UNIVERSITY OF GUAM

THE MARINE LABORATORY

TR 2

Tech Rept #2

STATUS OF ACANTHASTER PLANCI AND CORAL REEFS

IN THE MARIANA AND CAROLINE ISLANDS,

JUNE 1970 TO MAY 1971

Compiled by

ROY T. TSUDA

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AGANA, GUAM 96910 USA

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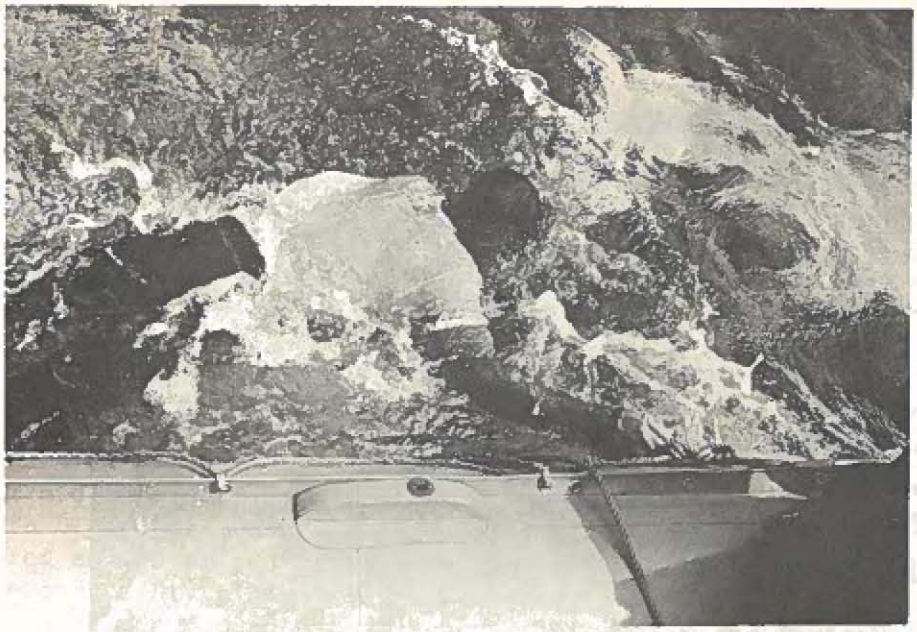
TECHNICAL REPORT No. 2

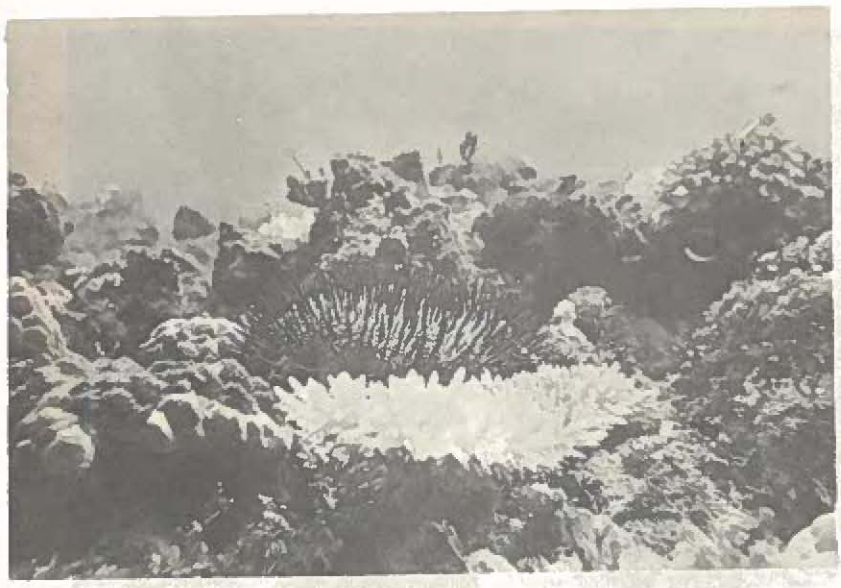
October, 1971



Monitoring team at work (Photo by M. R. Struck)

Herd of Acanthaster planci (Photo by P. G. Bryan)

Acanthaster planci feeding on *Porites* (Photo by P. G. Bryan)



White skeletal remains of *Acropora* (Photo by P. G. Bryan)

Preface

The presence of the crown-of-thorns starfish, Acanthaster planci Linnaeus, and its devastating effect on live coral reefs around certain Micronesian islands was first documented by a large-scale survey carried out by 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.

Prior to the Westinghouse survey, control efforts on the reefs of Guam were well underway under the direction of Dr. Richard H. Chesher utilizing funds appropriated by the Guam Legislature. The program was continued, after his departure from Guam, by the Government of Guam's Fish and Wildlife Division. On September 15, 1969, Mr. Milton L. McDonald was hired as a starfish control specialist by the Trust Territory's Marine Resources Division. He trained Micronesians in SCUBA diving and from these men formed starfish control teams in the Mariana, Palau, Truk, Ponape, and Marshall Island Districts of the Trust Territory. The Yap District was not included because of the clean bill of health given it by the Westinghouse report.

On May 30, 1970, a meeting of persons interested in the Acanthaster problem in Micronesia was held at the University of Guam. The participants were: Dr. Richard H. Chesher, Westinghouse Ocean Research Laboratory; Mr. Peter T. Wilson, Chief, Marine Resources Division, and Mr. Milton L. McDonald, Starfish Control Specialist, Trust Territory of the Pacific Islands; and Drs. Robert S. Jones, Daniel P. Cheney, and Roy T. Tsuda, University of Guam Marine Laboratory. The primary objective of this meeting was to discuss a continuous Acanthaster monitoring program for Guam and the Trust Territory. A preliminary monitoring program was designed that would provide trained marine biologists to monitor selected islands for further starfish activities.

The program would take a fourfold approach: 1) to delimit population levels and general movement of the starfish in newly infested areas, 2) to locate any additional reef damage incurred since the Summer 1969 Westinghouse Acanthaster survey, 3) to assess the control teams' efforts in each district, and 4) to observe any recolonization of corals in previously killed areas. A continual surveillance program by competent marine biologists would also provide valuable information on population dynamics and spawning cycles of the starfish, as well as other observations of biological significance, e.g., potential fisheries, pollution, or general abuse such as overfishing, dynamiting, or fish poisoning. The Marine Resources Division of the Trust Territory offered to furnish travel, per diem, and logistic support; the University of Guam would provide the expertise.

During the period from June 1970 to May 1971, the University of Guam's monitoring team resurveyed the islands of Guam and 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, one other high island (Aguijan) in the Marianas and ten other atolls (Eauripik, Elato, Faralup, Kayangel, Mogami Bank, Olimaro, Pulap, Puluwat, Pulusuk, and Satawal) in the Carolines were surveyed for the first time.

The cost of the monitoring trips to the Trust Territory was approximately $8000 (air fare, per diem, gasoline, and oil), while the cost to the University of Guam was approximately $10,000 in salaries. The amount spent by the Trust Territory was substantially reduced because of the cooperation of the United States Coast Guard and United States Navy in transporting the investigators and their equipment to certain of the islands.

Our studies reveal that an overall decrease in both Acanthaster and coral damage have occurred on those previously infested islands where full-time divers are actively engaged in killing the starfish. Approximately 200,000 Acanthaster have been killed throughout Micronesia. There has been no clear-cut pattern in the distribution of this starfish in the Micronesian area. The only trend seen, thus far, is that the atolls do not have as large a population of Acanthaster and reef damage as the larger more populated high islands. One might expect that the reefs of these atolls, which are smaller in size, would be completely devastated by now. At present, the islands of Truk and Ponape are the most infested of all the islands visited. During recent months, increased number of starfish have been reported by the local people from Ulithi, Yap, and Kusaie. A better method for killing starfish than the formaldehyde guns must be sought, since juvenile starfish may soon be appearing on the reefs of the Trust Territory islands. This has already occurred on Guam.

The ten original reports, which have been written and distributed as separates to governmental officials on Guam and the Trust Territory, are compiled here under one cover. The original pagination within each report has been retained on the upper corners but a consecutive numbering system has been added at the bottom of each page for easier retrieval of individual reports. It is our sincere hope that the combined reports will serve as a reference source which may prove of value to biologists studying the crown-of-thorns starfish and to other investigators who are merely interested in the present status of the coral reefs, i.e., dead versus live reefs, on a particular island or atoll. The reports have already provided a basis to those responsible officials of each district on the course of action that should be taken to preserve their reefs.

The Acanthaster monitoring program conducted by the University of Guam Marine Laboratory would never have materialized without the cooperation of the Trust Territory's Marine Resources Division, Government of Guam's Fish and Wildlife Division, Trust Territory's Liaison Office, United States Coast Guard, United States Navy, and the numerous individuals who aided us on each island. Special acknowledgement is given to Mr. Peter T. Wilson who had the foresight of visualizing the

value of these resurveys.

Roy T. Tsuda

Principal Investigator
Acanthaster Monitoring Program in Micronesia

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ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Truk Lagoon

Truk District
September, 1970

Submitted to

Marine Resources Division

Trust Territory of the Pacific Islands

Prepared by:

R. S. Jones
R. T. Tsuda
M. R. Struck

Marine Laboratory
University of Guam
Agana, Guam

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I. INTRODUCTION

A. Background

Due to reports of widespread coral destruction in Micronesia and other areas of the Pacific by the crown-of-thorns starfish, Acanthaster planci (Linnaeus), an expedition was mounted by the Westinghouse Ocean Research Laboratory to survey coral reefs in Micronesia. Ten teams of scientists surveyed 16 islands in Micronesia to ascertain population levels of A. planci and the extent of coral damage. The final report of the survey was drafted by Chief Scientist Richard Chesher of Westinghouse in October 1969.

The survey provided the scientific community and concerned administrators with a general picture of the extent of the starfish infestation as of the summer of 1969 and, in so doing, established a baseline against which future surveys might be compared.

B. Objectives

A meeting of persons interested in the problem was held at the University of Guam on May 30, 1970. The participants were Dr. Chesher of Westinghouse; Mr. Peter T. Wilson of the Marine Resources Division of the Trust Territory; Mr. Milton L. McDonald, Starfish Control Specialist of the Trust Territory; Dr. Roy T. Tsuda, Dr. Daniel P. Cheney and Dr. Robert S. Jones of the University of Guam Marine Laboratory. The primary objective of this meeting was to discuss a possible starfish monitoring program for Guam and the Trust Territory. A preliminary monitoring program was designed that would serve two purposes.

1. Resurveys would be conducted periodically by experienced marine scientists to assess any additional damage to reefs incurred since 1969, and to keep track of the population levels and general movement of the animals in newly infested areas.

2. It was also proposed that in return for the resurveys, scientists involved would be alloted time to conduct their own basic research. This would allow for maximum utilization of travel funds to areas normally remote to scientists.

To this end, it was considered most feasible for the TT to furnish travel and logistics support and for manpower to be furnished by various universities interested in cooperative research. In this way, the TT would profit by obtaining professional aid without the expense of permanent employment of scientists. University scientists would benefit in research travel opportunities at no cost to their institutions.

It was further recommended that the TT explore the feasibility of the program by using scientists from the Universities of Hawaii and Guam. These two institutions were obvious choices because of their proximity to the study area. If the plan proved workable, then other universities could be offered the opportunity to contribute researchers. It was further proposed that letters of inquiry be sent from the High Commissioner to the Governors of Hawaii and Guam to solicit their aid in contacting the proper university officials in each area.

As a final measure, it was suggested that one such monitoring expedition be mounted in the near future. To this end, it was proposed that Dr. Jones and Mr. Struck, who took part in the summer 1969 survey of Truk, and Dr. Tsuda, all of the University of Guam, return to Truk and conduct a resurvey. The TT would provide travel and logistic support and the University would provide the researchers.

The expedition was approved by the TT, Governor of Guam and the President of the University and was conducted over the period of June 10-23, 1970. The data to follow is a report on the Truk resurvey and the feasibility of future surveys.

II. METHODS

A. Transportation. Travel authorizations, tickets and per diem were provided by the TT for the researchers. Air Micronesia jet service was utilized for travel between Guam and Truk.

B. Logistics support. Logistics support was provided by the Truk Starfish Control Team which was in its training program during the expedition period. SCUBA gear, air compressor, boats and motors plus other miscellaneous field gear was provided by the control team. On one occasion, a 36 foot boat was provided as a base of operations for an expedition to Pis Island. The remainder of the field work was conducted on a daily basis from the island of Moen using the Starfish Control diving locker as a base of operations. Starfish Control Specialist McDonald accompanied the research team on most of the operations, except when his training duties required him to be elsewhere.

C. Operations. Resurvey work followed generally the methods outlined in Chesher (1969a.). Divers were towed in pairs behind the Starfish Control boat for 10 or 20 minute periods. During this time, the divers noted whether or not the sector of the reef being surveyed had a normal population of *Acanthaster planci* or was in one of the other five conditions of infestation as outlined in the Chesher report (Appendix). The amount of reef damage, if any, was noted and observations were included as to whether the damage was recent or represented a previous time of destruction. Numbers of *A. planci*

and recent feeding sites (white spots) were observed by each diver on his side of the boat's wake. These numbers were totaled following the tow.

D. Areas of Operation. Due to the large size of Truk (Fig. 1) and shortage of time, the areas of operation were chosen in two ways. First, a series of spots were picked to represent areas surveyed in the summer of 1969. These included both infested and uninfested areas in 1969. This constituted the resurvey portion of the operations which, when compared to baseline data, would be indicative of what further reef damage had occurred and whether or not populations of A. planci were increasing, decreasing or migrating significantly. A second group of areas were chosen which were not surveyed during the 1969 expedition.

E. Additional Research. As noted above, the feasibility of conducting basic research along with the monitoring program was to be explored. These data will be presented in a separate report.

III. RESULTS

A. Resurvey

1. Pis Island Operating Area. Three basic seaward reef sectors were surveyed near Pis Island in 1969 (Fig. 2). Nine stations surveyed in 1969 showed that the starfish infestation in the Pis Island area began in Sector 1 (Fig. 2) at Lamoil Island and extended all along the northern seaward reef in an easterly direction all the way to the Pis Island Channel. The infestation was rated a Condition 3 by the 1969 starfish team. (Appendix). Herds of starfish were distributed in a distinct band at depths from six to 28 meters. This band corresponded to a wide band of tabulate Acropora reticulata on which starfish were feeding. In a single 20 minute tow, 940 feeding sites were counted. Since starfish were not feeding in the daytime, the animals themselves could not be seen without searching under coral heads near feeding sites. In every case, numerous starfish were found near these sites. Over 50 starfish were found under coral heads in a 20 minute SCUBA dive. Three 100M^2 reef quadrats yielded 42 feeding sites and 20 starfish in one quadrat, 35 feeding sites and 13 starfish in another and 60 feeding sites and 15 starfish in a third. These data all indicated a high density of starfish and a high level of reef destruction during the 1969 survey.

The 1970 resurvey showed that the A. reticulata belt of the lower terrace, infested with starfish in 1969, was now completely destroyed and that the remnants of the starfish population had moved into shallower water to attack other coral species and growth forms (Fig. 3).

The greatest density of starfish was found near the Pis Island channel. Two 20 minute tows yielded 93 and 92 feeding sites respectively. The population tended to thin out to the west toward Lamoil Island where two tows yielded 28 and 48 feeding sites respectively. SCUBA dives in the survey areas showed an average of somewhat less than one starfish per feeding site. A rough quadrat of some 600M^2 yielded only 23 starfish from approximately 30 feeding sites. Both the tow and quadrat data show a much higher than normal density of Acanthaster planci but a considerable reduction in numbers since the 1969 survey. (See Addendum). The 1970 team rated Sector 1 as Condition 5.

Sector 2 was the seaward reef of Pis Island itself. Two tows along this reef in 1969 yielded a Condition 2 report. This infestation was located in the same tabulate Acropora reticulata zone as was the previous sector.

The 1970 resurvey showed that the Acropora zone which had only just come under attack in 1969 was now dead. The density of starfish and location of the population was similar to that described above for Sector 1 and was also rated Condition 5.

The 1969 survey of Sector 3 included several reef areas from Tonelik Island and eastward to Holap Island. The reefs in these areas were identical to those of Sectors 1 and 2. The tabulate A. reticulata band was present but free of either Acanthaster planci or their feeding sites. This beautiful reef was given a normal rating of Condition 1.

The 1970 resurvey team having noted the destruction of Sectors 1 and 2 to the west and the concurrent reduction in number of starfish, expected to find that the majority of the population had migrated across the channel to the east of Pis Island and would be attacking the Tonelik Island reef. To our surprise, we found the Tonelik reef and those south to Holap Island were still in good condition. This sector was again rated Condition 1.

2. Northeast Pass Operating Area. Three basic seaward reef sectors were investigated here in 1969. (Fig. 4).

Sector 1 to the seaward of Quoi Island presented 45 feeding sites in a 20 minute tow in 1969. This seaward reef was rated between Condition 1 and 2 in 1969 from Quoi Island all the way north to the Northeast Island.

Unfortunately, only the Quoi Island sector could be investigated in 1970 due to heavy seas on the day we studied the area. The Quoi Island area showed no major change since 1969. The team still rated it between Condition 1 and 2. (See Addendum).

Sector 2 was the mid-channel reef of Basis Island and Mor Island. This area was rated a definite Condition 2 in 1969 with hundreds of feeding sites observed on the seaward terrace.

The 1970 resurvey expected to find this area destroyed. However, at least 50 percent of the coral was still alive. Sixty-two feeding sites were counted in a 10 minute tow and 17 starfish were collected on a 45 minute SCUBA dive. The 1970 team still rates this a Condition 2. (See Addendum)

Sector 3 on the seaward reef terrace south of the ship channel was rated slightly higher than Condition 1 in 1969. Twenty-five feeding sites were seen in a 20 minute tow. Seventy to eighty percent of the reef was undamaged.

The 1970 survey found over 50 percent of the reef dead and counted 31 feeding sites in a 10 minute tow. Except for the additional reef damage and somewhat higher number of feeding sites, this was still rated slightly above Condition 1.

3. North Side Dublon Island Operating Area. A series of three tows in 1969, over a lush Acropora formosa thicket that characterizes this side of the island, yielded 25 starfish and 155 feeding sites on the first 20 minute tow, 53 starfish and 130 feeding sites on the second 20 minute tow and 37 starfish with feeding sites too numerous to count on the third tow of only 10 minutes. This area was rated Condition 3 by the 1969 team. The starfish were located in a band parallel to shore as indicated in Fig. 5.

The 1970 resurvey showed that the corals in the previous band of infestation were all dead. Two 20 minute tows yielded 39 starfish and 84 feeding sites and 33 starfish and 52 feeding sites respectively. A rough quadrat of some 500M^2 yielded 34 starfish. It should be noted that the starfish themselves are easier to see in this A. formosa thicket than those on the barrier reef.

The tows show a considerable reduction in feeding sites and a somewhat smaller reduction in starfish observed. Figure 5 denotes the location of the present starfish band. In spite of the reduction of feeding sites and starfish density noted above, the 1970 team still rated this area as a Condition 3. (See Addendum). The upper areas of the A. formosa thicket is still quite lush and the reef is far from destroyed as anticipated by the 1969 team.

B. New Surveys. A series of new surveys were conducted to fill in gaps left by the 1969 teams. This was considered advisable since the possibility of major infestations of Acanthaster planci might have been overlooked. Two large reef sectors were selected. The eastern sector covered the seaward side of the barrier reef from Northeast Pass south to Salat Pass. The second sector surveyed the seaward side of the southern barrier reef from Aualap Pass to Otta Pass.

1. Eastern Sector--ten minute tows were made on the seaward reef terrace opposite Eli Kanibu Island, Boquet Island, Alanelimo Island and Nottu Island. The seas were extremely rough on this day making towing operation both difficult and hazardous. In all tows, the upper reef terrace was found to be alive but with a sparse growth

of coral. There was a great deal of encrusting coral. The lower terrace was quite dead and covered with calcareous algae. Very few feeding sites and no starfish were observed. This entire reef was classified as Condition 1. The lower terrace appeared to have been dead for a good many years but it was not possible to attribute this to starfish damage.

2. Southern Sector--The first 10 minute tow from Aualap Pass to South Pass showed a coral fauna that was characteristic for the entire sector. Porites dominated with occasional tabulate Acropora coralla. Thirty-three feeding sites and three Acanthaster planci were observed in the tow. Most of the feeding sites were on Porites. This coral is not frequently eaten by the starfish. The area was rated between Condition 1 and 2.

The second 10 minute tow from Paquerion Reef to Aleon Pass yielded only seven feeding sites, mostly on Acropora. This area was rated Condition 1.

The next 20 minute tow was made from Pizon Pass through the Faleasioz Reefs. Coral reef that was 80-90 percent alive in the first part of the tow gave way to reef that was 50-80 percent dead at the end of the tow. Seventy-seven feeding sites were observed. The general area was rated as between Condition 1 and 2.

A final 10 minute tow was made on the seaward side of Otta Island. No white spots were observed but 80-90 percent of the reef was dead and had been for several years. It was not possible to tell if this was starfish damage.

IV. CONCLUSIONS

A. Resurvey. The destruction anticipated by the 1969 survey team in the Pis Island area was found to be nearly complete. Most of the lush coral areas of the lower terrace are gone and it is anticipated that the corals of the upper terrace may be destroyed during the calm late summer and early fall months of 1970. Rough weather tends to inhibit movement of starfish on the upper terrace (Chesher 1969b.). The fact that the starfish population seemed considerably reduced in this area and did not migrate to the Tonelik Island reef is a kind of mystery. What has become of the enormous number encountered in 1969? (See Addendum).

Unlike the Pis Island area, the Northeast Pass and Dublon Island areas were not destroyed as anticipated. Coral damage has definitely advanced somewhat but there seemed to be a reduction in feeding activity in both areas.

All data taken into consideration, the 1970 team felt that the starfish is still present in greater numbers than normal on Truk and still represents a threat that warrants continued control efforts in several localities. (See Addendum). However, the great reduction in numbers of starfish in the Pis Island area and to a lesser extent at Northeast Pass, coupled with the reduced feeding activity at Dublon may be indicative of a decline in the population. Such phenomena are common in population explosions of other organisms. Hopefully, we are witnessing the end of the outbreak but this observation should not be allowed to stimulate a false sense of security and reduction of vigilance.

From the standpoint of feasibility, the University of Guam Team found the monitoring expedition to be successful. The only difficulties encountered were brought about by the simultaneous training of the Starfish Control Team. In the future, the team will already be trained and will enhance rather than hinder the researchers.

B. Recommendations.

Control teams should conduct operations on the upper seaward terrace at Pis Island and the reef to the west. In addition, the team should kill starfish at Northeast Pass north to Northeast Island when the weather is favorable, and make a special effort to knock out the animals on the north shore of Dublon. (See Addendum).

During other times, the control team should involve itself with monitoring activities for large herds. Exceptionally large numbers should be reported and another team of scientists dispatched to measure the population size before control efforts are begun.

Specific areas to be monitored by control teams include, but should not be limited to:

1. The leeward reef south of Falalu Island.

2. The seaward terrace from Tonelik Island to Holap Island.

3. The seaward terrace from Quoi Island to Northeast Island.

All areas of the Truk lagoon that are not already destroyed should be systematically surveyed by the control team until the summer of 1971, at which time another scientific resurvey should be conducted.

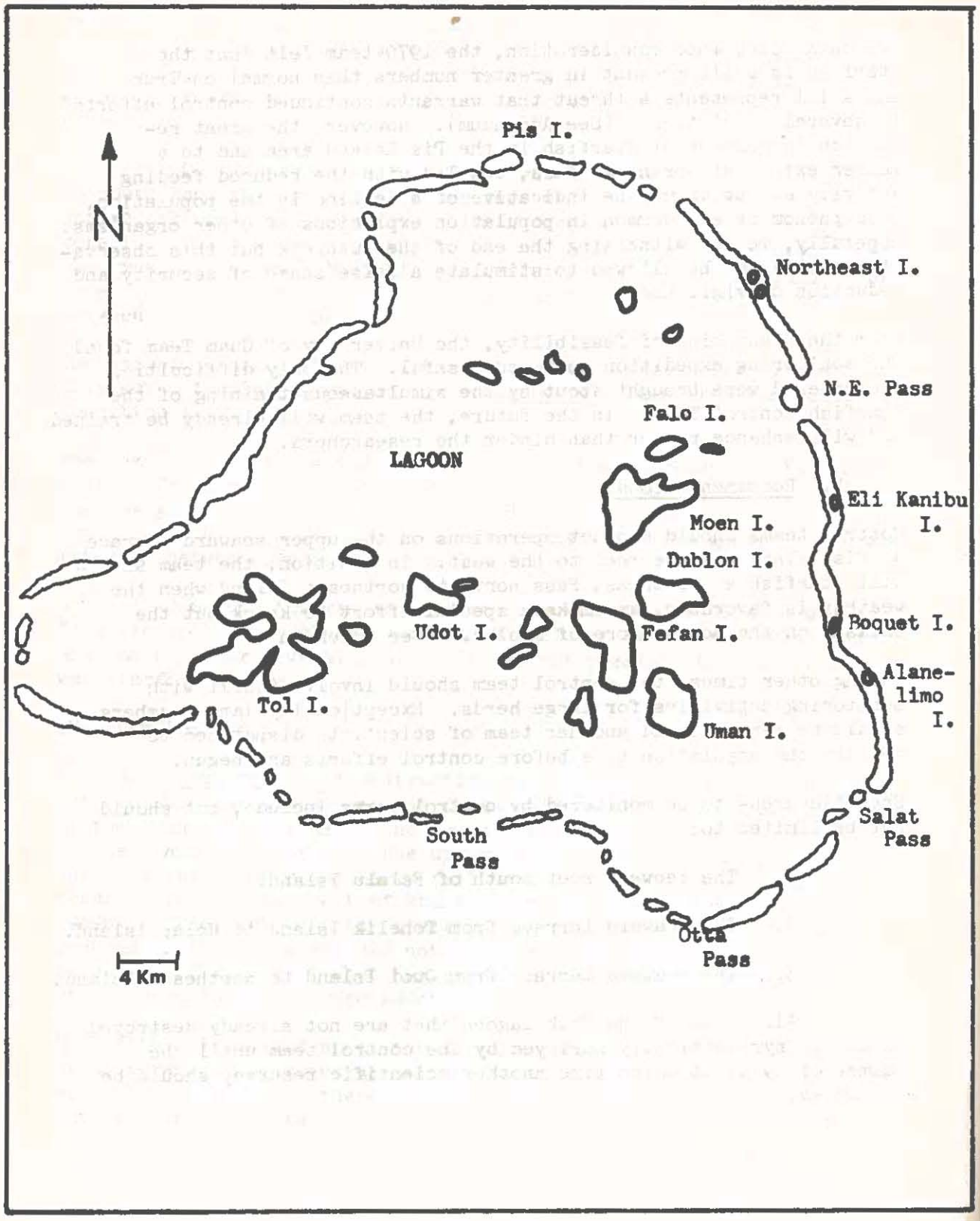

Figure 1. Truk Lagoon

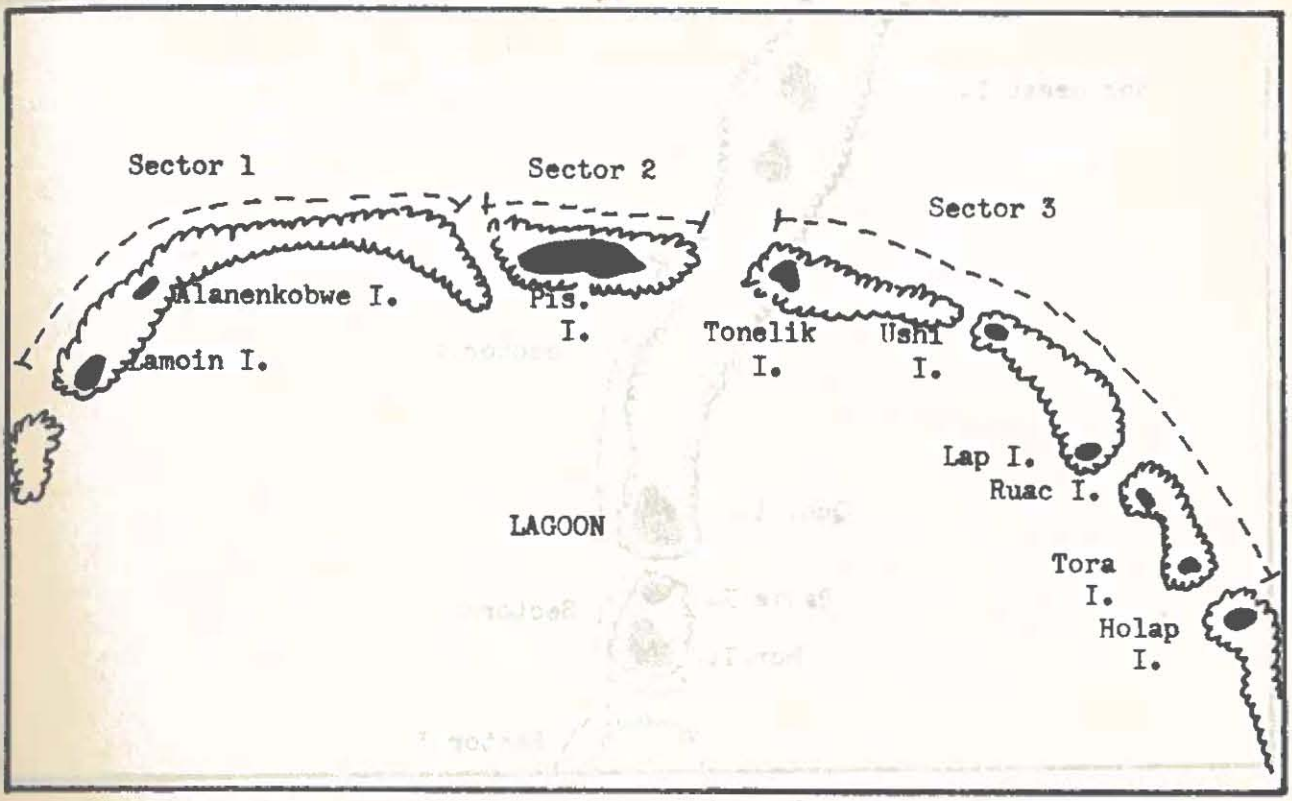

Figure 2. Pis Island Operating Area.

