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A STUDY OF SOME ASPECTS OF THE CROWN-OF-THORNS STARFISH (ACANTHASTER PLANCI) INFESTATIONS OF REEFS OF AUSTRALIA'S GREAT BARRIER REEF

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A STUDY OF SOME ASPECTS OF THE CROWN-OF-THORNS STARFISH (ACANTHASTER PLANCI) INFESTATIONS OF REEFS OF AUSTRALIA'S GREAT BARRIER REEF

by R. Endean and W. Stablum[1/]

ABSTRACT

The region of Australia's Great Barrier Reef lying between approximately Lat. 15° and 19° S. is known to have been affected by population explosions of Acanthaster planci during the 1960's. About 150 patch reefs, each several square kilometres in extent, lie between Lat. 16° 34' S. and 19° 20' S., and 82 of these reefs including most of the larger ones were visited between August, 1969 and May, 1971. Although 46 of the 82 reefs carried few or no A. planci when visited, it is known that 18 of the 46 had carried large numbers of starfish at some stage during the 1960's, and it is possible that two other reefs also carried large numbers of starfish during this decade. On these 20 reefs a massive destruction of hard corals had occurred. The picture of coral destruction on these reefs contrasts markedly with that found on the 26 reefs visited which have not been infested with starfish during the 1960's. On these reefs the percentage of freshly killed coral in the total coral cover is very low.

Thirty-six of the 82 reefs visited were carrying large numbers of starfish and destruction of hard corals was in progress on these reefs. The amount and location on each reef of freshly killed hard coral was related to the stage of starfish infestation reached. Initially, damage was confined to deep water around the perimeter of the reef where starfish first appeared in large numbers. Subsequently, the coral destruction spread to other areas of the reef as starfish ascended reef slopes and invaded reef flats. Population densities as high as 15 adult starfish per square metre over thousands of square metres of reef were observed.

Juvenile starfish were confined to shallow water areas, principally on reef crests, and in most cases appeared to be the progeny of invading starfish. Invasion of reefs appears to result from adult starfish migrating between reefs rather than being due to larval carriage from reef to reef by currents.

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It is suggested that population explosions of A. planci first occurred during the early 1960's on accessible inner patch reefs near the major centres of human population in North Queensland and that subsequently there was a spread of starfish to adjacent reefs. This spread is continuing.

INTRODUCTION

Population explosions of the coral-eating starfish Acanthaster planci were observed on reefs of the Great Barrier Reef in the Cairns region during 1962. By early 1963 it was apparent that Green Island Reef, near Cairns, was infested with starfish which were causing obvious damage to the hard coral cover of the reef (Barnes and Endean, 1964). Subsequently, a survey of the apparent extent of infestation by A. planci of the reefs of the Great Barrier Reef was carried out during the period March, 1966 to August, 1968. It was found (Endean, 1969; Pearson and Endean, 1969) that the region of infestation (Fig. 1) embraced reefs in the region lying between approximately Lat. 15° 18' S. (Lark Reef) and approximately Lat. 18° 58' S. (Broadhurst Reef). Although only a third, approximately, of the reefs in this region were visited the picture which emerged was clear. Most inner patch reefs and some of the outer reefs visited carried unusually large populations of A. planci which were causing extensive damage to hard corals on these reefs. Towards the end of 1967 an apparent decline in starfish numbers, probably owing to scarcity of food, on some inner patch reefs in the Cairns-Innisfail area was noted. At the same time some evidence was obtained that other reefs immediately to the south of this area were coming under attack.

Although there can be no doubt that a catastrophic mortality of hard corals has occurred in the area (Endean, 1969; Talbot and Talbot, 1971) available estimates (Endean, 1969; Pearson and Endean, 1969) of the extent of destruction of hard corals on particular coral reefs caused by the feeding activities of A. planci lack precision. In most cases they are visual estimates relating solely to the percentage of dead coral in the total coral cover present in a sampled area of reef after the reef had been devastated by the starfish or while the devastation was in progress. Apart from a lack of precision such estimates could be somewhat misleading since they do not take into account the overall extent of the coral cover or the amount of dead coral normally found on the reef when A. planci is present at low population density.

There is a dearth of information about the manner in which reefs of the Great Barrier Reef become infested with A. planci and the respective roles played by juvenile and adult starfish in initiating these infestations. Also, little information is available concerning starfish predators and other factors which might have some bearing on the genesis of the starfish infestations of reefs in Queensland waters.

