

UNIVERSITY OF GUAM

THE MARINE LABORATORY

PROCEEDINGS OF THE

UNIVERSITY OF GUAM - TRUST TERRITORY

ACANTHASTER PLANCI (CROWN-OF-THORNS STARFISH) WORKSHOP

MARCH 27-29, 1972

Compiled by

ROY T. TSUDA



AGANA, GUAM 96910 USA

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TECHNICAL REPORT No. 3

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CONTENTS

Program	1
Summaries of Papers Presented	
History and Control Programs of <u>Acanthaster</u> <u>planci</u> in Guam and the Trust Territory....	3
Biology of <u>Acanthaster</u> <u>planci</u>	9
Past and Present Status of <u>Acanthaster</u> <u>planci</u> in Guam and the Trust Territory....	18
Recommendations	30
Participants	35

UNIVERSITY OF GUAM-TRUST TERRITORY

Acanthaster planci (Crown-of-thorns) Workshop

ORGANIZERS: Dr. Roy T. Tsuda, University of Guam
Mr. Peter T. Wilson, Marine Resources, Trust Territory

PLACE: University of Guam (Science Building, Room 101)

DATE: March 27-29, 1972

PURPOSE:

The primary purpose of the Workshop is to provide a common meeting place for individuals who are presently involved with the Acanthaster problem in Guam and the Trust Territory. The approach of this program will be three-fold: 1) to provide information on the present knowledge of the biology of Acanthaster planci, 2) to present a progress report on the present status of the Acanthaster Control and Monitoring Programs, and 3) to formulate constructive recommendations on future action to be taken on the control, monitoring, and research efforts in Micronesia.

PROGRAM

March 27

Morning Session (Dr. Lucius G. Eldredge, Presiding)

9:00-9:10 Welcome
9:10-10:00 History of Acanthaster in Guam and the Trust
Territory by Roy T. Tsuda
10:00-10:30 Acanthaster Control Program in the Trust
Territory by James McVey
10:30-10:45 RECESS
10:45-11:15 Acanthaster Control Program in Guam
by Isaac Ikehara

L U N C H

Afternoon Session (Dr. Daniel P. Cheney, Presiding)

1:30-2:15 Life History of Acanthaster planci
by Masashi Yamaguchi
2:15-3:00 Spawning and Aggregation of Acanthaster planci
by Daniel P. Cheney
3:00-3:15 RECESS
3:15-3:30 Behavioral Orientation of Acanthaster planci
by Daniel L. Rosenberg
3:30-3:45 Fish Populations in "Acanthasterized" Areas, A
Study in Progress by Helen K. Larson
and Robert S. Jones
3:45-4:00 Recolonization of Corals in "Acanthasterized"
Areas by Richard H. Randall (presented by John H.
Rupp)
4:00-4:15 Associates of Acanthaster planci
by Lucius G. Eldredge

March 28

Morning Session (Dr. James A. Marsh, Jr., Presiding)

- 9:00-9:40 Past and Present Status of A. planci in Guam.
by Daniel P. Cheney
- 9:40-10:20 Past and Present Status of A. planci in the
Southern Mariana Islands by James A. Marsh, Jr.
- 10:20-10:35 RECESS
- 10:35-11:15 Past and Present Status of A. planci in the
Marshall Islands by Ben Sablan
- 11:15-11:55 Past and Present Status of A. planci in Yap
by Kuniwo Nakamura

LUNCH

Afternoon Session (Dr. James McVey, Presiding)

- 2:00-2:40 Past and Present Status of A. planci in Palau
by James A. Marsh, Jr.
- 2:40-3:20 1972 Re survey of Ponape for Acanthaster planci
by Richard C. Wass
- 3:20-3:35 RECESS
- 3:35-4:15 Past and Present Status of A. planci in Truk
by Kimiuo Aisek
- 4:15-4:55 Status of A. planci on atolls in the Central
Caroline Islands by Patrick G. Bryan

5:30 P.M. COCKTAIL RECEPTION

March 29

Closed Morning Meeting (Dr. Roy T. Tsuda, Presiding)

- 9:00-11:00 Discussion and Formulation of Recommendations

SUMMARIES

HISTORY AND CONTROL PROGRAMS OF ACANTHASTER PLANCHI

IN GUAM AND THE TRUST TERRITORY

History of Acanthaster in Guam
and the Trust Territory

by

Roy T. Tsuda

The presence of the crown-of-thorns starfish, Acanthaster planci, and its devastating effect on live coral reefs around certain Micronesian islands was first documented by a large-scale survey carried out by the Westinghouse Electric Corporation during the summer of 1969, at an approximate cost of \$225,000 to the Federal Government. Based on the results of this survey, it was recommended that control efforts be initiated around infested islands in hopes of decreasing the Acanthaster populations which posed an immediate threat to living corals.

Prior to the Westinghouse survey, control efforts on the reefs of Guam were well underway by the University of Guam utilizing funds appropriated by the Guam Legislature. The control program was continued after the survey by the Government of Guam's Fish and Wildlife Division until June 1971, after which the University of Guam's Marine Laboratory assumed responsibility so that research and control efforts could be coordinated under one agency.

Beginning in September 1969, the Marine Resources Division of the Trust Territory trained Micronesians in SCUBA diving and from these men formed starfish control teams in the Mariana, Palau, Truk, Ponape, and Marshall Island Districts.