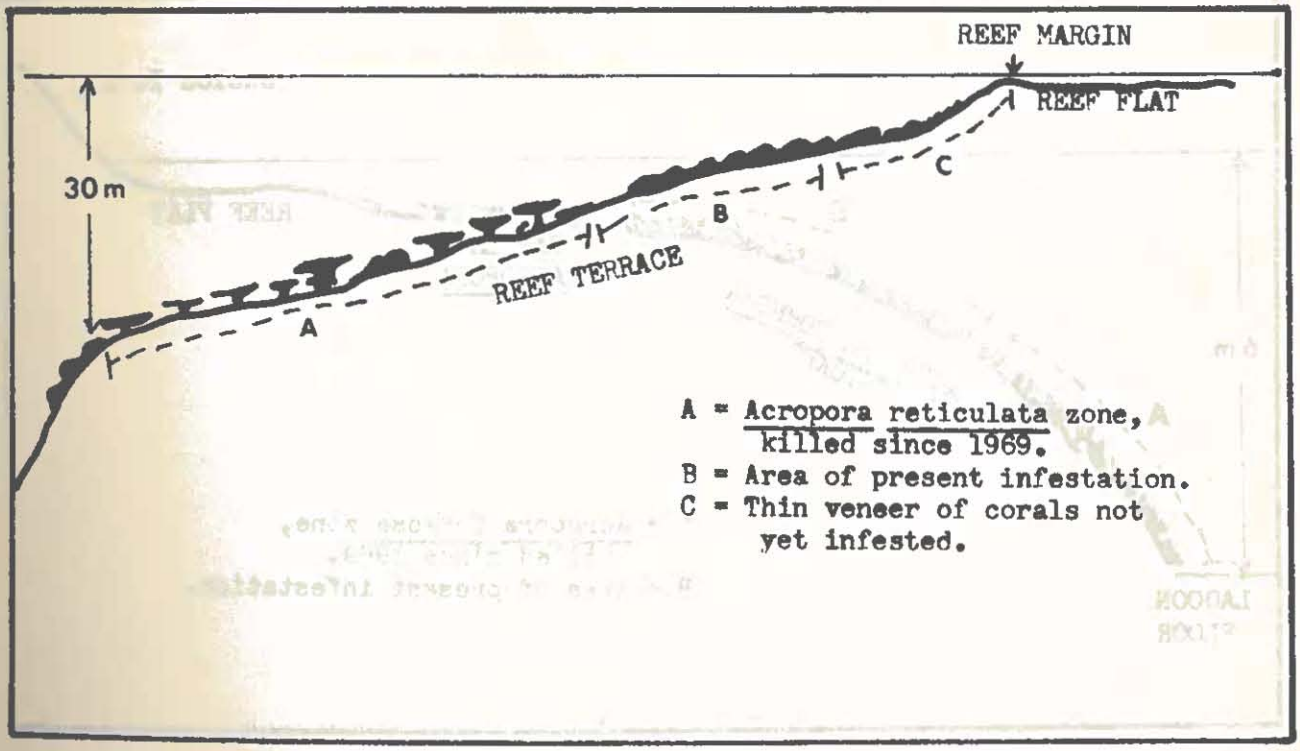

Figure 3. Pis Island Reef Profile.

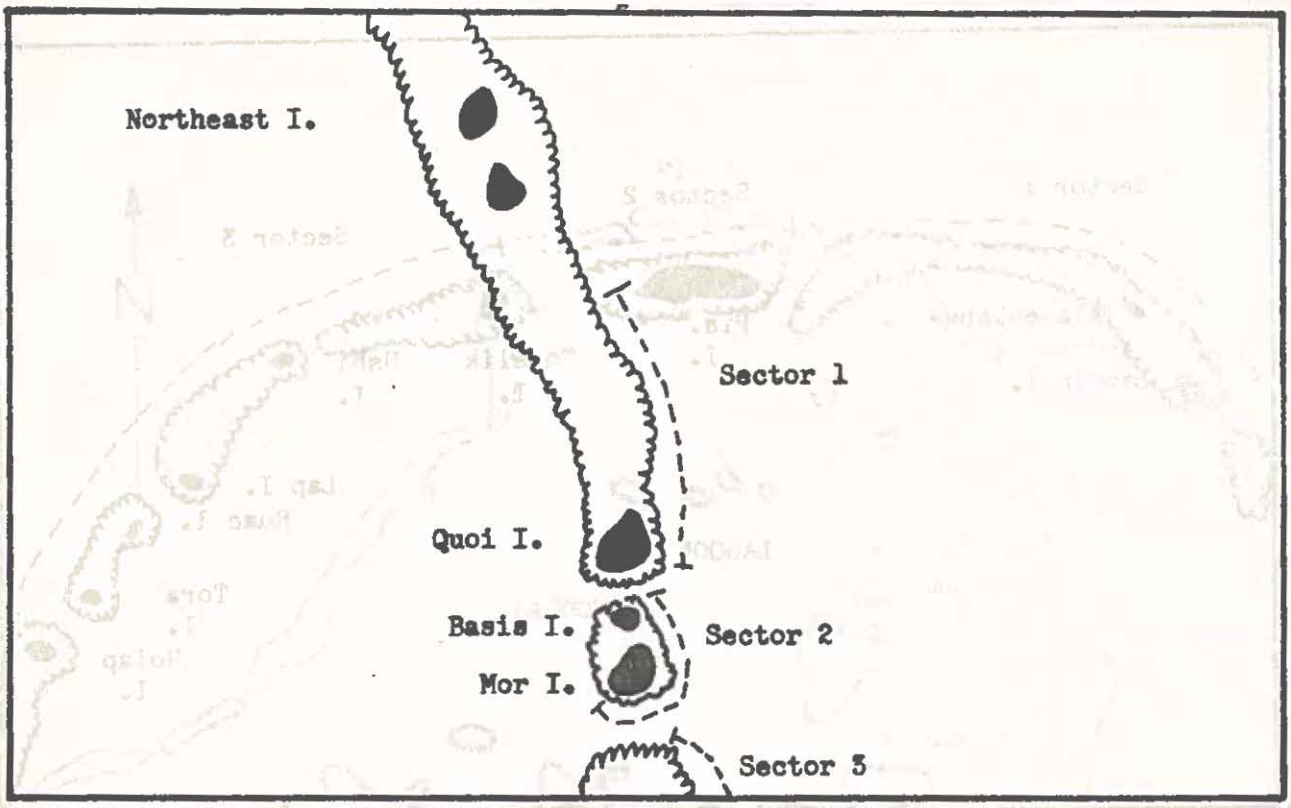

Figure 4. Northeast Pass Operating Area.

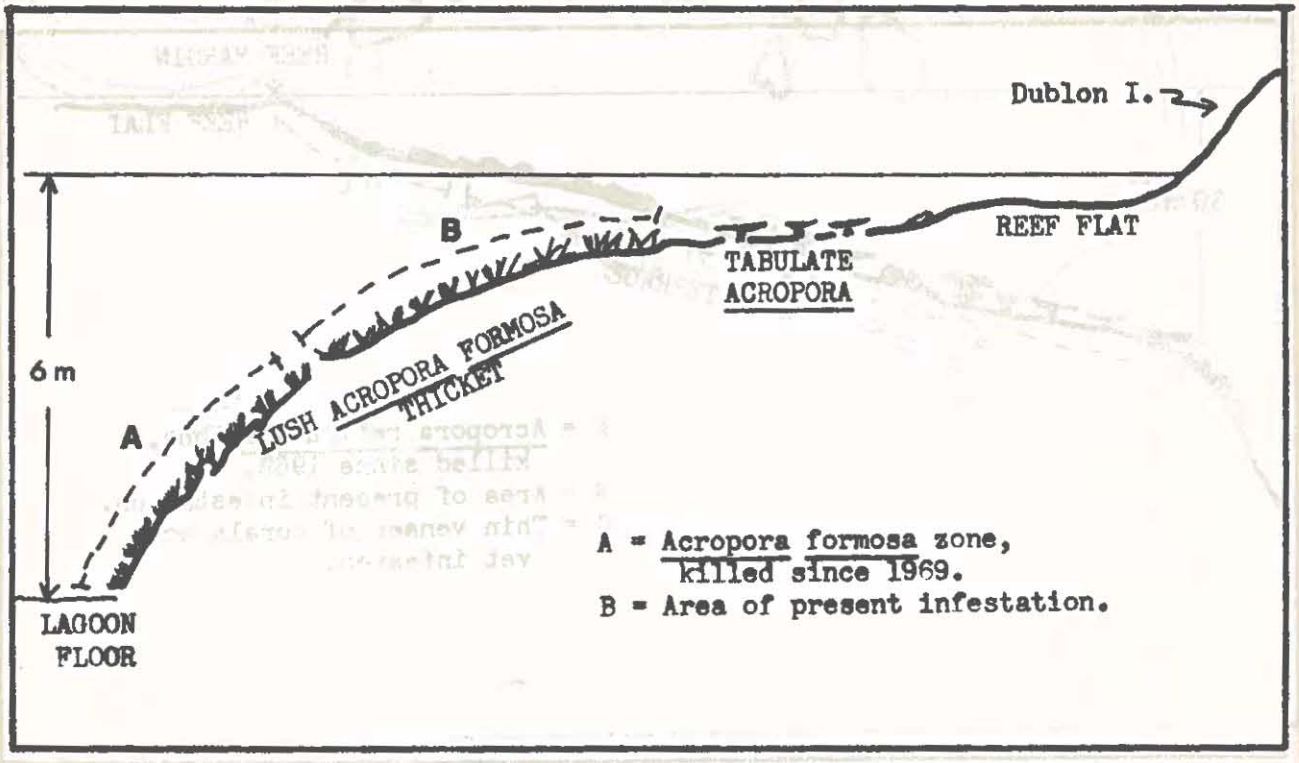

Figure 5. Lagoon Reef Profile, Dublon Island Operating Area. (Not to Scale).

V. REFERENCES

Chesher, R. H. 1969a. Acanthaster planci, Impact on Pacific Coral Reefs. Final Report to U.S. Department of Interior. Westinghouse Research Laboratories No. 69-951-Ocean-R2: 152 pp.

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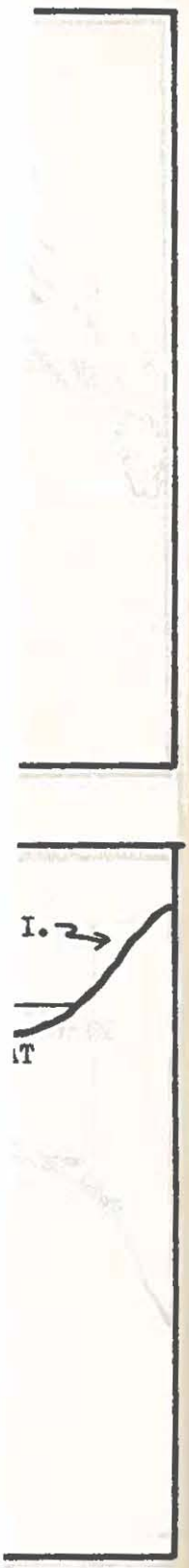

to Scale).

APPENDIX

Classification of Infestation (from Chesher, 1969a.)

1. Normal populations--differed so considerably from the other conditions that qualitative procedures were adequate to determine if reefs were infested or not.

2. Characterized by large groups of 500 to 1,000 specimens located within a very small area.

3. This condition represents an intermediate stage where the infestation expands rapidly over 2 or 3 kilometers (or more) of coastline. A. planci is distributed in herds of several hundred specimens. White, recently killed coral can cover several hundreds of square meters near the larger herds. The animals move into all depth zones. Condition 3 is short-lived, as the starfish rapidly deplete the living coral and the massive herds soon become separated by zones of almost completely dead coral.

*4. Exists when the herds form a front or fronts that take the form of a tightly packed band of animals oriented parallel with the shore and extending for one to many kilometers along the coastline.

5. Represents that stage when A. planci has grazed all of the corals on a particular island. Generally, only a small amount survives in shallow or turbulent water.

*6. Represents a minor population explosion, apparently to the level of Condition 2, which does not gain adequate recruitment to continue its development and disperses after killing off only a few kilometers of reef.

*Conditions not encountered in the Truk resurvey.

ADDENDUM

A series of unforeseen delays has made it possible to receive preliminary control reports from Truk prior to the release of our report. This gives us the advantage of being able to compare the efficiency of our report to that of the Truk Starfish Control Team.

To date, we have received information that this eight-man team has killed over 17,000 starfish on Truk in only 39 days. This is considered a phenomenal figure considering that a crack six-man team killed only 10,000 on Guam in six months. Recent correspondence from Starfish Control Specialist McDonald indicates that these figures may be somewhat, but not significantly, inflated. Hence our remark that the starfish remain a significant problem on Truk is not without merit.

More specifically, the control team has killed 1524 starfish in the Dublon operating area (we feel that there may be more yet). They killed over 3500 in the area from Quoi Island to Northeast Island and beyond. The most recent correspondence from McDonald reported a three-day kill of a phenomenal 5500 starfish in Sector 1 at Pis Island. McDonald took part in the latter kill so we know the figures to be accurate. A kill in this area last year would undoubtedly have produced even higher numbers.

Hence, it would appear that the Resurvey Team was correct in the reporting of these suspect areas. We have, we must confess, missed a large herd at Falo Island and another near the airport at Moen. The Moen group was rated Condition 2 by the 1969 survey and was not resurveyed this year.

The Truk Starfish Control Team should be complimented for the fine job they are doing. They have acted with considerable efficiency and initiative.

ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Kapingamarangi and Nukuoro Atolls

Ponape District
July 1970

Prepared by;

M. McDonald
K. DaVico
T. Paulis
P. Bryan

Marine Resources Division
Trust Territory of the Pacific Islands

I. INTRODUCTION

The final report issued by Westinghouse Ocean Research Laboratory at the conclusion of their Acanthaster planci survey recommends that due to the nature of the available information the atolls of Kapingamarangi and Nukuoro be resurveyed in one to two years. This survey should strive to determine if the A. planci populations are in equilibrium, decreasing or increasing. (See "A. planci, Impact on Pacific Coral Reefs" Final Report, pp. 133, paragraph 6.4.4)

As part of the Trust Territory A. planci control program, these two atolls were resurveyed during July 1970.

Mr. Kenneth DaVico who served as associate scientist with the Westinghouse team that originally surveyed the atolls of Kapingamarangi and Nukuoro was asked to join the survey. His presence added firsthand experience, knowledge, and continuity to the survey.

II. MATERIALS AND METHODS

1. Islands Selected: Kapingamarangi Atoll and Nukuoro Atoll.

2. Interisland Transportation and Communications: The survey team was transported to the islands by the privately owned yatch "Asa Kaza" which was chartered and financed through the Trust Territory Acanthaster planci Control Program. Normal Trust Territory communications system was used plus the radio in the boat to stay in contact with Trust Territory Headquarters and Guam.

3. Support Equipment: All support equipment was furnished by the Acanthaster control program and transported to the chartered vessel. One drum of gasoline was shipped by a Trust Territory field trip vessel to each of the islands to be used by the outboard motor boat.

4. Field Methods: The same methods of search were employed as were used by the Westinghouse survey. These consisted mainly of towing behind the boat at 2 to 3 knots and observing the reef face. When interesting areas were encountered they were examined more closely either by skin diving or with the use of scuba gear.

5. Other Assistance: Assistance was rendered to the survey team by the men of both Kapingamarangi and Nukuoro which helped to complete the survey in a short period of time and without major problems.

Every courtesy was extended to the survey team by the people of the islands.

III. RESULTS

1. Nukuoro

a) Area Surveyed. The passage, the entire outer barrier reef, the inter-reef on both sides of the passage, and isolated patch reefs.

b) Personnel. M. McDonald, K. DaVico, T. Paulis, and P. Bryan.

c) Dates. July 10 thru July 15, 1970.

d) Population of A. planci. A. planci were present throughout the entire reef area. There was no indication of any grouping or herding aggregates anywhere along the reef. The animals were widely scattered and very scarce. There appeared to be very little damage to the reefs that could be pinpointed to A. planci.

Mr. DaVico estimated that there was a population increase of 30 to 40 percent than one year ago, but no actual counts were available. Even with the apparent increase, the starfish are still well within the limits of what is considered to be a normal population.

A large number of Culcita sp. were seen scattered throughout the reef area. They were usually seen in close proximity to freshly killed corals and were noted at depths ranging to 120 feet.

2. Kapingamarangi

a) Area Surveyed. The passage, all of the outside of the barrier reef, the western portion of the inner edge of the lagoon and some patch reefs.

b) Personnel. M. McDonald, K. DaVico, T. Paulis and P. Bryan.

c) Dates. July 17 thru July 23, 1970.

d) Population of A. planci. The survey showed a small population of A. planci well scattered all around the barrier reef. At no place was this population aggregating into groups or herds. The number of animals on the lagoon side seemed to be far fewer than reported last year. This was contributed to removal of the animals by local fisherman and also to a general scattering and dispersal throughout the rest of the lagoon.

The atoll was judged to contain a normal population of A. planci with no apparent build up of numbers in the immediate future.

In the passage area and inner reef area the animal population may have dropped as much as 75 to 85 percent from last year, however, scattered individual animals showed up in areas where none were found last year.

The patch reefs seemed to contain one to two animals each.

IV. CONCLUSIONS

This survey showed a normal population of A. planci on both atolls. The animals were well scattered, with the largest groups containing only 3 or 4 animals.

There appeared to be an increase in number of animals on Nukuoro.

V. RECOMMENDATIONS

The local fisherman have been picking up the animals as they find them while fishing. It was stressed by the survey team that they should continue to do so.

Because the population is normal at this time, there is no need for any further immediate action. However, the team felt that since the population on Nukuoro is apparently increasing, in one or two years the atolls should be checked again.

It is also recommended that a program of continuing observation should be kept in effect throughout the islands.

VI. SURVEY PARTICIPANTS

Milton McDonald - Trust Territory Starfish Control Specialist

Kenneth DaVico - Associate Scientist with Westinghouse Survey. Original member of survey team on both Nukuoro and Kapingamarangi Atolls.

Toshiro Paulis - Trust Territory Fisheries Specialist, Palau District.

Patrick Bryan - Starfish Control Officer, Palau District.

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ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Saipan and Tinian

Survey of Aguijan

Mariana District
September 1970

Submitted to

Marine Resources Division

Trust Territory of the Pacific Islands

Prepared by:

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M. R. Struck

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As a continuation of the Acanthaster monitoring program in Micronesia, the reefs of Saipan and Tinian were resurveyed by four members of the University of Guam's Marine Laboratory. The purpose of the resurvey was to assess any additional reef damage incurred since 1969 (Chesher, 1969a) and to observe population levels and general movement of the starfish in newly infested areas. A reef survey on Aguijan was also undertaken for the first time. The first resurvey study (Jones et al., 1970) in Truk includes background information on the agreement made between the Government of Guam (University of Guam) and the Trust Territory Government for Acanthaster monitoring studies in Micronesia.

II. METHODS

A. Transportation. Travel authorization and per diem were provided by the Trust Territory Government for the four-man team. The United States Coast Guard provided transportation for the team, jeep, boat and equipment between Guam and Saipan. This enabled the team to be independent to carry out the study on Saipan, Tinian and Aguijan. To this end, the team extends its appreciation to Captain Glen Thompson, Commanding Officer, United States Coast Guard, Guam.

B. Logistic Support. Although the University team was self-sufficient with its own boat and equipment, Mr. Milton L. McDonald and his Starfish Control team assisted in most of the survey with a second boat. When both boats were used, the participants were divided into two four-man teams with two University personnel on each team.

C. Operations. The same procedure used by the Westinghouse 1969 survey (Chesher, 1969a) was followed in this study. Two individuals were towed behind the boat at a speed of approximately two knots for 10 to 30 minutes. The length of each tow depended on the sea or reef condition. When rough weather or a monotonous pavement with no corals prevailed, a short tow (10 minutes) was made. Longer individual tows (20 to 30 minutes) were made in those areas heavily infested with Acanthaster so that the same two individuals being towed could obtain a general picture of the population size and extent of damage. In the course of towing, each team member counted the number of fresh feeding sites (white spots) and A. planci seen on his side of the boat's wake. These numbers were totaled following the tow and provided a rough estimate of the population of Acanthaster in the area. Notes on the condition of the reef were also made. The majority of the tows were made in a zigzag manner to insure that corals growing at various depths were observed. The maximum depth of visibility varied from seven to fifteen meters depending on the turbidity of the water and the prevailing weather at the time the tows were made.

D. Additional Research. As agreed upon between the Trust Territory and the Government of Guam, the researchers involved in the resurvey were allotted time to conduct their own basic research.

III. RESULTS

A summarization of the one-year change in the Acanthaster populations and coral conditions on Saipan and Tinian is presented in Figures 1 and 2, respectively. The information presented on these maps is patterned after the Westinghouse report. In this way, any changes attributed to Acanthaster over a one year period can be readily seen. Figure 3 presents a baseline summarization of the Acanthaster and coral situation on Aguijan. The tow numbers are also depicted on each of the maps to provide some indication of the location of each area being discussed.

The terms "live corals" and "dead corals" are used in this report instead of "normal reef" and "dead reef" as used in the Westinghouse report. The reason for our preference of the former terminology is that most of the corals present around these islands merely represent simple communities of reef coral and not true coral reefs. According to Goreau et al. (1969), simple communities of reef corals "are open, unaggregated populations of reef corals growing upon an eroded rock surface or some other substrate of unrelated origin," while coral reefs "develop only when coral populations become so dense that their colonies grow upon each other to form interlocking aggregates."

A. Resurvey of Saipan (Aug. 17-25, 1970)

1. Infested Areas Reported in 1969. Goreau et al. (1969) and Chesher (1969a) report three large populations of Acanthaster planci on Saipan during the summer of 1969. These populations were located 1) at the northern end of Bahia Fununchuluyan outside the Grotto, 2) at the southwest reefs of Garapan and 3) at the southwestern edge of the Tanapag Boat Harbor.

The 1970 resurvey team found the coral community at Bahia Fanunchuluyan in still beautiful condition. Only six feeding sites were observed during a 30-minute tow (#10) through this bay. Not a single A. planci was seen during the tow. Scattered live corals were present in two to seven meters of water on the submarine terrace. A single dive made by six of us originating in the Grotto to the outside revealed no Acanthaster in water 27 to 33 meters deep. The Acanthaster population reported a year ago in this area had obviously done little damage within the past year and presently has disappeared.

The corals at Garapan were found to be 80 to 90 percent dead by the 1970 team. Six tows (#16-21) totaling 110 minutes revealed 122

fresh feeding sites and 41 Acanthaster. The highest Acanthaster count on Saipan occurred in this area (#16) where 29 Acanthaster were counted within a 20-minute tow. Sixty-three fresh feeding sites were also seen in this area. The Acanthaster population estimated by Goreau et al. (1969) to be about 5,000 to 10,000 had obviously killed the remaining corals and had also disappeared.

The third area just outside Tanapag Harbor reported infested in 1969 consists of several reef patches separated by sandy substratum and includes the southern end of the barrier reef. Most of the reef patches (tows #1, 2, 15) just west of Pt. Muchot had live corals. The large live heads of Pocillopora eydouxi observed by Goreau et al. (1969) at the southern end of the barrier reef were still in good condition. The seaward edge of the barrier reef (tows #4 and 31) possessed small corals (less than 20 cm high) in water two to five meters deep. Forty-one fresh feeding sites and four Acanthaster were seen in this area.

2. Other Areas. The seaward slope of Tanapag barrier reef opposite Managaha Island to Pt. Magpi (tows #5-9) had scattered live corals in water one to three meters deep. The corals in this area were also small and usually less than 20 cm high. Pocillopora verrucosa and Acropora nana were the dominant corals in this zone. Larger but fewer corals were present in four to seven meters of water. Live corals were for the most part absent in deeper water.

In five 20-minute tows, 54 fresh feeding sites and only two Acanthaster were seen. However, the majority of the white spots observed were small and seemed to indicate the feeding habit of Culcita novaeguinae (pillow-star). Culcita were seen on all tows in this area. Since the seaward slope consisted of small corals on a rather flat pavement, Acanthaster, if present, could be easily seen. In addition, even if Acanthaster were present adjacent to each of the fresh feeding sites, their population level of 46 per 50-minute tow was still within the normal range.

The 1970 resurvey team could not find the large dead coral areas depicted in the Westinghouse report. The 1970 team agrees that very few corals occurred in certain areas but these areas were only intermittent and never occupied large areas as shown on Figure 15 of the Westinghouse report.

Tow number 14 along the Sabaneta coast revealed no Acanthaster and 47 small white spots. These spots are probably attributable to Culcita. Three SCUBA dives made along this coast revealed no Acanthaster.

The lagoon corals inside the barrier reef were dead. Goreau et al. (1969) estimate that these reefs were killed in 1968. It was

quite surprising to see so few algae inhabiting this area but a closer look at the corals revealed large number of Echinometra inhabiting the corals. These sea urchins are known (Chesher, 1969b) to be herbivorous which could explain the lack of algae here. Echinometra were at times so numerous that a large coral head resembled a "swiss cheese". In time these large coral heads will erode.

Figure 15 in the Westinghouse report indicates that the southern end of Saipan between Pt. Agingan and Pt. Naftan with "normal reef". Our recent survey revealed that live scattered corals occupied the shallow areas but, for the most part, live corals were absent or dead in deeper water. Four tows totaling 55 minutes produced seven fresh feeding sites and only one Acanthaster.

Goreau et al. (1969) report the corals of Bahia Laulau to be colorful and diverse, and that all the intact corals to be alive. The 1970 team found live corals near the shore but very few live corals in water deeper than five meters. No Acanthaster were seen during three tows totaling 55 minutes and only five fresh feeding sites were seen.

Rough seas prevented the team from resurveying the windward side from Pt. Kagman to Pt. Tanke. However, Goreau et al. (1969) report this coastline to be virtually without corals and says, "....on the whole the macrobenthos is too sparse to relieve the monotonous barrenness of those tumbled rock slopes".

B. Resurvey of Tinian (Aug. 11, 14-16, 1970)

Chesher (1969a) cites Acanthaster planci in above normal concentrations at almost all stations and indicates five specific sites on his map where they were abundant. These locations were 1) at the northern tip, 2) between Pt. Asiga and Pt. Masalog, 3) just south of Pt. Castiyo, 4) one kilometer south of the harbor, and 5) just south of Pt. Diablo. Of these five infested areas, the 1970 team found A. planci still present, but in small concentrations, in two of the above areas cited (1 and 3).

A small population of actively feeding Acanthaster was seen on the northwestern tip where a 20-minute tow (#24) produced 111 fresh feeding sites and 56 A. planci. The corals in this area were approximately 75 to 80 percent dead. However, live scattered corals persisted on the submarine terrace on the northeastern tip of the island.

A population of Acanthaster reported in 1969 just south of Pt. Castiyo was still present in 1970. Other than a few scattered live corals in water one to three meters deep, the majority of the corals were dead. Three tows (#9-11) through this area revealed 57 Acanthaster and numerous fresh feeding sites in a period of 40 minutes. Fifty three of the Acanthaster occurred just south of Pt. Castiyo.

The corals in the other three areas reported as being infested by the 1969 team were dead except for a few scattered corals in shallow water. The Acanthaster populations were well below the normal range. Only eight Acanthaster were counted during four tows (#3-6) totaling 45 minutes made between Pt. Asiga and Pt. Masalog.

In addition to the two infested areas found by the 1970 team, another new population just south of Pt. Lananibot was located. A 20-minute tow (#20) through this area produced only 49 fresh feeding sites and 27 Acanthaster. The corals in this area were for the most part dead.

C. Survey of Aguijan (Aug. 12-13, 1970)

The entire coastline of Aguijan was surveyed since this represented the first time that a study has been conducted for this island. Large concentrations of A. planci were found on the northwestern and southeastern coast of the island (see Fig. 3). Three tows (#4-6) on the northwestern coast revealed numerous fresh feeding sites and a total count of 1468 A. planci in 55 minutes, while three tows (#1-3) on the southeastern coast totaling 30 minutes produced counts of 1300 A. planci including numerous fresh feeding sites.

Whereas the southern coast still possessed scattered live corals interspersed among the dead corals in shallow water, very few live corals were present on the northern coast. The extreme southwestern coast of Aguijan possessed the largest density of live corals.

There is only one area along the coast of Aguijan which can be termed a coral reef and this is located about one kilometer southwest of the northernmost tip of the island. Unfortunately, this reef is approximately 75 percent dead. Pocillopora meandrina and P. verrucosa were the dominant corals

Acanthaster were seen feeding in a definite band in water three to 10 meters deep on the northwestern coast and in three to five meters deep on the southeastern coast. Acanthaster were also seen in the shallow surge zones adjacent to the coastline.

Tows were also made around Nafutan Rock, located one kilometer southwest of Aguijan. Acanthaster and fresh feeding sites were not seen.

IV. CONCLUSIONS

The most obvious point that comes to our mind is the whereabouts of the large populations of Acanthaster planci reported last summer on Saipan. Where did they go? There are two possible explanations

for the present decrease in population - either the starfish have descended to deeper depths (deeper than 70 meters) or they have been killed off. The former may have been the case in the Pis Island area on Truk (Jones et al., 1970). A total of 5500 A. planci has recently been reported killed in an area which two months earlier had shown a somewhat smaller population. On the other hand, the Acanthaster may have migrated from an area farther west which was not resurveyed.

The disappearance of the Acanthaster along the coast of Saipan seems to present a different situation than that on Truk since most of the coastline of Saipan has been resurveyed. Mr. Milton McDonald has informed us that neither he nor any of his control team members have ever seen any trace of these large populations reported by Goreau et al. (1969) on Saipan. Acanthaster kill records reveal that 7,018 starfish were killed between March 1969 and May 22, 1970. This number represents Acanthaster killed before, during and after Goreau's survey undertaken from July 22 to August 6, 1969. It is regretful that the actual number killed after Goreau's survey is presently unknown. The data on the number of Acanthaster killed since May 22, 1970 by the Saipan Control team is available, in part, and is reproduced below.

May 25-29, 1970	------	182 killed
June 1-5, 1970	------	198 killed
June 6-30, 1970	------	figures unavailable
July 6-20, 1970	------	165 killed
Total		545 killed

This provides a total of 7,563 Acanthaster killed between March 1969 and July 1970. However, the total number of starfish reported killed on Saipan is cited as 20,000 (Mr. McDonald and Mr. Sablan, personal communication). Even if one estimates that 500 Acanthaster were killed between June 6-30, 1970 (kill figures unavailable), when were the other 12,000 Acanthaster killed? We are aware that a 15¢ bounty was placed on Acanthaster during this period and more than 4000 were reported collected (Chesher, 1969a). This still leaves 8000 animals as yet unaccounted for. If we do accept the mean estimate of 7500 starfish reported last summer at Garapan (Goreau et al., 1969) and propose a sum of 10,000 starfish at the other two areas reported infested in 1969, then we must assume that the control team and "bounty hunters" kill of 20,000 individuals should have wiped out the population. A puzzling matter is that the starfish population at Bahia Fanunchuluyan must have been killed prior to May 22, 1970. The kill records available reveal that the present Control Team has never killed any Acanthaster in this area. In attempting to account for some of the missing Acanthaster, it must be realized that a certain unknown number may have died of natural causes or have been killed by predators, other than man.

The live corals along the coast of Tinian have obviously been killed by the Acanthaster populations reported by the 1969 team. Those corals which are still alive are found in water less than three meters deep. The starfish population has also drastically declined within a one year period. Only 188 A. planci were seen in a total towing period of 395 minutes or 6.6 hours. About 72 percent of this number were counted in three isolated areas on Tinian. A week's killing effort in the infested areas should greatly reduce these small populations.

A very conservative estimate of about 3,000 to 4,000 A. planci probably occurs along the coast of Aguijan. The corals are, for the most part, dead. Information derived from the frequency of fresh feeding sites, the large areas infested, and the condition of the dead corals seem to indicate that the coral community along the coast of Aguijan has been killed within the past year.

V. RECOMMENDATIONS

Mr. McDonald and his control team are already aware of the Acanthaster populations and their specific locations on Tinian and Aguijan. On our last day on Saipan, the control team of Messrs. Ben Sablan, Enrique Taitano and Erminio Olopumar were preparing a week's trip to Tinian and Aguijan. By this time, the Acanthaster population on both Tinian and Aguijan should be drastically reduced. We feel that the Saipan Control team has done a decent job of controlling the Acanthaster population around the coast of Saipan.

