Chesher1970. "Acanthaster." Oceans, 3(5):10 17.

ACANTHASTER KILLER OF THE REEF

Text and photographs by Richard H. Chesher

On November 19, 1969 three members of the United States Senate proposed an all-out war on a bizarre red and green, 16-armed predator. Perhaps through man's rape of the global environment, the crown-of-thorns starfish has begun devastation of some of the most valuable real estate in the world-the coral reefs of the South Pacific. The senators' bill proposed that for the purpose of conserving and protecting coral reef resources of the tropical islands of interest and concern to the United States in the Pacific and safeguarding critical island areas from possible erosion and to safeguard future recreational and esthetic uses of Pacific coral reefs, the Secretary of the Interior and the Secretary of the Smithsonian Institution are authorized to cooperate with and provide assistance to the governments of the State of Hawaii, the territories and possessions of the United Mates, including Guam and America Samoa, the Trust Territory of the Pacific Islands, and other island possessions of the United States, in the study and control of the sea star "Crown of Thorns".. . .

ALMOST FIFTY MILLION YEARS before man built his first crude hut, countless trillions of oddly shaped, organized blobs of protoplasm began construction of the world's greatest edifices. Hampered by wind and wave, pampered by oceanic currents and sunlight, this strange mixture of plant and animal-the coral-steadily built up and out. Time and the great physical parameters of our globe impressed a continuing design upon the efforts of these small but relentless engineers, and coral reefs, nature's most spectacular, exotic and crowded megalopolises, slowly took shape. On submerged mountain peaks and along wave-beaten coasts these cities of life and color evolved in tropical seas. The largest, one of the seven natural wonders of the - world, is the 1,260-mile-long Great Barrier Reef in Australia. Several of the Pacific's beautiful coral atolls, small, isolated, ring-shaped islands, are the exposed portions of limestone edifices over a mile thick; their bases rest on the peaks of long submerged volcanoes.

Within the crowded coral complex dwells an entire universe of life; most of its members exist nowhere else. With the passage of aeons, these organisms have built their lives and habits into a framework of interassociations. Intimate, indispensable bonds have evolved between various members of the community until the magnificent web of life became thoroughly interdependent.

Cohabitation reached its ultimate inside the diaphanous tissues of the coral itself. Tiny organisms named zooxanthellae infect the coral tissue at birth and persist there in a mutually beneficial association until death. These creatures possess both plant and animal characteristics. At one stage of their life cycle, they are capable of movement like animals. Like plants, the zooxanthellae also contain chlorophyll. They function as microscopic chemical factories converting light from the sun, carbon dioxide, and organic nutrients from the coral tissue into oxygen and carbohydrates. Embedded in the tissue of the coral, they are protected from predators and supplied with phosphates and nitrates that are so scarce in clear tropical waters. Coral benefits from this symbiotic relationship by obtaining oxygen and carbohydrates for energy and by having their metabolic wastes recycled back into fuel within their bodies. Other organisms, from protozoans to man, also benefit from this delicate physiological cohabitation, for without it, coral reefs and coral islands would never have formed.
Coral begins life as an animated, minute larva called a planula. Although it can swim rapidly in its microscopic world, the planula's final destination is at the mercy of the great ocean currents. Should these maneuver the blind, unprotected mass of cells to a suitable habitat, the larva attaches to the bottom and becomes a polyp -a sea anemone in miniature, a hydra complete with a cylindrical body capped by a ring of tiny tentacles and a central mouth. This basic, two-layered beast divides and divides again, each new polyp remaining attached to the founder by a thin membrane.

Through an unknown chemical process, the polyp's body wall secretes calcium carbonate to form a hard, white skeleton. Each polyp has its own shallow "hole" in the communal skeleton into which it retreats during the day or when danger threatens. The polyps can only flatten themselves against their massive skeleton; they cannot withdraw completely into its protection. Theft soft, colorful tissues remain exposed to the elements and to predators.

