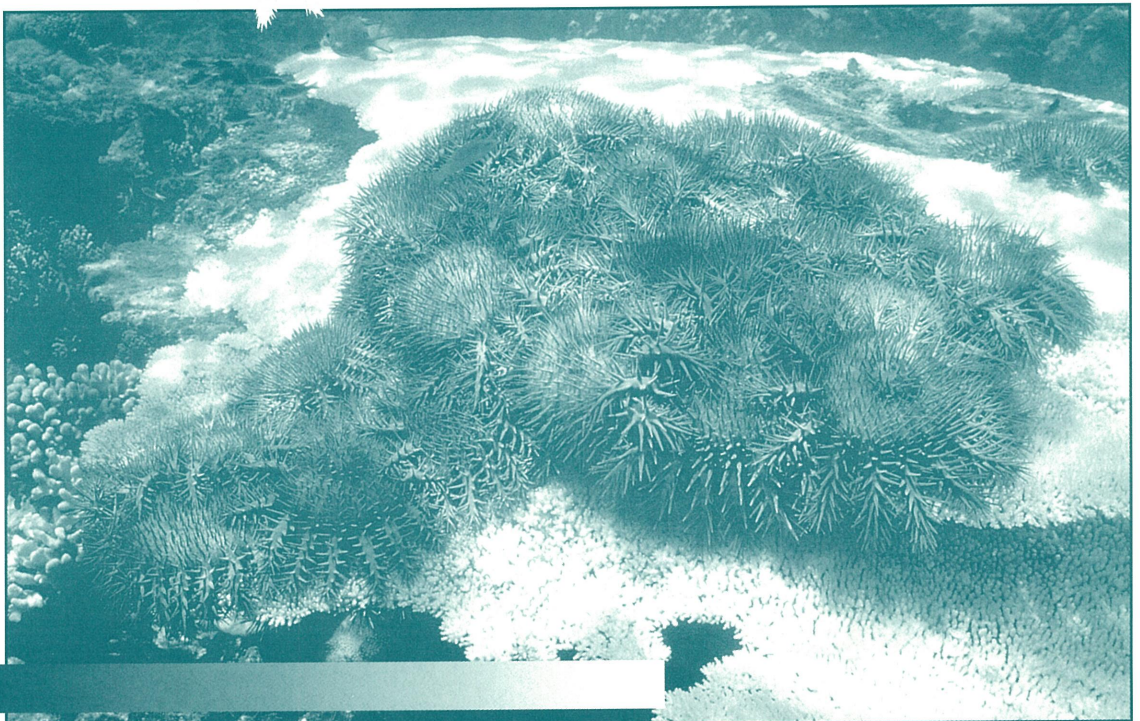
# S

## uccess 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





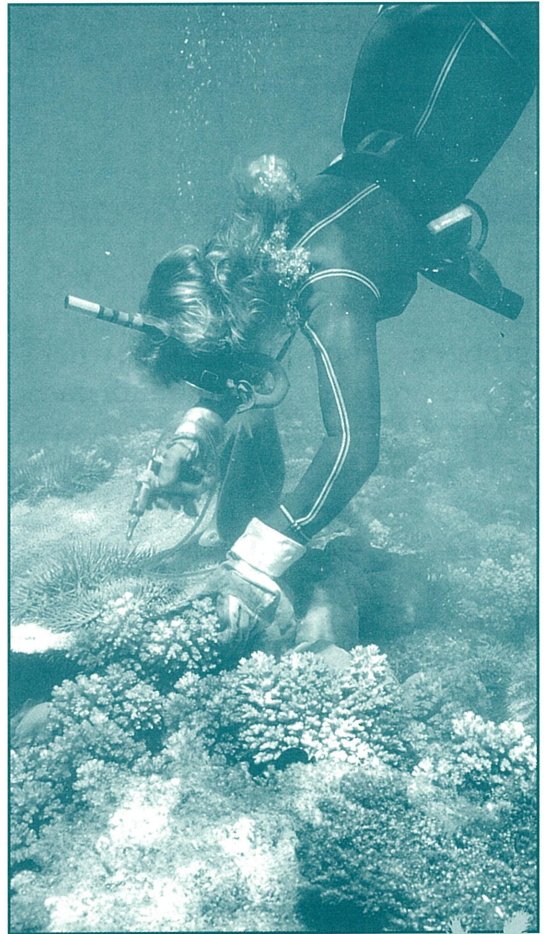
provide advice on survey techniques and we may also be able to organise for surveys in your area);

- 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.