In May 1970, the University of Guam agreed to cooperate with the Trust Territory in providing trained marine biologists to monitor selected islands for further starfish activities and to offer recommendations on the course of action to be taken for each of the islands surveyed. During the period from June 1970 to January 1972, the monitoring teams resurveyed 11 of the 16 Trust Territory islands previously visited by the ten Westinghouse teams. The islands included Rota, Saipan, and Tinian in the Marianas; and Yap, Palau, Truk, Ponape, Ant, Lamotrek, Woleai, and Ifalik in the Carolines. Personnel from the Marine Resources Division of the Trust Territory carried out a resurvey of the two southernmost atolls, Nukuoro and Kapingamarangi. In addition to these 14 islands and atolls, ten additional atolls (Eauripik, Elato, Faralup, Kayangel, Mogami Bank, Olimaro, Pulap, Puluwat, Pulusuk, and Satawal) in the Carolines were surveyed for the first time. In a companion effort, the Marshall Islands were revisited by marine biologists from the University of Hawaii.

Upon the recommendations of the monitoring teams, full-scale control efforts have been suspended in the Mariana District (September, 1970), in the Palau District (July, 1971), and in the Marshall District (January 1972). In addition, control efforts have been initiated in the Yap District. At the present time, full-scale control efforts are also underway in Truk and Ponape, with a limited control program being carried out on Guam.

As of February 1972, approximately 281,000 Acanthaster have been reported killed on the reefs of Guam and the Trust Territory -- 63,000 on Guam, 14,000 in the Mariana District, 16,000 in the Palau District, 5,270 in the Yap District, 113,000 in the Truk District, 69,000 in the Ponape District, and 610 in the Marshall District.

Acanthaster Control Program in the Trust Territory

by

James McVey

The Acanthaster control program in the Trust Territory was initiated late in 1969. Since that time control teams have operated in each of the six districts under the direction of the Marine Resources Division. The Truk, Ponape and Yap control efforts are still operational while Saipan and Palau have been discontinued after 14,000 and 16,000 starfish were killed in the respective programs. Truk and Ponape control programs combined have killed over 180,000 starfish and there are many starfish remaining.

At this time, each control team is equipped with a starfish control boat, SCUBA tanks and compressor as well as the starfish killing apparatus. The number of divers in each team is four and the number of teams per district depends on the degree of starfish infestation.

Acanthaster Control Program in Guam

(September 1969 to June 30, 1971)

by

Isaac I. Michara

Between the inception of Guam's Acanthaster Control Program in early 1969 and the end of June, 1971, a minimal estimate of 62,000 starfish were removed or killed from the reefs of Guam. The 4-man diving team employed by the Division of Fish and Wildlife killed an estimated 44,000 starfish; an additional 6,000 (estimated by R. Domingo, diving team Supervisor) were destroyed by volunteer divers and another 12,000 were killed by the University of Guam team operating prior to the initiation of the control and eradication program by the Division.

Our primary objectives were to keep constant pressure on the "front" areas that were to be located by the University monitoring team and also to keep a constant patrol and kill effort on the populations that were attacking the shallow reef areas inside the surf zone. If the advancing "fronts" could not be stopped, our alternate plan of action was to at least make a strong effort to protect the reef areas south of Tacpi Point and around and inside Merizo Lagoon.

The basic eradication and control work was performed by 4 SCUBA divers hired on a full-time basis specifically to kill starfish. The methods employed were to locate concentrations and to either inject formalin in at least several parts of the body of the animal and to leave the animal to die on the bottom or to physically pick up animals and dispose of them on land. A bounty of 10 cents was also paid for each whole starfish turned in, but the number of starfish turned in for bounty collection was insignificant. Our records show only 629 animals turned in for bounty payments.

During the early phases of the eradication program, although the enthusiasm was high, due to the massive number of starfish that we were faced with, we felt like the proverbial gentleman shoveling sand against the tide. Nevertheless, after 21 months of operation by the Division of Fish and Wildlife team of divers, we feel that our efforts helped in keeping the inner reefs in fairly good condition and that the "fronts" were stopped and that we were able to prevent the type of damage that took place in the heavily infested area extending northward from Tumon Bay to Ritidian Point and around Pati Point to Lefae Point. Judging from our recorded kill data, heavy concentrations were also encountered in the Asan-Piti area, the Sipalao-Agat area and also in the Merizo Lagoon area.

Unfortunately we were not able to get hold of the complete recorded kill data from several groups of volunteer divers that were making pickups and kills at night and during weekends. Before the termination of our eradication and control work, the diving supervisor compiled our recorded kill data by area. The entire coastline was cut up arbitrarily into 16 sections of roughly 5 miles each. The kill data are as shown in Table 1. These are preliminary rather than final figures.

TABLE 1

Crown-Of-Thorn Starfish Kill By Areas

(Guam -- 9/21/69 to 6/30/71)

(From Data Tabulated by R. Domingo)

<u>AREA</u>	<u>LOCATION</u>	<u>No. KILLED</u>
1	Ritidian Point (North) to Pati Point	2,535
2	Pati Point (South) to Janum Point	9,694
3	Luxuna Point to Taguan Point	1
4	Taguan Point (South) to Pago River	107
5	Pago Point to Talofofu Bay	53
6	Talofofu Bay (South) to Agfayan Bay	22
7	Agfayan Point to Mannel Channel	26
8	Merizo Lagoon	4,041
9	Mamaon Channel to Facpi Point	1,021
10	Anae Island to Neye Island	3,228
11	Tipalao Bay to Orote Point	2,065
12	Apra Harbor	176
13	Cabras Island to Asan	13,829
14	Adelupe to Saupon Point	397
15	Ipao to Hilaan Point	4,285
16	Hilaan Point (North) to Ritidian Point (South)	45
	TOTAL	<hr/> 41,525

SUMMARIES
BIOLOGY OF ACANTHASTER PLANCI

Life History of Acanthaster planci

by

Masashi Yamaguchi

The early life history of Acanthaster planci up to the coral-eating juvenile has been studied in the laboratory from eggs and sperm obtained by 1-methyladenine injection. This stage was reached six-months after metamorphosis of the pelagic larvae. The development of the starfish includes the normal life history stages shown by the majority of asteroids - gastrula, bipinnaria, brachiolaria, and metamorphosis.

