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APPENDIX B

RESULTS OF AN ACANTHASTER PLANCI (CROWN-OF-THORNS) SURVEY AROUND TUTUILA ISLAND, AMERICAN SAMOA

by

Richard C. Wass

DMWR#2

INTRODUCTION

Late in 1977 fishery biologists working for the Office of Marine Resources in American Samoa, reported that the "Crown-of-Thorns starfish" (Acanthaster planci (L.)) has caused severe damage to some local reefs around Tutuila Island. This coral-eating starfish, known locally as "alalamea", was responsible for extensive coral kills on many reefs in the late nineteen-sixties throughout the tropical Pacific Ocean, and now appears to constitute a threat to the entire reef system of American Samoa.

Freshly killed corals and numerous Acanthaster planci starfish were first noticed in American Samoa during September 1977 on fringing reefs along the north coast at Fagatuitui Cove. About 50 A. planci, ranging in size from 30-35 cm in diameter, were counted in November 1977 during a half-hour dive on the reef at this initial infestation site. Severe damage to corals attributable to A. planci was next seen in December 1977 on the offshore Taema Bank along the southeast coast. At this time, similar coral banks between Taema Bank and Anuu Island were reported to be free of A. planci infestation, although increased numbers of the starfish were being reported from the inshore fringing reefs along the south coast between Nuuuli and Aumi Villages. These initial observations along with increasing reports of other reefs infested by A. planci prompted the Office of Marine Resources, Government of American Samoa, to conduct a field survey of reef areas to determine the distribution and abundance of the starfish and to assess the extent of the resulting coral damage around Tutuila Island and offshore coral banks.

METHODS

The principal field surveys used in this report were performed during a year-long period between January 1978 and January 1979. The surveys were for the most part conducted by Dr. Richard C. Wass and Mr. Jan Swan of the Office of Marine Resources. Dr. Frederic Martini, Director of Research Programs of Marine Environmental Research, Inc., also accompanied the survey party in the field on two occasions.

During January and February of 1978 the following reef areas were surveyed: 1) reef-flat platforms at Afao, Leone, Nuuuli, Faganeanea, Matuu, Lauliituai and Auasi Villages; 2) reef front and seaward slope zones at Fagatele Bay, Steps Point, and Fagaalv Cove; Aua, Auasi, and Tula Villages and the entire coast between Breakers Point and Sinatau Point; and 3) offshore coral banks and patch reefs between Tafuna Airport and Aunuu Island. Several reef front zones along the north coast were also investigated during November and December, prior to the initial survey. Reefs on the eastern tip of Taema Bank, Nafanua Bank, and several other patch reefs situated between those two regions were resurveyed on April 18, 1978. On May 5, 1978 the reef front zone of fringing reefs along Tutuila's south coast near Faganeanea and Fatumfuti Villages were surveyed and reefs at Alega and Lauliituai Villages that were previously investigated during the first of the year were resurveyed. On June 1, 1978 the reef front and seaward slope zones of fringing reefs along the eastern end of the island were surveyed at places between Auasi Village on the south coast to Puputagi Point on the north coast. On June 6, 1978 the reef front and seaward slope zones of fringing reefs were surveyed along the north-central coast between Masefau and Fagasa Villages. On June 7, 1978 the reef front

and seaward slope zones of fringing reefs were surveyed along the northwest coast from Cape Larsen on the west side of Fagasa Bay to Luania Rocks at Cape Taputapu. Fagatele Bay was resurveyed in November 1978 and during the first week of January 1979 Cape Larsen on the north coast was resurveyed. Reef and lagoon areas around Tafuna Airport were also surveyed during the first week of January 1979. The above survey locations are shown in Figure 1.

Three methods were used to estimate distribution and abundance of A. planci and to determine the extent of the corals killed by them. Reef-flat platforms were surveyed by making 100 meter walks across the surface during low tides. During these reef walks A. planci were counted within a corridor four meters wide (two meters on each side of the observer) and the percentage of coral coverage recently killed (white bleached color) by the starfish was estimated. Extensive areas of the deeper forereef zones of fringing reefs and offshore coral banks were surveyed from depths of 2-20 meters by snorkelers towed on the surface behind a boat. When possible, A. planci and their feeding sites were enumerated and the percentage of coral recently killed by them were estimated during these tow observations. In reef areas deeper than 20 meters scuba divers counted all A. planci observed within a certain period of time and estimated the resulting coral damage.