In view of the foregoing, it was decided in 1969 to visit as many as possible of the larger reefs in the region of the Great Barrier Reef lying between approximately Lat. 16° 30' S. and 19° 20' S. with a view to ascertaining whether starfish had departed from inner patch reefs in the Cairns-Innisfail region and whether inner patch reefs south of this area were coming under attack. It was also decided to ascertain whether outer reefs in the region between Lat. 16° 30' S. and 19° 20' S. had been attacked by the starfish. At each reef visited visual estimates were to be made of the density and distribution of A. planci and of the major types of reef cover, particular attention being given to the respective amounts of living coral and recently killed coral present. At selected reefs these estimates were to be supplemented by and checked against quantitative data obtained by a sampling technique. It was also decided to analyse the structure of A. planci populations on some reefs with a view to obtaining information on the respective parts played by juvenile and adult starfish in the infestations of reefs. In addition, a search for starfish predators was to be made on all reefs visited.

MATERIALS AND METHODS

During the period between August, 1969 and May, 1971 82 reefs (Figs. 2 & 3) of the Great Barrier Reef lying between Lat. 16° 34' S. and 19° 20' S. were visited, some on more than one occasion. The reefs in this region are generally regarded as patch reefs. Those lying nearer the 100 fathom line are termed outer patch reefs and those nearer the 20 fathom line are termed inner patch reefs. The mean distance between adjacent reefs in the region approximates 10 km. Some reefs visited are not named on official charts of the region. These reefs are referred to in Figs. 2 & 3 by names conferred on them by local fishermen.

At some localities a general survey of a sector of reef was made by swimming over the area while wearing face mask and snorkel or scuba gear. At other localities reef areas were examined through a glass-bottomed box while traversing the areas by boat or were viewed by a diver who was towed on a manta-board behind a boat. Usually, sectors of the perimeter of a reef including the seaward slopes from reef crest to sea floor were examined. Sectors on the normal weather side and on the normal lee side of each reef were usually chosen (south-east trade winds prevail for approximately nine months of each year in the region of the Great Barrier Reef visited). If numerous coral pinnacles ("bombies") were present in lagoons or in extensive back reef areas on reefs visited some of these pinnacles were also examined. Occasionally, reef flat areas were examined. In each case an estimate of the area examined was made.

Visual estimates (Table 1) were made of the apparent abundance of A. planci (wherever possible the number seen in a twenty minute period for ready comparison with the results obtained in the earlier study made by Pearson and Endean (1969) was noted) in the reef sector examined. Also, the apparent pattern of distribution of A. planci on each reef visited was ascertained wherever possible. Searches were made in the vicinity of any freshly killed hard corals encountered as A. planci is cryptic when present at low population densities. At each sector of reef visited the proportion of the total area of the reef surface examined which was covered by live hard corals plus the skeletons of recently killed hard corals still in situ (i.e. the total hard coral cover) was estimated and referred to one of the following categories for inclusion in Table 1: sparse (Fig. 4), moderate (Fig. 5), dense (Fig. 6). Likewise, the proportion of recently killed hard corals (skeletons still in situ) in the total hard coral cover was estimated and referred to one of the following categories for inclusion in Table 1: low (Fig. 7), marked (Fig. 8), high (Fig. 9). Normally, no difficulty was encountered in assigning the total coral cover or the proportion of dead hard coral in the total coral cover of a reef sector examined (Figs. 10 and 11) to one of these categories but if some doubt existed this is indicated in Table 1. The extent of the soft coral (alcyonarian) cover present in each reef sector examined was also assessed.

At certain localities sampling stations were selected and attempts were made using a sampling technique developed by J. Laxton and W. Stablum to obtain quantitative data on the percentage of the area of the reef sampled which was covered by live hard corals (LHC), by the skeletons of recently killed hard corals remaining in situ (DHC), by soft corals (SC) and by algal-dominated substratum (ADS). These four categories of reef cover accounted for the bulk of the cover observed. Living sedentary animals other than hard and soft corals (e.g. sponges, gorgonians, anemones, colonial anemones, tunicates) were found attached to the substratum in the areas sampled but they comprised usually less than 1% of the total cover observed.

No difficulty was experienced in the field in distinguishing between living and dead corals. Recently killed corals were recognized by their stark white skeletons. It was noted that within two to three weeks these skeletons acquired a fine greyish or greenish coating of filamentous algae. Subsequently the algal covering thickened and darkened and coral skeletons became covered with dark tufts of filamentous algae. In some cases at least, coralline algae ultimately covered parts of the skeletons which can remain in situ for extended periods. For example, Pearson and Endean (1969) refer to the skeletons of two dead coral colonies which had remained in situ at Green Island Reef for almost three years when last observed. On the reef crests of some reefs a few hemispherical nodules were observed which, upon examination, were found to be comprised of coral skeletons heavily encrusted with coralline algae. These were included in the category of algal-dominated substratum but otherwise coral skeletons remaining in situ, irrespective of whether they were covered with algae or not, were placed in the category of dead hard corals. The category termed algal-dominated substratum included occasional patches of loose coral sand and apparently bare areas but, in the main, was comprised of consolidated and semi-consolidated reef debris covered with algae. Coralline algae predominated but other types of algae, particularly short filamentous forms, were represented and were especially common in some areas (e.g. reef crests). However, no attempt was made to differentiate among the algal species encountered.