Although each individual polyp remains small, the colony of budding and dividing polyps steadily increases in size and forms massive coral boulders. These coral boulders, covered with their thin, colorful blanket of living polyps, grow slowly and may require more than a hundred years to reach a diameter of six to nine feet. Coral trees, in which the skeleton becomes a branched or delicately laced structure, grow more rapidly.

Through millennia, the steady accumulation of coral skeletons and the skeletons of other reef creatures builds the massive bulk of the reef. These remains are cemented together by rapidly growing plants, the coralline algae, which secrete a hard, slippery form of calcium carbonate. Together, the assemblage of plants and animals creates the form and structure of the coral city.
And the surface of the city is alive. From the crashing, wave-beaten ocean surface to the quiet fantasyland of the deep reefs, the ramparts are blanketed with the tentacles, traps and snares of an endless variety of creatures that filter floating organisms from the passing seawater. These filter feeders (see "Filter Feeders" by Richard H. Chesher, Oceans, August 1969) are a major regulator in the checks and balances of the reef biomass. Almost all- members of the reef environment reproduce like corals, sending millions of offspring into the ocean currents each year. Only a fraction of the progeny survive the rigors of pelagic life, and the filter feeders of the

reef kill most of these survivors when they attempt to settle out of the plankton. Corals, sponges, clams and sea squirts are only a few of the organisms that not only eat their own species but the young of their reef mates. Without such a balance, catastrophe results.

The coral-eating starfish, *Acanthaster planci*, may represent just such a catastrophe, for the numbers of these animals are now far in excess of the limit which the coral environment can endure. Most large predators find coral unacceptable food. Its thin layer of life is so diffused over the massive, irregular skeleton that it cannot be economically harvested. A few fish, crustaceans and worms nibble at the coral colonies, but only one type of animal efficiently grazes on living coral-the starfish.

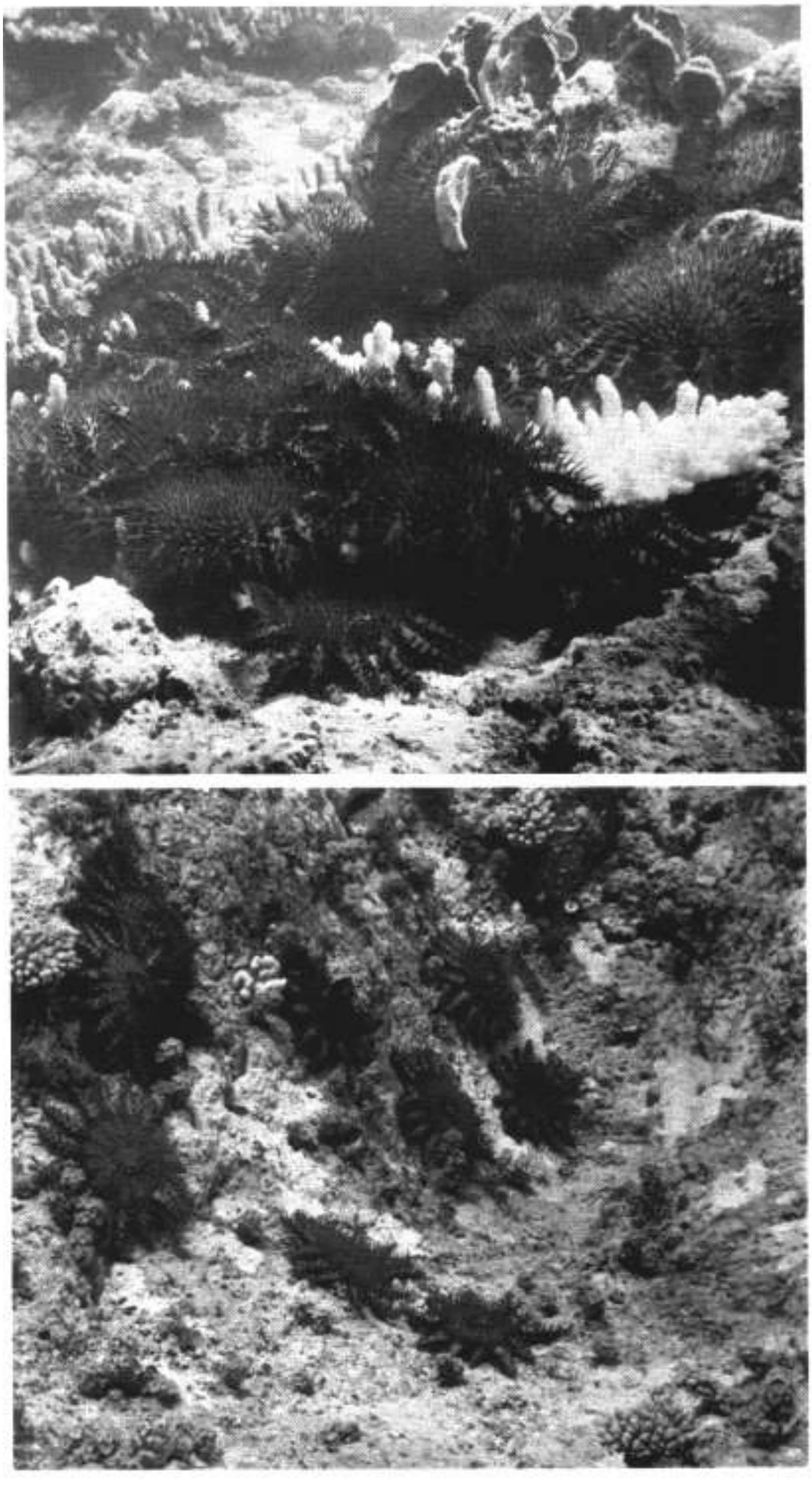
Starfish are the nemesis of coral defenses. While most animals must bring their food to their stomach (and thus find it difficult to attack the massive coral boulders), starfish can bring their stomach to the food. By evening the membranous stomach through their mouth and spreading it over the coral tissue, they can graze on the fields of brightly colored polyps. Digestive juices pour from the stomach tissue and liquify the coral polyps into a greenish slime. When the stomach retracts and the starfish moves on, only the pure white skeleton remains; soon a ragged growth of algae darkens the dead coral. Three starfish are known to feed in this way: the pincushion armless sea star, *Culcita*; the Panama spiny sea star, *Nidorellia*; and the crown-of-thorns sea star, *Acanthaster*.