The period of development varies according to temperature and larvae do not reach the fully developed larval stage, i.e., brachiolaria, at less than 25°C. After three to four weeks in the pelagic stages, the brachiolariae settle specifically on substrata encrusted with coralline algae and other benthic organisms. Metamorphosis takes place two days after settling.

The early juveniles have five arms, each with two pairs of tube feet, one terminal tentacle, and one eyespot. The juveniles feed on encrusting algae mainly coralline algae. Within a four-month period, they grow from .5 mm (just after metamorphosis) to about 8 mm in diameter at which time they begin to feed on coral. After the juveniles are three weeks old, additional arms are added at a definite position every nine to ten days until the total number of arms reaches 16 to 18.

A few juveniles, 60 to 90 mm in diameter, were collected from the field and kept in aquaria. They were fed corals, mostly Pocillopora damicornis, and exhibited linear growth curves. The growth rates of the larger juveniles are 30 to 40 mm per month. Extrapolating beyond the growth data of these, it is estimated that Acanthaster planci could reach a size of 30 cm in diameter within two years.

Spawning and Aggregation of Acanthaster planci

by

Daniel P. Cheney

This investigation summarizes data on the reproductive and migratory behavior of Acanthaster planci in Micronesia. These are believed to be important factors associated with the marked population increases of this predatory coral-eating starfish in the Indo-Pacific. A. planci were sampled from eight locations on the island of Guam (N = 454) from October, 1969, until March, 1972. Additional samples (N = 100) were also collected on the islands of Saipan, Tinian, Aguijan and Ponape (Trust Territory). Data gathered included estimated population density, total diameter, sex, reproductive maturity, and size of gonad.

Some seasonality was observed in gonad indices with ripe large gonads most abundant in the spring and summer. Spawning probably can occur any-time during the year in Micronesia, although it is not necessarily continuous. The estimated spawning times reported in this study and elsewhere suggest a positive correlation with maximum sea water temperatures for the respective areas.

Two behavioral modes, as defined by population density and feeding behavior, are apparent in A. planci. The isolated or dispersed populations exhibit negative phototaxis, highly variable size ranges, and low mean gonad indices. Aggregated populations exhibit no negative phototaxis, uniform size ranges and high mean gonad indices. The movement and mixing of aggregated populations was studied in two marking experiments conducted on the northern coast of Guam. Starfish were marked by trimming spines off two arms, and marked and unmarked animals were counted over a three-month period. Immediately after marking, the marked animals dispersed into deeper water on the submarine terrace; however, within one week, some of the marked A. planci reaggregated, mixing with unmarked aggregates 100 to 200 meters south of the marking area. Following reaggregation, there was a slow southward movement of 100 m per month. Since even small aggregates increase the chance of spawning success, high density populations should be given high priority for control, and the aggregates eliminated.

Behavioral Orientation of Acanthaster planci

by

Daniel L. Rosenberg

Behavioral orientation in Acanthaster planci, has been studied with respect to direction of movement, righting (orientation while turning over from an inverted position), and light.

From these studies it has been found that a high degree ($P \leq .01$) of non-randomness exists during periods of locomotion and righting. Certain rays (arms), are observed to be used as lead rays during such periods. This behavior suggests the existence of a physiological anterior-posterior axis occurring in Acanthaster planci.

Studies on behavior with respect to light have revealed a threshold light intensity necessary to trigger the characteristic photonegative (shade seeking) behavior observed both in the field and laboratory. Furthermore a differential response to selected wavelengths (red, yellow, green, and blue) has also been observed.

From the above studies, it would appear that behavioral orientation in Acanthaster planci, is not random, but predictable.

Fish Populations in "Acanthasterized" Areas,

A Study in Progress

by

Helen K. Larson & Robert S. Jones

Members of the University of Guam Marine Laboratory have been studying the reef environment at the Tanguisson Power Plant for the past two years to determine the effect of thermal effluent on a coral reef. Since the reef had previously been destroyed by Acanthaster, the study was broadened to include the effect of the starfish-killed area on the fish community. The fish study began in January 1971, and thus far no effect of thermal effluent has been observed on the fish populations over the reef edge. Therefore, any fish population changes are attributable to starfish effects.

Coral-dependent fish species obviously must leave a starfish-killed area, while other species (herbivores) may increase. However, no conclusions can yet be drawn because of lack of data from a comparative "non-Acanthasterized" area.

Recolonization of Corals in "Acanthasterized" Areas

by

Richard H. Randall*

The first part of the report is a distributional analysis of living corals at Tumon Bay, Guam, before Acanthaster planci (Linnaeus) predation of the fringing reefs there greatly altered the distribution of corals. The coral community there was composed of 150 species representing 36 genera. A zonal analysis of the corals is given which includes the inner reef flat, outer reef flat, reef margin, reef front, submarine terrace, and seaward slope zones.

The second part of the report describes the distribution of reef corals at Tanguisson Point, Guam, after the fringing reef corals had been subjected to intensive Acanthaster predation. A zonal analysis of the reef corals is given for the same zones that occur at Tumon Bay. The reef community at Tanguisson Point is composed of 96 species represented by 33 genera.

*Presented for Mr. Randall by Mr. John H. Rupp.