Because of the large population of A. planci observed at Taema Bank, a more intensive survey was conducted there to measure starfish density so that an estimate of the total population of the entire bank could be made. The bank was divided into four sectors (I-IV) from west to east (Fig. 1). The bank in each sector was divided into three zones consisting of the backreef slope facing the island, the relatively flat upper surface, and

the forereef slope facing the sea. Two to three transects were run simultaneously across Taema Bank from its shoreward to seaward edge in each of the Sectors I-III. In Sector IV, a number of rectangular quadrats 2.15 meters wide by 10.75 meters long were used instead of transects to measure A. planci densities because of a very high population concentrated in a narrow band along its backreef slope. The transects in Sectors I-III were established by scuba divers swimming along the bank surface with a fishing spear 2.15 meters long held at right angles to their direction of movement. Transect lengths were calculated from navigation charts by taking bearings on various landmarks on Tutuila Island at the shoreward and seaward ends of the sector transects. Average A. planci densities for each sector were calculated by counting all the starfish within each of the 2.15 meter wide transect bands in Sectors I-III and within the quadrats in Sector IV. The percentage of corals killed by A. planci were estimated for each bank sector from observations made while making the transect and quadrat starfish counts. Total A. planci populations for the bank sectors were calculated from the area of each respective sector and its average starfish density. The area for each of the Taema Bank sectors was calculated from navigation charts of the Pago Pago Harbor area.

RESULTS

Taema Bank Survey

Sector I

Sector I of Taema Bank was surveyed on January 18, 1978. The transects across this sector of the bank were run on a bearing in line with Fatu Rock

and the television towers located on Alava Mountain. Relatively few A. planci were observed in the westernmost Sector I of Taema Bank, however, about 95 percent of the reef corals were dead in many places indicating that large numbers of starfish had already passed through the area.

In a seaward direction along this transect the backreef slope shoals from 28 to 15 meters. Over 90 percent of the reef corals were dead and only three A. planci were observed. Scattered Pocillopora colonies and a few arborescent patches of Acropora make up most of few remaining living reef corals. Tabletop Acropora species were once common, but none were found alive. The upper surface of the bank is relatively flat, averaging about 15 meters in depth. No A. planci were observed and about 20 percent of the coral coverage was still alive. Originally the reef community in this zone was composed mostly of Pocillopora and some arborescent Acropora species. The forereef slope dips downward from 15 to 34 meters. Rubble covers most of the slope and apparently there was little coral previously growing in this zone. About 50 percent of the scattered corals on the slope are still alive and ten A. planci were seen at 31 meter depth feeding on a single unidentified coral species with large conspicious calices.

Based upon average starfish densities the current A. planci population for Sector I was estimated at about 5000.

Sector II

Sector II was surveyed on the same date as Sector I by running three parallel transects, 405 meters long, across Taema Bank on a bearing in line with the Pago Pago Harbor rangemarkers.

Thirteen A. planci were observed on the backreef slope which shoals from a depth of 31 to 12 meters. About 10 percent of the corals were still alive along its length. Greatest starfish density in Sector II was found on the upper bank surface where a total 74 were observed. Water depth on the low undulating upper bank surface averages about 12 meters and only about 10 percent of the corals were still alive. The forereef slope dips downward from 12 to 34 meters and has a rubbly surface, similar to that observed on the Sector I transects. Judging from the few living and dead corals, it is doubtful that much coral was previously growing on the rubbly forereef slope. Only four A. planci were observed in this zone.

A total of 91 A. planci were observed along the entire length of the three transects across Sector II. This total gives an average starfish density of 1/28.7 m^2 for the three transects and on overall population for Sector II at 13000.

Sector III

Sector III was surveyed on January 24, 1978 by running two parallel transects, 476 meters long, across Taema Bank on a bearing in line with Lepua Church and Breakers Point.

Corals on the backreef slope were mostly dead with less than 5 percent of them still living. All the tabletop Acropora species, most of the arborescent Acropora patches, and all but a few scattered Pocillopora colonies were dead. Only 27 A. planci were observed in this mostly dead coral zone. Numbers of starfish increased dramatically on the shallower upper bank surface where 182 were counted along the two transects. The

starfish were especially abundant along the seaward edge of the upper bank surface but upon reaching the forereef slope they were conspicously absent where a rubble substrate was encountered with few living or dead corals present.

