A Thorny Problem
Crown of Thorns Starfish in W.A.

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In 1963, a tourist operator at Green Island on Queensland's Great Barrier Reef discovered that large starfish were killing coral in his reef viewing area. Marine biologists were called in and it was soon discovered that starfish 'plagues' were widespread in the central zone of the Barrier Reef.

The starfish, known technically as *Acanthaster planci*, is popularly called Crown of Thorns. Adults grow as large as 70 cm in diameter. Their pudgy bodies and many short arms are covered with razor-sharp venomous spines.

These strange animals feed by protuding the stomach from the mouth and applying its juice-secreting digestive surface to the living tissue of the coral prey. When the coral flesh is mushy the stomach is retracted along with a load of part-digested food leaving behind the empty, white skeleton of the coral which soon becomes greyish-green with algal slime.

One average-sized adult starfish, at one meal, will kill the coral polyps over an area about the size of a dinner plate. Hundreds of thousands of them may completely devastate a reef.

During the 60s and 70s, crowds of Crown of Thorns attacked many central Queensland reefs, including many of the prime tourist areas, causing severe damage. The infestations diminished in the mid-70s, but they came back with a vengeance in 1979. Are these events the norm in the life of coral reef systems? Could it be that it has all happened before but was not noticed? Or is this something new?

Some scientists have argued that populations of starfish and other echinoderms are naturally subject to massive fluctuations in numbers, occasionally reaching 'plague' proportions. There are many examples in temperate seas. These scientists believe that the Crown of Thorns

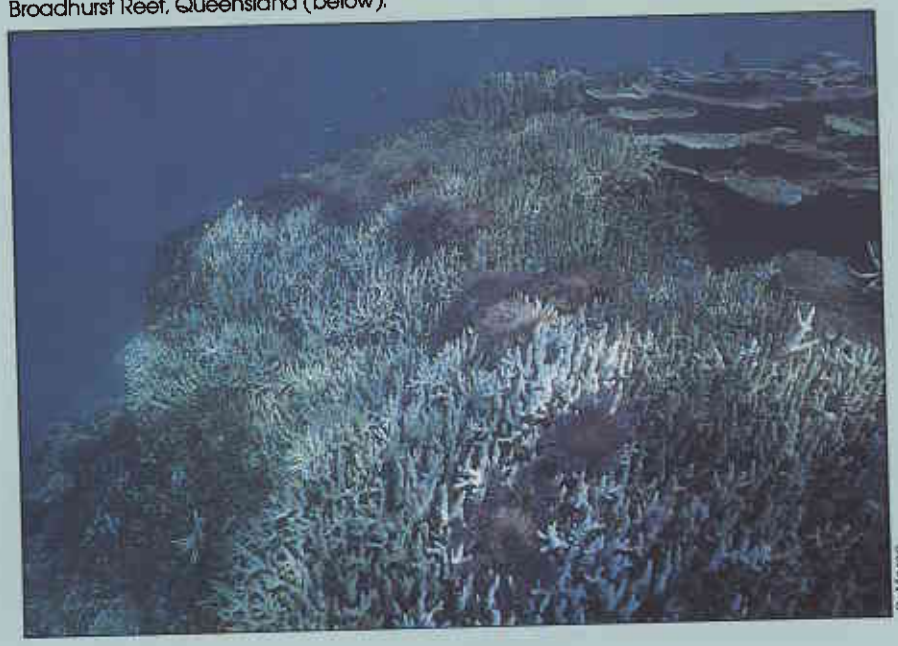
outbreaks are normal, perhaps even playing an essential role in coral reef ecology.

Other scientists believe that the Crown of Thorns infestations of this magnitude are the result of an ecological upset caused by humans. There are many theories about the cause, but after 25 years no firm conclusions have been reached. Two general theories are given most credence. The 'predator pressure release theory' holds that humans have interfered is some way with one or more of the natural predators of the starfish. For example, the giant triton *(Charonia tritonis)*, is known to prey on adult Crown of Thorns and it has been argued that shell collectors have taken so many of these handsome shells from the Great Barrier Reef that the starfish have been released from their normal ecological constraints.

Other scientists propose that coastal waters have been polluted by pesticides or excessive nutrients from rivers draining newly developed agricultural lands, creating conditions especially favourable to the Crown of Thorns larvae. What is lacking in this debate is information on the condition of coral reefs and the size and effects of Crown of Thorns populations prior to the 1960s. There is very little knowledge of what is 'normal' in coral reef ecosystems and hence it is hard to judge whether these episodic outbreaks of the starfish are 'abnormal'.