We highly recommend that future control teams keep accurate records of the number of Acanthaster killed as well as the dates and locations of kill. This will prevent any future complications that may arise as with the kill record on Saipan. In addition, this information provides critical data to the researchers.

The decision on the fate of the Saipan Control team after completion of their efforts on Tinian and Aguijan is now left in the hands of the administrators of this program. However, a quarterly check for A. planci in those areas on Saipan possessing live corals should be conducted during the next 12 months.

The island of Rota which was not covered in this study should be resurveyed as soon as possible. With the completion of a Rota resurvey, a general picture of the starfish situation along the southern Mariana Islands will be complete and will further our overall studies on this destructive organism.

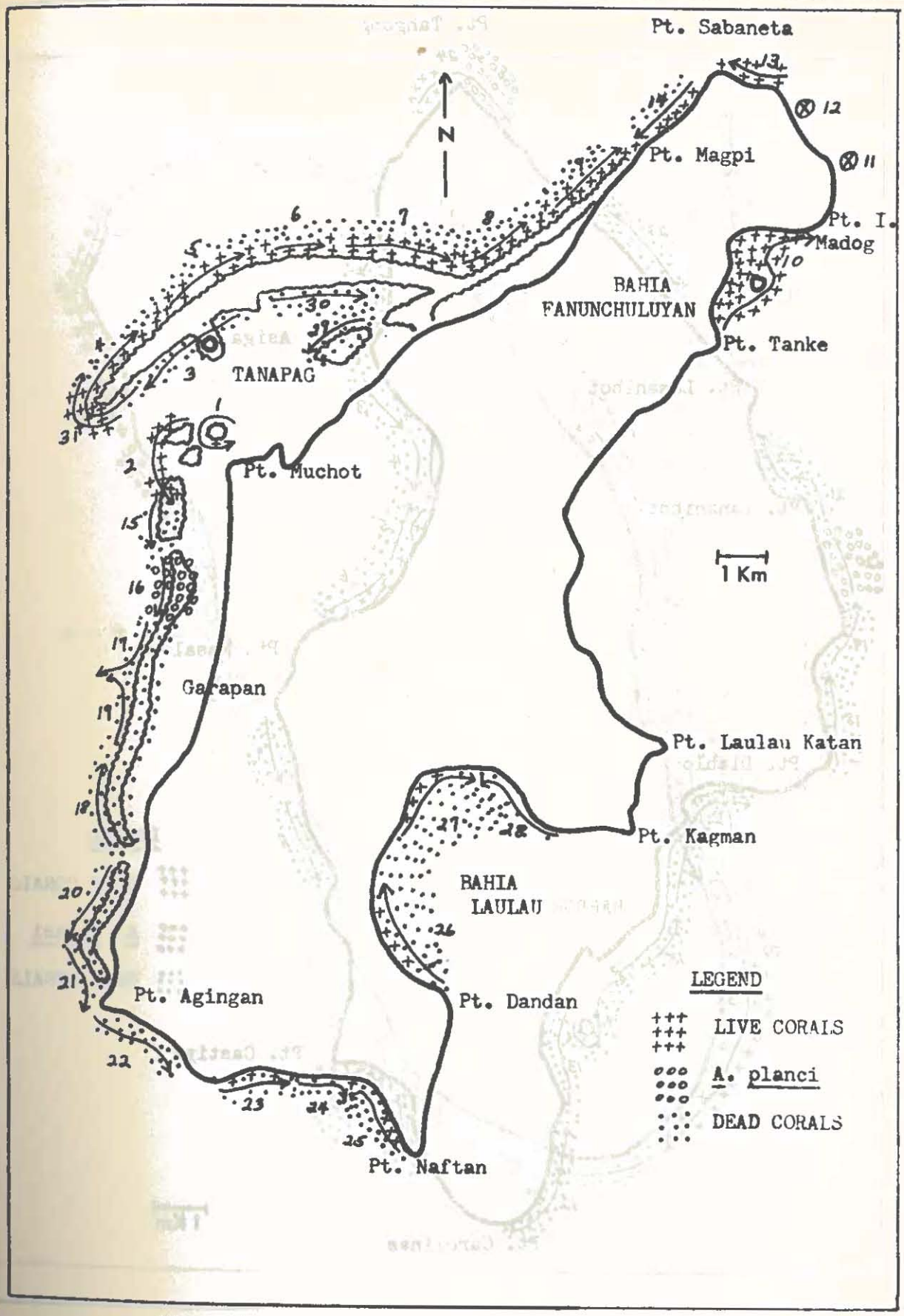

Figure 1. Saipan survey.

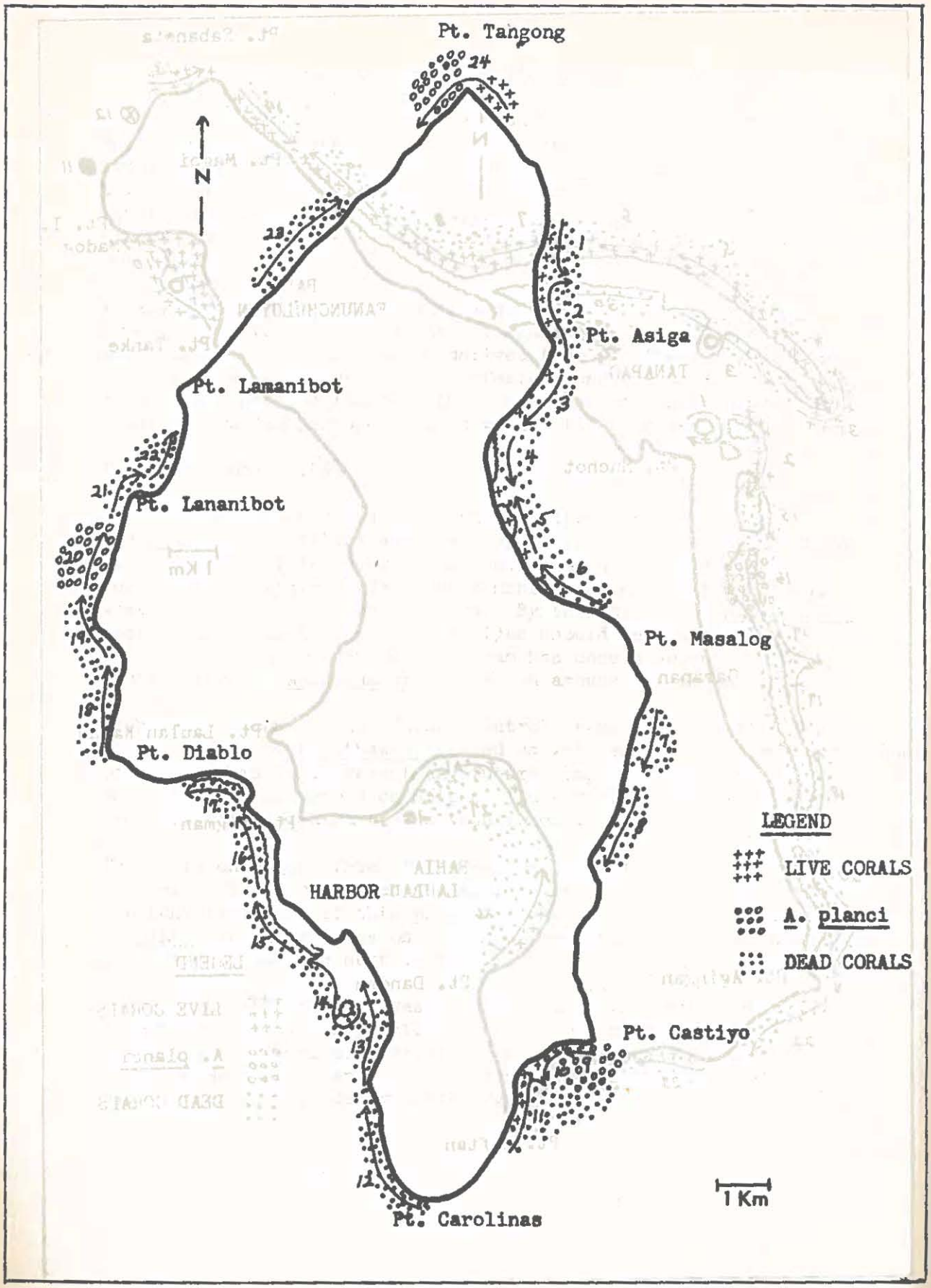

Figure 2. Tinian survey.

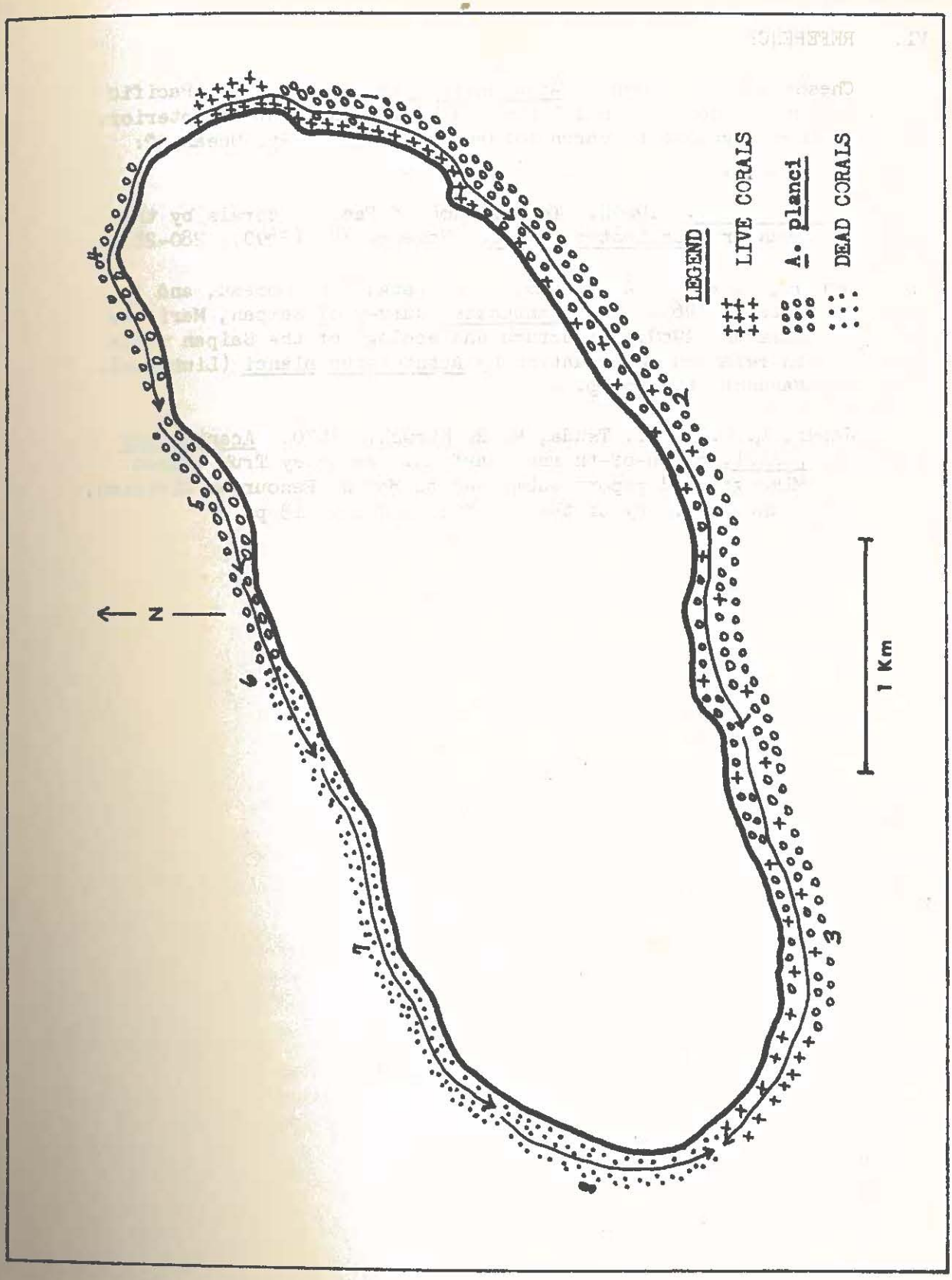

Figure 3. Aguijan survey.

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ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Guam

September 1970

Submitted to

Governor of Guam

Prepared by

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I. INTRODUCTION

In conjunction with the Marine Laboratory's (University of Guam) research program on the "crown-of-thorns" starfish, Acanthaster planci, a resurvey along the coastline of Guam was conducted during late August to September 1970. The objectives of the study were 1) to observe population levels and general movement of the starfish in newly infested areas, 2) to assess any additional reef damage incurred since the Summer 1969 Westinghouse survey (Chesher, 1969), and 3) to observe any recolonization of corals in previously killed areas.

These observations provided some indication on the success of the Starfish Control team's (Division of Fish and Wildlife) efforts in curbing the starfish population on Guam. An opportunity was also presented to compare our location of infested areas to those reported by the control team over the past year, thus providing a critical evaluation of the accuracy of the rapid resurvey technique (nine days) used by the University team.

It should be pointed out that short-term reconnaissance of infested areas as well as on living coral communities has been carried out periodically by both the control team and the University team during the past 12 months.

We acknowledge Mr. I. Ikehara (Chief, Division of Fish and Wildlife) and Mr. R. Domingo (Leader, Starfish Control team) for kindly providing the information on the numbers and locations of A. planci killed over the past 12 months on Guam.

II. METHODS

A. Participants. The following members of the Marine Laboratory's staff participated in the Guam resurvey.

R. T. Tsuda (Team Leader)

M. R. Struck	J. A. Marsh
R. H. Randall	R. S. Jones
R. J. Lujan	A. J. Fortin

B. Operations. The same procedure used by the Westinghouse 1969 survey was followed in this study. Two individuals were towed behind the University of Guam's boat "Tanguisson" at a speed of approximately two knots for 10 to 35 minutes. In the

course of towing, each team member counted the number of fresh feeding sites (white spots) and Acanthaster seen beneath his side of the boat's wake. These numbers were totaled after the tow and provided a rough estimate of the population of Acanthaster in the area.

The total number of fresh feeding sites per tow were used as an indicator of whether or not an area was infested. Past observations by the control team have shown that the starfish retreat to concealed hiding places, e. g., crevices, during the daylight hours and reappear in the open at night to feed. Recent surveys by the University team on Truk (Jones et al., 1970) and Saipan (Tsuda et al., 1970) have revealed that if one looks hard enough, at least one starfish may be found within close proximity of each fresh feeding site.

III. RESULTS

Figures 1 and 2 show the location of Acanthaster as well as the condition of the corals along the coast of Guam during the Summer of 1969 and 1970, respectively. Any movement of the starfish or destruction of additional corals during that one-year period can easily be seen by comparing the two maps. An area is considered infested with Acanthaster when one or more fresh feeding site is counted per minute while towing. Areas where counts are less than one starfish per minute are considered normal and are not shown on the figures.

A. Infested Areas. During the Summer of 1969, two large populations of Acanthaster were observed on the northeast and west coasts of Guam. One population was located between Ritidian Pt. and Catalina Pt., while the other population was seen outside of Apra Harbor between Piti and Anae Island. A third, but smaller population, was present in Cocos Lagoon.

The 1970 survey shows that the northeast starfish infestation is still present, though somewhat reduced in size and area covered. Our data show that during the past year, the majority of the population has shifted somewhat and is now located almost entirely between Pati Pt. and Catalina Pt. in 42 meters (130 ft.) of water.

This becomes more obvious when the control team's kill data show only 417 starfish killed between Ritidian Pt. and Pati Pt. over the past 12 months. On the other hand, we are encouraged by the fact that the population between Pati Pt. and Catalina Pt. has

as yet not migrated south. A total of 9821 starfish was killed along this northeast coast since September 1969 which suggests that control measures may be responsible for arresting any massive movement south. Of the above total, 4212 starfish were killed during the months of July and August 1970 which indicates that there is still a large concentration of the animals and control measures are still warranted.

The population seen during the Summer of 1969 between Piti Channel and the southwest terminus of the Glass Breakwater has migrated in three directions after killing the corals in that area. The majority of the starfish has migrated into the shallow inner reefs of the Asan-Piti area. A total of 11,951 Acanthaster has been killed in this area during the past 12 months, about 80 percent of which were killed on the inner reef flat.

A survey inside Apra Harbor indicates that a small population has entered the harbor area. A twenty-minute tow along the inner side of the Glass Breakwater revealed 88 fresh feeding sites but no Acanthaster. Repeated dives in this area failed to encounter any starfish. Since the corals appear to have been killed within the last 30 hours (lack of algal growth), the divers suspect that the Acanthaster are seeking shelter during the daylight hours in the deep crevices of the breakwater. There is also a small population of Acanthaster along the reef front and submarine terrace from Gab Gab Beach to Orote Pt. A 45-minute tow revealed 65 fresh feeding sites and only one Acanthaster. Only 54 starfish have been killed to date by the control team in the Harbor area.

The third route of migration has been across the channel to Orote Pt. where the starfish have regrouped with those between Orote Pt. and Anae Island. Although the majority of corals between Orote Pt. and Agat Bay are dead, live corals persist south of this coastline. Scattered populations of Acanthaster are still present along this coast but with the greatest concentration around Anae Island. As can be seen in Fig. 1, the starfish have not migrated in mass south of Anae Island. Between October 1969 and August 1970, 4582 Acanthaster were killed in this area.

The population in Cocos Lagoon still persists but is decreasing in number through the efforts of the control team. A total of about 1900 Acanthaster has been killed in Cocos Lagoon within the last 12 months.

B. Additional Coral Damage. The population reported between Ritidian Pt. and Pati Pt. in the Summer of 1969 has killed the majority of the corals in this area. The corals present in 1969

between Piti Channel and Agat Bay are for the most part dead. However, a small area south of Agat Bay still possesses live corals. The corals in Cocos Lagoon still appear in good condition even though a starfish population has persisted here over a one-year period. Other than the previously infested areas seen in 1969, very little additional damage has taken place. The entire coastline on the eastern side of Guam between Catalina Pt. and Cocos is still in excellent condition. Likewise, a small area between Cocos and Anae Island still possess live corals.

C. Recolonization of Corals. Observations made while towing and diving show that very little or no recolonization of corals has taken place in previously killed areas. A detailed study, supported by a FWQA grant to the University of Guam, is presently underway on this very subject.

IV. CONCLUSIONS

From the results of the recent resurvey of Guam and information received from the Starfish Control team, the starfish have done little additional damage to the corals of Guam except perhaps in shallow water. The control team, with the aid of volunteer divers, has killed about 32,000 Acanthaster between September 1969 and August 1970. Previous to September 1969, Dr. R. H. Chesher and his team had killed about 12,000 Acanthaster (Chesher, 1969:32). This provides a grand total of 44,000 Acanthaster killed along the coast of Guam during a 20-month period. If one considers an average adult Acanthaster to weigh about two pounds, approximately 88,000 pounds or 44 tons of starfish have been eliminated to date. The Starfish Control team and the volunteer divers should be commended for a job well done.

However, this active control program must continue to insure the protection of the live corals remaining on Guam. A population estimated to be about 3,000 starfish still occurs between Pati Pt. and Catalina Pt. (Mr. Domingo, personal communication). Also, an unknown number of starfish still inhabit the areas around Anae Island, Cocos Lagoon and the inner reefs of the Asan-Piti area. The coastline between Anae Island and Cocos Lagoon should be protected at all cost since it represents the only extensive live coral communities and reefs on the leeward (western) side of the island.

Our rapid resurvey technique when compared to the findings of the Starfish Control team has proven to be quite accurate in delimiting areas of infestation. The University team will continue to utilize this technique to gain a general picture of the starfish concentrations and coral conditions in future surveys.

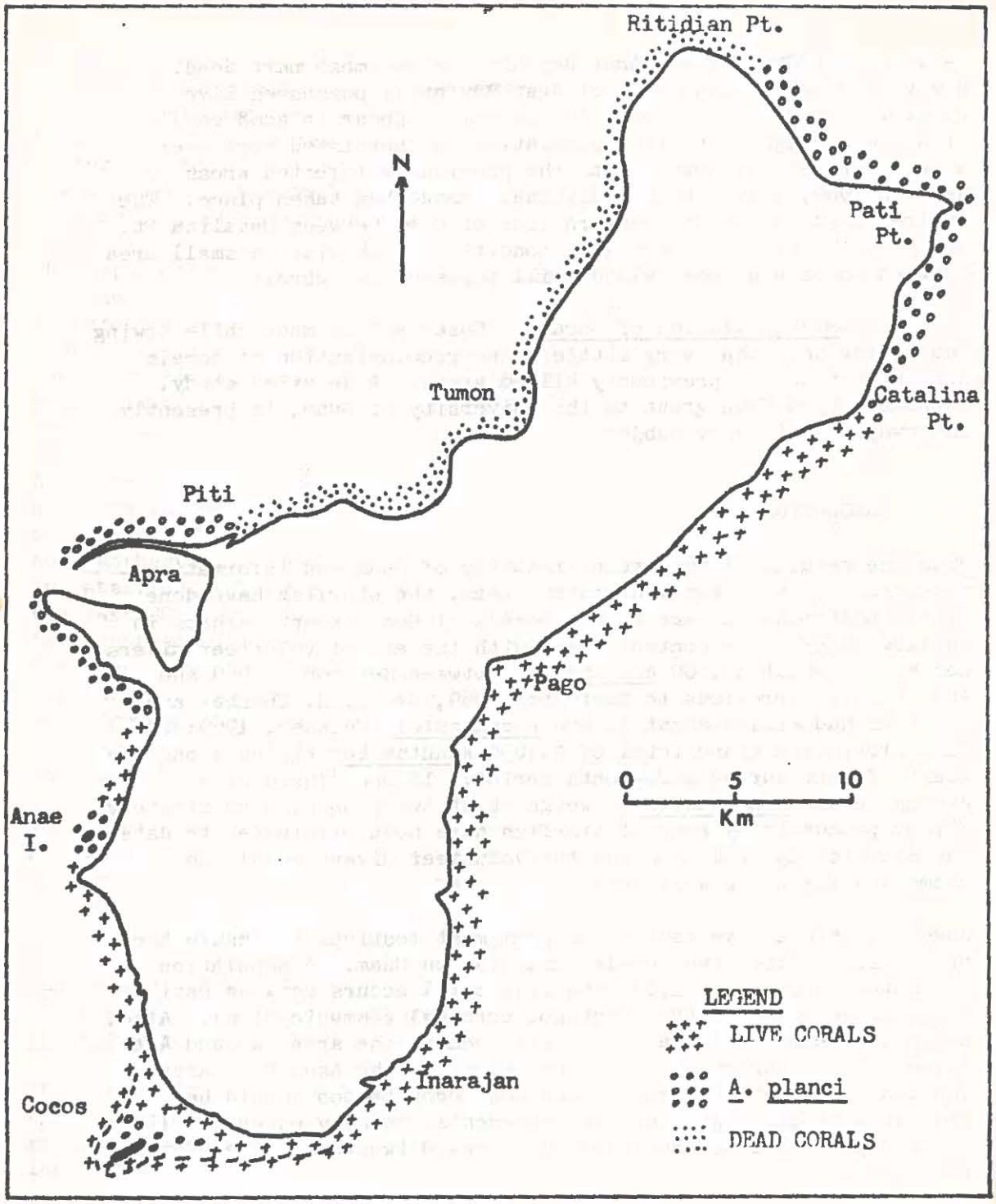

Figure 1. Status of Acanthaster planci and coral conditions on Guam during Summer 1969. (Adapted after Chesher, 1969).

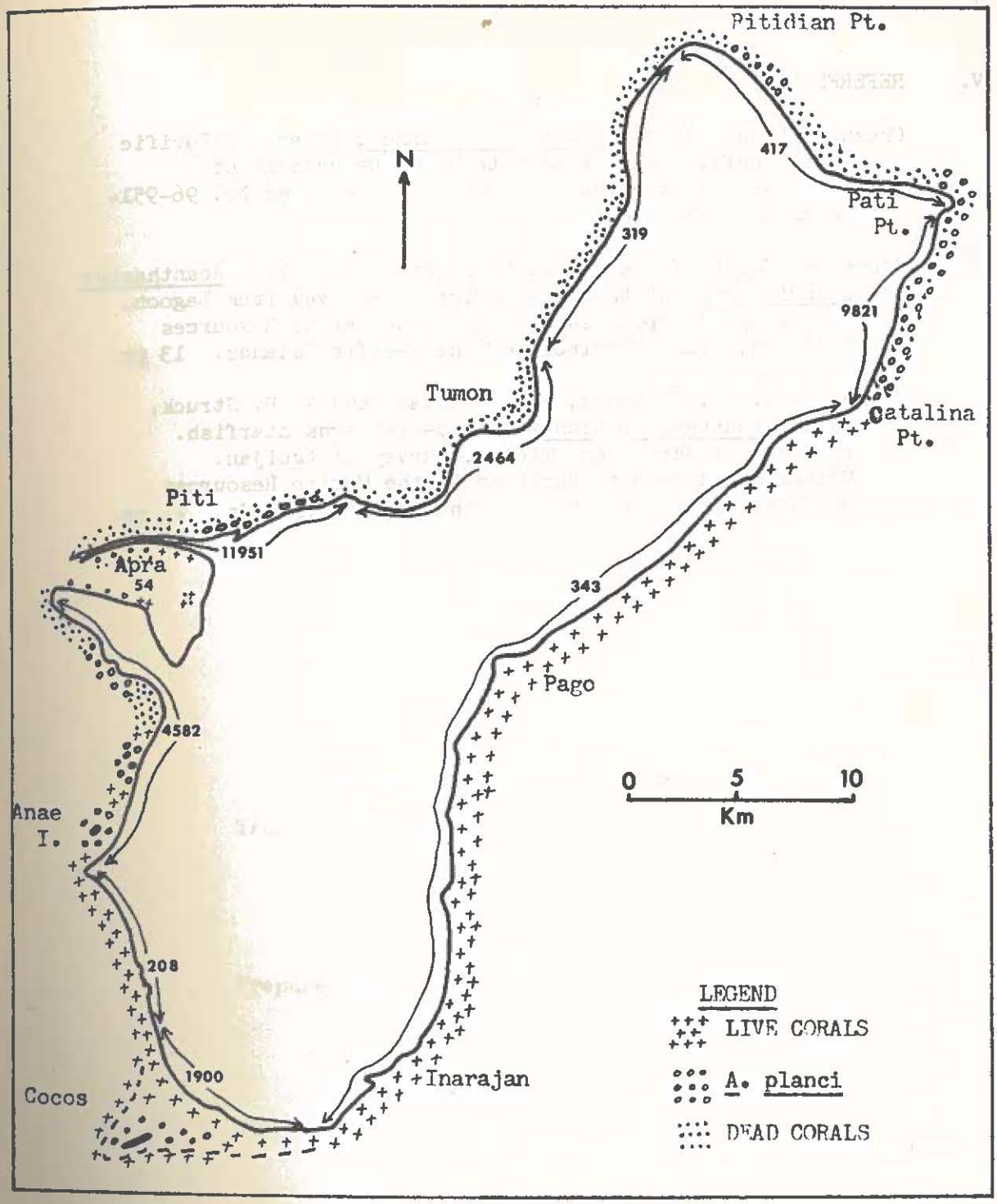

Figure 2. Status of Acanthaster planci and coral conditions on Guam during Summer 1970. (Note: Numbers represent starfish killed between September 1969 and August 1970 in different areas).

V. REFERENCE

Chesher, R. H. 1969. Acanthaster planci, Impact on Pacific coral reefs. Final Report to U. S. Department of Interior. Westinghouse Research Laboratories No. 96-951-Ocean-R2: 152 pp.

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ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Rota

Mariana District
October 1970

Submitted to

Marine Resources Division

Trust Territory of the Pacific Islands

Prepared by:

R. T. Tsuda (Team Leadear)
M. R. Struck
R. J. Lujan
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APPENDIX

Potential Shark Hazard on Rota

It has come to our attention while towing that a large number of the blacktip sharks, Carcharhinus limbatus inhabit the reefs of Rota. A total of 54 blacktip sharks and two whitetip sharks, probably Triaenodon obesus, were encountered during the four-day survey. The sharks were especially numerous on the eastern side of Sosanjaya Bay and outside the channel of West Dock. Sixteen blacktip sharks were encountered during a 60-minute tow along the east coast of Sosanjaya Bay.

On six different occasions, a blacktip shark swiftly ascended from depths of seven to ten meters making a "bee-line" towards the individuals towing behind the boat. On all but two occasions the sharks came to a sudden halt about two to three meters behind the individuals, lingered at the surface for about 15 to 30 seconds and abruptly turned, swimming off in the opposite direction. However, during the other two occasions, the sharks passed within two to three meters on the side of the individuals at the surface and continued forming a circular path around the swimmers. Whenever a shark made an approach, the individuals who were towing would immediately drop off the tow line and remain stationary at the surface pointing their "bang sticks" toward the intruder. This action was taken by the individuals since swimming frantically to the boat would most likely only excite the shark further. It is difficult to say whether this "bee-line" approach of the sharks was an aggressive behavior or merely curiosity on their part.

Since the island of Rota is beginning to attract more tourists, we highly recommend that a shark control program be initiated, especially in Sosanjaya Bay. The abundance of sharks in Sosanjaya Bay can prove hazardous to inexperienced tourists swimming or skin-diving in this beautiful bay. As the local fishermen of Rota can attest, this bay possesses an abundance of fish which could be easily obtained if not for the potential danger of sharks. We are sure that local fishermen have lost many a fish to sharks in this area.

The shark population can be drastically reduced by merely fishing for them with hook and line from the safety of a boat. Since very little is known about the biology of the blacktip shark, biologists at the University of Guam are very much interested in being at the scene when the sharks are fished out. Information on size ratios, sex ratios, gonad condition and food habits can be easily derived with little effort expended at this time. It should be emphasized that we do not advocate complete annihilation of the sharks on the reefs of Rota but simply to lower their numbers in potential recreational areas. The shark, as gruesome as it may appear, does possess a place in the marine ecosystem.

ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Yap

Yap District
December 1970

Submitted to

Marine Resources Division

Trust Territory of the Pacific Islands

Prepared by:

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J. A. Marsh, Jr.
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FIGURES

I. INTRODUCTION

Of the 16 islands in the Trust Territory covered in the Summer 1969 Westinghouse Acanthaster Survey (Chesher, 1969), Yap was one of six islands cited as being free from Acanthaster infestation. Sixteen months have elapsed since this initial survey, and it was felt that a resurvey was long overdue for this island group. The resurvey seemed imperative at this time especially since observations of increased populations of Acanthaster were being reported by a few of the local people on Yap.

Through the cooperation and partial financial assistance of the Division of Marine Resources, Department of Resources and Development, Trust Territory of the Pacific Islands, four members of the University of Guam's Acanthaster Monitoring Team conducted a resurvey of Yap from November 23 to December 3, 1970. The purpose of the resurvey was mainly to investigate the reported increased numbers of starfish and to assess any resultant reef damage.

We extend our appreciation to Mr. Leonard Aguigui, District Administrator of Yap, Mr. Kunio Nakamura, Economic Development Officer and Mr. Jesus Mangarfir, Economic Development Advisor, for all the support they provided during our stay on Yap. We also acknowledge the help extended to us by Ltjg. Daniel Schatte, Commanding Officer, and Chief Gerry Stewart, both of the United States Coast Guard on Yap.