Associates of Acanthaster planci

by

L. G. Eldredge

Associates are defined here as any other animal which is associated with A. planci. These include possible predators as well as true commensals. There are at least fifteen species from four phyla which are known to live with A. planci throughout its range. Undoubtedly, there are more. The known records are outlined:

1. Crustaceans

a. Copepods

- (1) Onchopygus impavidus Hume and Crassey--More than 350 copepod specimens were washed from 2 A. planci from Madagascar. The authors write, "The Copepods probably do not seriously interfere with the well-being of the host, though little evidence is available in this regard" (Hume and Crassey, 1958).
- (2) Stellicola acanthasteris Hume--This species was described from A. planci from Eniwetok (Hume, 1970).
- (3) Copepod specimens are commonly seen and collected from A. planci from Guam. They are found crawling on the respiratory papillae on the aboral surface. All specimens are the same color as the host starfish. Identification is not yet verified.

b. Caridean Shrimp

- (1) Hymenocera elegans Keller--Commonly called "painted shrimp," this species is very delicate and unusually colorful. Pairs of shrimp have been observed in aquaria turning A. planci upside down and proceeding to devour it (Wickler and Seibt, 1970). A movie sequence of this was made for the NBC Special "The Great Barrier Reef," however, this has never been observed in the natural environment. This species should be considered rare, for only one possible sighting of this shrimp has been made from among 63,000 starfish killed on Guam. No specimens have been collected in other Micronesian waters.
- (2) Palaemoid shrimp (Periclimenes ?sp.)--There is one (or possibly two) species of a small, less than 1.5 cm, shrimp associated with A. planci on Guam. Specimens walk among spines on the aboral surface.

The more common form has longitudinal markings from the rostrum to the telson. Basically the color of both forms is the same as that of the starfish. It is not known what they eat or anything of their behavior.

2. Polychaet annelid

- a. Hololepidella nigropunctata (Horst)--This species of polychaet is recorded from A. planci from Hawaiian waters. It is known from ophioroids where specimens can be found 60% of the time. (Devaney, 1967).
- b. Specimens of a polychaet, tentatively identified as above, are common on A. planci from Guam. They are found on 10% of the starfish examined. The worm is always on the coral surface, usually under the ambulacral grooves. Specimens have never been observed separate from the host starfish.

3. Molluscs

- a. Charonia tritonis (Linnaeus) (Triton trumpet) [also known as Cyprina tritonis]--This large gastropod is a well known natural predator of A. planci. There have been numerous sightings of C. tritonis feeding on A. planci. Overfishing for this gastropod has been advanced as one of the theories for the population explosion.
- b. Cassis cornuta (Linnaeus) (Helmet Shell)--This species of gastropod has also been seen feeding on A. planci in the natural environment.

4. Fishes

- a. Siphania--Investigations are currently underway on the association of this apogonid fish and A. planci (Allen, pers. comm.). Members of this genus are known to be associated with other echinoderms.
- b. Balistidae (Trigger fish)--In the Solomon Islands a fish called "balubalu" has been seen to turn A. planci over and eat it from the underside (Gainer, 1971). Randall (pers. comm.) indicates this is probably a trigger fish.
- c. Pseudobalistes flavimarginatus (Ruppell) (Green Trigger Fish)--In Fiji the stomach contents of two of thirty fish netted on the reef contained spines of A. planci (Owen, 1971).
- d. Cheilinus undulatus Ruppell (Double-Headed Maori Wrasse)--Spines of A. planci have been found in the stomach of this fish. Research is currently underway in Palau.

- e. Carapus murlani (Petit) (Pearl Fish)---Two specimens of this fish have been collected from A. planci from Guam. This fish is usually associated with Culcita on Guam.
- f. Encheliophis gracilis (Bleeker). One small specimen of this pearl fish was found with A. planci. To date it has been known only from reef holothuroids on Guam. (Cheney, pers. comm.).
- g. Pipefish--Unidentified specimens of pipefish have been seen each in a vertical position with their snout among the spines. It is thought that the fish may be feeding on the associated copepods. (Rosenberg, pers. comm.).

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23

24

25

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27

28

29

30

SUMMARIES

PAST AND PRESENT STATUS OF ACANTHASTER PLANCI

IN GUAM AND THE TRUST TERRITORY

31

32

33

34

35

36

Past and Present Status of Acanthaster planci in Guam

by

Daniel P. Cheney

An increase in Acanthaster planci and its devastating effect on live coral reefs around Guam was first documented by Chesher in 1969. Based on the results of surveys conducted around Guam, it was recommended that control efforts be initiated to decrease the starfish population. Control was initiated early in 1969 by the University of Guam and transferred to the Division of Fish and Wildlife in September 1969. Up until June 1971, 62,000 starfish were killed either by formalin injection or removal from the reef. An additional 1000 starfish were killed from December 1971 to March 1972 by the University of Guam control team reestablished in November 1971 to replace Fish and Wildlife control.

Starfish resurveys of Guam were conducted in 1970, 1971 and early 1972. They reveal a general stabilizing trend in the numbers of Acanthaster, apparently the result of the massive control effort of 1969-70; however, starfish were observed to be moving further south on the windward coast. The present control program is being supported by a vigorous surveillance program and integrated into ongoing University of Guam research studies in an effort to maximize coordination between control and research.

We have recommended a reduction in control effort for Guam with emphasis on existing aggregations and inshore reefs, but it is too early yet to predict the eventual fate of Acanthaster.

Past and Present Status of Acanthaster planci
in the Southern Mariana Islands

by

James A. Marsh, Jr.

Populations of Acanthaster have been surveyed three times in Saipan and Tinian and twice in Rota and Aguijan. Saipan, Tinian, and Rota had large aggregations of starfish at the time of the Westinghouse survey in the summer of 1969. Aguijan was not surveyed at that time but was found to have aggregations in August, 1970. Populations of Acanthaster had declined greatly in Saipan, Tinian, and Rota in 1970. Saipan and Tinian had a further decline to normal levels from 1970 to 1971. Aguijan had a decline to almost no starfish between August, 1970, and October, 1971.