# L abour 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.

## C ontrol 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 ( $\text{CuSO}_4$ ), also called 'blue stone'. It was recommended because it was effective, inexpensive, widely available and safe when handled correctly.

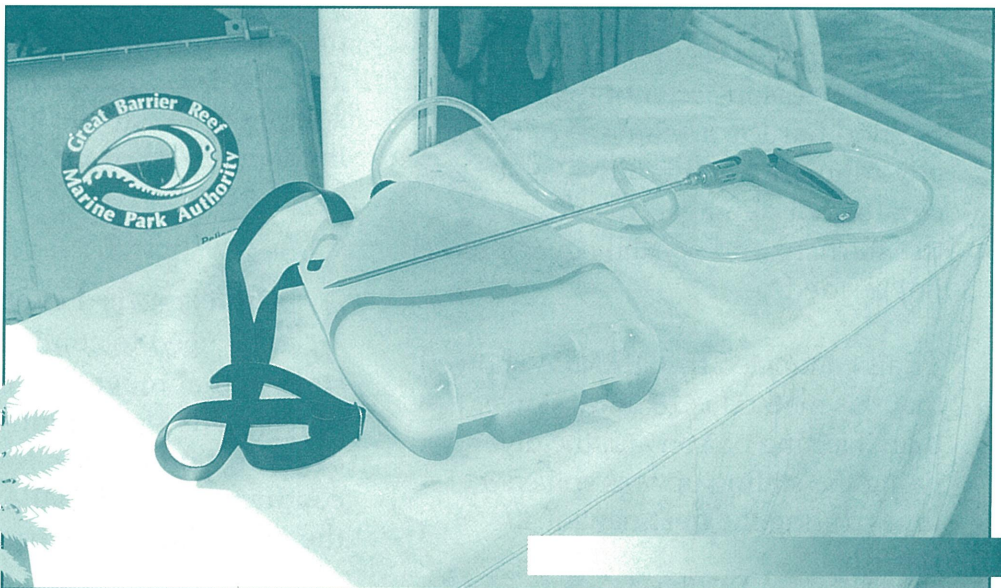
Other poisons that have been used include formalin; concentrated aqua ammonia solution and hydrochloric acid. These aren't as effective as copper sulphate, they tend to damage the injection guns and they are usually more hazardous to use (particularly in a rocking boat). Getting the dose right was critical - 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 underwater). 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.

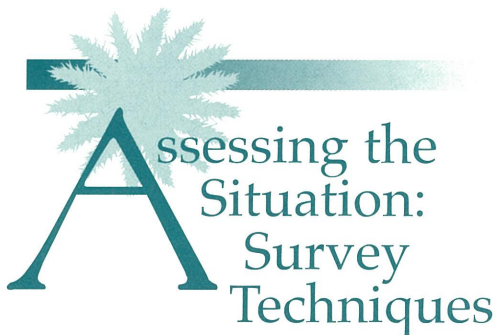
## *Underwater Fences*

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.