II. METHODS

A. Transportation. Travel authorization and per diem were provided by the Trust Territory Government. We extend our deepest appreciation to Captain Glen Thompson, Commanding Officer, United States Coast Guard, Guam, for providing air transportation for the team and equipment between Guam and Yap. Special thanks go to LtCmdr. Conner, Chief Air Operation Officer, and to Lt. Merrill, Assistant Air Operation Officer, who arranged the flight logistics. A portable rubber raft (14-foot Zodiac) and a 20 HP outboard motor also accompanied the team. However, it was soon realized that a rubber raft powered by a single 20 HP outboard motor was not too dependable in the high seas which we experienced during our stay on Yap. We extend our gratitude to the Administrator of the hospital for the loan of one of his 16-foot "Boston Whaler's"; and to the Department of Public Works and the Department of Agriculture for the loan of two outboard motors.

B. Operations. Since smaller boats were used in this operation, the individuals were towed on the sides of the boat rather than from the stern. Tows were made for 10 to 20 minutes at a slightly faster

speed of 3 or 4 knots. Each team member counted the number of fresh feeding sites (white patches) and Acanthaster seen beneath his side of the boat. These numbers were totaled after each tow and provided a rough estimate of the population of Acanthaster in the area. The assessment of reef damage was analyzed by estimating the percentage of both coral cover and dead corals observed during each tow.

C. Additional Research. Heavy seas considerably slowed the resurvey operations, thus limiting the time available for the Monitoring Team to conduct their own basic research. However, small collections of algae, fishes and invertebrates were made.

III. RESULTS

A total of 74 tows or stations (Figure 1) were made along the barrier reef of Yap. Thirty-seven tows were made along the outer edge of the barrier reef over water 3 to 20 meters deep, and 37 tows or stations were made along the inner reef and lagoon over water 1 to 10 meters deep. Extremely rough seas prevented us from towing or even making a spotcheck of the major portion of the northeastern sector outside the barrier reef. Only one tow was completed between the northernmost point to Gofenu Entrance. The stations are cited in numerical order, beginning on the northeast coast and numbered in a clockwise direction. Stations 1 to 37 were made outside of the barrier reef while stations 38 to 74 were made on the inner side. The numerical arrangement was done to simplify location of each station and does not reflect the order in which the tows were actually made.

Figure 2 and 3 show the locations of Acanthaster planci as well as the condition of the corals along the reefs of Yap for July 1969 and November-December 1970, respectively. A comparison of the two figures shows the changes that have taken place over the 16-month period.

An area is considered infested when one or more fresh feeding sites or Acanthaster are counted per minute during a 10 to 20 minute tow. Counts less than this usually indicate a normal population. However, another category was used in this study which represents 10 to 19 fresh feeding sites observed per 20-minute tow. These areas indicate sites of potential infestations, especially since most of them were found in adjacent areas on both the eastern and western side of the island. Since only a total of 11 Acanthaster was seen throughout the survey, feeding sites are used as indicators of the abundance of Acanthaster in any given area.

A. Infested Areas. As stated previously, the 1969 Westinghouse survey found Yap to be relatively free from Acanthaster and cite

all areas visited as possessing normal reef (Figure 2). Our recent survey revealed only one area where feeding sites were in excess of 20 per 20-minute tow. Station 23 (see Figure 1) possessed 30 fresh feeding sites but no Acanthaster. A dive which had been scheduled in this area at a later date was cancelled due to rough seas prevailing over the remainder of our stay on Yap. From our experience on past resurvey studies, we are convinced that at least an equal number of Acanthaster could be found in concealed areas in the vicinity of the fresh feeding sites.

Five other areas revealed feeding sites numbering 10 to 19 per 20-minute tow. Three (Stations 22, 24, 25) of these sites were located adjacent to Station 23 on the southwestern side of the island. The three stations possessed 10, 10, and 12 fresh feeding sites, respectively. The other two sites (Stations 2 and 4) were located on the eastern side of Gagil, where 15 and 19 fresh feeding sites were seen, respectively.

B. Areas Reported to Possess Acanthaster. Three sources of information pertaining to the past and present locations of Acanthaster were at our disposal during this trip. The first source of information was found in the transcribed dialog of the briefing session held last summer at the University of Guam between D. R. H. Chesher and the participants (Dr. D. Deveney, Mr. T. Phelan and Mr. R. Kiwala). According to this report, the 1969 team found a total of 20 Acanthaster during the entire survey. The largest single population they encountered was 11 Acanthaster on the southeast side, outside the barrier reef. They admit that this count may be inaccurate since several investigators were counting, thus making possible repeated counts on a single Acanthaster. Our recent survey in this area revealed the corals to be about 95% live. Also, only one fresh feeding site and no Acanthaster were encountered in this area.

A discussion with Mrs. Margerie Falanruw, a fellow faculty member in the Division of Biosciences, provided our second source of information on the location of Acanthaster on Yap. She informed the team leader that an increased number of Acanthaster had been reported to her on the western side of the island near Nimpol Entrance and in the Tomil Harbor area. Three tows (Stations 26, 63, 64) in the Nimpol area failed to reveal any Acanthaster. Only one fresh feeding site was found at Station 26. However, eight large, healthy Acanthaster were found south of the channel. Fresh feeding sites were seen within a 5 to 10 meter radius of where the starfish were found. The corals in these areas were still in very good condition.

The third report citing starfish location is relayed in a letter by Mrs. Elaine Migvar, Supervisor of Science in Yap, to Mr. Milton McDonald, Starfish Control Specialist for the Trust Territory. In this letter, Mrs. Migvar cites three areas where Acanthaster were seen in increased numbers - 1) lagoon off North Fanif, 2) lagoon around Rumung Island, and 3) one kilometer north of Gofenu Entrance outside the barrier reef in water 11 meters deep. The site at North Fanif, pointed out to us on a map by Mr. Phillip Riggs of the Economic Development Office, and the lagoon area around Rumung Island were investigated. Only four feeding sites were observed during a 50-minute tow (Stations 64-66) in the north Fanif area, where, two months earlier, Mr. Riggs and Mrs. Migvar had collected five juvenile starfish. Likewise, a 55-minute tow around Rumung Island revealed only three fresh feeding sites and no Acanthaster.

The only area which we were not able to check was the reportedly infested site just north of Gofenu Entrance. According to Mrs. Migvar's letter, Mr. Bill Hienkel, Principal of Yap School, was the individual who saw a large number of Acanthaster in about 10 meters of water. Our discussion with Mr. Hienkel revealed that he estimates the population to be about 100 individuals. Prior to our arrival on Yap, Mrs. Migvar, Mr. Richard Muungwaath from the Economic Development Office and two boatmen visited the area on November 16, 1970, but saw no starfish nor any evident coral damage along a three kilometer sector. However, the population may have migrated elsewhere since Mr. Hienkel's observations were made approximately three months previous to their visit. The feeding sites that we observed just south of Gofenu Entrace may have been caused by a portion of the population Mr. Hienkel had seen north of this entrance.

C. Coral Damage. The 1969 Westinghouse survey team cites all the reefs visited as normal. Our resurvey reveals that the reefs of Yap are still in beautiful condition. We did observe a few areas with dead corals but most of the stations possessed less than 10% dead corals. However, we did encounter eight stations (Stations 2, 3, 4, 7, 8, 32, 35, 36) where approximately 50% of the corals were dead. The corals seemed to have been killed recently, that is, within a year's period, although this is strictly an estimate based on no concrete facts. We assume that if a 50% coral kill occurred in certain areas during the 1969 survey, the 1969 team would have mentioned this somewhere in their field notes. It is a strong possibility that Acanthaster was responsible for the observed dead corals. The reason we say this is because small populations of Acanthaster feed in such a manner that after an individual has fed on a single coral, it will migrate a given distance before it begins to feed again, thus leaving dead corals in among live corals.

D. Acanthaster Abundance. One of the more remarkable features of Yap is its very low population of Acanthaster. In fact, echinoderms as a phylum were not nearly as abundant as on Guam. The large populations of asteroids and echinoids common on Guam, were almost nonexistant on Yap. This is an interesting, but as yet unexplained phenomenon.

IV. CONCLUSIONS

The resurvey study conducted on Yap indicates that at least two small populations of Acanthaster are present outside the barrier reef in water 5 to 12 meters deep. The larger of the two populations, which is estimated to be about 100 to 150 individuals, occurs on the southwestern side of the island. The other population estimated to contain about 50 individuals occur between Gofenu Entrance and Pelak Entrance on the eastern side of the island. (Note: Our estimates are larger than the actual numbers counted because not all the areas along the sectors were investigated). The corals outside the barrier reef and in the lagoon areas are still in beautiful condition.

We know that several lagoon areas inside the barrier reef contain Acanthaster but all of these populations are relatively small (less than 10 individuals). An exception may be the area just north of the channel near Tomil Entrance which may possess a slightly larger population.

The situation that we encountered during our interviews with the local people on Yap was that the words "many, several, plenty" may represent a population as low as five Acanthaster in an area. These words are simply relative to the number of starfish that have been seen in the past.

Most dredging operations are presently being conducted near shore in Tomil Harbor. These sites possess few corals and mainly consist of a sandy substratum inhabited by the seagrass, Enhalus acoroides. It is highly unlikely that Acanthaster larvae could settle and survive in this type of situation.

V. RECOMMENDATIONS

We strongly recommend that the two areas cited, especially the area on the southwest side, be closely watched since these may represent seed populations. With further recruits in each of these areas, the population may pose a threat to the living reefs throughout Yap.

The Economic Development Officer should solicit divers to clear these two areas of starfish. Since these two populations are small, local divers, possibly from the Peace Corp volunteers, could greatly decrease these populations during weekend dives. If this problem cannot be handled at the local level, the Palau Control Team should visit Yap for a week and kill the starfish with their formalin injection guns.

VI. REFERENCE

Chesher, R. H. 1969. Acanthaster planci, Impact on Pacific coral reefs. Final Report to U. S. Department of Interior. Westinghouse Research Laboratories No. 96-951-Ocean-R2: 152 pp.

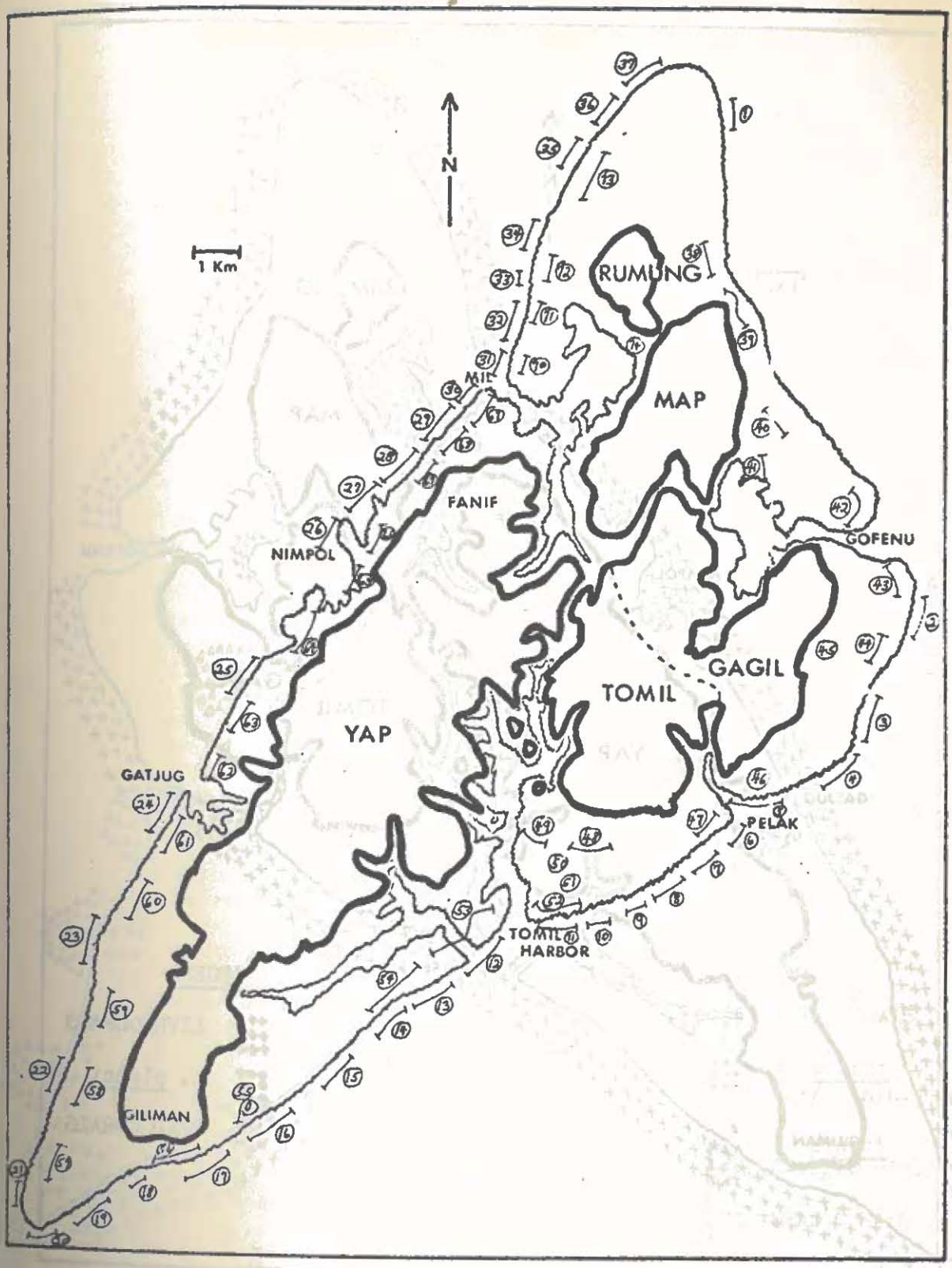

Figure 1. Locations of tows and stations made on Yap.

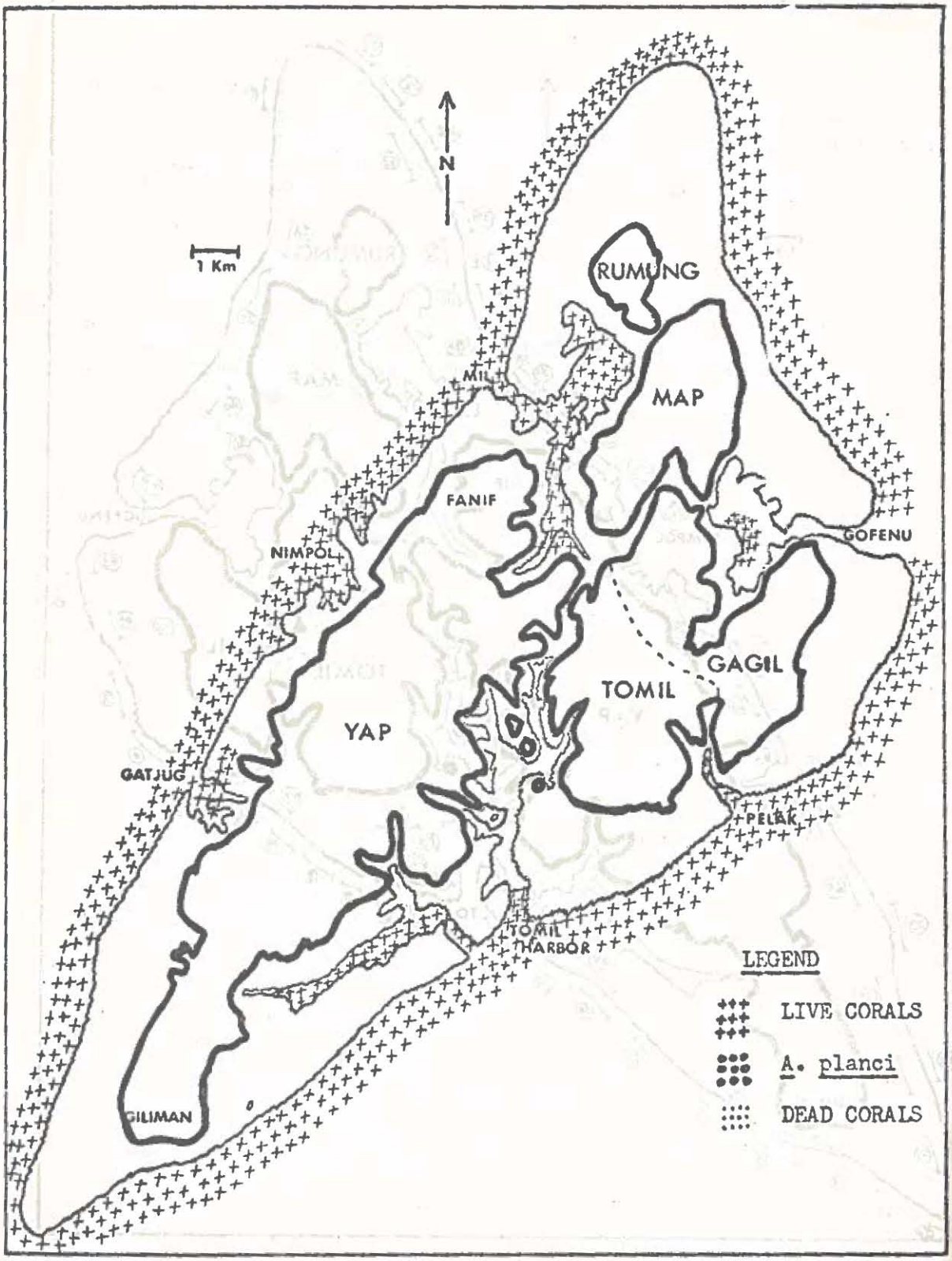

Figure 2. Status of Acanthaster planci and coral conditions on Yap during July 1969. (Adapted after Chesher, 1969).

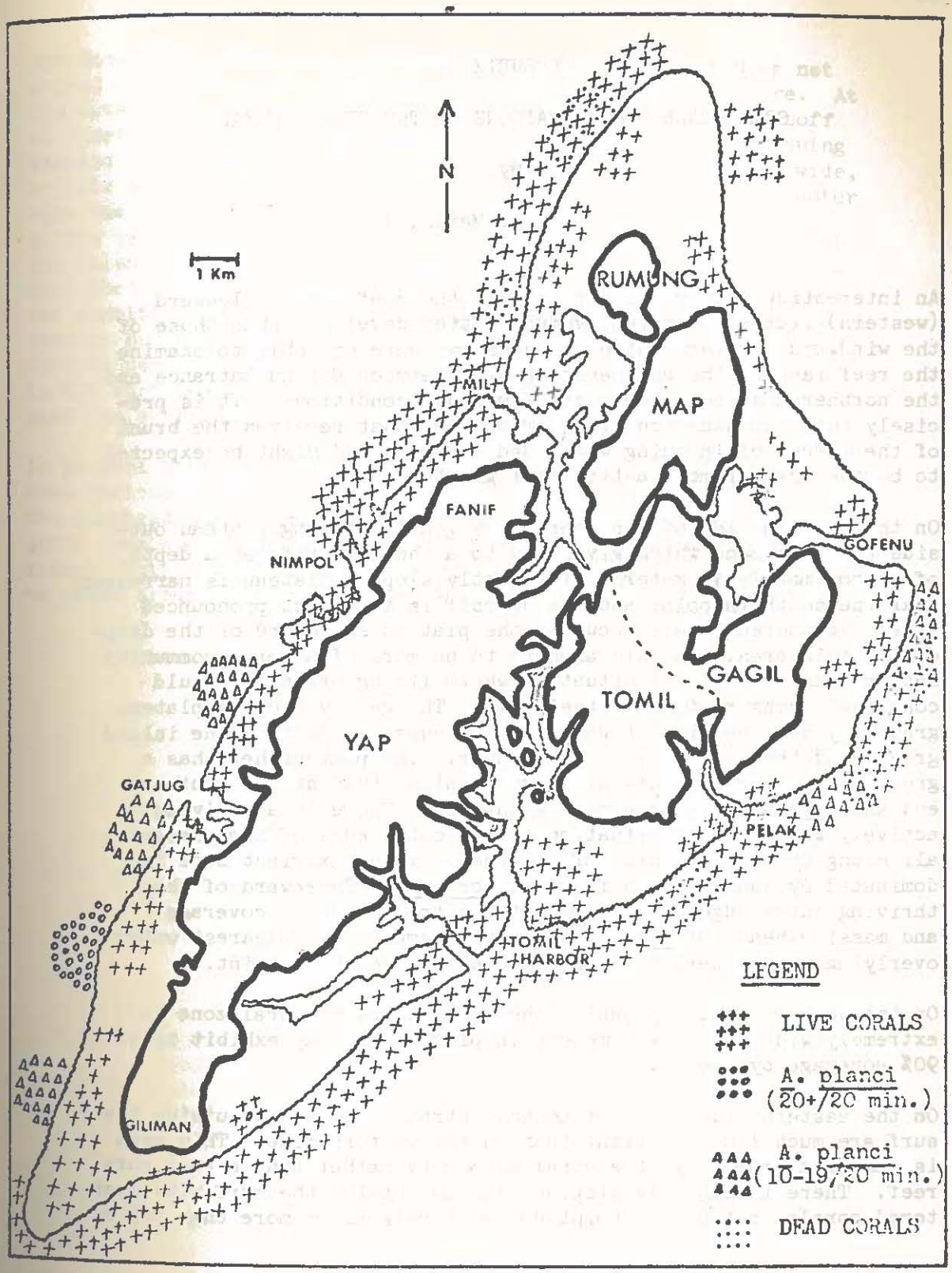

Figure 3. Status of Acanthaster planci and coral conditions on Yap during November-December 1970.

APPENDIX A

SOME GENERAL OBSERVATIONS ON THE REEFS OF YAP

by

J. A. Marsh, Jr.

An interesting feature of Yap is that the reefs on the leeward (western) side are apparently much better developed than those of the windward (eastern) side, although we were not able to examine the reef face on the northeastern side between Gofenu Entrance and the northernmost point because of weather conditions. It is precisely this northeastern side, of course, that receives the brunt of the forces of incoming waves and currents and might be expected to be the area of most active reef growth.

On the western side of Yap there is a gently sloping plateau outside the surf zone which gives way to a sheer dropoff at a depth of approximately 10 meters. The gently sloping plateau is narrowest near the southern point and the dropoff is also most pronounced here. Scattered corals occur on the plateau shoreward of the dropoff in this area, but this appears to be more of a coral community rather than a true reef situation where living organisms would contribute construction of their own. The gently sloping plateau gradually becomes wider toward the northwestern part of the island group, and the dropoff is not as sheer. The plateau here has a greater coverage of reef-building organisms than at the southern end and approaches a true reef situation. There is a thriving, actively growing reef situation at the outer edge of the plateau all along the western side of the reef. This luxuriant zone is dominated by table growth forms of Acropora. Shoreward of this thriving outer edge the Acropora tends to decline in coverage, and massive heads of Porites are more common. The clearest water overlying the western reef is found at the northern point.

On the western reef top inside the surf the outer coral zone is extremely wide, up to 200 meters in places, and may exhibit up to 90% coverage by corals.

On the eastern side south of Gofenu Entrance the zones outside the surf are much less luxuriant than on the western side. This area is composed primarily of a coral community rather than a true coral reef. There is a gently sloping plateau outside the surf with scattered corals, but at no point do the corals cover more than 50% of

the non-living substrate. In most areas coral coverage does not exceed 25% at the most, and 10% would be a more common figure. At the outer edge of this gently sloping plateau there is a dropoff of 2 meters or so, with another gently sloping plateau continuing seaward. The inner plateau is approximately 30 to 35 meters wide, and its outer edge occurs at a depth of 2 to 3 meters. This outer edge has a well developed lip in most areas and is composed of active reef-building organisms. Along the entire eastern side of the island group immediately inside the surf zone there is a zone with good coral development, but at no point does this approach the condition on the western side with regard to width of the coral zone or percent coverage by reef-building organisms. This coral zone is narrowest at the southern end where the land lies closest to the surf zone. It would be instructive to examine the area outside the surf zone on the northeastern side.

In general the reefs of Yap appear to be especially productive, with various species of fish being quite abundant in most areas. The humphead parrot fish is particularly common. Turtles are also quite common outside the surf zone on both the eastern and western sides. This luxuriant and thriving reef presents a marked contrast to other areas of Micronesia which have suffered Acanthaster damage.

APPENDIX B

FISH POPULATION ON YAP

by

D. P. Cheney

Gross observations of the fish biomass were conducted during tows and by dives to establish relative comparisons between the reefs of Yap and elsewhere in Micronesia. The general consensus of the monitoring team was that the abundance of many species was very high especially beyond the reef edge. No observations were made in the surge zone, due to the very heavy wave action during the survey. Most fish were associated with living coral, and the rock rubble and broken and dead corals usually seen in and around the lagoon entrances were almost void of fish.

Fishes on the reef slope were primarily represented by the surgeonfishes (Acanthuridae), butterfly fishes (Chaetodontidae), wrasses (Labridae), triggerfishes (Balistidae) and parrot fishes (Scaridae). The large humphead parrot fish (Chlorurus gibbus) was frequently seen in schools of up to 30 individuals. One team member counted 173, 2 to 3 feet long, in a 20 minute tow at Station 3. Parrotfish and their feeding scars were numerous on the reef slope south of the Tomil entrance and along the leeward reef. An unknown species of grey or blue speckled sting ray was sighted above sand-filled grooves on the reef slope (10 individuals) and in the lagoon. A total of 16 sharks were seen--2 nurse sharks (mean length 2 m), 8 blacktips (mean length 1 m), 3 whitetips (mean length 2 m) and 3 unknown species (mean length 2 m). With the exception of 2 blacktips and the 3 unknown species found in the lagoon, all were seen outside the barrier reef, mainly around the southern tip of the barrier reef.

Inside the barrier reef, fish species generally included butterfly fishes, wrasses, surgeon fishes, damselfishes (Pomacentridae) and goatfishes (Mullidae). Fish were usually small in size but large concentrations were noted, especially of the Chaetodons (mainly in the staghorn areas north of the Tomil entrance--tows 48 to 52).

APPENDIX C

MARINE PLANTS ON YAP

by

R. T. Tsuda

The marine flora on the live reef of Yap is very limited in terms of species diversity and standing crop. This phenomenon is not unusual since other islands where lush corals thrive have revealed this same situation. There seems to be a direct correlation between the greater diversity and number of fishes and a live coral reef, while a negative correlation exists between the smaller algal numbers and a live reef. Likewise, a dead reef usually supports a large algal flora but a limited fish fauna. The obvious reason for a greater algal flora on dead reefs is the larger settling surface available to the zygotes.

The most conspicuous plant community in the marine situation on Yap is the Enhalus acoroides community which forms a band of about 50 meters or more around the entire shoreline of the three islands. Various algal species, e.g., Dictyota cervicornis, Halimeda opuntia, Halimeda macroloba, Caulerpa racemosa and Gracilaria sp., are found in the Enhalus beds.

In the sandy areas among the live corals in the outer reef zone, the blue-green alga Lyngbya majuscula and the green alga Caulerpa urvilliana predominate. Polysiphonia spp. and Pterocladia sp. cover the branches of the dead Acropora.

It should be mentioned that the team did not find the commercially harvestable red alga, Eucheuma, during the survey. The reef of Yap is indeed a very poor area for any avid algologist.

ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Palau

Palau District
February 1971

Submitted to

Marine Resources Division

Trust Territory of the Pacific Islands

Prepared by:

R. T. Tsuda (Team Leader)
P. G. Bryan
R. J. Lujan
A. J. Fortin

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FIGURES

I. INTRODUCTION

A 16-day resurvey along the reefs of Palau was undertaken from December 30, 1970 to January 14, 1971 by four members of the University of Guam's Acanthaster Monitoring Team and four members of the Palau Starfish Control Team. The purpose of this resurvey was to delimit the population levels of the "crown-of-thorns" starfish, Acanthaster planci, and to assess any additional reef damage incurred since the Westinghouse survey (Chesher, 1969b).

Three sources of information serve as a baseline to delimit the starfish and reef conditions of Palau during April 1969. All of the information is based on a ten-day survey conducted under the supervision of Dr. R. H. Chesher from April 3 to 12, 1969. The references are in the form of 1) field notes obtained during the survey, 2) Chesher's report (Chesher, 1969a) to the Fisheries Division of the Trust Territory based on the field notes, and 3) a condensed report with map (Chesher, 1969b) delimiting the infested areas and the condition of the reefs surveyed.

We acknowledge the Division of Marine Resources, Department of Resources and Development, Trust Territory of the Pacific Islands, for providing per diem to the University Team. We sincerely appreciate the full cooperation of Mr. Peter T. Wilson, Chief of Marine Resources, for the use of the boats and SCUBA tanks.

We again acknowledge Captain Glen Thompson, Commanding Officer, United States Coast Guard, Guam, for providing air transportation for the team and equipment between Guam and Palau. Our sincere appreciation is extended to Lt. Merrill, Assistant Air Operation Officer,and to LtCmdr. Conner, Chief Air Operation Officer,for arranging the flight logistics.

II. METHODS

Palau is by far the most extensive area that the team has ever surveyed. A total of 184 tows or stations (Figure 1) were made along the various reef areas of Angaur, Palau proper, Kossol Reef and Kayangel Atoll. As in all the other previous Acanthaster reports, an area is considered infested when one or more fresh feeding sites (white patches or Acanthaster are counted

per minute during a 10 to 20 minute tow. Counts less than this usually indicate a normal population. Only 10 minute tows were made during most of this survey, mainly because of the vast area that had to be covered.

The Palau survey was divided into the following four phases.

Phase I. (Dec. 30-31, 1970) - Since the Coast Guard plane landed on the island of Angaur, prearranged plans were made with the Palau Control Team to meet us with their 30-foot diesel powered boat "Ngeremeyaus" in order to transport the University Team and equipment to Koror. Before heading across the channel to Peleliu, a 20-minute tow was made on the west side of Angaur (Sta. 1). After entering the southwest entrance of Palau proper, four other tows were made along the reefs of selected Rock Islands (Sta. 2-5). After spending the night on one of these islands, the team arrived in Koror the following afternoon.

Phase II. (Jan. 1-3, 1971) - During this holiday weekend, the four members of the University Team surveyed the reefs around Koror (Sta. 6-10) and along the fringing reef on the west coast of Babelthuap (Sta. 11-40).

Phase III. (Jan. 4-9, 1971) - This particular phase involved a 6-day survey of the inner and outer portion of the western barrier reef, Kossol Reef and Kayangel Atoll. Three boats were involved in this operation - "Ngeremeyaus", "Omekang" (a 32-foot diesel powered boat), and the University of Guam's Zodiac (a 14-foot rubber boat). Food, SCUBA tanks, compressor, and fuel were carried on the two larger boats.

Four members of the Palau Control Team joined us in this operation. The eight persons involved were divided into two 4-man teams.

Team A	Team B
R. T. Tsuda, Team Leader	*P. G. Bryan, Team Leader
A. J. Fortin	R. J. Lujan
R. Illuches	T. Adelbai
M. T. Redchor	A. J. Brel

*Mr. Bryan, a biology graduate student at the University of Guam, was the individual who initiated and supervised the Acanthaster Control Program in Palau. He also accompanied Dr. Chesher on the initial survey carried out in April 1969, thereby being a valuable asset to the recent resurvey program.