The Saipan control team was active on all four islands for approximately one year, terminating activities near the end of 1970. As of October, 1970, approximately 20 to 26 thousand Acanthaster had been killed in the southern Mariana Islands (excluding Guam), according to estimates of the control team and Mr. Milton McDonald. However, this may be an inflated estimate, since it is possible to account for no more than half this number of starfish in the daily records of the control team.

Bounty systems on Saipan, Tinian, and Rota were not very effective in terms of the numbers of starfish killed.

The reefs of all four islands suffered extensive damage, but there are still predominantly live areas on all except Aguijan.

It appears that the numbers of Acanthaster in the southern Mariana Islands peaked before or during 1969, with the likely exception of Aguijan. Starfish populations in Saipan, Tinian, and Aguijan are presently within normal limits. The situation for Rota is unclear, since it was last surveyed in October, 1970. Control efforts are not needed in the southern Mariana Islands at the present time.

Past and Present Status of Acanthaster planci
in the Marshall Islands

by

Ben Sablan

Investigators from University of Hawaii visited Majuro and Arno Atolls in the Marshalls in the Summers of 1969 and 1971 (June). On both trips, Kwajalein Atoll was visited and in 1971 Namorik Atoll was also examined. The objective of the first trip was to gain an understanding of the distribution of Acanthaster planci on selected atolls; the second trip, two years later, was primarily concerned with evaluating the changes associated with the coral eating starfish.

According to Dr. Joseph Branham, the general distribution on Majuro had not changed in the two years since their last survey. The densest aggregation remained on the patch reef just west of North West Passage near Eroj Island. The greatest population density estimated by the transect method, in which I participated, on the lee side of the reef, was approximately one starfish for each 45 square meters of reef in the affected area. Estimated total population in the area was about 300 animals, slightly less than the 1969 estimate. The estimated figure in 1969 was about 400. Dr. J. Branham's report indicated the total diameter of the starfish averaged 3 1/4 cm. It was noted that in the first survey no measurements were made. Comparisons of photographs taken in 1969 with those made during 1971 indicated that the animals were perhaps 5 cm larger in 1971. Dr. Branham reported in 1969 that the starfish were feeding predominantly on table Acropora on the steep lee slope of the reef. In 1971 this slope consisted mainly of dead coral (all species) and the starfish were more abundant on top of the reef on table Acropora in about two meters of water. None of the animals collected in the day-time were actively feeding. All were sexually mature and the gonads contained an abundance of gametes.

Areas previously infested on Arno Atoll ~~was~~ examined. According to Dr. Branham's report, the area east of the pass where Acanthaster were abundant in 1969 showed little effect from the starfish. Most of the corals were alive.

The dead patch reef near Dodo passage was examined for coral recovery. A reliable source from Majuro Atoll reported having seen this same area infested by Acanthaster in July 1968. The same area in 1969 appeared mostly dead and had a small population of large A. planci. No starfish were found on the same area and the reef was still dead in 1971. A closer examination was made by placing a square meter frame on the reef in various places and determining in detail the species and size of living coral colonies. Personal communication with Dr. Branham indicated that the area seemed to have a good chance of recovery.

Areas of dead coral probably killed by Acanthaster are in the vicinity of Dodo and Tagelib passage on Arno. Pinnacles and patch reef examined near Arno Anchorage on the leeward side of the atoll were dead.

Kwajalein was not re-examined in 1971. Verbal communication between myself and Dr. Branham and the Kwajalein divers on the location where starfish have been observed since 1969 indicate that the starfish have not moved nor increased in population.

Namorik Atoll was chosen for observation because of its small size and enclosed lagoon with no deep passes. Isolated Acanthaster were found on various patch reefs and pinnacles on the main reef, but aggregations were absent. These isolated starfish were actively feeding during the day.

Monthly Kill Records

<u>Date</u>	<u>Number of Acanthaster Killed</u>
Feb. 1971	73
Mar.	67
Apr.	53
May	64
June	40
July	143
Aug.	58
Sept.	84
Oct.	0
Nov.	38
Dec.	0
Jan. 1972	(Control Program Suspended) _____
	TOTAL 610

Past and Present Status of Acanthaster planci

in Yap

by

Kuniwo Nakamura*

The Westinghouse survey in the summer of 1969 reported Yap to possess live coral reefs which were essentially free of Acanthaster planci, thus indicating no control program needed in this area. In November and December, 1970, the University of Guam's monitoring team resurveyed Yap and reported small populations of A. planci in two areas outside the barrier reef.

Upon this finding, two divers were hired in May 1971 to rid these two areas of the starfish. By July 1971, a full-scale control team consisting of four divers were actively at work on both the inner and outer reefs. From May, 1971, to February, 1972, a total of 5,270 Acanthaster were hand-collected from the reefs of Yap. Based on the number of starfish collected each month and the man-hours involved, it was estimated that the cost per starfish on Yap was 38¢ from May to June 1971, with the cost slightly increasing to 45¢ per starfish from July 1971 to February 1972.

Although the number of Acanthaster killed on Yap is rather low, control efforts should be continued to preserve the luxuriant coral growths on Yap. The plan is to initiate control efforts in Ulithi within a few months, as soon as the number of Acanthaster is reduced in Yap.

*As summarized by R. T. Tsuda from Mr. Nakamura's presentation.

Past and Present Status of Acanthaster planci

in Palau

by

James A. Marsh, Jr.

The original survey of Palau in April, 1969, revealed four large populations of Acanthaster concentrated in localized areas; hence, Palau was considered "infested" in the Westinghouse report. A resurvey in January, 1971, indicated that only one area (the Seventy Islands) of the original four still had abnormally high concentrations of starfish. This resurvey further indicated that there had been an overall decline in starfish numbers even though there were scattered areas with abnormal counts of white spots (presumed to be Acanthaster feeding sites). Another resurvey completed in January, 1972, indicated very little change in Acanthaster populations during the preceding year.