I first encountered *Acanthaster planci*, the crown-of-thorns starfish, in 1966 when I read accounts of a mysterious population explosion of these creatures on the Great Barrier Reef in Australia. According to the reports, *Acanthaster* exhibited an insatiable appetite for living coral, and had already killed vast acreages of the renowned coral gardens at Green Island. The Australian government had reportedly commissioned a small group to study the problem while residents of Green Island conducted a massive battle to save their reef.

As a specialist in echinoderms, the phylum to which starfish belong, I was interested in the "serious imbalance" on the Australian reef but was certainly not concerned since localized population explosions of echinoderms are common and usually short-lived. The oyster starfish, *Asterias*, is a well-known threat to the oyster fishing industry and its population explosions and declines have been followed for many years.

A coral specialist, Dr. Thomas Goreau, had already reported that *Acanthaster planci* fed on coral and described the mechanisms involved. Although normally a scarce, but interesting, scientific oddity, the crown-of-thorns was well-known to scientists and to native fishermen for many years before the population upset in Australia. *Acanthaster* is covered with long, extremely sharp, poisonous spines and lives in relatively shallow water where people occasionally have accidentally stepped on it. Those speared by the razor-sharp spines have reported pain, swelling, infection, and even nausea and vomiting. Reports of specimens of *Acanthaster* came from the Red -Sea, the Indian Ocean and the Pacific, but not from the Atlantic. Since, in 1966, I was working in the Caribbean, the *Acanthaster* problem seemed a remote but interesting curiosity.

Two years later my preconceptions and lack of concern fell apart as I hovered over the total wreck of what must have been a truly magnificent coral reef. I was on the island of Guam, two thousand miles from the Great Barrier Reef. Countless *Acanthaster* paraded below me, leaving a dark grey-green ruin where once a fifty-million-year-old ecology had thrived.