The survey started at Uchlong Island and moved in a northern direction. The Zodiac was used for the survey along the shallower inner reef, while one of the larger diesel powered boats was used in the survey of the outer seaward terrace. The other larger boat, with one operator, remained close to the 3-man team in the Zodiac as a safety measure. Sixty-six stations (Sta. 41-107) were made along the western barrier reef.

With the completion of the survey of Kayangel Atoll (Sta. 108-119) and Kossol Reef (120-124), the original plan was to return to Koror via the eastern coast of Babelthuap where the survey would continue. This would then complete the survey of the entire northern sector of Palau. However, a tropical storm on Jan. 9 made it impossible to carry out our original plan, thus forcing the two teams to return to Koror via the more protected western lagoon passage.

Phase IV. (Jan. 11-13, 1971) - A southern trip to the Rock Islands and Peleliu Island was undertaken, after a well-deserved rest on Jan. 10 (Sunday). Since only the lagoon portion of the southern sector was to be surveyed, we felt that another speed boat, besides the Zodiac, would be much more efficient for this phase. A conservation speed boat was placed at our disposal. The "Ngeremeyaus" was also used to carry provisions and equipment. Thirteen tows (Sta. 125-137) were made on our way to a preselected campsite about five kilometers southeast of the Seventy Islands. From this focal point, the inner barrier reef was surveyed (Sta. 138-182). On our return trip to Koror, two other stations (Sta. 183-184) were made on the east side of Koror.

III. RESULTS

The results of our recent survey is summarized in Figure 3. A comparison of this figure with that of Figure 2 shows quite clearly the changes that have taken place in Palau over a 21-month period.

A. Infested Areas. In the Westinghouse report, Chesher (1969b) reports large populations of actively feeding Acanthaster at four sites (Fig. 2) - 1) Iwayama Pass, 2) Seventy Islands, 3) off Konrei, northern tip of Babelthuap, and 4) along the reef fringing the western coast of Koror. The largest population was located at Iwayama Pass where about

500 starfish were counted. Ninety-six starfish were collected in a three-hour period in heavy Acropora thickets in the Seventy Islands. The approximate size of the populations at Konrei and at the west coast of Koror were not mentioned by Dr. Chesher.

Our recent survey revealed a population of approximately 100 Acanthaster in the Seventy Islands area. A total of 109 fresh feeding sites and 48 A. planci were counted during six tows (57 minutes) over the reefs. Acanthaster were either absent or in normal populations in the other three areas cited as being infested during April 1969. This is not at all surprising when one considers that few live corals now remain at Konrei and at Iwayama Pass.

Eighteen additional abnormal populations (Table 1) of A. planci were found scattered throughout the Palau area. However, none of these populations could be considered as migrating herds.

B. Reef Damage. Only three dead coral areas were denoted in Chesher's map reproduced here as Figure 2. These areas are located 1) on the inner barrier reef west of Babelthuap, 2) just southwest of Uchlong Island, and 3) on the reef flat east of Iwayama Bay.

Our survey revealed that the reefs of Uchlong and Iwayama Bay are still very much dead with no evidence of recolonization of new coral colonies. Except for the patch reefs on the west coast of Babelthuap and around some of the Rock Islands, most of the dead areas denoted in Figure 3 were not caused by A. planci.

The dead areas around the island of Peleliu denote sandy areas and coral areas killed when exposed at low tides. The southern tip of Cormoran Reef may or may not have been killed by A. planci. Some of the dead corals must be attributed to storm damage since huge Acropora branches were lying on their sides. The dead corals in the lagoon of Kayangel Atoll were in most cases killed by exposure during low tides and appeared as rather flat pavements. Coral growth was relatively sparse in the lagoon except for some Acropora thickets near the channel entrances.

It should be made very clear that many of the areas which are denoted as live corals in Figure 3 do possess some sectors where most of the corals are dead. However, these areas are scattered and may represent a site of about 20 meters in diameter. A live coral area is any area that contains an average of about 75 per cent live coral.

The most obvious area not covered during this survey was off the eastern coast of Babelthuap. However, a survey along this coastline was conducted by the Palau Starfish Control Team during the month of October 1970. Mr. Illuches, leader of the Palau starfish team, told the team leader that fresh feeding sites and A. planci were absent during their survey. He describes the coastline as having a rather flat pavement with few scattered corals.

C. Control Efforts. Control efforts in Palau began on March 5, 1969. During the period from March 5, 1969 to December 1970, a total of 14,591 A. planci has been killed. A breakdown in reference to the number of starfish killed per month is as follows:

March 5, 1969 - May 22, 1970	= 7,018	A. planci killed
June, 1970	= 2,818	
July, 1970	= 643	
Aug., 1970	= 1,076	
Sept., 1970	= 885	
Oct., 1970	= 0	(Survey Conducted)
Nov., 1970	= 721	
Dec., 1970	= 1,430	

IV. DISCUSSION

Our recent survey revealed that small scattered populations of Acanthaster planci were still very much evident in Palau. Large herds of starfish were absent on all reefs surveyed. This was primarily due to the control efforts being carried out since March 1969. It is of interest to note that 96 per cent of all Acanthaster killed in Palau were in four areas (see Figure 3). The damage done over the past 21 months on the reefs is not very extensive which may be again attributed to the control efforts. The staghorn coral (Acropora) seemed to be the only genus affected by Acanthaster.

All of the Acanthaster were confined in the lagoon. Unlike other islands with barrier reefs, e.g., Truk, Yap, Saipan, Acanthaster and reef damage were completely lacking outside the barrier reef.

The greyish appearance of all of the Acanthaster seen on Palau is quite distinctive, since the Acanthaster on other islands are usually of a greenish, reddish or purplish color.

Although a thorough search was made for A. planci near fresh feeding sites, only 182 Acanthaster compared to 1129+ fresh feeding sites were observed during the entire survey. Only a few of these fresh feeding sites (less than 10) can be attributed to the pillow-star, Culcita novaeguinae. We are well aware that most of the Acanthaster were hidden in the Acropora thickets. However, there were several situations where the white patches were located in open areas with no Acanthaster in sight. It may very well be that we are over-emphasizing the counts of fresh feeding sites as indicative of Acanthaster population size. Further surveys may show that a single Acanthaster may be responsible for several white patches which may only appear new to the observer. If this is true, then algal colonization must be occurring at a slower pace in certain areas. We are quite sure that this is not true for all situations since we did obtain at least a 1:1 radio (starfish: coral) on Truk.

Only 13 sharks (4 whitetip, 4 greys, 1 nurse, 4 unknown) were encountered while towing. Eighteen turtles, mostly hawkbills, were counted during the survey.

V. RECOMMENDATIONS

There are three recommendations that we would like to propose at this time.

1. The Palau Starfish Control Team should revisit all of the areas where our survey found abnormally high starfish populations. Each area should be covered intensively, and only when that area is obviously free of Acanthaster should the Control Team move on to the next site.

2. The team should be stringently supervised. Weekly conferences with a knowledgeable supervisor should be initiated. The Control Team had no business spending up to two weeks

on Kayangel Atoll. This is just a waste of time and money, particularly since A. planci is absent from this area. Not a single Acanthaster has been killed on this atoll since the inception of this project.

3. Unless the Control Team plans to spend several days in a given area, daily trips should be carried out in a speed boat. In this way, several widely separated sites can be checked within a single working day. The diesel powered "Ngeremeyaus" is simply too slow. The team leader has just been informed (Milton McDonald, personal communication) that this problem has been solved by the arrival of a speed boat in Palau to be used for Starfish Control.

VI. REFERENCES

Chesher, R. H. 1969a. Report to the Fisheries Division of the Trust Territory on the presence of the Sea Star Acanthaster planci in Palau. Mimeographed report submitted to the Marine Resource Division, Trust Territory of the Pacific Islands. 7 pp.

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Table 1. Data for the 19 areas in Palau which had abnormally high counts of fresh feeding sites or Acanthaster planci.

STATION NO.	LOCATION	DEPTH (m)	MINS. TOWED	NO. OF FEEDING SITES	NO. OF A. planci	FEEDING SITE PER MINUTE	A. planci PER MINUTE
16	Inner West Barrier	2-7	15	18	6	1.2	.40
23	W. Babelthuap	1-2	5	22	2	4.4	.40
35	W. Babelthuap	2-7	5	18	1	3.6	.20
38	W. Babelthuap	1-2	10	18	0	1.8	.00
40	W. Babelthuap	1-7	10	12	2	1.2	.20
50-51	Inner West Barrier	1-4	40	ca.100	56	2.5	1.40
62-63	Inner West Barrier	1-4	20	22	0	1.1	.00
80,81,83	Cormoran Reef	2-3	27	42	0	1.6	.00
87-90	Cormoran Reef	2-3	60	80	2	1.3	.03
121	Kossol Reef	1-2	10	12	1	1.2	.10
124	Kossol Reef	1-2	10	16	1	1.6	.10
125-127	W. Malakal Ent.	2-8	55	206	5	3.7	.11
131	Rock Islands	1-2	10	24	0	2.4	.00
135,137	Rock Islands	1-2	20	44	0	2.2	.00
140,144 147,149,150	SW Inner Barrier	2-3	50	70	7	1.4	.14
153-138	Seventy Islands	1-3	57	109	48	1.9	.84
169	SE Inner Barrier	1	10	13	0	1.3	.00
181-182	SE Inner Barrier	2-3	20	83	3	4.2	.15
183	E. Malakal Hbr.	3-7	10	33	0	3.3	.00

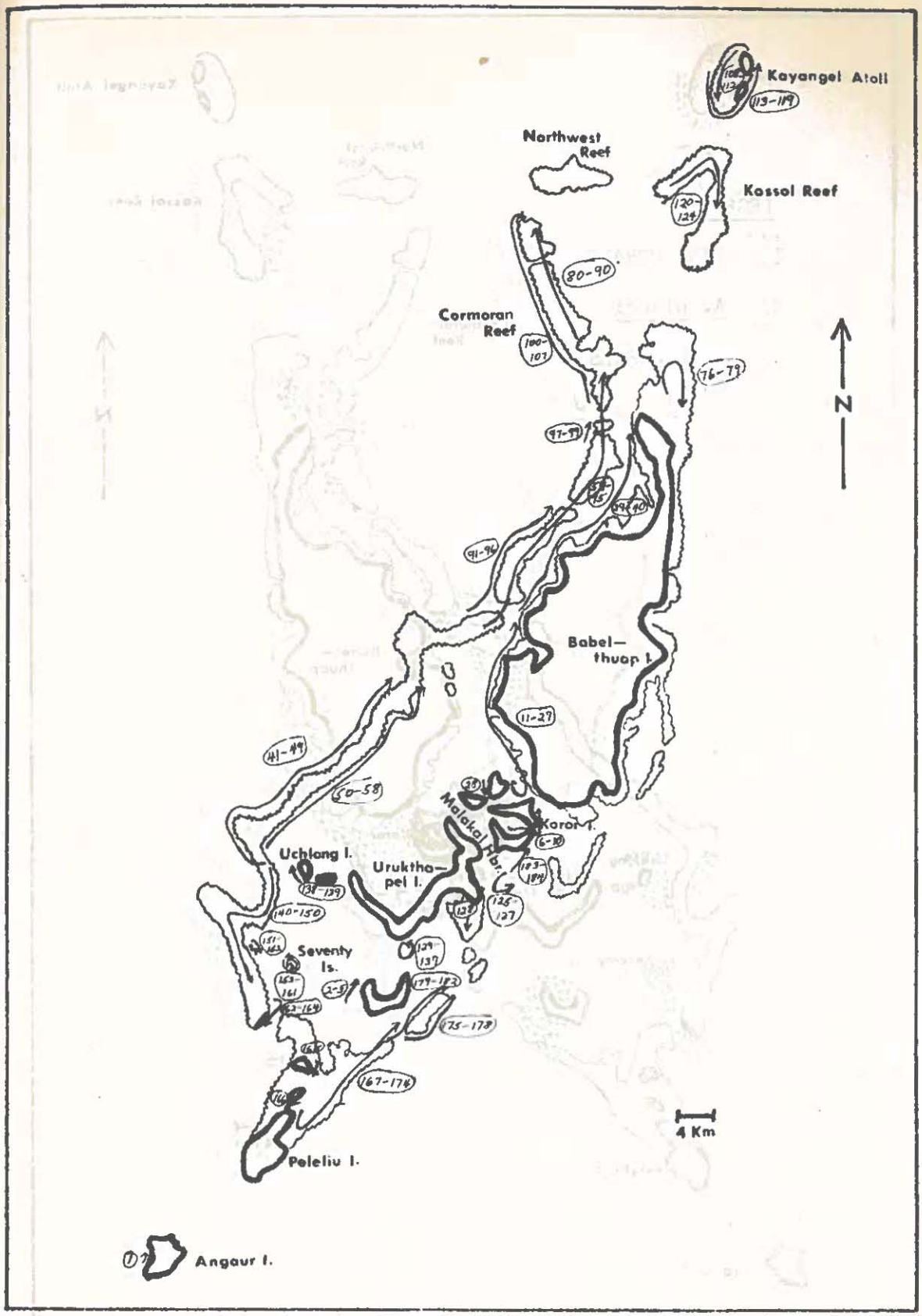

Figure 1. Locations of tows made on Palau.

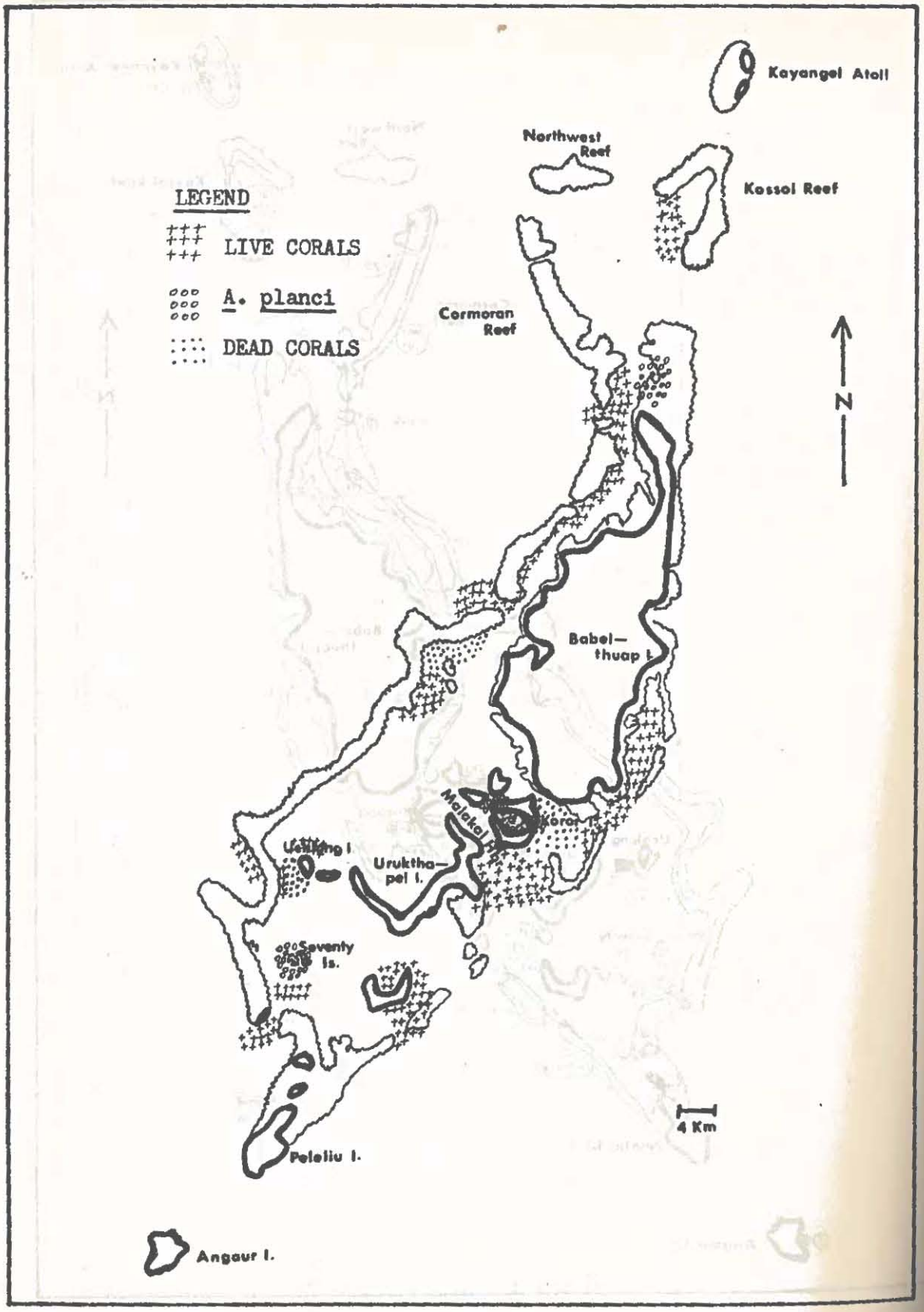

Figure 2. Status of Acanthaster planci and coral conditions on Palau during April 1969. (Adapted after Chesher, 1969).

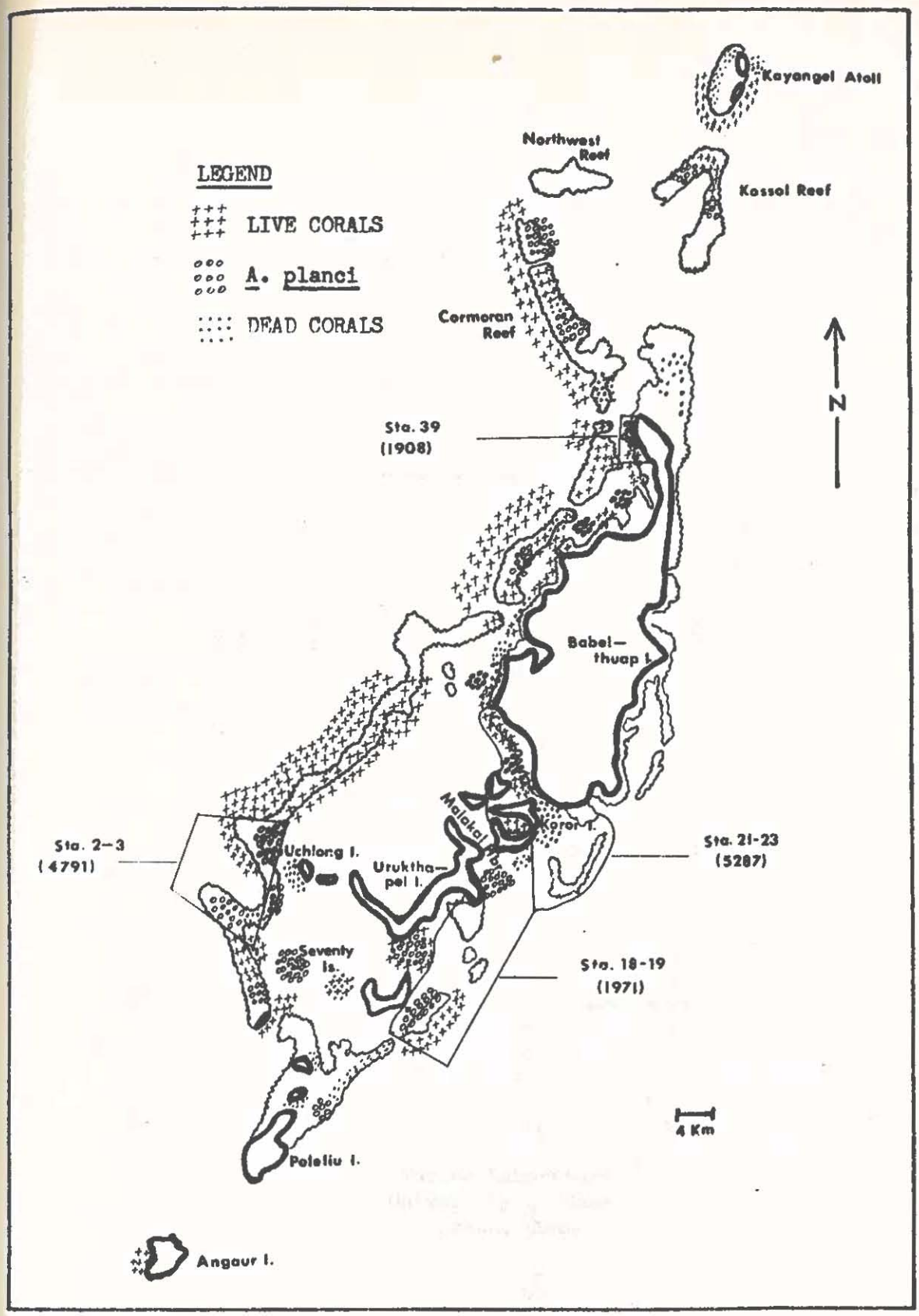

Figure 3. Status of Acanthaster planci and coral conditions on Palau during December 1970 and January 1971. (Note: Numbers represent Stations and Starfish killed between March 1969 and December 1970 in four localities).

ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Resurvey of Ponape and Ant

Ponape District
April 1971

Submitted to

Marine Resources Division

Trust Territory of the Pacific Islands

Prepared by:

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FIGURES

I. INTRODUCTION

A five-day resurvey along the inner and outer barrier reefs of Ponape and a one-day resurvey of Ant Atoll were undertaken from April 4 to 10, 1971 by four members of the University of Guam's Acanthaster Monitoring Team with assistance from five members of the Ponape Starfish Control Team. The purpose of this resurvey was 1) to delimit the population levels of the "crown-of-thorns" starfish, Acanthaster planci, 2) to locate any additional reef damage incurred since the Westinghouse survey (Chesher, 1969), and 3) to assess the control efforts of the Ponape Starfish Control Team.

Two sources of information pertaining to the past condition of the coral reefs and to the locations of the starfish were at our disposal prior to the resurvey. The first source of information was the transcribed dialog of the briefing session held on August 1969 at the University of Guam between Dr. R. H. Chesher and the biologists (K. Read, G. Anderson, A. Johnson and J. Johnson) who made the original survey of Ponape and Ant. The second source was Dr. Read's summary of their findings which was included in the 1969 Westinghouse report (Chesher, 1969).

We acknowledge Mr. Peter T. Wilson of the Division of Marine Resources, Department of Resouces and Development, Trust Territory of the Pacific Islands, for providing plane fares via Air Micronesia and per-diem. We also acknowledge the Ponape Starfish Control Team (Messrs. Victor Edwin, Henerick Weber, Rooney Philip, Johnston Rott and Kelemins David) for their help during portions of the resurvey.

II. METHODS

A total of 106 stations was made at regular spaced intervals along the inner and outer sides of the barrier reef of Ponape (Figure 1). Except for three areas where spotchecks were made due to rough seas, all of the other stations were made by towing either one or two individuals for an average of ten minutes. Two boats were used during the entire operation on Ponape. The 19-foot fiberform boat was used on the outside of the barrier reef where four individuals alternated and towed in pairs from the stern at the end of 15-to 20-meter long ropes. The smaller less stable Mokilese boat was used on the inner portion of the barrier reef where one or two individuals towed from the sides of the boat. The number of individuals working from the smaller boat varied in relation to the number of Control Team members who showed up for work.

Since the outboard motors on the Mokilese boat were not functioning properly, only the 19-foot fiberform starfish boat was used in the resurvey of Ant Atoll. It should be pointed out that the two 40-HP

outboard motors on this boat were also in need of repairs. Only 18 stations (Figure 1) were made along the barrier reef of Ant. Fifteen of these stations were made outside of the barrier reef, while the remaining three stations were made on the eastern lagoon side of the atoll.

As in all the other previous Acanthaster reports (see Reference section), an area is considered infested when one or more fresh feeding sites (white patches) or Acanthaster are counted per minute during a ten-minute tow. Counts less than this usually indicate a normal population.

III. RESULTS

The results of our recent resurvey is summarized in Figure 3. A comparison of the results obtained from the present Acanthaster resurvey with that of the 1969 survey (Figure 2) shows the changes that have taken place on the reefs of Ponape and Ant over a 21-month period.

A. Infested Areas. Chesher (1969) reports large populations of Acanthaster in three areas on Ponape - 1) inner portion of the northeast barrier reef, 2) inner portion of the southern barrier reef, and 3) both inner and outer portions of the northern barrier reef. Our recent resurvey reveals that the reefs of Ponape are still seriously infested with Acanthaster which forms a continuouse belt on the outer portion of the western and northeastern side of the island. Approximately 1200 fresh feeding sites and 123 Acanthaster were counted on the northeast side (Stations 1-15), while approximately 1400 fresh feeding sites and only 18 Acanthaster were counted on the western side (Stations 26-44). The starfish population formed a belt in water 7 to 13 meters deep on the northeastern side (windward side) and were scattered in water 3 to 13 meters deep on the western side. It seems obvious that the calmer waters on the western side allowed the starfish to occur in shallower waters near the reef margin.

The infestations in the inner portion of the barrier reef were in isolated localities and contained much smaller populations. The number of fresh feeding sites and Acanthaster counted per infested station (see Figure 1) on the inner barrier reef is listed below.

Station Numbers	Minutes Towed	Number of White Patches	Number of Acanthaster
53	10	19	10
58	10	15	11
79	10	18	17
82-83	20	87	44
87-88	20	26	17
91	10	ca.75	2
96-97	20	ca.75	12
104-105	20	45	5

Twenty specimens each were collected from two areas located at the inner portion of the western side (Kebara Channel) and eastern side (Aru Channel) of the barrier reef on Ponape to obtain information on their size and gonad conditions. Seven of the Acanthaster collected at Kebara Channel and six from Aru Channel possessed ripe gonads. The mean diameter, average number of arms and sex ratios are presented below for the two populations.

Locality	$\bar{x}$ diameter	$\bar{x}$ disk diameter	$\bar{x}$ number of arms	Sex Ratio (Male:Female:Immature)
Kebara Channel	27.8 cm	11.9 cm	14.2	18:1:1
Aru Channel	23.2 cm	10.4 cm	13.0	7:6:7

The 1969 Westinghouse report states that out of the five spotchecks made in the lagoon of Ant Atoll, two of these stations were infested with Acanthaster. The lagoon side of the only passage was reported to contain the larger infestation. See Figure 2 for the locations of the infestations. Only two infested areas were on the outside portion of the barrier reef. Approximately 100 fresh feeding sites were seen on the northeastern tip of the barrier reef but only on the edge of the seaward terrace in 10 to 13 meters of water. Only three fresh feeding sites were seen on the inner reef terrace during a ten-minute tow. On the northwestern tip of the barrier reef, thirteen fresh feeding sites were seen in the same general zone during a five-minute tow. However, no Acanthaster were seen in either areas.

B. Reef Damage. The infested reef areas on the outer portion of the barrier reef possessed anywhere from 20 to 90 percent dead corals. Although infested, the northeastern side still possessed certain areas with luxuriant coral growth. Since the eastern and southern portions were pretty much dead, the Acanthaster seem to be migrating in a southerly direction towards the only live uninfested coral area on the southeast side.

The starfish population seen in the summer of 1969 had already killed most of the corals on the northern and southern side of Ponape. The corals on the inner portion of the barrier reef were generally in good condition except in isolated areas (see Figure 3). The dead reef area seen at Station 100 was caused by exposure during low tides.

The entire west coast of Ant Atoll is characterized by a rather steep dead coral cliff. The coral area just east of the passage possesses approximately 70 to 80 percent dead corals. It is unknown whether the Acanthaster were responsible for killing the corals in this area, since no Acanthaster was seen here or in the adjacent live coral areas. The eastern and northern sections of Ant Atoll possess one of the most

beautiful reefs the team leader has ever seen.

C. Control Efforts. The Ponape Starfish Control Team was organized on September 9, 1970. During the period from September 9, 1970 to March 24, 1971, a total of 29,459 Acanthaster were killed. A breakdown of the number of starfish killed per month is as follows.

September, 1970	=	6165 Acanthaster planci killed
October, 1970	=	6395
November, 1970	=	6453
December, 1970	=	1398
January, 1971	=	2285
February, 1971	=	2463
March, 1971	=	4300

As can be seen in Figure 3, the majority of the starfish were killed in the inner portion of the barrier reef (see numbers in parenthesis) in water about a meter deep. However, the kill data merely reflects the areas where control efforts have been concentrated, since there is just as many starfish on the outside of the barrier reef.

IV. DISCUSSION

Our recent resurvey of Ponape reveals that the populations of starfish found by the Westinghouse Team during the summer of 1969 have scattered so that presently the entire western, northern and northeastern areas outside the barrier reef are infested. Acropora was again the main coral attached by Acanthaster.

The fringing reefs around the island have a relatively small number of Acanthaster, mainly due to the small amount of corals present and fresh-water runoff. The seagrass, Enhalus acoroides, is the dominant organism inhabiting these areas.

We feel that the Ponape Starfish Control Team has done a commendable job in lowering the population levels of the starfish in the inner portion of the barrier reef. The team was wise to concentrate their efforts in the lagoon area since this is the area where most of the spearfishing is done. However, the outer portion of the barrier reef is too heavily infested to be neglected at this time. The team needs further assistance immediately. We estimate that at least another 15,000 Acanthaster still inhabit the waters of Ponape.

The recent resurvey of Ponape also reveals that the outer portion of the barrier reef supports a large population of food fishes in certain areas. The outer portion of the northeastern barrier reef which is presently infested with Acanthaster still possesses live corals, and is exceedingly rich in fishes, e.g., Lutjanids, Serranids, Scarids, Teuthidae, Acanthurids and Plectorhynchids. However, a scarcity of

semi-pelagic fishes, e.g., Carangids, Scombrids and Syphraenids, was conspicuous around Ponape.

The richness of Ponape's fish population on the northeastern barrier reef may be due, in part, to the movement of fishes into this area from adjacent dead areas. This presents further reason why control efforts should be initiated immediately in this area to conserve this large potential source of protein from disappearing.

The atoll of Ant is not as dead as the Westinghouse report states. Since time prevented us from resurveying most of the lagoon reefs, we are unable to estimate the starfish population, if any, in the lagoon.

V. RECOMMENDATIONS

There are two recommendations that we will make at this time.

1. The Ponape Starfish Control Team should spend at least one or two days surveying the lagoon of Ant Atoll, and kill any starfish present. They should undertake this only after their outboard motors are functioning properly. Problems with the motors and the bad weather prevented us from making a return visit to Ant Atoll. If time permits, the two populations on the outer side of the barrier reef should be investigated.

2. We strongly feel that a bounty system of ten-cents per starfish should be initiated. The local people could go to the infested areas in the inner portion of the barrier reef and safely gather the starfish in the shallow waters about a meter deep. This will then free the Control Team members, who are trained SCUBA divers, to kill the starfish in the deeper waters over the barrier reef. The Team should begin their control efforts outside of Matalanim Harbor and work northward to protect the live corals on the eastern side from further damage.

The initiation of a bounty system would be cheaper in the long run since it is presently costing the Trust Territory approximately 16 cents per starfish killed on Ponape. This is a fantastically low price when one considers that it costs the Government of Guam about one dollar for each starfish killed.