W.A.'s coral reefs may prove to be particularly helpful in this regard. They are areas of relatively low human population and over-fishing of any predators of the starfish seems a remote possibility. There is virtually no agriculture in the catchments of the rivers and no pollution from pesticides or nutrient-enrichment from fertiliser to affect coastal waters in this region.

A group of Crown of Thorns starfish feeding on a bank of staghorn *Acropora* at Broadhurst Reef, Queensland (below).



P. Moran

Barry Wilson taking a tissue sample from a Crown of Thorns, Kendrew Island, April 1987 (right).

The spines are razor-sharp and covered with a venomous slime. Enderby Island, April 1987 (below).

Kevin Marshall

Barry Wilson

Field studies in Queensland and elsewhere have shown that the Crown of Thorns eat branching and plate *Acropora* corals in preference to other species, but in heavily affected areas almost all the hard corals may be killed. There is very little knowledge about the resilience of coral reef ecosystems following such destruction, i.e. whether the systems will return to the original condition eventually.

Crown of Thorns starfish are not the only sea creatures to eat corals. Many coral-reef fishes do so. Fish bite marks may often be seen on living corals, but the vegetative growth of the coral polyps usually quickly covers the damaged areas.

One group of gastropod molluscs (genus *Drupella*) feeds on living corals by rasping the living tissues with file-like mouth parts (radulae). *Drupella cornus* is a common species on W.A.'s coral reefs. Like Crown of Thorns starfish, these snails prefer to eat branching or plate *Acropora* corals. Groups of them attack corals and leave large white feeding scars which look very much like Crown of Thorns' damage.

Drupella cornus has been discovered in large numbers recently in the Ningaloo Marine Park where it has devastated large areas of coral. Since 1980 there have been reports of similar extensive destruction of coral reef by species of *Drupella* at other localities in the Pacific. Is this evidence that echinoderms are not the only marine predators characterised by large-scale variation in population numbers?

Throughout the tropical Indian and Western Pacific Oceans Crown of Thorns starfish are found on coral reefs, at very low densities, i.e. less than 1 per 1 000 sq m. For example, on the Ningaloo Reef, only occasional, solitary Crown of Thorns are seen. Aggregations of the starfish have not yet been reported along this reef, or elsewhere in W.A., except in the Dampier Archipelago.

In 1971 W.A. Museum staff discovered a dense population of Crown of Thorns starfish at Kendrew Island in the Dampier Archipelago. In the three-year study which followed, it was found that they were at densities of up to 5 per 1000 sq m in the reef-front zone, more than is considered to be 'normal' elsewhere. In shallows rich in branching and plate *Acropora* corals at the western end of the reef the starfish were in densities of up to 34 per 1 000 sq m. Where the starfish were in such numbers they did extensive damage to corals. Although these aggregations were not comparable to the countless thousands on heavily infested Queensland reefs, they were, nevertheless, at densities which would be

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Crown of Thorns hiding under a coral ledge. Kendrow Island, April 1987 (below).

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A group of the gastropod *Drupella cornus* feeding on a tabular *Acropora* coral. Note the white, eaten area. Ningaloo Marine Park, April 1987 (above).

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Fish bite marks on a massive coral, Ningaloo Marine Park, April 1987 (right).

A branching *Acropora* coral colony half killed by Crown of Thorns. Kendrow Island, April 1987 (below).

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generally regarded as abnormal 'infestations' by most research workers in the field.

In 1987 a team from the Department of Conservation and Environment did some manta-board tow surveys in the Dampier Archipelago. They found numbers of starfish along the fronts of several reefs, including Sailfish Reef off Rosemary Island and Kendrew Reef.

A team from CALM and the Australian Institute of Marine Science, revisited the Museum's Kendrew Island study area in April 1987. We again found relatively high concentrations, i.e. 5-25 per 1000 sq m. The shallow western areas where *Acropora* corals had been so prolific in 1971 were now poor in living coral cover.

Looking further afield within the Archipelago we found a sparse population of Crown of Thorns on Sailfish Reef. Little living hard coral grew there but there were many soft corals. This reef gave the impression of having been hit by the starfish several years previously. Off the north-west shore of Enderby Island we found a beautiful reef with prolific hard coral. But also there in one section was the most dense population of Crown of Thorns we encountered during these surveys, eating away.

The starfish found at Kendrew and Sailfish Reefs were relatively small and even-sized. We believed that they were a single age-class from a single spawning season two or three years previously. At Enderby Reef there was a greater range in size, possibly indicating more than one age-class. Alternatively, the different size of animals at different sites could be the result of variation in food abundance or quality.