Sightless Acanthaster use chemical sensors to find coral (top photograph). They can migrate almost a mile per month in areas where coral growth is poor (bottom). Large herds of Acanthaster-normally a rare creature - now swarm over Pacific coral reefs; causes for the bizarre increase in their population are uncertain.

Upon the recommendation of Senator Richard Taitano (who made a series of site inspection dives with me), the Government of Guam commissioned me, as a member of the University of Guam's Department of Marine Studies, to carry out an emergency, six-month research program to study the invasion and attempt to control its spread.

By March of 1969, over ninety percent of the reef was dead along 24 miles of Guam's coastline. Starfish were killing the reef from the intertidal zone to the depth limit of coral at a rate of about one half-mile per month. The Australians reported the invasion was still going strong on the Great Barrier Reef and numerous other areas reported infestations, including Fiji, Saipan, Rota, Palau and Borneo. Obviously, the hope that the population explosion was a short term, localized phenomenon was no longer acceptable.

The more I studied *Acanthaster*, the more concerned I became. When the coral died, a community of algae smothered the skeletons and changed the entire complexion of the reef from a world of pastel colors to a drab, inert graveyard. The myriad reef creatures which had been evolving for millions of years, adapting to the living - coral reef, suddenly faced an alien environment. The most noticeable absentees from the dead reefs were the larger fish. Several hypotheses can explain why the fish and mobile invertebrates vacated the dead reef but, in essence, it was the alteration of the total environment by a change in color and texture that shattered the animal associations. Algae had literally smothered many, of the smaller filter feeders. Feather duster worms, for example, which normally dot the coral heads in shallow water, could not raise their colorful plumes above the encroaching algae to capture food from the ocean currents. The infinite caves and crevices of the reef became clogged and overgrown as algae bloomed everywhere. *Acanthaster* killed the coral and the subsequent imbalance destroyed most of the associated fauna.

Certainly such devastation is dangerous to the whole reef community and, particularly on more remote islands, this community includes man. Islanders obtain almost all of their protein from the sea. Even in technologically advanced areas, where outside protein sources are available, fishing is a valuable tourist resource. Coral gardens themselves are a strong attraction for tourists and are important for local recreation and sports. In addition, coral is instrumental in maintaining reefs which protect the coastline from erosion during storms.

An accurate assessment of the consequences of the massive coral predation by *Acanthaster* is impossible, however, since knowledge of coral reef dynamics is almost negligible. I was, in fact, surprised and distressed when, in the spring of 1969, I began to realize how little was actually known about the delicate ecology that was in danger.

I discovered that the Australian research efforts had come to a temporary halt and I could find no other marine scientists actively working on the problem in the Pacific. And; of course, the spring of 1969 was a financially difficult time for America's research interests. Still, it was clear the problem required the concerted efforts of a number of scientists; therefore, obtaining their interest became the next objective in the *Acanthaster* project.

Unfortunately, I discovered that many scientists were reluctant to accept the evidence and considered the entire incident an isolated, temporary problem of little importance. The leaders in coral reef biology knew otherwise and had, in the fall of 1968, declared the problem of vital importance after witnessing the devastation in Guam and previously on the Great Barrier Reef. Sir C. M. Yonge, Dr. T. F. Goreau, Dr. Siro Kawaguti, The only documented predator of the crown-of-thorns, the triton (top two photographs at right), attacks *Acanthaster* at night. After capturing its prey, the triton throws its heavy shell to one side and flips the helpless victim onto its back to prevent its escape. Shell collectors who have decimated the triton population are one possible reason for the starfish increase.

A skin diver's spear is a simple but effective way of removing *Acanthaster* when they plague underwater parks (right).

Dr. J. W. Wells and others resolved, in the International Biological Program Conference in Palau, to recommend immediate research into the problem. Even so, skepticism was widespread in the minds of those younger scientists who might be able to devote time to laborious research on remote Pacific islands and in the minds of those who controlled the funds necessary for such research.