A total of 209 A. planci were counted along the two transects of Sector III giving it an average starfish density of 1/9.8 m^2 and on overall population of 68000.

Sector IV

Sector IV was surveyed on the same date as Sector III. A very large concentration of A. planci was found on the forereef slope of this sector. The starfish were aggregated along the slope, parallel to the main axis of the bank reef, into a narrow band about 5-8 meters wide and 800 meters long similar to the classic "fronts" discribed by Chesher (1971). Because of the concentration of starfish into a band, a quadrat method of measuring starfish density was used. The starfish front extended from the eastern end of Taema Bank to a point in line with bearings between the television tower on Alava Mountain and the western tip of Breakers Point. By plotting those bearings on a navigation chart the starfish front was estimated to be about 800 meters long.

The first quadrat survey was conducted on January 24, 1978 at a location along the starfish front in line with a bearing between the television tower on Alava Mountain and the navigation light on Breakers Point. Two quadrats at this location averaged 400 starfish each. On February 1, 1978 the starfish front was surveyed again at two more locations. Two quadrats at the first of these two survey sites, located on a bearing in line with the television tower on Alava Mountain and the

top-most peak at Breakers Point, averaged 364 starfish inch. At the second survey site, located on a bearing in line with the television tower on Alava Mountain and the middle part of Breakers Point, two quadrats averaged 340 starfish each. Based upon densities from these three survey sites the average starfish density along the front was estimated at 15.9/m^2. Using this average density value and on area 800 meters long by 6.5 meters wide, the total starfish front population was calculated to be about 83,000.

The A. planci front appeared to be moving up the reef slope and across the upper bank surface at Sector IV in a seaward to landward direction. The white skeletons of the recently-eaten corals were obvious immediately behind the front. The white coloration of the coral skeletons graded into yellow-green and finally brown-green as one proceeded seaward indicating increased algal growth and an increasing period of time since the starfish had passed. Immediately landward of the front the corals were mostly living and free of starfish. As the starfish front moved across the bank only about 80 percent of the corals were eaten, however, large numbers trailing behind were eating the remaining corals. About 48,000 starfish were estimated to be trailing behind the actual front itself, which gives Sector IV a total population of 128,000.

At the time of the sector surveys the total A. planci population of Taema Bank was estimated to be about 212,000 with an estimated 80 to 90 percent of all the corals killed.

A resurvey of the eatern tip of Taema Bank (Sector IV) on April 18, 1978 revealed that the well established starfish front observed earlier in the year had broken up. The breakup of the front was probably very recent as observers from Marine Environmental Research, Inc., reported numerous starfish there just three weeks earlier.

Offshore Patch Reefs and Nafanua Bank Surveys

Offshore Patch Reefs A-D

On February 6, 1978, four patch reefs (A-D) situated between the eastern end of Taema Bank and the western end of Nafanua Bank (Fig. 1) were surveyed.

Patch Reef A is located a few hundred meters inshore from the eastern tip of Taema Bank. It is surrounded by water at least 80 meters in depth and rises to within 20 meters of the surface at places. Seventy-nine A. planci were counted during a fifteen minute scuba dive at about 15 meters depth on the upper patch reef surface. A second member of the survey party saw five A. planci during a three minute observation period on the patch reef slopes below 35 meters in depth. Most of the tabletop Acropora species were dead, but more than half of the arborescent Acropora and other coral species were still alive.

Divers were towed across the seaward and landward edges of Patch Reef A and along the seaward edge of Patch Reef C. Both patch reefs were heavily infested by A. planci. The starfish were not banded into a distinct front, but appeared to be scattered with denser concentrations occurring in areas of richest coral growth. Tabletop Acropora species, which are the prefered corals of A. planci, were mostly dead on Patch Reef B and about half dead on Patch Reef C. Other reef corals were eaten to a lesser extent.

A tow survey along the entire length of Patch Reef D revealed numerous scattered starfish. About half of the tabletop Acropora species encountered were dead, but little of the arborescent Acropora species had been killed.

On April 18, 1978 a short resurvey of Patch Reefs C and D was made. On Patch Reef C two five minute scuba dives revealed only 17 A. planci, but about 90 percent of the reef corals were dead. Evidently most of the starfish had left the patch reef after killing most of the available coral. Two similar five-minute scuba dives made on Patch Reef D revealed a total count of 47 starfish. Most of the corals on the deeper parts of this patch reef were dead with few starfish observed, but the shallower areas had considerable numbers present that were feeding on more abundant living corals.