Kill records for Palau indicate a total of 14,591 Acanthaster killed from March, 1969, through December, 1970. An additional 1191 animals were killed during the first three months of 1971. No records are available for the remainder of 1971, but the control program apparently terminated in July of that year.

Reef damage in Palau has been confined to localized areas, and the reefs are very healthy overall.

Acanthaster infestation has apparently been continuous in the Seventy Islands since April, 1969, despite control efforts in that area. Coral damage has been severe, with the area appearing mostly dead; but approximately 150 starfish were still found there in January, 1972. This is the only area in Palau where control measures would presently be worthwhile.

1972 Re-survey of Ponape for Acanthaster planci

by

Richard C. Wass

The 1972 Ponape Acanthaster survey was made during 8 days between February 24 and March 21. It covered the inner and outer portions of the barrier reef and some patch and fringing reefs inside the lagoon. The Ponape Starfish Control Team led by Victor Edwin carried out the survey with help from Ben Sablan (Starfish Control Team Leader from the Marshall Islands District) and direction from Dr. Richard Wass, Fisheries Specialist, Ponape District.

Two observers were towed behind or alongside the boat at 117 stations around Ponape. A total of 353 Acanthaster were counted for an average of 3.0/tow; 1792 white patches (possible feeding sites) were counted for an average of 15.3/tow. An average of 46.4% of the hard substrate was estimated to be covered with live coral. Forty-two areas could be termed "infested" (more than 10 starfish plus white patches per tow).

Two areas, heavily infested with Acanthaster, were found at opposite sides of the island. The largest concentration was located on and inside the barrier reef and on patch reefs in the lagoon off the SW corner of Ponape. At 6 stations counts ranged between 22 and 31 starfish per tow.

Another major concentration was located outside the NE (windward) barrier reef. Again, the concentration was not extremely dense. Counts of 32 and 17 Acanthaster were made at the two most heavily infested stations. This population was scattered over a broader area than the one off the leeward side.

A third, relatively minor, concentration was found inside and outside the reef in the vicinity of the entrance to Kolonia Harbor. Acanthaster were also found in low numbers at most of the stations inside the reef.

A total of 68,793 Acanthaster has been killed since the Ponape control team was organized on September 9, 1970. (Monthly totals are appended). Approximately 39,000 of these were killed subsequent to the starfish survey by the University of Guam team (April, 1971). The recent survey, however, indicates that the density and locations of major concentrations have remained virtually unchanged during the past 11 months.

Monthly Kill Records

<u>Months</u>	<u>Number of Acanthaster Killed</u>
Sept. 1970	6,165
Oct.	6,395
Nov.	6,453
Dec.	1,398
Jan. 1971	2,285
Feb.	2,463
Mar.	4,300
April	3,622
May	2,682
June	4,314
July	4,758
Aug.	3,604
Sept.	2,508
Oct.	1,863
Nov.	4,783
Dec.	4,074
Jan. 1972	4,792
Feb.	<u>2,334</u>
	TOTAL
	68,793

Past and Present Status of Acanthaster planci

in Truk

by

Kimiuo Aisek

Truk Lagoon (40 miles in diameter and 125 miles in circumference) is considered the largest atoll in the Trust Territory. The Acanthaster control program began on Truk in June 1970, eight months after the Westinghouse survey reported large infestations of Acanthaster in several areas of the lagoon.

During the period from June 1970 to June 1971, a total of 70,836 starfish were killed. An additional 42,814 Acanthaster were reported killed from July, 1971 to February, 1972. At present, the starfish on 50% of the barrier reef and seaward reef terraces have been killed. Brief surveys indicate a similar number of starfish existing on the remaining reef areas as well as a partial reinfestation in those areas already covered.

One of the significant points of this program is the presence of large schools of fishes returning to the areas which have been cleared of Acanthaster. Even the local fishermen have informed us of their abundant catches in those areas cleared of starfish.

The foremost problem among the divers is the fear of sharks which are abundant in the lagoon and seaward terraces. In fact, one of the divers was attacked by a shark in the early part of 1971, and it required two weeks for his wounds to heal. In addition, the urgent need for star-guns and outboard motors (40 HP) should be considered as a primary factor in bringing this control program to its fullest potential.

Some magistrates, legislators and chiefs from the various islands comprising the Truk District have been complaining that the control program is presently restricted to the District Center. The people from the Halls, Mortlock and the western islands claim that Acanthaster inhabit their islands and have been clamoring for our services for a long time. I suggest that surveys and control efforts, when needed, be made on these islands. A second resurvey of the Truk Lagoon should be made soon to assess the Acanthaster populations and their resultant damage to the coral reefs.

Acanthaster Killed at Truk*

June 15, 1970 - Feb. 28, 1972

<u>Month</u>	<u>Total from Monthly Reports</u>	<u>Total obtained by Adding up Daily Reports</u>
1970:		
June	No total	1,241
July	10,109	10,109
Aug.	13,490	13,490
Sept.	4,149	2,773
Oct.	4,086	3,821
Nov.	5,683	3,963
Dec.	No total	2,077
1971:		
Jan.	7,367	5,240
Feb.	11,131	9,446
Mar.	5,611	7,202
April	3,417	2,166
May	6,268	6,606
June	5,992	2,702
July	4,452	4,274
Aug.	4,609	6,194
Sept.	9,537	4,875
Oct.	11,704	11,704
Nov.	No total	6,726
Dec.	No total	2,781
1972:		
Jan.	1,816	1,816
Feb.	4,444	4,444
		<hr/> 113,650

*As compiled by Dr. Gerald R. Allen.