The sampling technique used to obtain quantitative data involved the running out of a 100 metre transect line, marked off in one metre lengths, across the region to be sampled. As far as was possible under the conditions prevailing at the time of the visit a station or stations were chosen on the normal weather side and on the normal lee side of each reef visited. One end of the transect line was normally anchored in water 5 - 20 metres deep, seawards from the reef edge, the line run out towards the nearest point on the reef crest and secured on the reef crest or reef flat at some distance (10 - 30 metres) from the reef edge. Usually this procedure resulted in the line being oriented at right angles to the reef edge in the region sampled. Also, particularly on windward sides of reefs, it usually resulted in the transect line traversing the seaward slopes of the reef sampled from sea floor to reef crest.

Estimates of the percentage cover of LHC, DHC, SC and ADS respectively were made as follows: a metre square grid was placed at the start of the transect line and photographed from a point perpendicular to the plane of the grid and at a distance of approximately 2 metres from it. When the slope of the reef surface below the transect line was less than 70° from the horizontal the grid was photographed in a similar way at intervals of ten metres along the transect line. When the slope was greater than 70° the grid was photographed at shorter intervals. Sometimes conditions (heavy wave action, strong currents, poor visibility etc.) were unfavourable for transect work and fewer quadrat photographs than usual were taken.

Two identical prints (Fig. 12) were made of each negative obtained. One was kept as a record. From the duplicate the images of living hard corals, recently killed hard coral skeletons in situ and soft corals respectively were carefully excised. The remainder of each print was regarded as representing algal dominated substratum. The pieces belonging to each category were weighed to the nearest 0.0001 gram. Each weight thereby obtained was then expressed as a percentage of the total weight of the print. This procedure yielded the percentage area of each print occupied by each category of reef cover investigated and it was assumed that the figure obtained in each case corresponded with the actual percentage area occupied by the particular category of reef cover in the area of reef surface depicted in the print. It was intended that the area of each print should correspond with the area of the quadrat (1 metre squared) used. However, this was frequently not the case and the area of each print merely approximated 1 metre squared (mean for 551 prints was 1.12 m^2 and the range was 0.82 - 1.88 m^2. Mean figures for the percentage area occupied by each category of reef cover on each transect were then calculated and are listed in Table 2.

Attempts were made to assess the density and distribution of A. planci at each transect made. The number of specimens visible in each quadrat was determined (Fig. 13). Information on the size frequency distribution within starfish populations on some reefs was also obtained. To obtain this information without disturbing the population the maximum radius of each starfish was measured in situ in some cases.

RESULTS

The reefs visited, estimates of the area of each reef sector sampled, estimates of the percentage of each reef area sampled which was covered by live hard corals and the skeletons of recently killed hard corals still in situ, estimates of the percentage of recently killed hard corals in the total hard coral cover and a description of the general condition of the reef cover are given in Table 1. Also included in Table 1 is information on the apparent abundance and distribution of A. planci in the areas of each reef examined. Data obtained from quadrat sampling along transects made on 24 reefs are presented in Table 2. These data include figures for the percentage of the total reef cover occupied by each of the 4 categories of reef cover selected for detailed investigation, the percentage of the total hard coral which had recently been killed and the mean number of coral colonies per print. The number of colonies per print approximates the number per quadrat (i.e. per m^2). It should be noted that the figures presented reflect the actual situation only for the areas specified at the dates specified. Because of camera malfunctions, incorrect exposures etc., a few quadrat photographs were unsuitable for analysis and were discarded. The number of quadrat photographs included in the analysis of each transect is given.

It can be seen from Tables 1 and 2 that the percentage of the surface of a reef which is covered by living hard corals and the skeletons of recently killed hard corals remaining in situ (i.e. the total hard coral cover) varies markedly from reef to reef and from one region to another of the same reef. Water depth and degree of exposure to wave action were two factors which obviously affected the density of hard corals growing in any particular area of a reef but no attempt was made to assess the relative importance of these or other factors. It might be mentioned however, that although hard corals were usually well developed on the seaward slopes of the reefs visited they usually became sparser in water deeper than about 15 m. Even so, they were usually well represented on seaward slopes until the consolidated and semi-consolidated material comprising the reef proper merged with unconsolidated coral sand and reef debris around the perimeter of the reef. The depth at which this occurred varied somewhat from reef to reef but in general was about 25 m for the inner platform reefs and about 35 m for the outer platform reefs visited. The extent of the surface of a reef covered by soft corals varied from reef to reef and from one part to another of the same reef. A variable but frequently high percentage of the surface of each reef sector was devoid of living hard or soft corals or the skeletons of recently killed corals. Usually these reef areas were dominated by algae, particularly calcareous algae.