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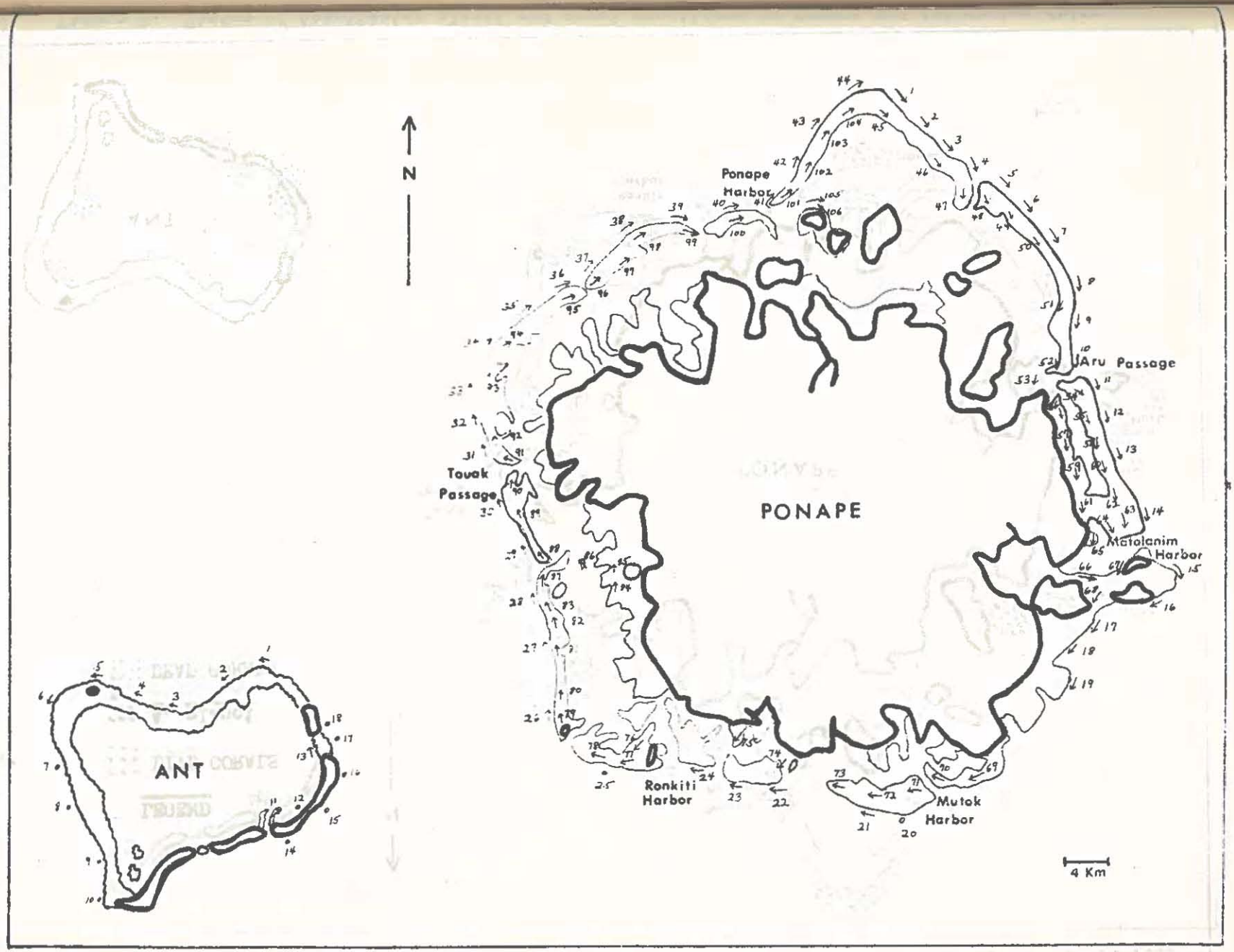

Figure 1. Locations of stations made on Ponape and Ant Atoll.

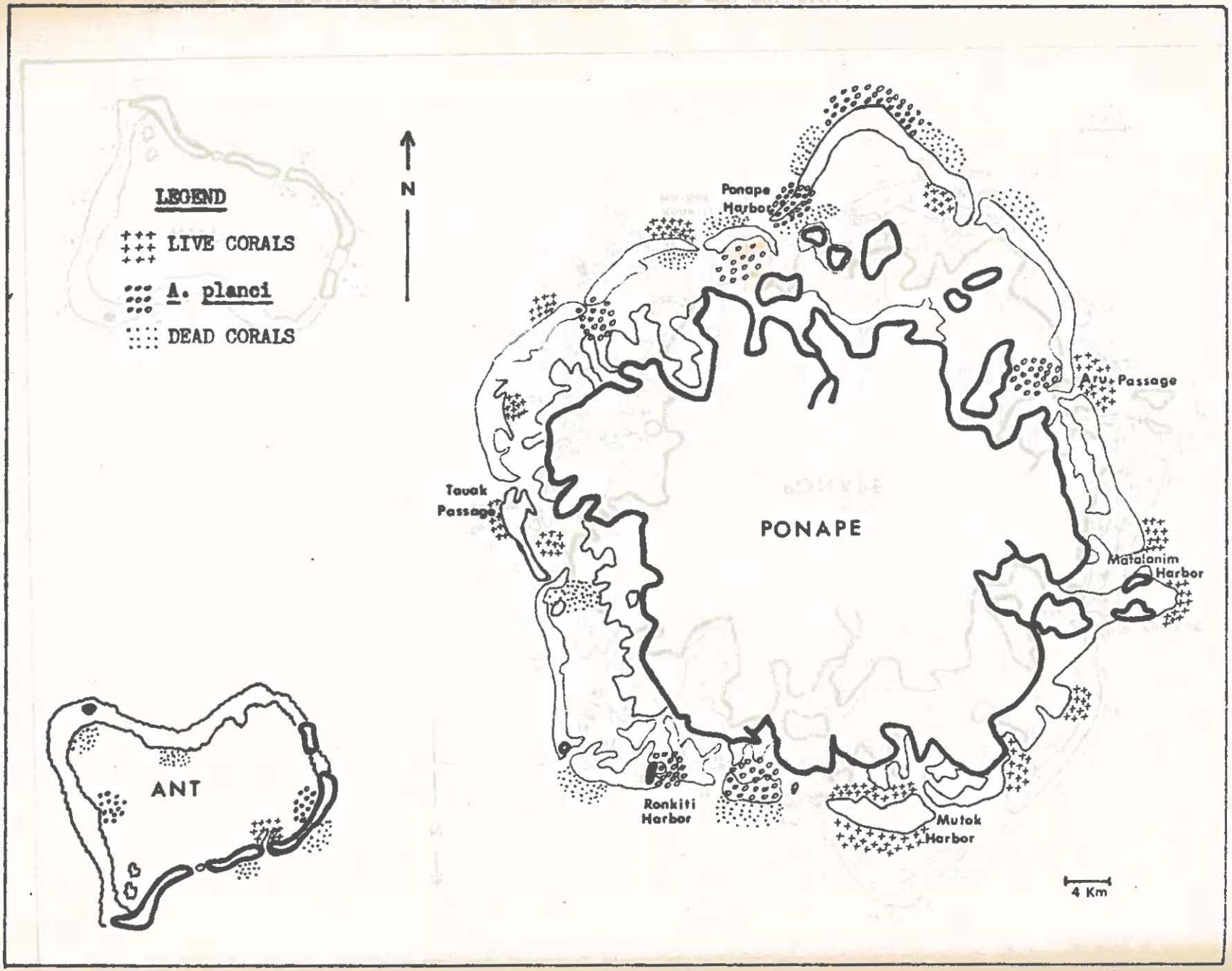

Figure 2. Status of Acanthaster planci and coral conditions on Ponape and Ant during July-August 1969. (Adapted after Chesher, 1969).

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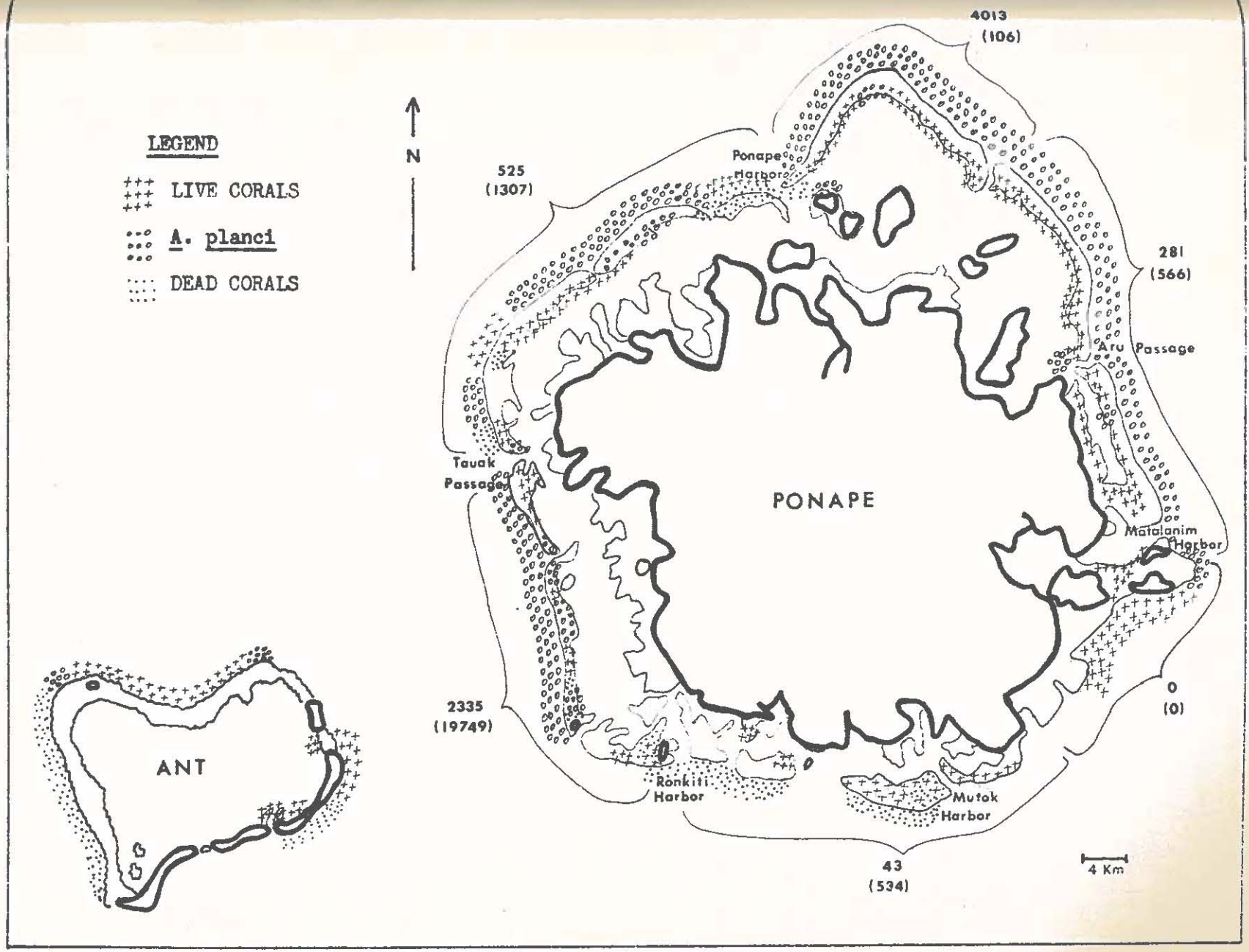

Figure 3. Status of Acanthaster planci and coral conditions on Ponape and Ant during April 1971. (Note: Numbers represent A. planci killed outside and inside (in parenthesis) of barrier reef).

ACANTHASTER PLANCI

Resurvey of Guam

April 1971

Submitted to

Governor of Guam

Prepared by

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I. INTRODUCTION

The Crown-of-thorns starfish, Acanthaster planci, was monitored on Guam during surveys conducted in 1969 (Chesher, 1969) and 1970 (Tsuda, 1970). The purpose of these surveys was to ascertain the effectiveness of the starfish control programs in limiting the spread of known populations. They also provided comparative information on yearly changes in starfish numbers and aspects of reef destruction and recovery. Additional reconnaissance of infested areas was carried out periodically by University of Guam and Division of Fish and Wildlife personnel throughout the 1969 and 1970 period.

The University of Guam Marine Laboratory, in cooperation with the Division of Fish and Wildlife starfish control team, conducted a resurvey of Guam from March to April, 1971. This survey provided more information on seasonal fluctuations in starfish populations throughout Guam as well as presenting a current summary of the starfish problem on the island.

We acknowledge Mr. I. Ikehara (Chief, Division of Fish and Wildlife) and Mr. R. Domingo (Leader, Starfish Control team) for providing the information on the numbers and locations of A. planci killed over the past 9 months on Guam.

II. METHODS

The 1971 Guam resurvey was conducted by staff members of the University of Guam Marine Laboratory, other University personnel and members of the Starfish Control team.

The operations and procedures were similar to those used by the 1969 Westinghouse survey (Chesher, 1969) and the 1970 resurvey (Tsuda, 1970). Depending on availability and location towed, one of four Marine Laboratory boats was utilized. The Starfish Control team used their own vessel. During each towing cycle, two individuals were towed behind or beside the boat at approximately 2 knots for 10 to 20 minutes (normally 20 minutes). Whenever possible, we attempted to tow in a zig-zag fashion covering the reef from the surge zone to the maximum visible depth which varied from 10 to 20 meters. During the course of towing each team member counted the number of fresh feeding sites (white spots) and Acanthaster seen beneath his side of the boat. Additional observations were made on the percent of living and dead coral cover and relative abundance of the major fish fauna. The fish were grouped as Acanthuridae, Chaetodontidae, Scaridae, and miscellaneous large carnivones. No effort was made to determine species types.

SCUBA and snorkel dives were made over infested sites and Acanthaster in a few locations were measured and sexed. All observations and notes were recorded directly by employing a tape recorder or slate as soon as possible after each tow.

III. RESULTS

The 1971 resurvey of Guam included most outer reef slope and terrace areas, the fringing reef lagoons of Tumon, Anae and Cocos, and the Outer harbor of Apra Harbor. The Marine Laboratory and Fish and Wildlife teams completed 65 tows and 12 SCUBA and/or snorkel dives.

The distribution of Acanthaster on Guam remains generally similar to that observed by the Marine Laboratory team in 1970 (Tsuda, 1970). Some significant changes have occured, however, and these may be noted by comparing the 1971 distribution chart (Figure 1) with the figures in the 1970 resurvey report (Tsuda, 1970).

Acanthaster are still concentrated in large numbers from Catalina Point to Pati Point and from Anae Is. to Tipalao. Smaller groups were also observed in the lagoon and seaward slope of the west reef at Cocos. The density of starfish in these areas was one per square meter to one per 100 square meters. Less concentrated aggregations were seen from Pago Bay to Catalina Point, Tumon Bay (on the reef flat) and Piti lagoon.

Specific Observations

1. Catalina Point. Within the area enclosed by Catalina Point and Pati Point, Acanthaster has been able to maintain its numbers at a level nearly equal to the early "plagues" seen on the now-destroyed northwestern reefs. At Catalina Point a band of starfish, 15 to 30 m (45 to 90 ft.) wide was seen at a depth of 15 m (45 ft.). No starfish or feeding scars were seen at less than 15 m.

A SCUBA dive in 20 m (60 ft.) about 1 km north of Catalina Point revealed a coral cover of 70 to 80% but only 20% of this coral was alive. Starfish were not all actively feeding and feeding sites were not numerous. Density of Acanthaster was low, one per 10 to 100 square meters. These starfish probably were remnant individuals, consuming remaining available corals.

South of Catalina Point a different picture was seen. We saw small groups of starfish and feeding sites as far south as Pago Bay. No starfish were seen in earlier surveys. During January-February of this year a small population was recovered in 20 to 40 m (60 to 120 ft.) of water off the Marine Laboratory (Pago Bay). All were large, nearly two feet in diameter (30 to 50 cm), sexually mature, and mainly feeding on Acropora sp.

2. Anae Island. The fringing coral reef from Anae Is. north to Tipalao Bay has suffered heavy damage and still supports large numbers of Acanthaster. Our results do not differ from the 1970 survey results. The beautiful reef around Anae Is. (a potential conservation area) was fairly clear but a grey sponge has displaced much of the coral.

3. Cocos. The reef flat of the leeward side of Cocos lagoon was badly damaged by earlier starfish outbreaks. The Acanthaster were widely dispersed and feeding on the few remaining coral heads. The reef slope of the same area has scattered, small groups in 10 m (30 ft.) to 30 m (90 ft.) of water. Most of the starfish were located 1/4 to 1/2 km from the southern tip of Cocos Island, on the outer reef flat.

4. Piti-Agat-Tumon. Acanthaster populations of these areas were moderate, and were feeding on the remains of nearly dead coral reef. The starfish were small and often deformed, few were sexually mature and little spawning activity was expected.

Feeding Site Observations

Apra Harbor was infested; but, as was also noted by Tsuda (1970), no starfish were seen. Many white spots or feeding scars were seen on coral adjacent to the Glass Breakwater in 3 m (10 ft.) to 10 m (33 ft.) of water. The damage was mainly to one type of coral, Pocillopora damicornis (Linnaeus, 1758). There were many areas classed as normal such as Inarajan to Pago Bay which had less than five feeding sites per tow but no starfish. These white spots probably resulted from feeding activity by Culcita or Cushion stars.

Control

The Fish and Wildlife Starfish Control team has been averaging 1229 starfish killed per month from October 1970 to June 1971. A total of approximately 44,000 starfish have been killed by the team since September 1969. Prior to September 1969, Dr. R. H. Chesher and his team killed about 12,000 Acanthaster (Chesher, 1969). The kill records from September 1969 to June 1971 are presented in Table I. The general trend has been a decrease in numbers of starfish killed in relation to amount of effort expended. Those cases with a decreased kill rate reflect poor weather and sea conditions and increased depth of starfish---Catalina Point; or decreased concentration density of starfish--Apra Harbor to Pati Point.

Coral Cover

Live coral cover has not been greatly reduced since the 1970 Marine Laboratory survey. The Catalina Point area has, however, lost a large amount of live coral and will continue to do so until the existing Acanthaster population is brought under control.

Recolonization and regeneration is occuring on some reefs. In Tumon Bay, for example, there is regrowth of partially damaged heads and development of new colonies. Unfortunately there are still starfish in these areas which are feeding on the new growth. For further information on the regeneration of the coral cover in Tumon Bay see Randall (1971).

Fisheries Aspects

Our survey was too crude to present much relevant information on the changes in fish species and numbers due to the killing of corals. Comparative information will depend on further, more detailed surveys. A few specific features were noted as follows:

1. Chaetodonts (butterflyfish) were almost non-existent on dead reefs, they were abundant on living reefs.

2. Acanthurids (surgeonfish) appeared to have nearly equal relative numbers over living and dead reefs, although species differences may exist.

3. Few pomacentrids (damselfish) and other coral-head inhabitants were found in dead corals.

4. Many fish seek the protection or cover afforded by colonies of branching or tabular corals. When these corals are killed they distintegrate and rapidly become covered with sediment and algae. Thus a substantial component of the habitat is lost to many fish. It would be interesting to know what affects this change in the community structure might have on the fishes.

IV. CONCLUSIONS AND RECOMMENDATIONS

Three expanding or potentially expanding populations still exist at Catalina Point, Anae Island to Tipalao Bay and Cocos Lagoon. Lower concentrations or densities of Acanthaster are widely distributed on Guam. These populations are probably "remnants" of the original population explosion.

The survey results indicate that:

1. Acanthaster have done little additional damage to the corals of Guam except in the Catalina Point area.

2. Starfish sightings at Pago Bay and elsewhere up the windward coast represent a new phenomenon in the Acanthaster picture on Guam. It is not known if these starfish are isolated groups or are shallow-water intrusions of a larger deep-water population.

3. The control teams have significantly reduced the starfish population on Guam, first, by reducing the numbers of actively feeding animals and second, by decreasing the density of potential spawners so as to probably reduce the chances of successful reproduction.

4. Control must be continued, putting the greatest effort on living and endangered coral reefs and sites where Acanthaster are especially large and/or concentrated. However, except for the three areas named above and the lagoon areas of Piti and Tumon, control in other areas is of questionable significance. The control team could be reduced to two or three divers if they were adequately equipped. The present kill rate of 15 to 70 starfish per day does not justify the need for four divers.

V. REFERENCES

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Randall, R. H. 1971. Tanguisson-Tumon, Guam, reef corals before, during and after the Crown-of-thorns starfish (Acanthaster planci) predation. Master of Science Thesis, University of Guam. 119 pp.

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TABLE I

Acanthaster kill record for Guam, September 1969 to June 1971.
Compiled from records of the Guam Division of Fish and Wildlife

Area	September 1969 to August 1970		October 1970 to June 1971		March 1971 to June 1971	
	11 mo. total	avg./ mo.	8 mo. total	avg./ mo.	3 mo. total	avg./ mo.
Cocos to Anae Is.	208	19	169	21	165	55
Anae Is. to Apra Harbor	4582	417	1753	219	537	179
Apra Harbor to Piti	11951	1086	2695	337	522	174
Piti to Pati Pt.	3200	291	2396	300	241	80
Pati Pt. to Catalina Pt.	9821	893	744	93	87	29
Catalina Pt. to Cocos	343	31	154	19	154	51
Cocos Lagoon	1900	173	1921	240	673	224
Grand Totals	32005	2910	9832	1229	2379	793

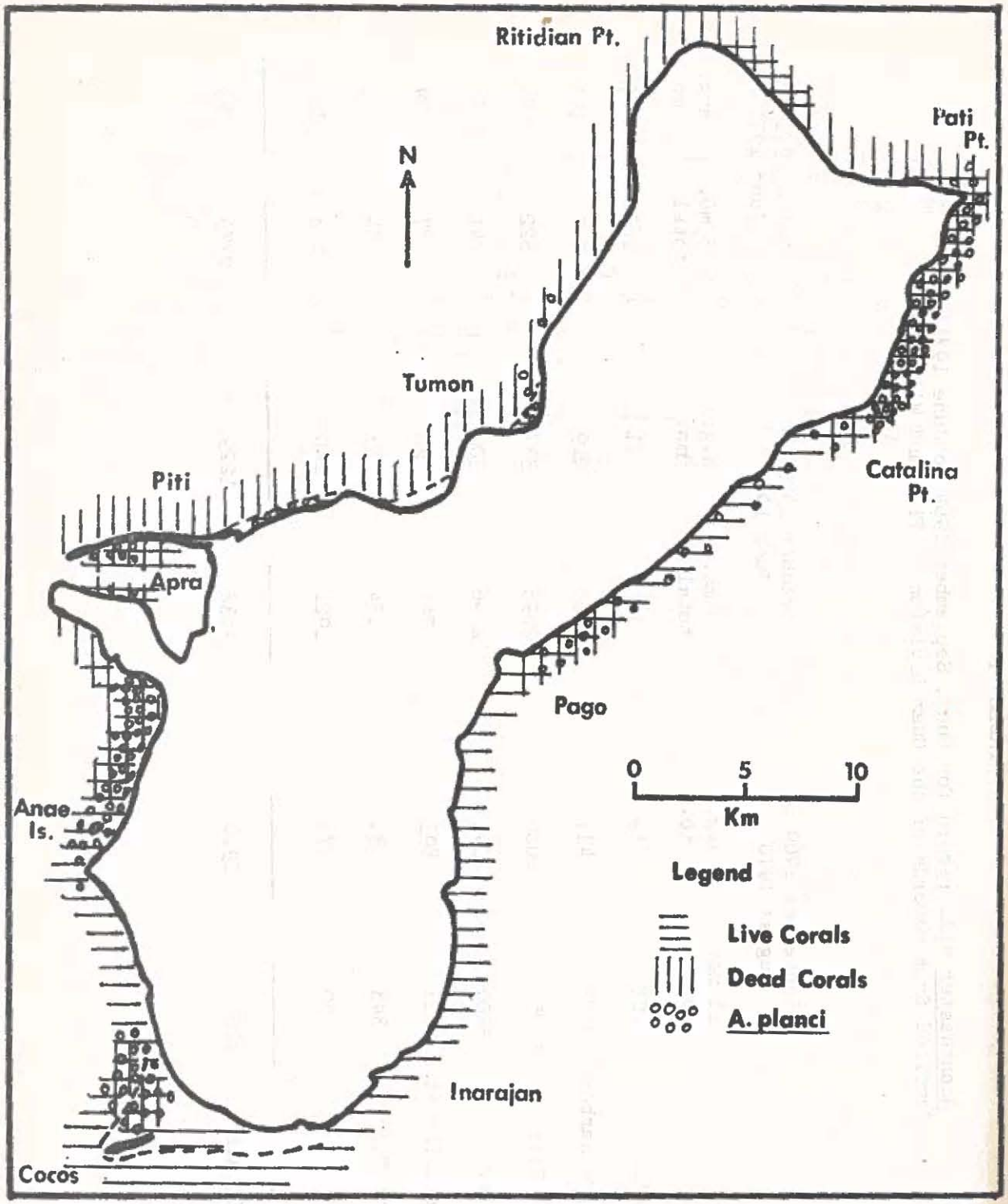

Figure 1. Status of Acanthaster planci and coral conditions on Guam during April 1971.

ACANTHASTER PLANCI

CROWN-OF-THORNS STARFISH

Survey of islands and atolls

in the Central Carolines

Yap and Truk Districts

May 1971

Submitted to

Marine Resources Division

Trust Territory of the Pacific Islands

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and

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I. INTRODUCTION

A general survey of several atolls and islands of the Truk and Yap groups (Figure 1) was undertaken by two members of the University of Guam's Acanthaster Monitoring Team during May 9-24, 1971 while aboard the "USS WANDANK." The purpose of this survey was 1) to resurvey and monitor Acanthaster planci populations and general reef conditions with special reference to earlier Westinghouse surveys done on Lamotrek, Woleai, and Ifalik. 2) to delimit the population levels of Acanthaster planci and assess any reef damage which might be found on any of the islands and atolls surveyed for the first time.

Information pertaining to the resurvey of Lamotrek, Woleai, and Ifalik came from the summaries of the original surveys made of these atolls and included in the 1969 Westinghouse report (Chesher, 1969)

We wish to express our thanks to Lt. Cmdr. R. J. Sands, U. S. Navy, for inviting us on this trip. Special appreciation is given to Captain J. L. O'Brien and the crew of the "USS WANDANK" for their cooperation and help extended to us during the cruise.

II. METHODS

A total of 104 stations covering 11 atolls and one bank area were made. Of these, all were 10 minute tows except one 25 minutes dive on Elato (Figure 12, station 2), one 10 minute swim on Ifalik (Figure 7, station 9), and three spot checks on Mogami Bank. All tows were made with two observers. A Zodiac inflatable boat powered by a 25 horsepower Johnson outboard engine was used for towing one observer on each side of the boat with one person operating. The boat and engine were carried on the stern of the "WANDANK" and were launched at each stop for survey work. Each atoll or island was covered as thoroughly as possible according to the amount of time alloted us by the Captain. The Namanuito islands (Ulul, Magur, and Pisaras) could not be covered because of darkness, storm weather, and ultimately, contaminated fuel which broke down our outboard engine. The following lists our surveillance itinerary:

Island	TA	TD
Pulap	120700	121600
Puluwat	121800	131200
Pulusuk	131600	131900
Satawal	140800	141100
Lamotrek	141430	160700
Elato	160830	161100
Olimaro	161330	161600
Eauripik	170900	171130
Woleai	171830	181100
Ifalik	181430	190001
Faralap	190700	191030
Mogami Bank	200200	200300

The same standards used in the original Westinghouse surveys were used, that is, an area is considered infested when one or more fresh feeding sites (white coral) or Acanthaster are counted per minute during a ten-minute tow. Counts less than this usually indicate a normal population.

III. RESULTS

A. Resurveys of Lamotrek, Woleai, and Ifalik.

1. Lamotrek

The stations and results of the Lamotrek resurvey can be seen in Figure 3. The results of the 1969 survey can be seen in Figure 2.

Chesher (1969) reports only one Acanthaster seen on Lamotrek. We found four Acanthaster (stations 12 and 25) and indications (white patches) of minor infestations along the outside at depths of 6 to 80 feet extending around the southwestern corner and along the entire northern side of the atoll (stations 12-16). Listed below are the significant stations according to numbers of feeding sites and Acanthaster counted.

Station No.	No. of Feeding Sites	No. of Acanthaster
6	12	0
12	20	3
13	10	0
14	12	0
15	15	0
16	22	0
25	5	1

Chesher (1969) also reported that the coral on Lamotrek was lush, normal, and healthy. We found essentially the same situation. Stations 12-16 where we found significant feeding sites appeared to be extremely healthy with per cent coral coverage from 5 to 100 and per cent live from 60 to 90. Three stations (stations 23, 25, and 26) located on the lagoon side had beautiful live areas interspersed with completely dead areas which sloped down from a depth of 5 to 10 feet to the lagoon bottom at approximately 60 feet. These dead areas gave the appearance of alluvial fans and appeared to be recent disasters. No indications of dynamite were seen but poisons may have been responsible. We do not suspect Acanthaster. The southwestern reef (lee) is characterized by quick dropoffs and cliffs and is the richest in coral growth both outside and on the lagoon side.

2. Woleai

The stations and results of the Woleai resurvey can be seen in Figure 5. The results of the 1969 survey can be seen in Figure 4.

Dr. McCloskey's team in 1969 found one small population of Acanthaster

consisting of about 20 large animals on the inside of the lagoon (Chesher, 1969). We began our resurvey in this same area (stations 1 and 2) and found evidence of a small population of Acanthaster still inhabiting the area. Stations 1 and 2 had a total of 51 small feeding sites (less than 10 centimeters in diameter) and one small Acanthaster approximately six inches in diameter in water 5 to 15 feet in depth. Along station 8 we counted only six feeding sites but saw 23 Culcita. The entire eight stations produced 76 feeding sites and one Acanthaster.

Stations 1 and 2 where we found abundant white patches had coral coverage of from 60 to 75 per cent with a live count of 80 per cent. Although we believe there is a small population of Acanthaster in this area the situation appears to be well balanced.

On the outside along station 7 in water 10 to 30 feet in depth we found 90 per cent coral coverage but with less than 10 per cent live. This area consists of old dead massive coralline structure almost completely covered with a very dark brown bluegreen alga.

3 Ifalik

The stations and results of the Ifalik resurvey can be seen in Figure 7. The results of the 1969 survey can be seen in Figure 6.

Chesher (1969) reports finding three Acanthaster on Ifalik. We made a total of 11 stations, seven along the outside and four on the lagoon side, finding a total of 41 feeding sites and no Acanthaster. Along the outside of the eastern reef (station 3) we counted 15 very small white spots and saw several Culcita. All of the feeding sites counted during the resurvey were very small and were probably caused by Culcita which were abundant in most of the stations.

The reefs on Ifalik appeared to be normal and healthy. Only stations 1 and 7 bordering each side of the channel had low live counts and this was probably due to siltation.

B. New surveys of Pulap, Puluwat, Pulusuk, Satawal, Elato, Olimarao, Eauripik, Faraulep, and Mogami Band.

1. Pulap

The stations and results of the Pulap survey can be seen in Figure 8.

We found one small population of Acanthaster along the outside of the northwestern reef (stations 4 and 5) in water 15 to 60 feet in depth. A total of 28 feeding sites and three Acanthaster were counted at these two stations. For the entire 16 stations we found 93 feeding sites and six Acanthaster. The eastern (windward) side could not be surveyed.

The survey revealed no observable dead areas as a result of Acanthaster. Stations 3-7 are characterized by steep cliffs with luxuriant coral growth 100 per cent live except for some fresh feeding sites. The

southern half of the western side and the entire eastern side is made up of submerged reef approximately 30 feet in depth. We found two dynamited areas along station 16 on the lagoon side near the village.