The most feasible interpretation of what we found in 1987, taking account of the previous studies, is that at least since 1971, these Dampier Archipelago coral reefs have carried numbers of Crown of Thorns, although there may have been episodic outbreaks of denser populations following years of exceptional breeding success. If episodic waves have occurred, then we should expect the condition of the reefs (in terms of coral growth) to have varied over time, and from place to place within the Archipelago, depending on the frequency and location of starfish buildups. The differences we observed in the condition of the Kendrew, Sailfish and Enderby Reefs might represent different stages in the starfish attack-coral regrowth cycle.

Critical questions which follow this interpretation are: what is the frequency of starfish outbreaks, what is the period required for coral-reef recovery after heavy attack, and is this kind of cycle the normal condition of reefs in the area or a human-induced phenomena of recent decades?

If the high densities we observed are an ecological abnormality due to recent human activity then we might expect the cause to be the same as the cause of similar localised outbreaks elsewhere in the Indian and Pacific Oceans. Yet the conditions in the Dampier Archipelago are very different to those at affected areas in Queensland or elsewhere.

With no agriculture in this region, nutrient enrichment from river run-off cannot be blamed here as in Queensland. There is some fishing to be sure, but the known fish predators of adult Crown of Thorns are not target species of amateur or professional fishermen. Shell-collecting is a common local activity but the coral reefs in question are not popular locations. There is a slight possibility that industrialisation at Dampier could be changing local water conditions in some way, but there is no evidence of this. Alternatively, the relatively high density and variation in the starfish population numbers in the Dampier Archipelago may be a normal feature of the species' biology in that area. Episodic change in reef condition following starfish attacks may be a normal feature of the predator-prey relationship of Crown of Thorns to coral, i.e. when coral becomes dense it is removed by starfish.

We prefer the second explanation but we cannot be sure. There are no historical data prior to 1971, and incomplete data since then. If it is true it will mean that the scale of natural ecological change in these coral reefs is very much greater than we would have supposed.

Perhaps the recently observed outbreak of the coral-eating gastropod *Drupella cornus* at Ningaloo Reef is another example of drastic change in the predator-prey balance of coral reed exosystems. Here, too, it is difficult to imagine that localised human disturbance could be involved, for this reef is close to pristine in condition.

The Crown of Thorns' story epitomises a recurent and critical issue for environmentalists. Our primary conservation objective is to maintain diversity and natural ecological processes, but is 'natural' a static state or a state of constant change? And if the latter, what is the natural amplitude of variation and what are the causes? In the past many people have assumed that environmental management should aim at maintaining a status quo. But perhaps that is a fundamental error and we should be aiming to accomodate natural change.

In grappling with this critical question we must learn what is normal in ecosystems. At present we do not have this knowledge for coral reefs.□

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COVER PHOTO:
Stark silhouettes evoke the spirit of our remote regions. This photograph was taken near Quairading by Hans Versluis.

EDITORIAL

Public participation in land management sounds like a great idea: the community has a chance to study and comment upon the government's proposals. The scientists and managers can keep their fingers on the pulse of public demand. But sometimes good ideas are hard to put into practice.

Last April the Department of Conservation and Land Management released draft management plans for the south-west forest regions, and a draft timber strategy for W.A. The release of the plans was accompanied by a series of workshops and public meetings, and extensive media releases. Four hundred and thirty-five letters offering briefings and speakers were sent out. Ninety groups responded. Public comment on any aspect of the plans and the strategy was invited.

4070 responses were received. This included 3505 proformas (from 30 organisations) and 565 substantial submissions, some up to 200 pages in length. Many submissions endorsed the plans in their entirety; some rejected them out of hand; others suggested hundreds of minor changes.

How can so many, and such varied, views possibly be integrated simply and sensibly into a final plan? What weighting should be given to the views of different groups or individuals? Who decides what is 'right' when pure value judgements are to be made and values are in conflict? How should one resolve an issue when the views of a large section of the public are quite different from those of a small group of scientists working closely on the problem? These questions represent the sharp end of public participation. It's a relatively new game for W.A.'s land managers, and one in which the rules are still unwritten and ill-defined.

What is certain is that the Department's policy and planning staff have a big job ahead of them, and a job which must be done to the highest possible professional standard. It is important that the final plans for our south-west forests reflect the tremendous thought, effort and interest shown by the community; and it is essential that there are efficient mechanisms for public involvement in conservation and land management, because these processes will be the norm, not the exception in years ahead.

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