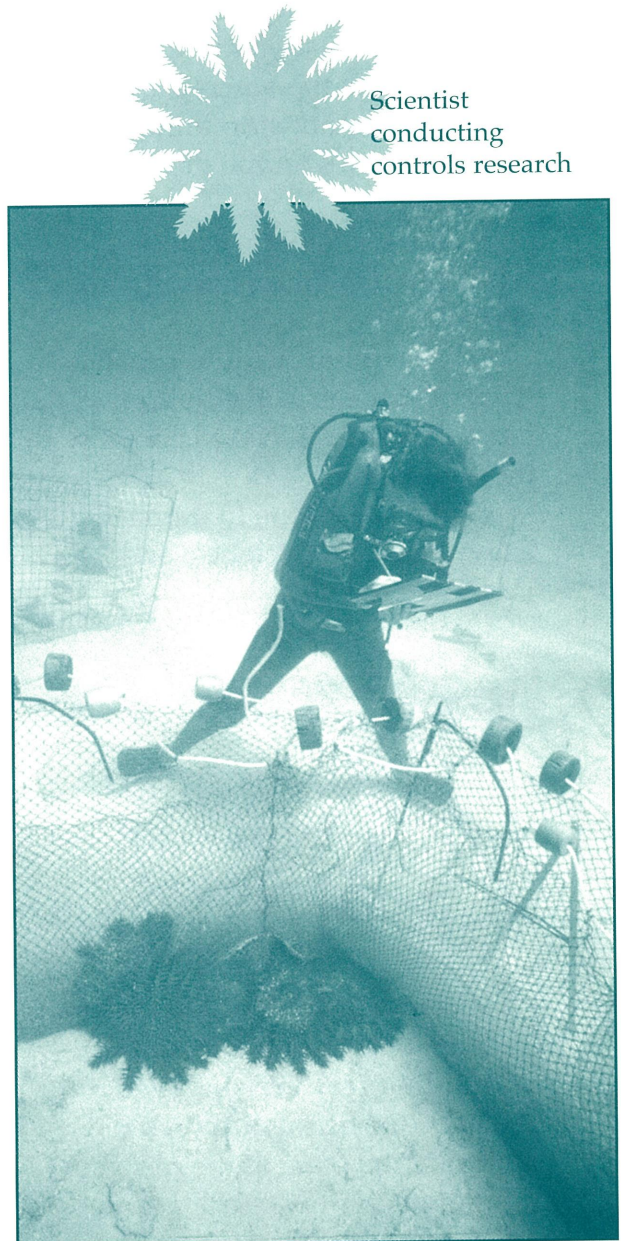
A combination of manta towing and spot dives will probably give the best description of the situation. Manta towing can be used to locate the aggregations of starfish and spot dives can be used to get a good estimate of the number of starfish at those sites.

## Searching for Starfish

If the control program is to be successful, nearly all of the crown-of-thorns starfish have to be removed from affected areas. Divers searching for starfish must swim very close to the bottom, paying special attention to crevices, cracks and overhangs where the starfish may be hiding. While doing this it is very easy to get disoriented and lose track of where you've been unless the area is quite small. Systematic searches will add considerably to the effectiveness of the program. Searches should be repeated to minimise the number of starfish missed.

Having a large-scale map or aerial photograph will help in recording the areas checked for starfish. These can be obtained from the Australian Surveying and Land Information Group (AUSLIG) (Freecall telephone number 008 800

173) or from GBRMPA. Where the affected area is mainly patch reefs several divers should work around the sides of the patches at different depths. One diver could search say 0-3 m, another diver 3-6 m and so on to cover the full height of the reef. Obvious white feeding scars indicate that a starfish is close by and can be used to locate hidden starfish.



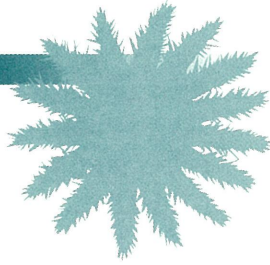
Scientist  
conducting  
controls research

Where the reef patches are large or where the reef is continuous it is best to lay down weighted ropes so that defined areas between the lines can be searched systematically. The ropes should be about 2.5 m apart and marked with a buoy for easy location. Although this preparation involves extra time and effort it will help to ensure that few starfish are missed and the program is successful.

should state that the activity is not for commercial purposes (or else it will attract a processing fee) and it should be lodged several weeks prior to when the activity will be undertaken.

# Reporting Results

## Permits

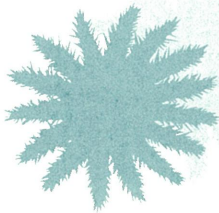


A permit from GBRMPA and the Queensland Department of Environment and Heritage is needed to conduct crown-of-thorns starfish control programs on the Great Barrier Reef. Permit application forms can be obtained from either of these organisations. Applications

Permit holders are required to keep a log of the numbers and sizes of starfish killed or collected. The following additional information may help in developing more effective and efficient local control techniques:

- Starfish numbers in the area before and after the program;
- Methods used for surveys and killing or removing starfish;
- The size and depth of the area affected;
- Diver hours spent injecting; and
- Costs etc.