In May, the difficulties seemed almost impossible to overcome. Reports kept arriving of other islands that were "infested." It was clear from many of the reports that normal populations of starfish were being mistaken for infestations. A few seemed truly abnormal situations, but since most reports came from amateur divers and shell collectors, the true extent of the problem was unknown. A standardized search was needed. Scientists and legislators had to be advised and interested in the need for action. Guam had done what it could to point out the nature of the problem, now it needed help.
With these problems in mind, I approached Westinghouse Ocean Research Laboratory (WORL) for assistance.

After a review of the data, Dr. R. D. Gaul, Director of WORL, responded rapidly and decisively.
In less than a week WORL scientists consulted with other tropical marine specialists, contacted government officials, wrote a proposal, printed and submitted it, and got tentative approval from the Department of the Interior to proceed with the proposed plan. They intended to conduct an expedition lead by competent marine scientists who could survey the reefs of entire islands underwater. The international participants would immediately converge on the United States Trust Territory to establish population levels of *Acanthaster planci* and determine the extent of coral damage. The scientists would gather data on possible causes and controls of infestations in the areas examined and would design a temporary control program if the data warranted action.

Because of the rapidity with which starfish could kill irreplaceable coral reefs, the survey had to take place that same year. The scientists could only participate during summer months when they would be free of university obligations. September in the mid-Pacific is typhoon season. All these factors determined that the survey had to be between July 1 and August 31. On June 6, Under Secretary of the Interior Russell E. Train gave support to the program and appointed H. H. Eckles of the Office of Marine Resources as coordinator.

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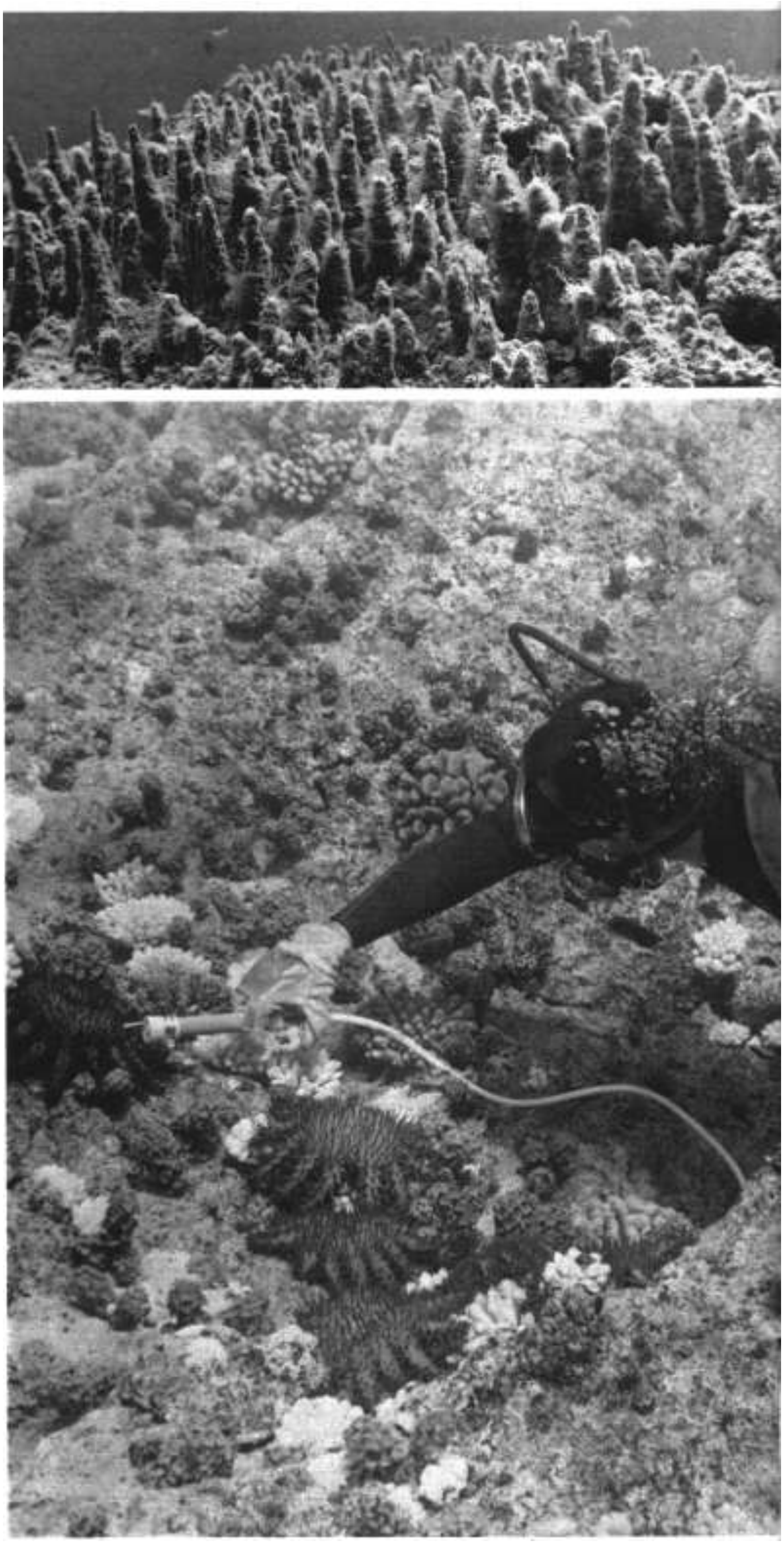
June was a fury of planning, organizing and traveling. The single largest problem was transportation between islands. Some islands, like Kapingamarangi, were hundreds of miles from the nearest airstrip. At the last minute, the U.S. Navy materialized two seaplanes to supplement their own air-sea rescue vehicles and final plans were worked out the night before scientists arrived in Guam on July 1. Researchers came from Australia, England, Jamaica, South America and the large marine research centers of the United States. The University of Hawaii organized a companion effort to survey Central Pacific islands and sent team leaders to Guam to examine the damage there and assess the standardized search techniques that had been set up. The Department of the Interior, the Office of Naval Research, the U.S. Navy and Coast Guard, the Universities of Guam, Hawaii and the West Indies, and the Smithsonian Institution provided financial and logistic support to the Westinghouse survey.