Nafanua Bank Surveys

On February 6, 1978 divers were towed along the entire forereef slope of Nafanua Bank. Most corals, including tabletop Acropora species, were alive. Few A. planci were observed, but those that were seen were small, ranging in diameter from 6.7 to 9 cm. Feeding scars observed were also small and the starfish secretive. In contrast to the forereef slope, the upper surface of the bank was free of A. planci with no evidence of feeding scars.

On April 17, 1978 Nafanua Bank was resurveyed. Deeper parts of bank at this time were mostly dead, but regions shallower than 15 to 20 meters were still living and free of A. planci. Starfish density on the forereef slopes appear to be greater on Nafanua Bank, at its time, than anyplace else on the banks and patch reefs off the south coast of Tutuila Island. The small A. planci (6.7-9 cm dia.) previously observed on the forereef slopes were absent, as all the starfish observed during the resurvey were relatively large. It is unlikely that the present abundant and large sized starfish are the same population as the smaller ones observed earlier, but instead represent an eastern movement of the previous large populations observed on

Taema Bank and patch reefs to the west. On April 20, 1978, 74 A. planci were counted along a 100 meter transect across the forereef slope. The deeper end of this transect crossed a region of corals recently killed and algal-covered with few starfish observed. The algal-covered zone graded into freshly killed corals and a somewhat loosely aggregated front of starfish along the shallower end of the transect. The front was not as well defined as the one observed earlier on Taema Bank, but it was definitely moving up the reef slope as evidenced by the deeper recently algal-covered corals.

Tutuila Island Surveys

Reef Flat Surveys Along the Southeast Coast

Reef flat surveys along the southeast coast were conducted during the first five weeks of 1978. Most of the reef-flat platforms between Nuuuli and Fatumafuti Villages to the west of Pago Pago Harbor and the reef flat east of the harbor mouth at Lauliituai Village were found to be heavily infested with A. planci. A few A. planci were observed on the forereef slopes seaward of the infested reef-flat platforms, but most of the corals were alive. With the exception of a concentration of very large A. planci found on the north coast near Fagatutui Cove in September 1977, and those infesting the reef-flat platforms adjacent to the Pago Pago Harbor area, the remaining fringing reefs surveyed around Tutuila appeared to be largely free of A. planci at the present time.

Forereef Slope Surveys Along the Southern Coast

During January and February 1978 the forereef slopes at Fagatele Bay, Steps Point, and Fagalua Cove; Aua, Auasi, and Tula Villages; and the entire coast between Breakers Point and Sinatau Point were surveyed. All were found to be free of A. planci except at Alega Village and Sinatau Point

where one and six starfish were seen respectively during towing surveys.

On May 5, 1978 the forereef slopes near Alega and Laulilituai Villages were resurveyed by two divers by making five minute scuba dives in opposite directions. At Alega Village no A. planci were observed, but one fresh and one old feeding scar, possibly attributable to starfish feeding, were seen. At Laulilituai Village ten A. planci were counted (4 by one diver and 6 by the other) and considerable coral damage was observed at 20 to 26 meter depth.

Forereef slopes west of Pago Pago Harbor entrance near Faganeanea Village (Sweets Rock) and Fatamafuti Village were also surveyed on May 5, 1978 by making five minute scuba dives in opposite directions. At Faganeanea Village site 14 A. planci were counted (4 by one diver and 10 by the other) and numerous feeding scars observed at 13 to 20 meter depths. Most of the deeper corals appeared to have been killed some time ago. Four starfish were also observed at this site at a depth of 32 meters moving across a sand covered terrace some distance seaward of the reef itself. Possibly these starfish were migrating away from offshore bank and patch reefs that were previously infested by large numbers of A. planci. At Fatamafuti Village no A. planci were observed, but numerous feeding scars were observed at 20 to 23 meters depth.

Forereef Slope Surveys Along the Eastern Coasts

Forereef slopes were surveyed on June 1, 1978 by making ten minute tows with a single diver at Auasi and Tula Villages and along the entire coast from Nuutele Rocks to Puputagi Point.

No A. planci were observed along the Auasi and Tula Village tows. Earlier surveys at these two villages produced similar results during the

first five weeks of 1978.

Between Nuutele Rocks and Papaloa Point 71 A. planci were counted along three fronts which appeared to be moving parallel to the shore. Between these starfish fronts abundant live corals was observed.