2. Puluwat

The stations and results of the Puluwat survey can be seen in Figure 9.

A total of 12 fresh feeding sites and one Acanthaster were seen in eight stations. Ten of these 12 feeding sites and the one Acanthaster were found along the western side (stations 4 and 5) in water 5 to 40 feet in depth.

We found no dead areas. Most of the outside is characterized by gently sloping pavement with little coral coverage. Station 5 was the richest area with 90 per cent coral coverage, 90 per cent live.

3. Pulusuk

The stations and results of the Pulusuk survey can be seen in Figure 10.

The western side of the island had a small population of Acanthaster at a depth of 10 to 80 feet. Station 4 contained a count of 32 feeding sites and 11 Acanthaster. Station 5 had feeding sites too numerous to count with seven Acanthaster. Stations 1-3 had a total count of four feeding sites and no Acanthaster.

The western side is characterized by a steep cliff along the reef front with 90 per cent coral coverage. Along the infested area (stations 4 and 5) extensive coral damage was obvious with live coral constituting only 20 to 60 per cent of the coverage. The eastern side (windward) is characterized by gradual sloping terraces out to a distance from the reef margin. Coral coverage is 70 to 90 per cent with live coral estimates from 10 to 50 per cent.

4. Satawal

The stations and results of the Satawal survey can be seen in Figure 11.

We covered the entire island in five tows counting a total of 24 feeding sites and no Acanthaster. Most of the feeding sites were small and many were accompanied by Culcita. The Peace Corps Volunteer on the island informed us that he and 20 of the islanders did their own survey of the island last fall and counted about 35 Acanthaster along the eastern (windward) side correlating with station 3. We found only five feeding sites and no Acanthaster in this area.

Satawal contains a normal reef, and we found no concernable damage.

5. Elato

The stations and results of the Elato survey can be seen in Figure 12.

Because of time, we could make only two stations, one 10 minute tow and one 25 minute dive on the outside near the northwestern tip. A total of 10 feeding sites were monitored with no Acanthaster. Sharks, one a Carcharhinus albimarginatus, prevented us from close investigation of the feeding sites during the dive. Depth was 20 to 90 feet.

The two stations exhibited 100 per cent coral coverage, 100 per cent live. A steep drop-off begins at approximately a 50 foot depth.

6. Olimarao

The stations and results of the Olimarao survey can be seen in Figure 13.

Twelve stations, seven outside and five on the lagoon side, gave us a total of 30 feeding sites and no Acanthaster. All of the feeding sites were found on the outside of the reef (stations 3-9). We were constantly bothered by sharks on the outside.

Olimarao's outside reef is characterized mostly by flat sloping pavement and lacks lush coral banks and heads. Stations 3-8 had coral coverage from less than 5 per cent to 50 per cent with live counts from 60 to 80 per cent. Station 9 along the southern end had 80 per cent coral coverage, 100 per cent live from the reef margin to a steep barren drop-off.

The lagoon sides are mostly sand with some live corals near the reef flat. Station 12 had several large coral heads heavily cemented with Porolithon.

7. Eauripik

The stations and results of the Eauripik survey can be seen in Figure 14.

Eight stations were made, all on the outside and covering close to three-fourths of the atoll. A total of 27 feeding sites and two Acanthaster were seen. Both Acanthaster were found along the southern side (stations 3 and 4) with station 3 having a count of 12 feeding sites

Stations 2-4 had coral coverage of 40 to 90 per cent with only 50 per cent live. These areas were characterized by old cemented regions interspersed with live corals. Station 1 was heavily covered with soft corals. We found no evidence of reef damage caused by Acanthaster.

8. Faraulep

The stations and results of the Faraulep survey can be seen in Figure 15.

Six stations along the outside revealed a total of 82 feeding sites with one Acanthaster at station 1. Most of the white spots were small and we found an abundance of Culcita around the entire atoll. Stations 2 and 3 had a feeding site count of 26 and 23 respectively. All of the feeding sites were less than 10 centimeters across.

Faraulep featured luxuriant coral growth around the entire atoll. All stations had coral coverage of 90 per cent with 80 to 95 per cent live. Station 6 faded into sand-coral-sand coverage as we entered the lagoon. There were no dead or damaged areas.

9. Mogami Bank

Mogami Bank was infested with sharks which prevented us from towing. The spotchecks that were made revealed a very flat bare pavement with just a light sprinkling of coral. Visibility with any distinction was estimated to be 80 feet. We saw no signs of Acanthaster.

IV. DISCUSSION

Resurveys of Lamotrek, Woleai, and Ifalik showed essentially the same status as existed during the 1969 surveys. Lamotrek has a minor infestation of Acanthaster along the outside of the southwestern and northern barrier reefs. The infestation was not noted in the Westinghouse report (Chesher, 1969).

We detected no abnormal reefs on these atolls except for the dead areas having the appearance of alluvial fans on the lagoon side of parts of the southern reef on Lamotrek. No obvious reasons for these areas were apparent.

Of those islands and atolls that we surveyed for the first time, Pulap, Pulusuk, Eauripik, and Faraulep have signs of minor Acanthaster infestations. Of these, Pulusuk and Faraulep have sufficient signs of Acanthaster infestations to warrant concern over the possibility of major infestations in the future.

Almost all of the reefs around these islands and atolls are normal and healthy. Pulusuk has obvious reef damage in those areas of Acanthaster infestations along the outside of the western reef.

V. RECOMMENDATIONS

In view of the results of this report, we would like to make two recommendations.

1. A future survey of the Central Carolines should be made following one or two years to further enhance our knowledge of the dynamics of Acanthaster populations in these islands.

2. The Truk Starfish Control team should survey the Namanuito Islands as soon as possible to complete that part of the Central Carolines which we were unable to cover. This can easily be done by utilizing the Trust Territory field trip vessel in cooperation with the Trust Territory Government.

VI. REFERENCES

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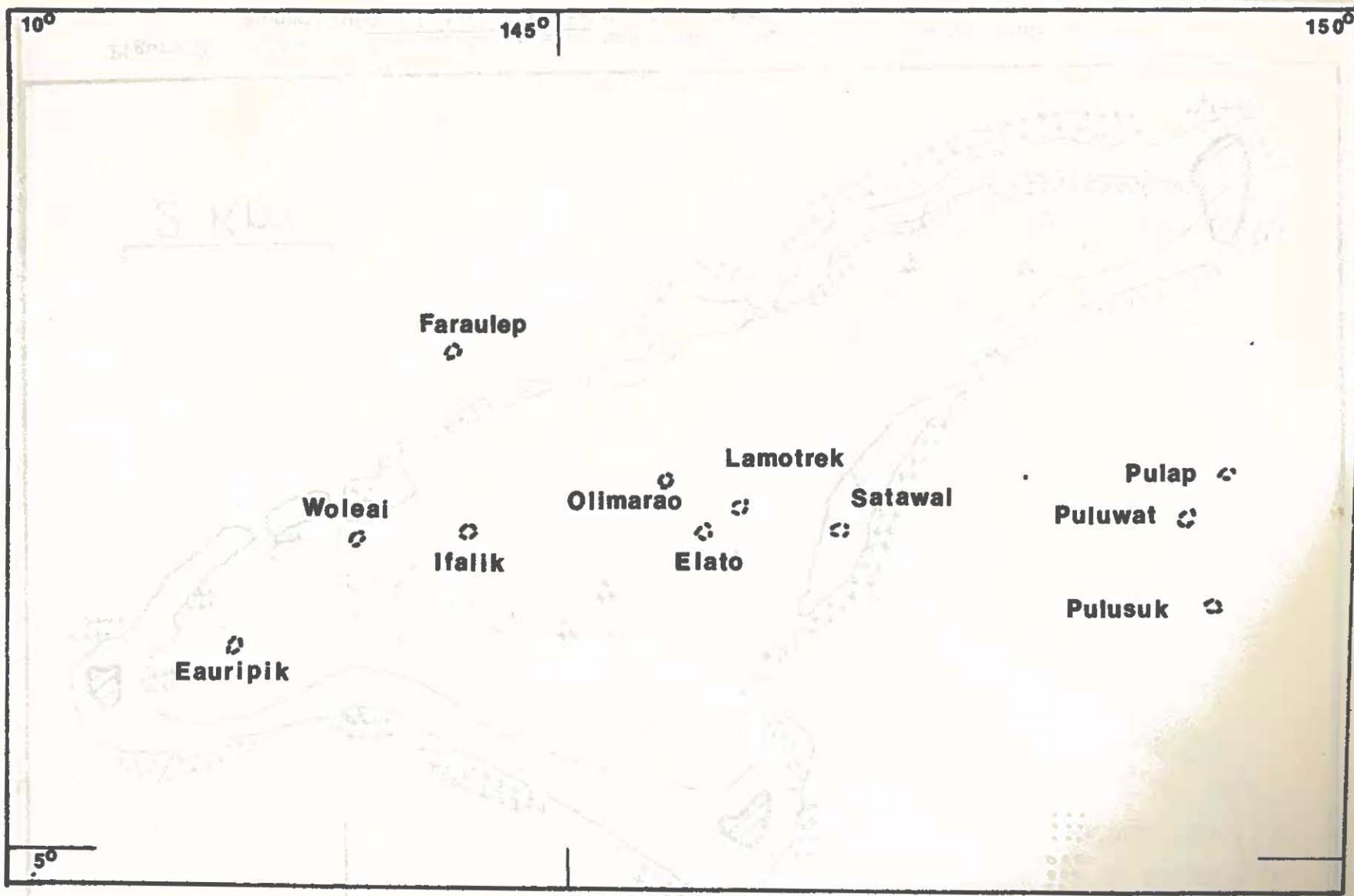

Figure 1. Islands and atolls of the Central Carolines surveyed during May 1971.

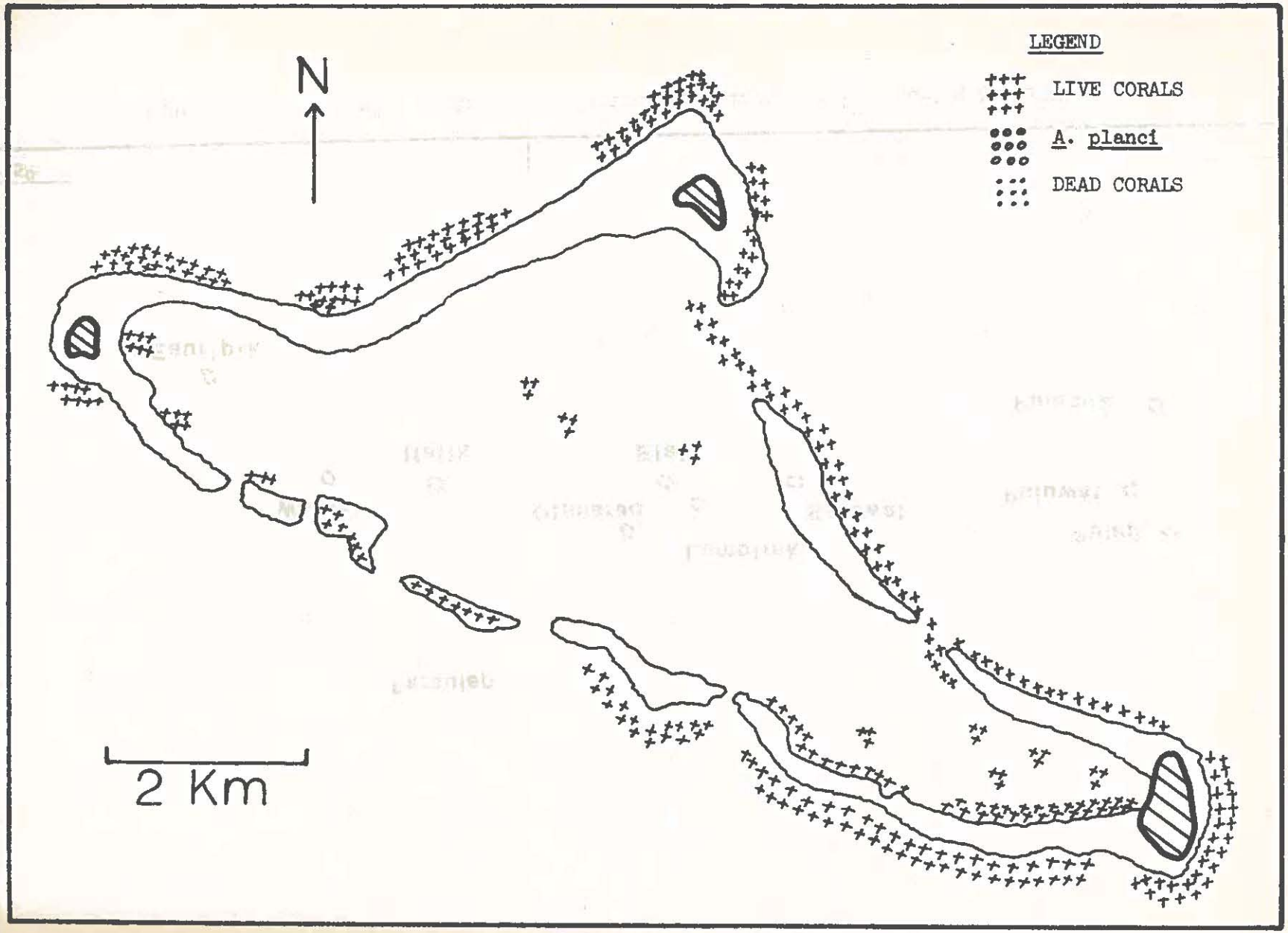

Figure 2. Status of Acanthaster planci and coral conditions on Lamotrek during August 1969. (Adapted after Chesher, 1969).

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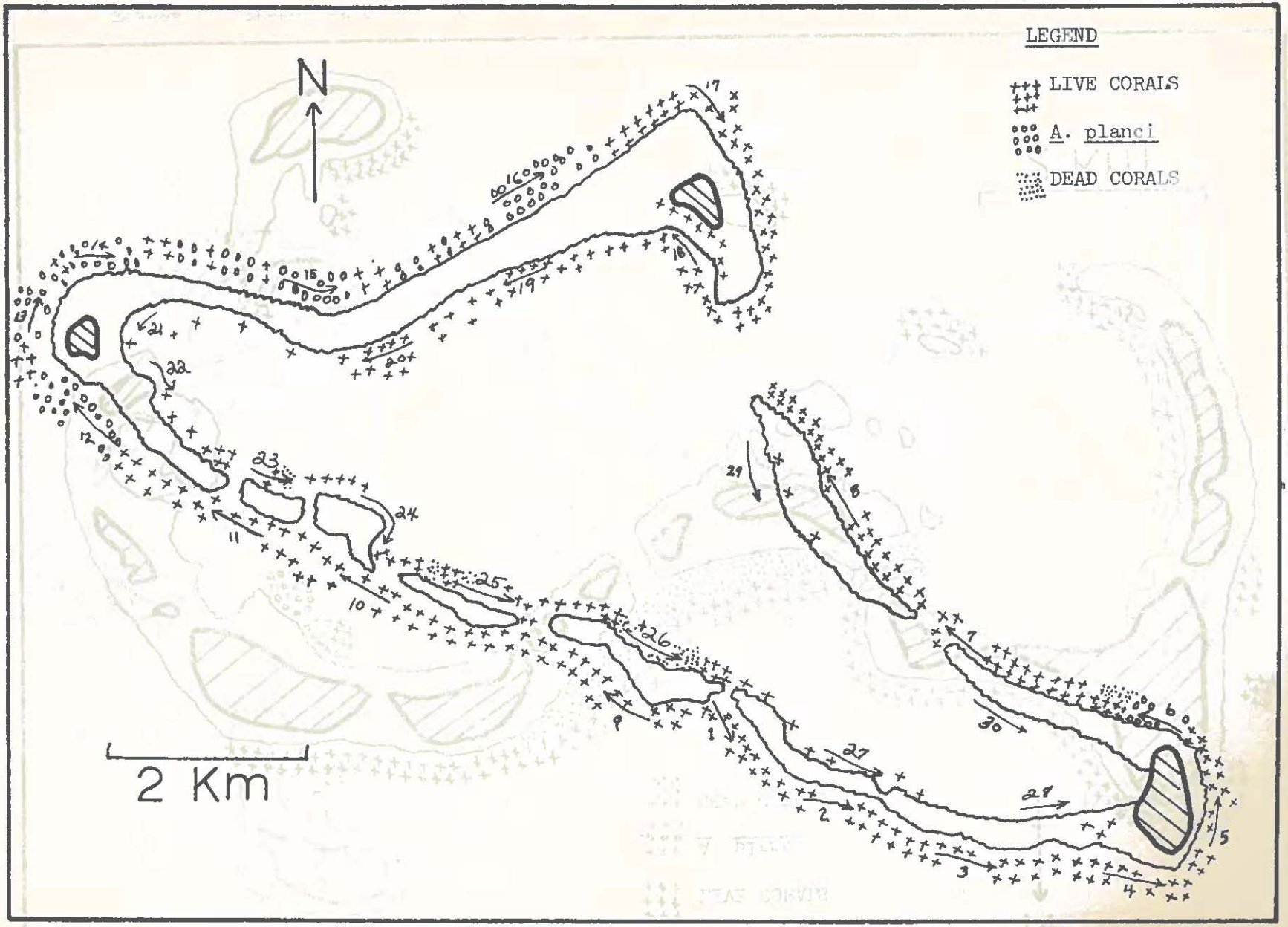

Figure 3. Locations of stations, status of Acanthaster planci, and coral conditions on Lamotrek during May 1971.

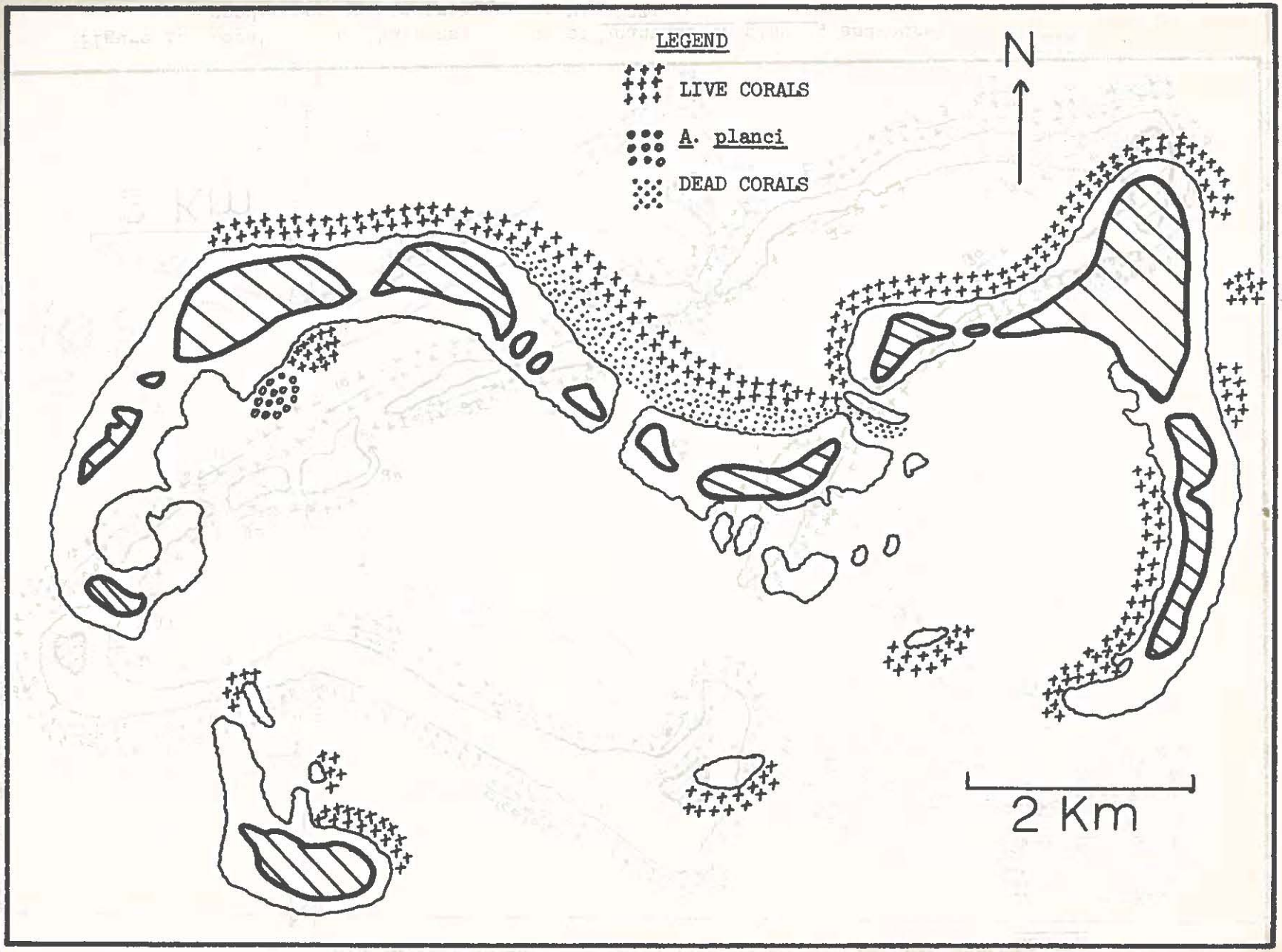

Figure 4. Status of Acanthaster planci and coral conditions on Woleai during July-August 1969. (Adapted after Chesher, 1969).

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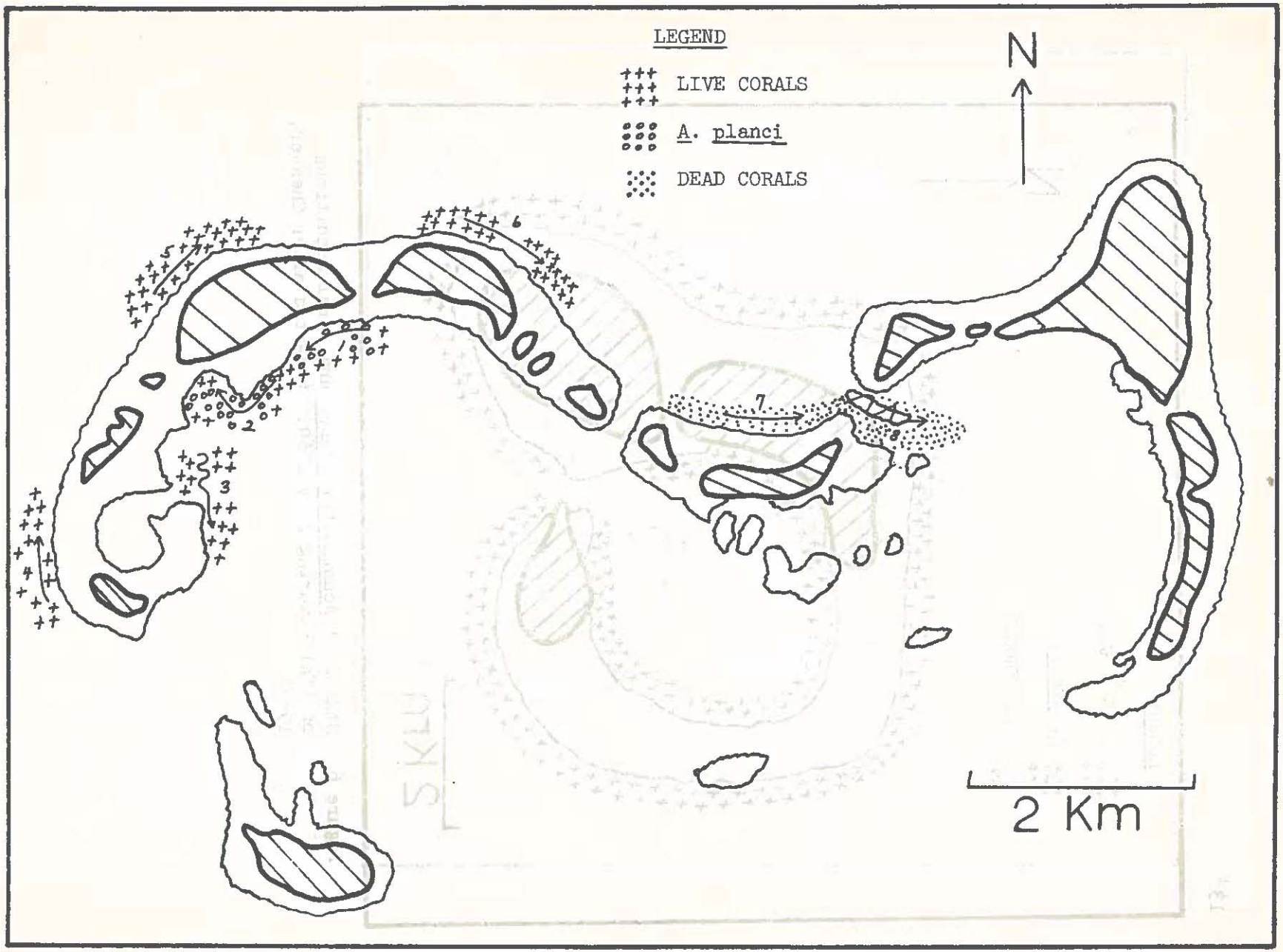

Figure 5. Locations of stations, status of Acanthaster planci, and coral conditions on Woleai during May 1971.

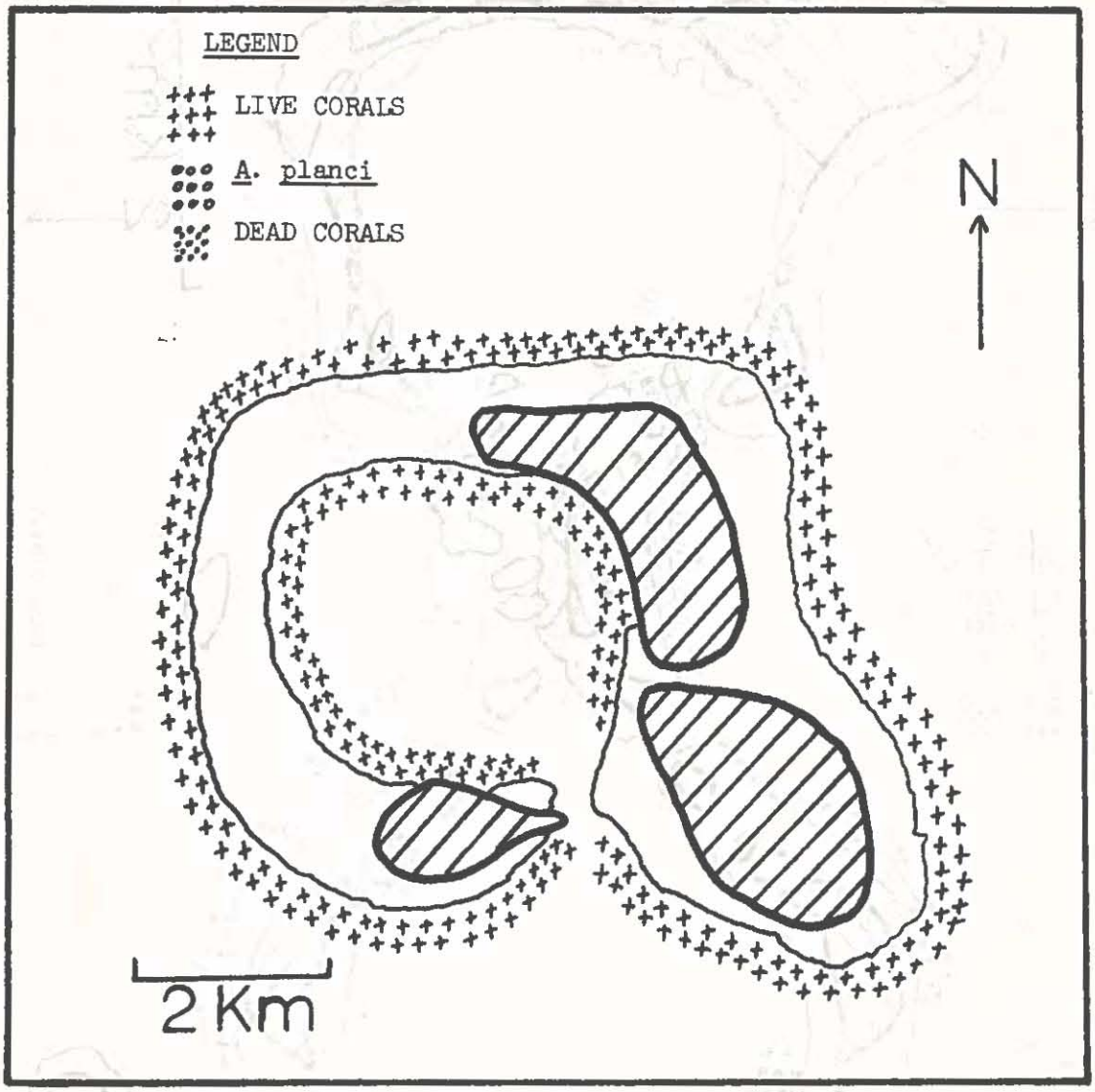

Figure 6. Status of Acanthaster planci and coral conditions on Ifalik during July 1969. (Adapted after Chesher, 1969).

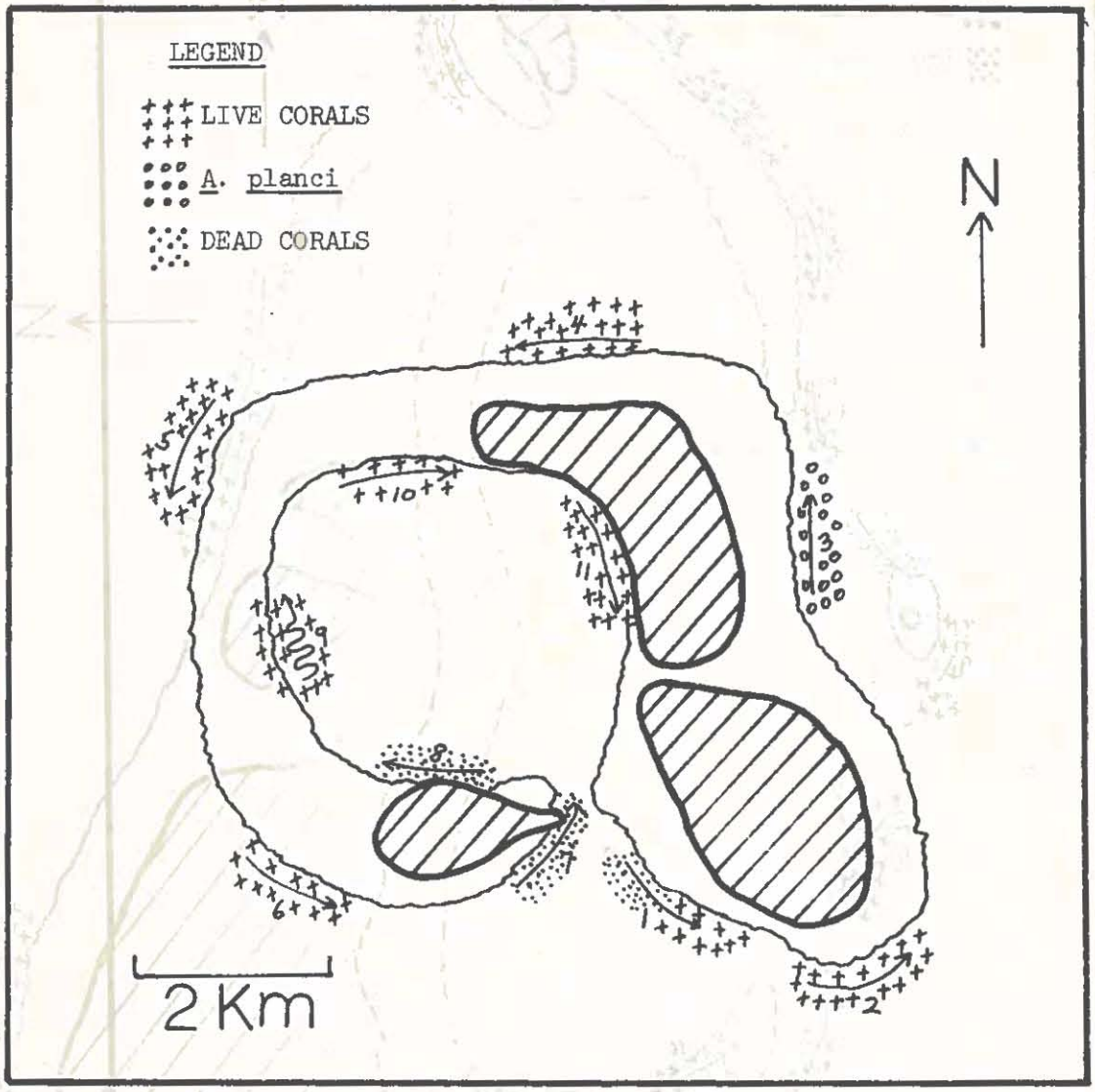

Figure 7. Locations of stations, status of Acanthaster planci, and coral conditions on Ifalik during May 1971.