A three to four day orientation period in Guam was arranged for the scientists. They operated in four-man teams and an average of three teams arrived in Guam each week. Following the orientation period where they surveyed the Guam reefs, familiarized themselves with search techniques and observed the starfish, they departed for the islands carrying equipment for life support and diving in remote conditions. Provisions included inflatable boats with outboard motors, scuba tanks and a compressor, charts and data on their destinations, special logbooks, and countless smaller items including a shark gun.

The first team returned to Guam only a few days after the last team left for the islands. As the scientists returned home via Guam, they prepared a report and sat for hours discussing their findings. Suddenly, it was September and three man-years of raw data engulfed my office. In assessing the results, we placed considerable reliance on the subjective impressions related by the scientists during debriefing sessions. The vast majority of the data was easy to interpret. Either the starfish were quite scarce and the reefs normal and healthy or the starfish were present in vast herds which were doing obvious and wholesale damage to the living coral.



Dead, algae-covered coral (left, top) is the ultimate result of an Acanthaster attack. One method of killing the predators is to inject them with formaldehyde (bottom). The diver's syringe automatically refills itself.

Saipan, Rota, Guam, Truk and Ponape all had large herds of Acanthaster obviously damaging the coral. Yap, Ifalik, Woleai, Lamotrek, Mokil and Kwajalein had fewer than twenty starfish per hour of search (the usual number was less than five per hour in such normal conditions). Palau and Arno had large numbers of starfish concentrated in one or more local shallow reef areas. On Nukuoro, Kapingamarangi and Pingelap small herds of Acanthaster had done some limited reef damage. Tinian, Ant and Kuop had been largely denuded of living coral on all except some reefs in very shallow water where wave action had kept the starfish at bay.

By October 15, the data had been completely analyzed and a lengthy report written and dispersed to a review panel of the Department of the Interior. This panel met to discuss the report at the Scripps Institution of Oceanography in La Jolla, California. It recommended that funds be made available as soon as possible for an intensive research program on Acanthaster and its effects on coral reef dynamics and that control measures be initiated on certain islands, where necessary, to prevent the loss of valuable reefs.