The Authority's  
COTSWATCH  
reporting form



**CROWN-OF-THORNS STARFISH SURVEY**

Great Barrier Reef Marine Park Authority

**Please read this section before you complete this form.** Simply complete this assessment for each reef you visit. During your visit, note the condition of the coral and the presence or absence of crown-of-thorns starfish. Count all the crown-of-thorns seen on each dive. The information you provide will help us to keep a check on the starfish on the Great Barrier Reef. If you would like more information on the crown-of-thorns just tick the box on the back of this form. **Zero Sightings:** Please note that it is equally important to complete reports for reef visits during which no starfish are sighted.

1 Name of reef: \_\_\_\_\_  
to number from GBRMPA map  
Date of visit: \_\_\_\_\_

2 If possible, please sketch a map of the reef in the space provided on the back of this page.  
(This can use your GBRMPA zoning map to help you identify the exact location)

3 How did you examine the reef?  
Scuba Diving  snorkelling  Reef Walking   
Other: \_\_\_\_\_

4 How much of the reef did you examine?  
Most  Several sites  One site   
(Mark on your map the site/s examined.)

5 About how long did you examine each site?  

Site 1	hr.	min.
Site 2	hr.	min.
Site 3	hr.	min.

6 What proportion of the corals appeared to be dead?  
**A recently dead (ie. coral whole or covered by fuzzy, green algae)**

	Site 1	Site 2	Site 3
No dead coral			
Few < 1/4			
Some < 1/2			
Much > 3/4			
Most > 3/4			

  
**B long dead (ie. corals entirely covered by brown algae)**

	Site 1	Site 2	Site 3
No dead coral			
Few < 1/4			
Some < 1/2			
Much > 3/4			
Most > 3/4			

7 Did you see any crown-of-thorns? Yes  No

**IF NO photos and post your survey, thank you for your assistance. IF YES, please continue.**

8 How many crown-of-thorns did you see on each site?  

	Site 1	Site 2	Site 3
None			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			

9 What depth of water were they in?  

	Site 1	Site 2	Site 3
0-1m			
1-2m			
2-3m			
3-4m			
4-5m			
5-6m			
6-7m			
7-8m			
8-9m			
9-10m			
10-11m			
11-12m			
12-13m			
13-14m			
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54-55m			
55-56m			
56-57m			
57-58m			
58-59m			
59-60m			

10 Generally, where were the crown-of-thorns seen?  
 Hidden under coral  
 On top of coral  
 On sand

11 Generally, how were they grouped?  
 Clustered together  
 Uniformly scattered  
 Single individual

12 How large were the crown-of-thorns starfish?  
 Smaller than palm  
 Size of outstretched hand  
 Much larger than hand

13 Have you visited this reef before?  
 Yes  No  If yes, when?  /  /   
 Did it have similar numbers of crown-of-thorns?  
 Yes  No  If no, more  less

**WARNING**  
 THE SPINES OF THE CROWN-OF-THORNS  
 STARFISH ARE VERY POISONOUS. PLEASE  
 AVOID CONTACT. ALWAYS WEAR A SAFE DIVER'S SUIT.  
 Please read and post your assessment. Thank you for your assistance.

# F

## irst Aid

The spines of the crown-of-thorns starfish are very sharp, about 5 cm in length and prone to breaking off in wounds. The covering of the spines produces a venom which is deposited in the tissues on penetration. Skin penetration by the spines is painful and can lead to secondary infection and continued swelling. The pain is usually immediate, very severe and it may persist for a few hours. Vomiting may commence about one hour after the injury and recur every few hours for the next few days. Localised allergic reactions may also occur in susceptible individuals. Repeated spikings (even if months or years apart) may result in progressively more severe reactions.

Details of first aid are described in appendix 1.

# F

## urther Reading

Birkeland, C. and Lucas, J.S. (1990) *Acanthaster planci*: major management problem of coral reefs. CRC Press, Boca Raton, USA. 257 pages.

Engelhardt, U. and Lassig, B. (1992) Crown-of-Thorns Starfish Research Update 1991/92. Great Barrier Reef Marine Park Authority, Townsville, Australia. 19 pages.