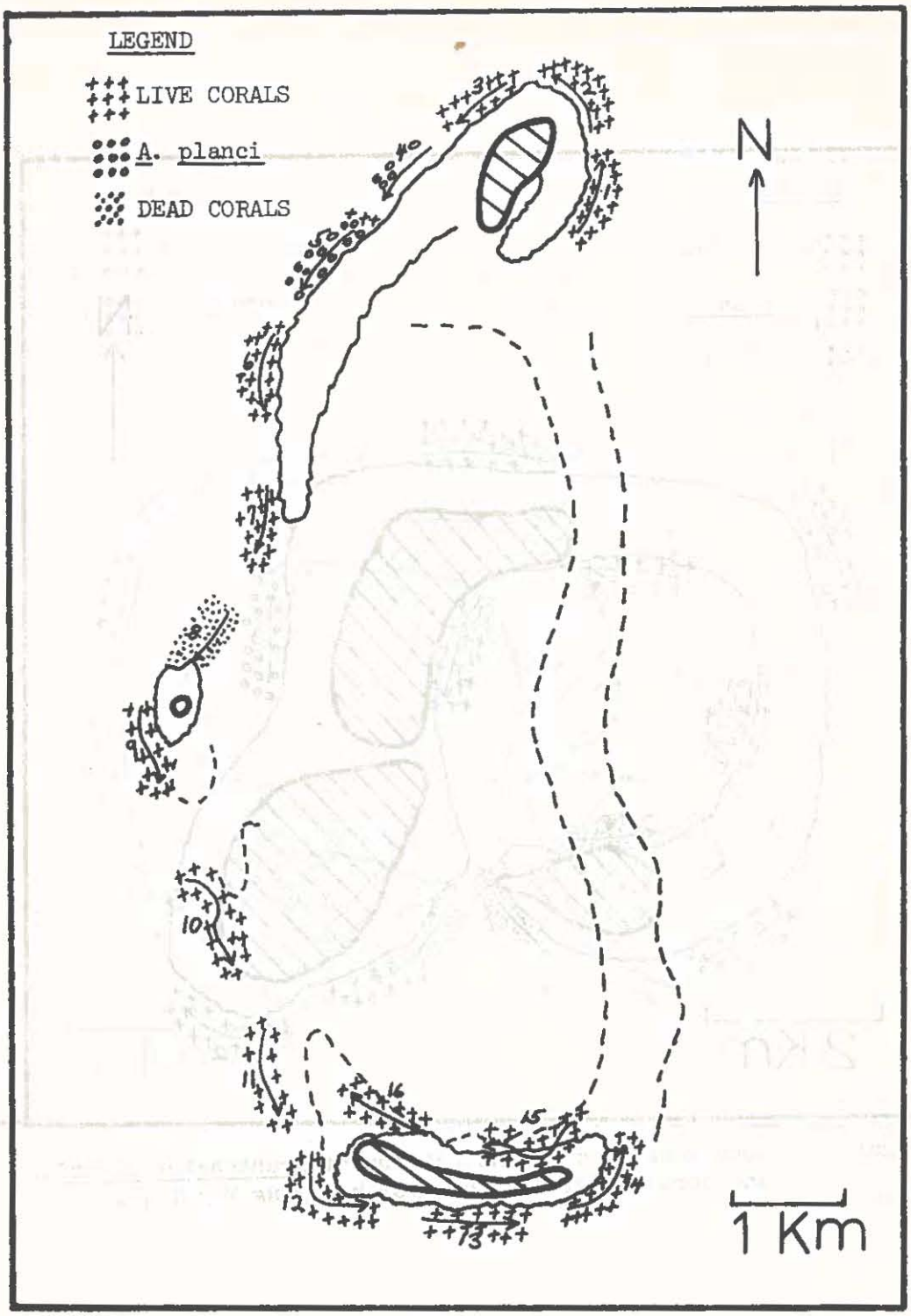

Figure 8. Locations of stations, status of Acanthaster planci, and coral conditions on Pulap during May 1971.

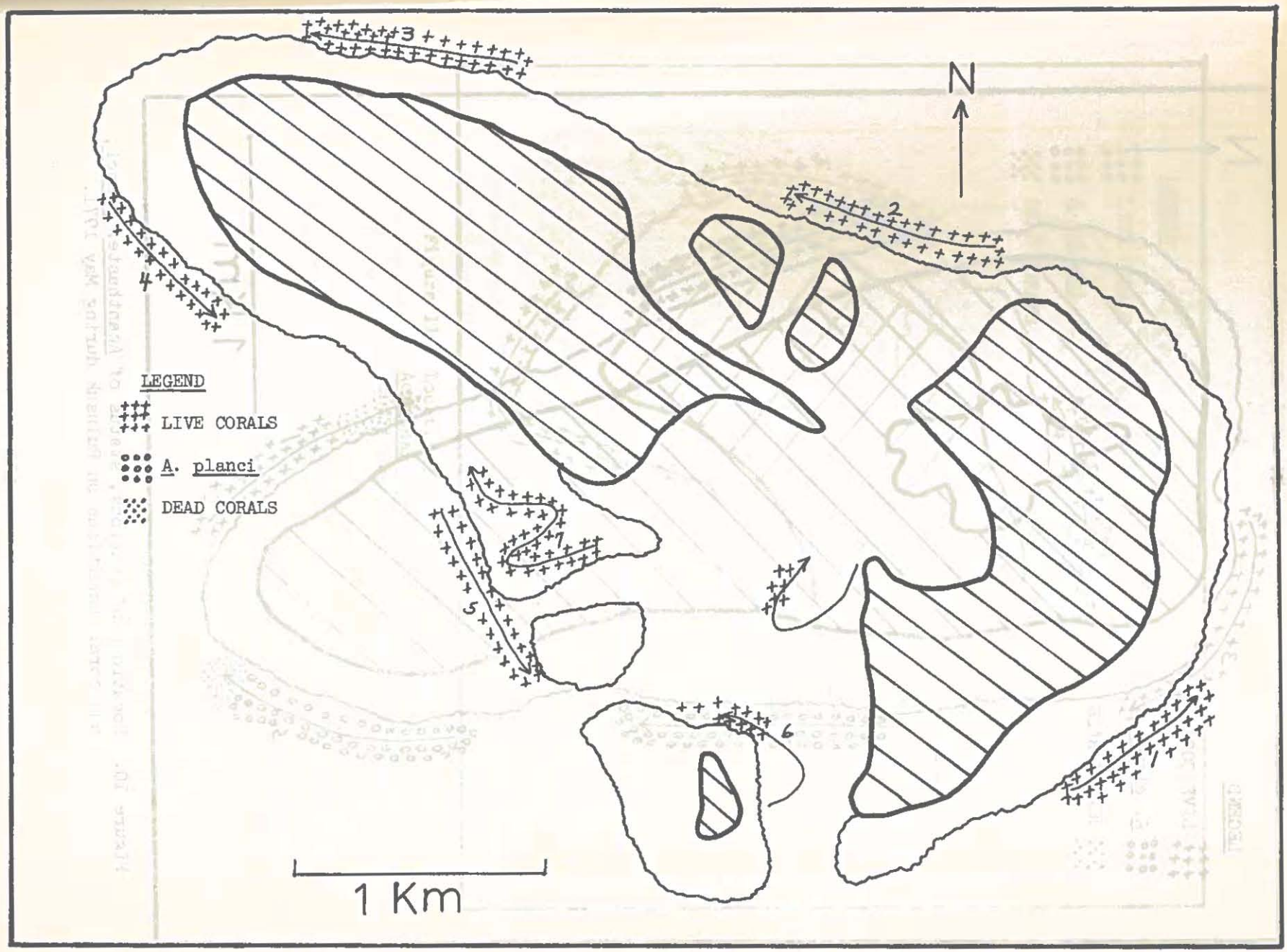

Figure 9. Locations of stations, status of Acanthaster planci, and coral conditions on Puluwat during May 1971.

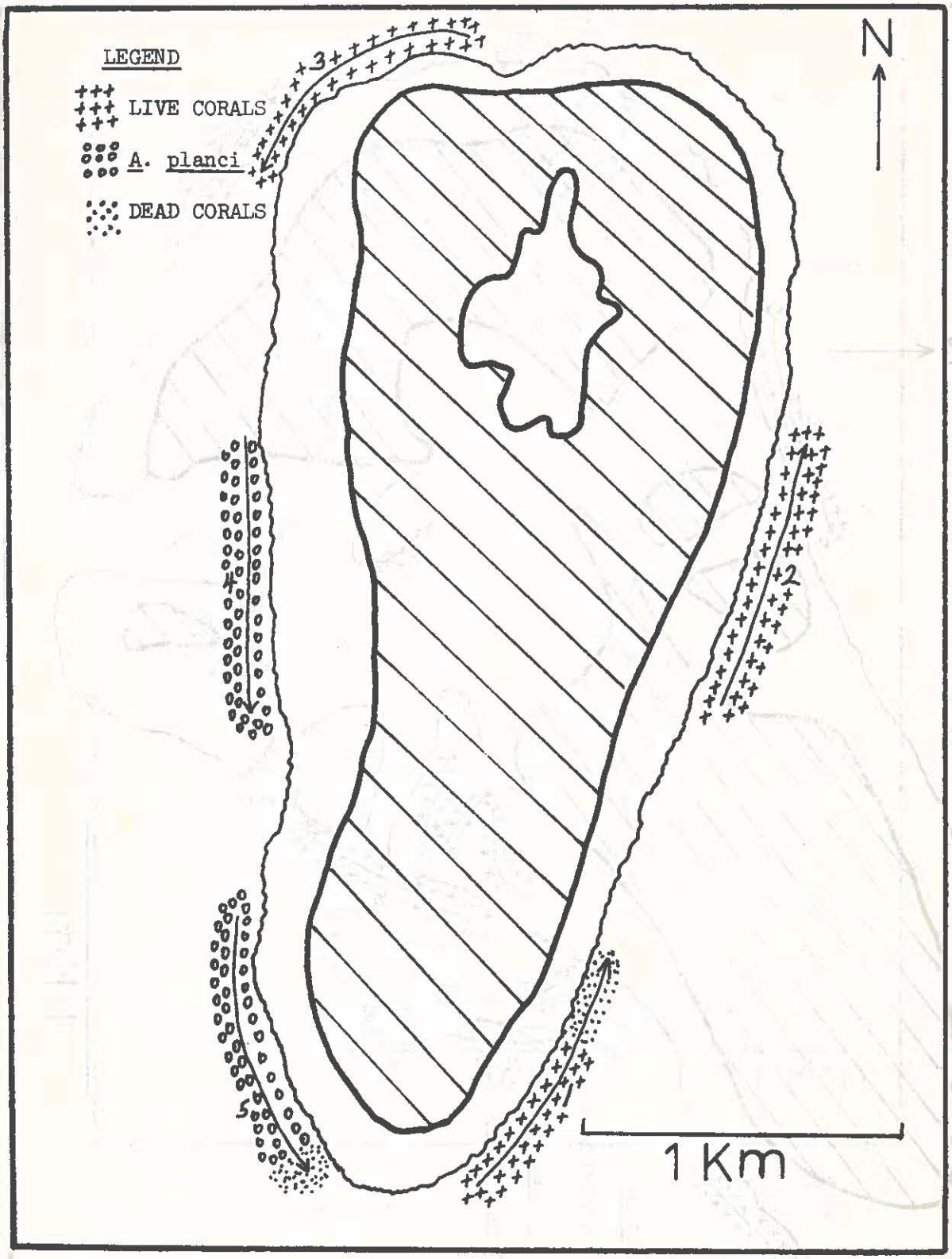

Figure 10. Locations of stations, status of Acanthaster planci, and coral conditions on Pulusuk during May 1971.

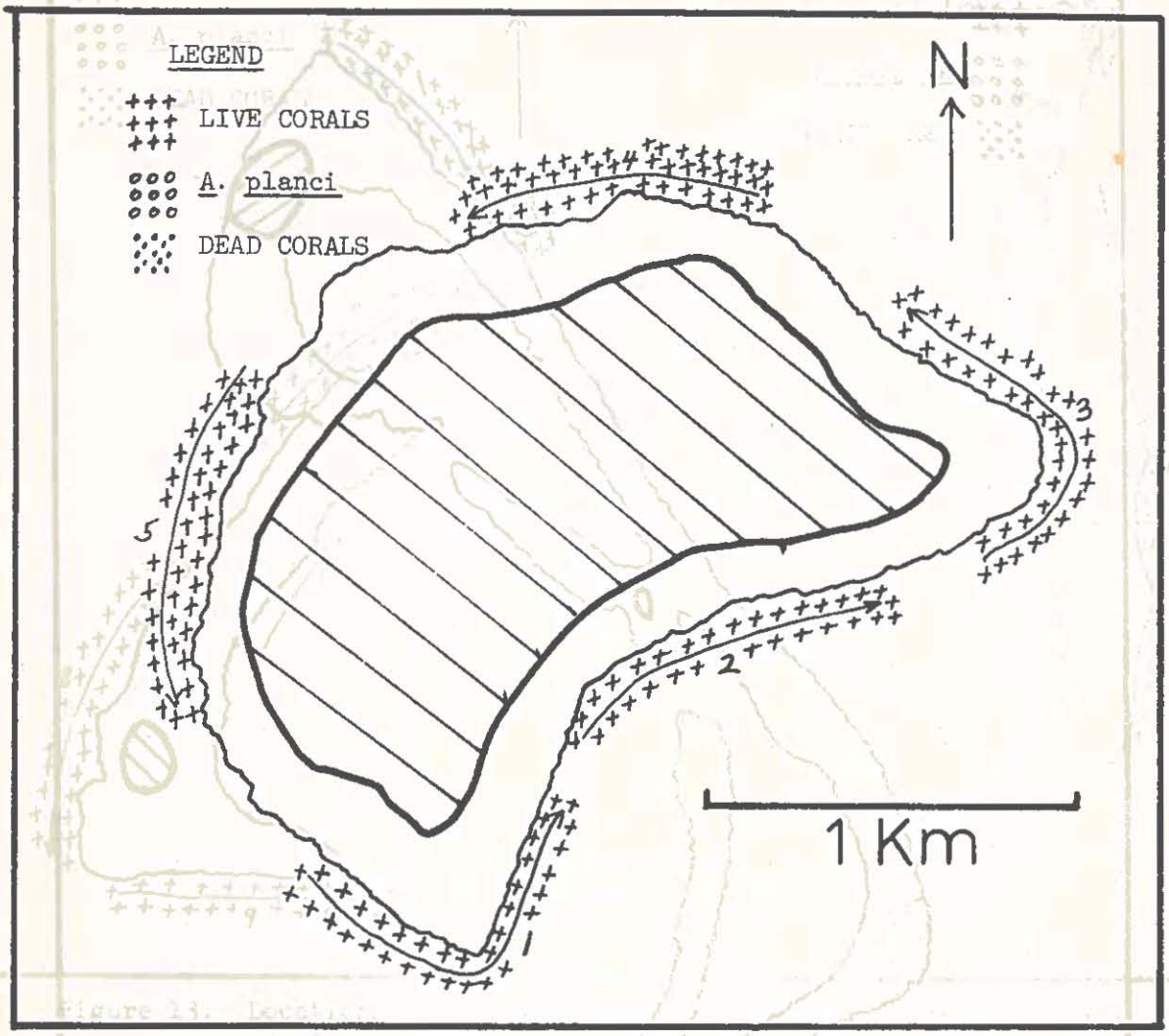

Figure 11. Locations of stations, status of Acanthaster planci, and coral conditions on Satawal during May 1971.

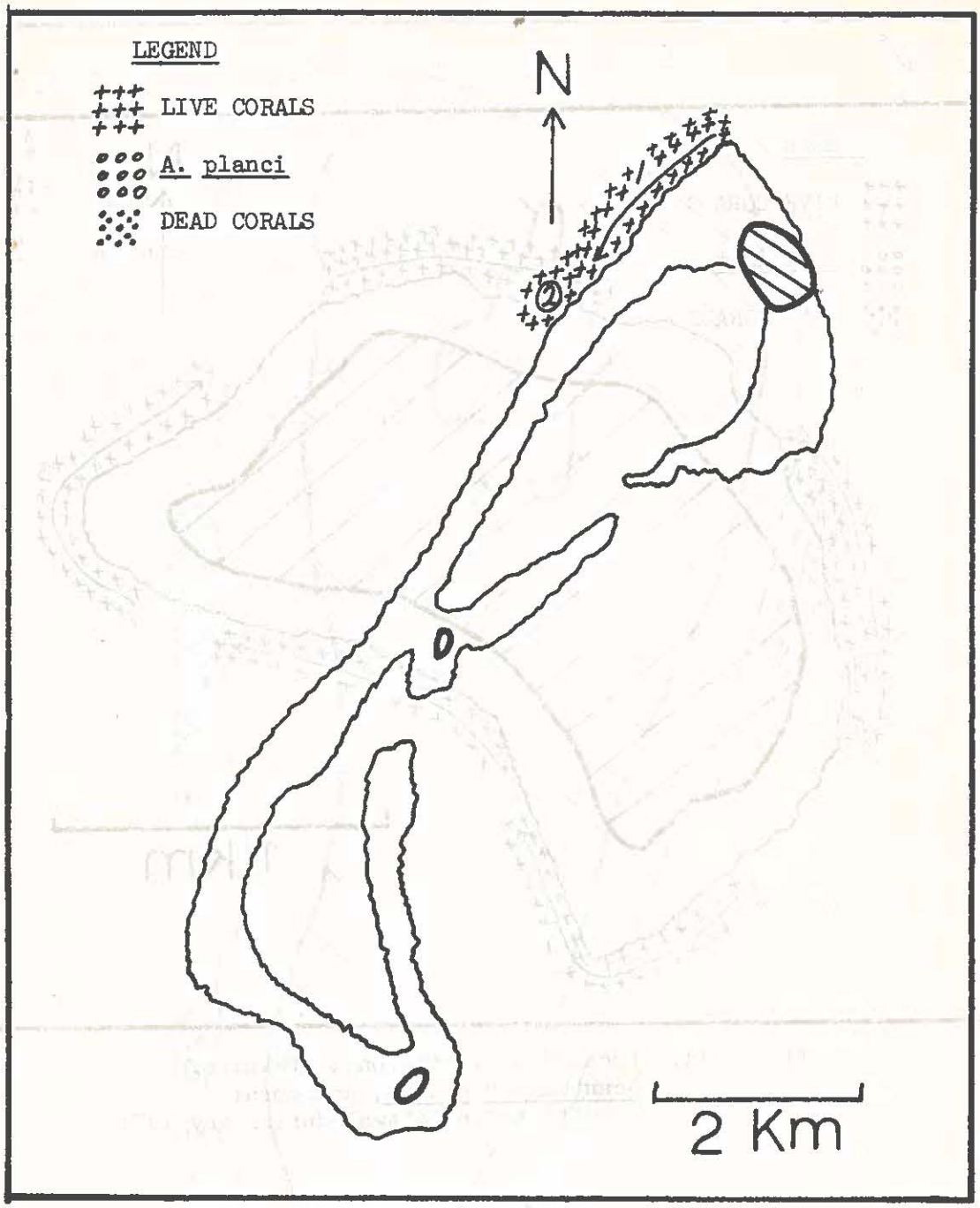

Figure 12. Locations of stations, status of Acanthaster planci, and coral conditions on Elato during May 1971.

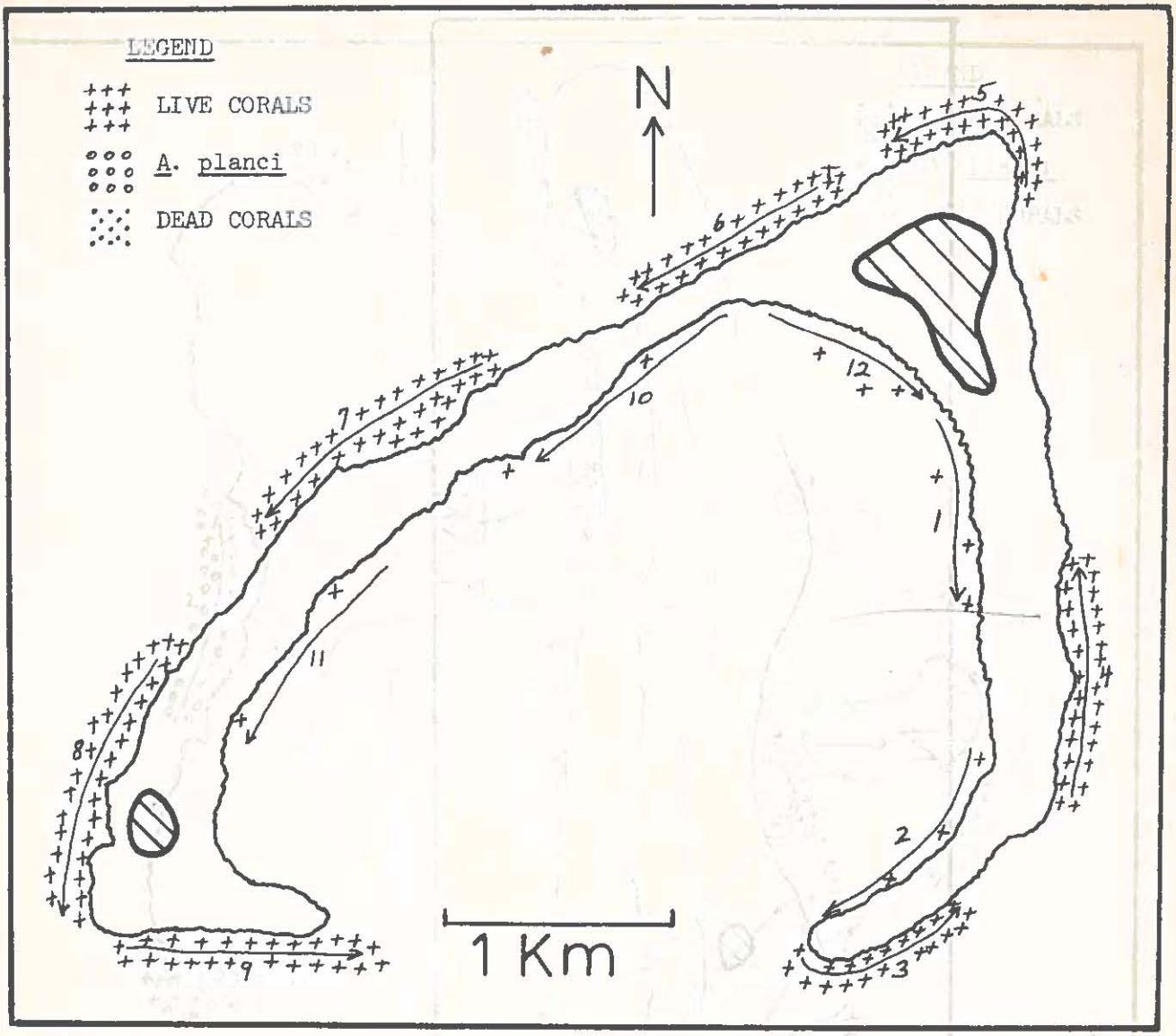

Figure 13. Locations of stations, status of Acanthaster planci, and coral conditions on Olimarao during May 1971.

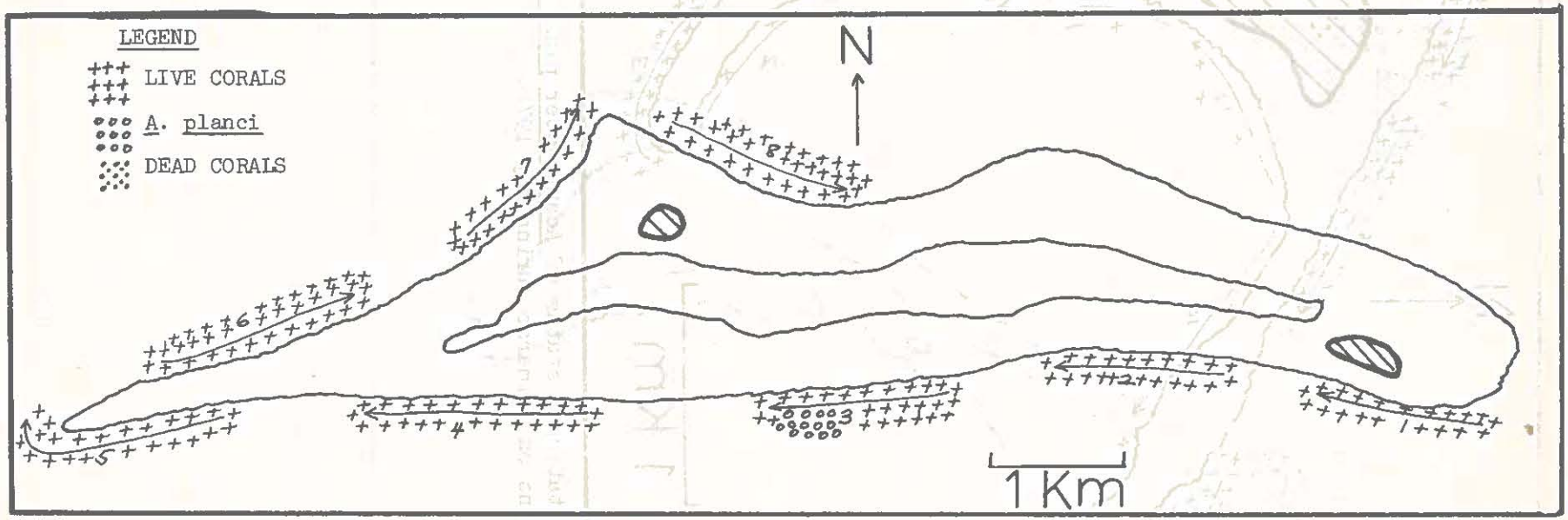

Figure 14. Locations of stations, status of Acanthaster planci, and coral conditions on Eauripik during May 1971.

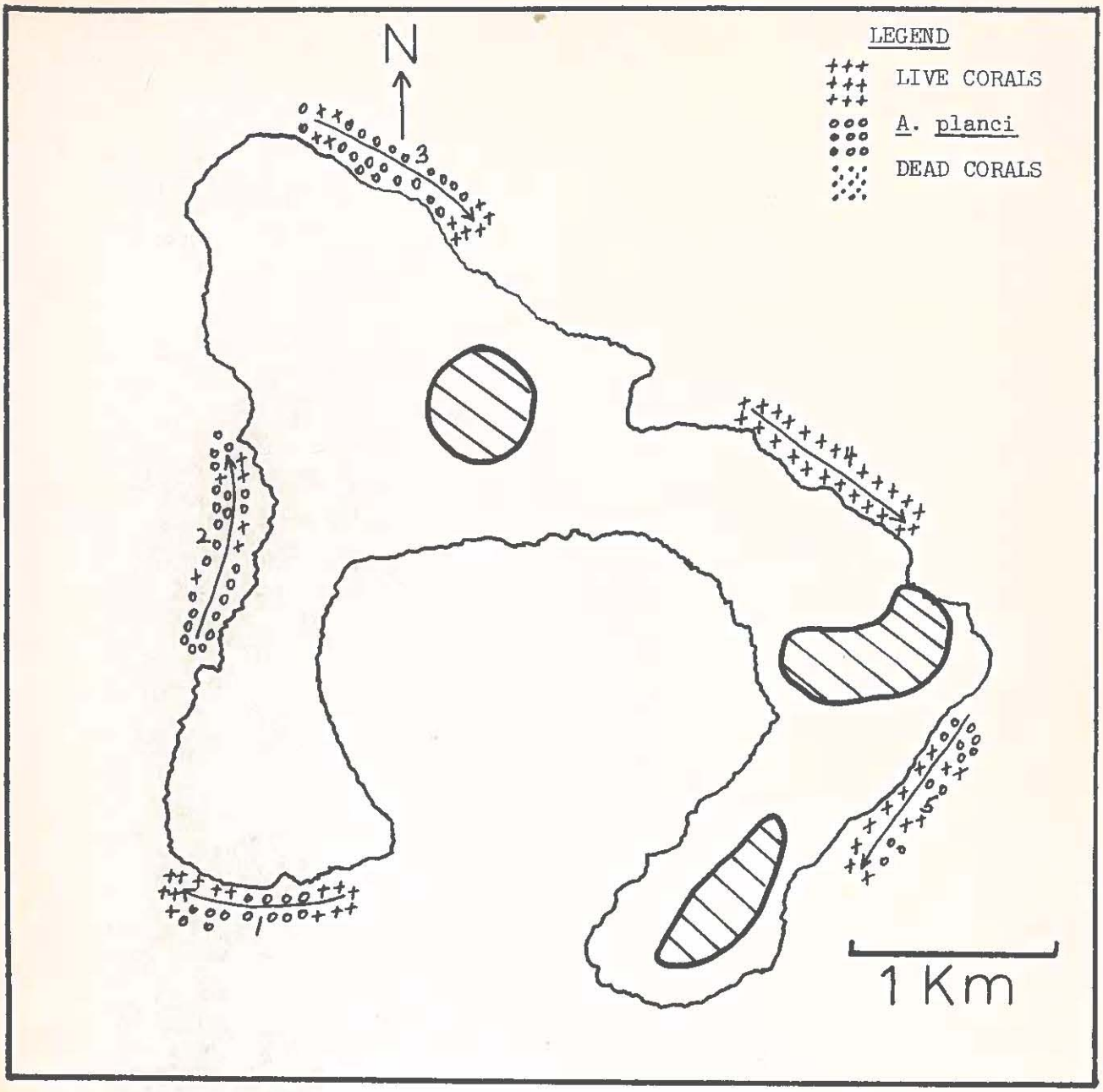

Figure 15. Locations of stations, status of Acanthaster planci, and coral conditions on Faraulep during May 1971.