Status of Acanthaster planci on Atolls
in the Central Caroline Islands

by

Patrick G. Bryan

An Acanthaster planci survey extending through the Central Caroline Islands and including Pulap, Puluwat, Pulusuk, Satawal, Lamotrek, Elato, Olimarao, Eauripik, Woleai, Ifalik, Faraulep, and Mogami Bank was made by two members of the University of Guam's Acanthaster monitoring team during May, 1971. The survey was accomplished by utilizing a light inflatable boat (Zodiac) with an outboard engine, operating off the stern of the Navy vessel USS WANDANK during a cruise through the islands. Stations were made by towing, and starfish and feeding-site counts were made according to the standards set by the 1969 Westinghouse surveys. The three atolls surveyed in 1969 (Lamotrek, Woleai, and Ifalik) were found to be essentially the same except that a small population of starfish was found on Lamotrek which had not been recorded in 1969. Several unaccountable areas resembling alluvial fans were observed along the lagoon side of Lamotrek. Of the other islands, Pulap and Eauripik had signs of small Acanthaster populations. Pulusuk and Faraulep appeared to be threatened by larger masses of Acanthaster. Sharks were common throughout the survey. Sharks encountered on Elato, Olimarao, and Mogami Bank were intolerably aggressive. Mogami Bank is essentially barren flat pavement with less than one percent coral coverage.

RECOMMENDATIONS

Recommendations agreed upon by the participants of the Workshop fell within seven general categories - 1) islands and atolls where control efforts should be continued, 2) islands and atolls which should be monitored, 3) research efforts, 4) handling of daily record sheets, 5) maintenance of equipment and safety precautions, 6) letters of appreciation to organizations which have aided the Acanthaster programs, and 7) future meetings between Guam and Trust Territory personnel.

1. Control Program

It was reemphasized that the main purpose of the control program is to eliminate those aggregates of Acanthaster which pose an immediate threat to living corals, not merely to kill starfish in a random manner or attempt to eliminate every single starfish from the reefs.

As of this date, large numbers of Acanthaster are only present in the Truk and Ponape Districts. Thus far, a total of 281,000 Acanthaster have been reported killed throughout Guam and the Trust Territory. We cannot help but assume that the elimination of this many starfish has prevented some of the reef corals from being killed. The recommendations for the control program are as follows.

- a. Truk - The two teams of eight divers should continue to kill the starfish by injecting them in deeper waters and collecting them in shallower waters, until such time as a monitoring team comprised of marine biologists can resurvey the area and assess the need for further control measures.
- b. Ponape - The two teams of seven divers should continue the program similar to Truk. Dr. Richard C. Wass, the fisheries specialists residing on Ponape, has agreed to be responsible for the control program and can best judge when the starfish situation is under control.
- c. Yap and Ulithi - The one team of four divers will continue to collect the starfish in infested areas. We were assured by Mr. Kuniwo Nakamura, Economic Development Officer for Yap District, that his control program on Yap will soon cease, at which time a team of divers will be organized on Ulithi to initiate control measures there. An additional six-month period was cited by Mr. Nakamura as sufficient time to carry out his control program in this district.
- d. Palau - Although the control team has been terminated in Palau, periodic collecting of starfish in the Seventy Islands, a conservation area, will be continued by regular fisheries personnel. Dr. James McVey assured us that he will be responsible for this phase.
- e. Guam - Under the direction of Dr. Daniel P. Cheney of the Marine Laboratory, selective control measures will be continued on the aggregation of Acanthaster at Catalina Point to prevent a southern migration along the windward side of Guam. In addition, periodic control measures will be continued in the inshore areas of Piti and Tumon.

2. Monitoring Program

For the past two years, the University of Guam Marine Laboratory has assumed the enormous task of monitoring various islands in the Trust Territory for starfish activity. These personnel have already covered 22 islands and atolls in the Trust Territory. Needless to say, it is impossible for one organization to cover every single island which requests such a survey. However, these islands outside the district centers which claim to possess abnormal populations of Acanthaster should be visited by Trust Territory personnel as soon as possible.

Thus far, the islands of Kusiae in the Ponape District and the Halls and Mortlocks in the Truk District have requested surveys. In addition, Ujelang in the Marshall District and Pulusuk in the Truk District which are known to possess abnormal populations of Acanthaster should be revisited.

The participants recommend the following surveys be initiated as soon as possible.

- a. Kusiae - One of the two Ponape control teams should be sent immediately to Kusiae to carry out a survey and initiate control measures as needed. Dr. Richard C. Wass or his designate will serve as team leader.
- b. Mortlocks, Halls, Pulusuk - One of the two Truk control teams should be sent to these islands to check the reports of abnormal populations of Acanthaster and initiate control efforts if necessary. Mr. Kimiwo Aisek agreed to lead the team to these islands.
- c. Ujelang - A team from Ponape should be dispatched to this atoll and carry out control measures as needed. Mr. Ben Sablan agreed to serve as team leader.

We emphasize that a responsible person must lead each of these trips to the outer islands to avoid incidents which have occurred in the past, e.g., Palau. In this case, the now defunct Palau team spent about a month's period supposedly killing starfish in the small atoll of Kayangel. However, examination of the kill records revealed that no starfish were ever killed there. The absence of Acanthaster from this atoll was also verified by the University of Guam monitoring team.

It is imperative that governmental officials allow the Captains of the field trip vessels to cooperate fully with the divers, especially in terms of providing sufficient time for the divers to carry out their objectives. The logistics can be worked out between the Captain of the vessel and the team leader.