English, S., Wilkinson, C. and Baker, V. (1994) Survey manual for tropical marine resources. ASEAN - Australian Marine Science Project: Living Coastal Resources. Australian Institute of Marine Science, Townsville, Australia. 368 pages.

Moran, P.J. (1986) The *Acanthaster* phenomenon. *Oceanogr. Mar. Biol. Ann. Rev.* 24: 379-480.

Zann, L.P. and Eager, E. (1987) The crown-of-thorns starfish. *Aust. Sci.*

If you would like further information on crown-of-thorns starfish or on controls, please contact the Coordinator of the Crown-of-thorns Starfish Program, Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, Queensland, AUSTRALIA 4810 {Telephone (077) 81 8811 or Facsimile (077) 72 6093}. I would be grateful for any comments you have for improving this manual and for information about your control programs.



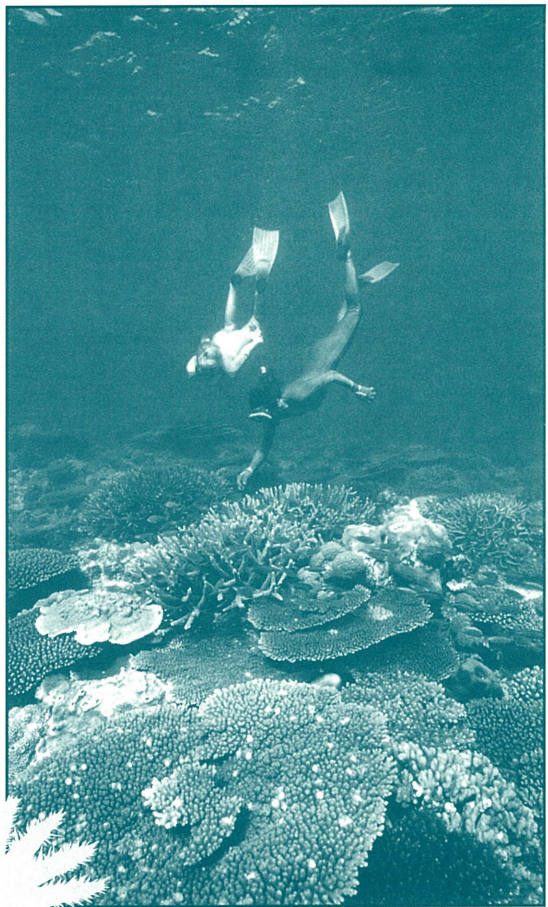
# G BRMPA Policy on Controls

'Broadscale control of crown-of-thorns starfish is not to be attempted in the Great Barrier Reef Marine Park unless human activity is proven to cause or exacerbate outbreaks, or unless any future outbreaks are much more extensive and intensive than the two that have been observed.

Local control of crown-of-thorns starfish (by any method involving treatment of individual starfish) must be consistent with zoning plan provisions and should be consistent with management plan provisions.\*

Recognising the potentially high risks associated with biological and chemical control measures in complex coral reef environments, research into biological and chemical control of crown-of-thorns starfish should not be supported other than in identifying potential agents whose application is consistent with the two policies above.

In the event of a causal relationship between human activity and crown-of-thorns starfish outbreaks being established, the Authority should use all its powers and influence to regulate that activity to minimise the effects of that activity on crown-of-thorns starfish populations, and should also seek to minimise the effects of outbreaks.



*\*Note: A permit will be required for local control measures in General Use 'A' and 'B' Zones where it is desired to collect more than 5 starfish per person in any 28-day period. A permit may be granted for local control measures in higher protection areas (MNP 'A' and 'B', Conservation Park, Buffer and National Park Zones) where the provisions allow for the taking of animals that pose a threat to ecosystems or the use and amenity of an area.'*

MPA 148 (12)



# Details of Poison Injection and First Aid

## *Injection Devices*

Poisons can be injected with large syringes or similar devices. Agricultural injectors (made for multiple use on cattle and other livestock or injection of herbicides into trees) are best. These devices have long needles (which minimise the risk of divers being spiked and allow starfish in inaccessible places to be reached) and they carry a 5-litre reservoir of poison (which means that divers rarely have to swim back to support vessels to refill).