Senators Fong, Inouye and Jackson introduced a special bill into the Senate the following month requesting expenditure of monies to be controlled by the Department of the Interior and the Smithsonian Institution in carrying out the recommendations for research and control.

Dr. Robert S. Jones, Director of the University of Guam Starfish Control Project, testified before the Senate Committee on Interior and Insular Affairs on March 18, 1970 that "Today, while this hearing goes on thousands of these starfish are devouring coral species on the island of Guam and our neighbor islands of the Trust Territory." He went on to say that "Time is of the essence when one's most valuable natural resource is literally being eaten alive."

As Senior Scientist with WORL, I testified on the same day that:

"The major facts are undisputed; coral reefs are dying. They are dying rapidly and in many island areas. Coral reefs are valuable. We must find out if we are responsible for this ecological upset. We must determine what will happen if the reefs die. While doing this, we must protect the more valuable coral reefs with a well planned control program.

Meanwhile, the Government of Guam continued its research efforts under the direction of Dr. Jones. The administration of the U.S. Trust Territory of the Pacific provided finances for its fisheries director, Peter Wilson, to carry out emergency control measures until a more comprehensive program could be activated.

Japanese scientists, particularly Dr. Yasuo Suehiro, have begun research projects on the Acanthaster problem. Dr. Suehiro has experimented with an electrical barrier and a copper-ion barrier to halt the migrations of the starfish.

An ad hoc committee of the Australian Academy of Science published a review of the Acanthaster situation on the Great Barrier Reef in February 1970 (Report No. 11, available free from the Academy). The committee's conclusion was the same as that reached by the American ad hoc committee which met at Scripps in October: there is need for a great deal of research and localized control to protect valuable reefs. The Australians stressed the fact that the Great Barrier Reef was not in danger as a geological structure and that the present problem concerns destruction of the living coral mantle. Regeneration of this living mantle may occur but "It was emphasized, however, that there was no evidence that the plague is in any way subsiding and that there is no way of knowing what its ultimate extent might be."

Data accumulated to date seems only to prove that there is, indeed, an infestation and that massive herds of this relentless coral predator are devouring large tracts of valuable Pacific coral reefs. There is not enough data to conclude much more. What has caused the population imbalance? Has man somehow upset the ecology of the remote coral reefs? How long will it take before the reefs reestablish themselves or will they be able to recover at all? What effects does the destruction have on the intricate, interdependent food web of the coral community? How can the starfish be stopped? Can balance be restored to the ecology?

There are many hypotheses to answer each of these, plus a multitude of other related questions. Although a considerable body of circumstantial evidence supports some of these hypotheses, they remain only thoughts to begin developing new lines of research. Those who argue on both sides of such questions as the role of man in the population explosion and the relative damage the starfish might finally cause, agree that there is simply insufficient data. The debates have come to a momentary halt while proponents of various hypotheses and issues seek new facts.

It is a discouraging note that, to date, the pessimistic predictions have been proven the more accurate and, most often, they were not pessimistic enough. Today, the problem is more widespread and serious than the most ambitious alarmists predicted in 1964. The population increase which began in the early sixties has not slowed at all and the amount of reef recovery has been negligible. In addition, the vigorous control measures on Guam seem, at the moment, to be failing.

It is clear that the *Acanthaster* problem is not likely to vanish as quietly or as quickly as it began. It is time for more scientists to take an active interest in this important ecological problem. Time to collect more data and to instigate intensive, broad-based research programs ranging from the biology of coral, *Acanthaster* and *Acanthaster* predators to techniques for improved control measures.
People are urgently needed to investigate the myriad problems. For example, anyone who explores the Pacific underwater world can contribute to defining the present population levels of the starfish. Data on techniques which will make such surveys interrelate with others are presented in my report "°Acanthaster planci; Impact on Pacific Coral Reefs," available from the Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151 ($3:00). Reports can be sent to me at 9879 East Fern Street, Miami, Florida 33157.

Note: The report is also available for download as a PDF file here:

www.**tellusconsultants**.com/Thread/ACANTH.HTM