3. Research Program

Although marine biologists from the University of Guam Marine Laboratory have devoted considerable time and effort to seeking further knowledge of the biology of Acanthaster planci, there is much more information that must be sought. There is still much disagreement among biologists

on the actual long-term impact of Acanthaster on coral reefs, e.g., how quickly the corals will regenerate and how the fish population will be affected. These will remain merely academic questions unless further studies and long-term observations are continued in a coordinated manner. The participants of the workshop urge biologists to seek fundings to continue their research efforts on this controversial organism.

4. Record Keeping

One of the major topics that kept surfacing throughout the workshop was the poor handling of the daily kill records. We have stated previously that approximately 281,000 Acanthaster have been reported killed throughout Guam and the Trust Territory. However, this figure may be considerably inflated as brought out by several participants during the workshop.

Examples of the inflated nature of the actual numbers of starfish killed can be seen for Saipan and Truk. The University of Guam monitoring team can account for only 12,000 Acanthaster killed on Saipan as opposed to the figure of 20,000 usually cited for this island. Likewise, the figure of 113,000 Acanthaster killed on Truk is also questionable. Dr. Gerald R. Allen, a fisheries specialist for the Trust Territory who has since resigned, accompanied the Truk starfish team on its daily patrol on February 3, 1972. In a short summary of his experience on this one day, he writes,

"I counted a total of 39 killed by a man I accompanied on one dive. Upon surfacing this person reported a kill of 76 starfish. The numbers that are turned in on the reports are probably indicative to a certain extent of the actual population, but may be inflated by as much as 20-50%."

The importance of keeping accurate records is imperative since the number of starfish killed provides indication of where Acanthaster is abundant and also approximates the population size remaining on the islands or atolls.

It was recommended that the responsibility of keeping accurate records should fall on the control team leaders, who should in turn be provided extra compensation for this service. The leaders should be certain that each of the divers can count accurately and also instill in the divers an appreciation of the primary goal of the control program. The question of whether or not the divers can count accurately may seem insulting, but the participants believe that this may be the major reason for the inflated kill numbers.

The fate of those copies of the kill records which have been sent to the Marine Resources Division Headquarters was also brought up. At present, no one has the responsibility of reviewing these records which contain a wealth of information on the location and approximate number of Acanthaster on the various islands. Dr. Daniel P. Cheney of the University of Guam Marine Laboratory will make arrangements with Mr. Peter T. Wilson to receive copies of past and future kill records so that a thorough analysis can be carried out.

5. Maintenance of Equipment and Safety Precautions

The maintenance of equipment, especially outboard motors, is an important factor in the effectiveness of the control program. We all understand the difficulties encountered in obtaining parts and finding competent personnel to repair the motors. All we can recommend is for each team leader to manage the best he can under the present situation.

However, new motors should be purchased to replace old ones that have outlived their services. Administrators must realize that these motors are used approximately 160 hours a month and the life-span of these motors cannot be compared with those used by the average weekend fisherman.

The purchase of new starfish guns should be authorized immediately for both Truk and Ponape. Wet suits should also be issued to all divers on Ponape and Truk for protection against weather and other hazards. This may seem like a luxury item to the laymen and even to administrators, but the experience of shivering in an open boat during a cloudburst cuts down on the efficiency of the control operation, particularly if this continues all day.

6. Letter of Appreciation

All of the participants highly recommend that letters of appreciation be sent to the United States Coast Guard and to the United States Navy for their help in the starfish program in the Trust Territory.

7. Follow-Up Meeting

There was a suggestion that a follow-up meeting on the Acanthaster situation be held at the University of Guam in May, 1973, during the Pacific Science Inter-Congress.

PARTICIPANTS

Participants

- Aisek, Mr. Kimiuo, Team Leader, Acanthaster Control Team, Truk District, Marine Resources Division, Trust Territory.
- Bryan, Mr. Patrick G., Graduate Student, Marine Laboratory, University of Guam.
- Callaghan, Mr. Paul N., Associate Dean, School of Business Administration, University of Guam.
- Cheney, Dr. Daniel P., Assistant Professor, Marine Laboratory, University of Guam.
- Edmond, Legislator Ioanis, Chairman, Resources and Development Committee, Ponape District Legislature, Trust Territory.
- Edwin, Mr. Victor, Starfish Leader, Acanthaster Control Team, Ponape District, Marine Resources Division, Trust Territory.
- Eldredge, Dr. Lucius G., Director, Marine Laboratory, University of Guam.
- Ikehara, Mr. Isaac, Chief, Fish and Wildlife Division, Government of Guam.
- Larson, Mrs. Helen K., Graduate Student, Marine Laboratory, University of Guam.
- Marsh, Dr. James A. Jr., Assistant Professor, Marine Laboratory, University of Guam.
- McVey, Dr. James, Fisheries Specialist, Palau District, Marine Resources Division, Trust Territory.
- Nakamura, Mr. Kuniwo, Economic Development Officer, Yap District, Trust Territory.
- Rosenberg, Mr. Daniel L., Graduate Student, Marine Laboratory, University of Guam.
- Rupp, Mr. John H., Graduate Student, Marine Laboratory, University of Guam.
- Sablan, Mr. Ben, Team Leader, Acanthaster Control Team, Marshall Islands, Marine Resources Division, Trust Territory.
- Santos, Legislator Lutik, Chairman, Ways and Means Committee, Ponape District Legislature, Trust Territory.
- Tsuda, Dr. Roy T., Associate Professor, Marine Laboratory, University of Guam.
- Wass, Dr. Richard C., Fisheries Specialist, Ponape District, Marine Resources Division, Trust Territory.
- Yamaguchi, Dr. Masashi, Visiting Scientist, Marine Laboratory, University of Guam.
- Zachary, Mr. Wyman X., Director, Resources and Development, Trust Territory.