From the relatively short distance between Papalao Point and Ogefao Village 1080 A. planci were counted. Even so, the distribution of the starfish were rather patchy. Corals in particular, at the basal periphery of large mounds were being eaten, but the upper shallower surfaces were relatively free of starfish. Starfish were found in all sizes ranging from 6.8 to 40.5 cm in diameter, although most were in the 18 to 22.5 cm range.. Depth distribution was also variable, with some observed as shallow as 1.7 meters, but most were found between 6 to 9 meters depth. Although the starfish apparently moved into the present shallow infested regions from deeper water, the percentage of living corals in the latter (about 70%) were greater than that found in the shallow reef areas.

Between Ogefao Village and Solo Point 270 A. planci were counted on the forereef slopes. About 90 percent of the corals on the outer part of the reef-flat platform were alive with relatively few starfish observed. Along the remaining tow sectors surveyed along this coastline the numbers of starfish counted steadily decreased from 200 between Solo and Motusaga Points, 17 between Motusaga Point and Taligai Cove, and 4 between Taligai Cove and Puputagi Point.

From the above survey it appears that a fairly large population of A. planci is located along the northeast coast between Motusaga Point and Nuutele Rocks. The large size range of the starfish suggests that the popula-

tion is composed of individuals from several larval recruitment periods.

Forereef Slope Surveys Along the North-Central Coast

The reefs along this north-central part of Tutuila Island were surveyed at twelve sectors between Tiapea Point and Fagasa Bay on June 6, 1978. Acanthaster planci counts and condition of the reef corals were made by towing a diver for ten minutes on the surface behind a boat in each sector.

Within each of the sectors the following numbers of starfish were observed: none between Tiapea Point and Masefau Reef Flat, 212 between Nuusetoga Island and Lepua Point where they were more or less restricted to projecting points of land; none between Tapisi Point and Oa Village, Vainuu Point and Anapeapea Cove, Craggy Point and Amalau, Vatia Village school and Pola Island, and along the reefs within Vaaogeoge Cove; 51 between Manofa Rock and Puaneva Point where they were mostly restricted to a point of land at Manofa Rock; and 11, 13, 12, and 0 along four contignous sectors between Mulivaisigano Point and the back side of Fagasa Bay. Along the latter four sectors some reefs were undamaged while others appeared to have been dead six months to a year. Starfish distribution must have been patchy as there were numerous living reef areas intersperced among the dead regions.

Forereef Slopes Surveyed Along the Northwestern Coast

On January 7, 1978 reefs along the northwestern coast of Tutuila Island were surveyed along twelve sectors between Cape Taputapu and Cape Larsen. Acanthaster planci counts and the condition of the reef corals were made by towing a single diver at the surface behind a boat for ten minutes.

Within each of the sectors the following numbers of A. planci were observed: 27 between Luania Rocks and Tiaoalii Rock, 10 between Tiaoalii Rock and Leopard Point, 112 between Faiaiulu and Faga Points, 236 between Faga Point and Maloata Bay, 30 between Fagamalo Village and Paapala Cove, 39 between Pa Cove and around Square Head, 6 between Tolotolooteoti and Mataututele Points, none between Aoloau Bay and a prominent point to the east, 3 in the vicinity of Nuutavana Rock where considerable dead corals were found, none between Siliage Point and Asau Village, none between Fagatiale and Ogegasa Points, and none between Agalua Rock and Cape Larsen. With the exception of the sector in the vicinity of Nuutavana Rock and the last two sectors surveyed, there was no reef damage whatsoever along this section of the coast. On the last two sectors surveyed no starfish were observed, but many dead reef corals were seen.

Survey at Fagatele Bay Along the Southwest Coast

In November 1978 Fagatele Bay along the southwest coast was resurveyed. Earlier in February 1978 this bay was free of A. planci, but now was found to have very little live coral down to depths of 45 or more meters. The shallow forereef slopes still had considerable amounts of live coral present, but numerous starfish were observed to be moving into this remaining live coral zone.

Other Surveys

During the first week of January 1979 numerous A. planci were found on a reef opposite the east end of the runway at Tufuna Airport. The starfish here were very numerous, but scattered, in water ranging from 3 to 6 meters deep. Many dead corals were observed, but some living reef areas were intersperced amoung the starfish patches. Numerous starfish were also observed in front of the Vortoc Station, but not as abundant as at the end of the runway.