In Australia, the recommended model is the DuPont Velpar Spot Gun fitted with the optional 50-cm needle (rather than the standard shorter type), and a 5-litre plastic bladder. This is available from larger agricultural supply retailers. The units cost about A\$110 each. The injector is mainly plastic in construction. Metal and glass models should be avoided because the metal components corrode and the glass syringes are easily broken.

The injector guns require regular maintenance. Metal parts of the DuPont Spot Gun are very prone to corrosion. The metal parts of the guns, particularly the springs of the non-return valve, must be disassembled at the end of every day of use, washed in fresh water and oiled. It is best to store the springs in a light machine oil if the guns won't be used for

several days. If this is not done the guns won't work after only 2-3 days of use.

Have a nominated person responsible for the maintenance of the guns. Even with careful maintenance the metal parts of the non-return valves have a finite life. Order several sets of spare springs with every gun (stainless steel replacements are available and these will last longer). If the non-return valve is faulty the gun will inject seawater into the starfish, not the poison!

## *Mixing and Injecting the Poisons*

**Sodium bisulphate** is the Number 1 choice. Sodium bisulphate, or 'Dry Acid', is a white, crystalline powder. Add about 1/3 of a metric cup (20 teaspoonsful or 140 grams) of the chemical to each litre of seawater (the volume of water will depend on your immediate requirements). Plastic 2-litre milk bottles are good for mixing. Use a funnel to minimise spillage of the crystals. One litre of the solution is enough to kill about 40 adult starfish.

Because the solution is colourless, it is difficult to see if the gun is working underwater. Adding a small quantity of food colouring (blue works well) helps.

To inject the starfish, set the injection dose meter on the gun to 2 ml. Carefully push the needle under the skin of the central disc of the starfish and pull the trigger carefully. To avoid pushing the needle right through the

**CAUTION:** Sodium bisulphate is relatively safe to handle, however, contact with the skin (and especially eyes) should be avoided. It should be handled in accordance with the manufacturer's instructions.

starfish and out the other side, push the needle in at an angle. Inject the starfish 3 times at this site (for a total dose of 6 ml) and then repeat this injection procedure 3 more times (at different places on the disk) to give a total dose of 24 ml. Before injecting starfish it is a good idea to pull the trigger to fill the syringe (seawater tends to be sucked back into the syringe if it hasn't been used for a few minutes).

### **Copper sulphate - the last resort.**

One litre of the poison solution is sufficient to kill about 200 starfish. Take 1-2 litres of fresh or sea water (depending on your immediate requirements) and add the copper sulphate crystals (spoonfuls at a time), mixing well. Continue to add the crystals until no more dissolve.

To inject starfish, set the injection dose meter on the gun to 2 ml. Inject the starfish two to four times in different places on the central disk (4 times for large adults over 35 cm in diameter), giving a total dose of 4-8 ml.

**CAUTION:** Copper sulphate is relatively safe to handle but it is very poisonous if swallowed or inhaled. Keep well away from SCUBA regulators as the spray can be inhaled. It is also highly corrosive to metals. It is best mixed ashore and kept in a strong plastic container (never metal) which is stored in a bucket or bin to prevent spillage. It can be toxic to other marine animals so do not dispose of any unwanted solution in the sea. It should be handled in accordance with the manufacturer's instructions.

Don't use more than the recommended dose of copper sulphate. Copper sulphate is poisonous to other marine life and it accumulates in some organisms (like clams). This may cause long-term health problems for the reef.

### *First Aid*

First aid treatment is the same as that given for all venomous fish stings.

1. Remove any very loose spines. Spines that are embedded should be left until medical help is available. Avoid excessive tugging at spines as the tips may break off and be difficult to locate.

2. Place the injured part into hot, but not boiling water. The temperature of the water should be tested by someone other than the patient before use.

3. Apply local anaesthetic around the wound to provide pain relief.

4. Clean the wound, washing out with sterile hot saline solution.

5. Dress and loosely bandage the wound.

6. Arrange bed rest and antibiotic treatment as appropriate.

7. Supervise any further pain relief.

8. Seek medical advice.

**Note:** *Do not apply an arterial tourniquet, nor a pressure or immobilisation bandage.*

Although there is no physiological explanation, a widespread traditional remedy for spinings is to hold the starfish's lower surface (with the suction feet) against the wound. This allegedly relieves pain and disability.