Despite intensive searching of areas visited by trained observers familiar with the behaviour of A. planci, specimens of the starfish were not observed on 36 of the 82 reefs visited. Less than 4 starfish were seen on each of another 10 of the 82 reefs visited. It is known that 13 of these 46 reefs which appeared to be devoid or virtually devoid of A. planci in 1969, 1970 or 1971 had carried large numbers of starfish at some stage during the 1960's (Endean, 1969; Pearson and Endean, 1969) and reports from reliable witnesses have been received that another 5 reefs (Cayley, McCulloch, Hall-Thompson, Eddy and Farquharson) visited during the recent survey but not visited when the earlier studies were made were also invaded by starfish during the 1960's. It is noteworthy that destruction of hard corals as evidenced by the ratio of recently killed hard coral skeletons in situ to total hard coral cover on these 18 reefs has been particularly heavy and the living hard coral cover of these reefs is now remarkably sparse. The percentage of coral skeletons in the total hard coral cover of these reefs (as well as the total hard coral cover) would in many cases be even higher if allowance had been made for the fact that soft corals (Figs. 14 and 15) have covered the skeletons of many of the recently killed hard corals. Indeed, on many of these 18 reefs soft corals cover extensive areas and have obviously proliferated after hard corals were destroyed since they have grown over the skeletons of recently killed corals.

Of interest was the finding that coral damage caused by starfish was extensive on only the lee sides of another two reefs apparently devoid of A. planci when visited in 1971. One of these reefs, Horseshoe Reef, had not been visited during the 1960's. The other, Potter Reef, had been visited briefly in 1969 but starfish which must have been present in the lagoon at this time were missed. Some damaged corals were in fact observed on this reef in 1969 but the damage was attributed to storms.

As far as can be established the remaining 26 reefs which were devoid of A. planci during the recent visits had not carried abnormal numbers of the starfish at any stage during the last decade. Two starfish were observed during a 15 minute search at Noggin Reef in 1966 (Pearson and Endean, 1969) but invasion of this reef by large numbers of starfish does not appear to have occurred since the hard coral cover in the areas visited in 1970 showed no evidence of recent damage attributable to A. planci. Some recent coral damage possibly caused by starfish was apparent near the reef crest at Hedley Reef but the damage was not extensive and no starfish were observed when this reef was visited in 1970.

It is instructive to note that the skeletons of recently killed hard corals remaining in situ formed only a minor percentage (usually less than 10%) of the cover of the 26 reefs which had not carried large numbers of A. planci during the last decade. The dead hard coral which occurred was mainly confined to the higher parts of the reef crest, to the tops of coral pinnacles lying to windward of the reef crest or in back reef areas and to reef flats. These are all regions which may be bared to the atmosphere periodically at times of low water spring tides. They are also regions subjected periodically to heavy wave action. There was also a slight increase in the ratio of dead to live hard coral with increasing depth on some of the reefs visited. A higher ratio of dead to living coral was normally found in lagoons and on reef flats than on the seaward slopes of reefs.

Alcyonarians were conspicuous among the surface cover of the 26 reefs which had not carried large numbers of A. planci during the last decade but they accounted for only a minor percentage (usually much less than 10 per cent) of the surface cover of these reefs. They tended to occur more commonly in lagoons and back reef areas than on seaward slopes.

Figures reflecting the amounts of dead coral cover on reefs which were under attack by A. planci varied depending on whether the starfish had been active in the area sampled. Of the 82 reefs visited during the period August, 1969 to May, 1971, 36 reefs were found to be carrying numerous specimens of A. planci and on these reefs the starfish were causing obvious damage. Starfish densities in terms of the number seen per 20 minute swim (Table 1) ranged from 0 to 526 in the areas of these reefs sampled. However, it became apparent that normally the starfish were not uniformly distributed. Instead, they tended to aggregate in particular reef areas. The location of each group of starfish was related to the stage of infestation of the reef reached and also to the mean size of the starfish. During the earlier stages of infestation of a reef the starfish tended to be cryptic and nocturnal. Subsequently, when they moved onto the reef flat, they fed during daylight hours and many were completely exposed at such times (Fig. 16). Sometimes the arms of adjacent starfish overlapped and a coral colony became completely enclosed by a mass of feeding starfish (Fig. 17). Because starfish were not uniformly distributed on a reef and because they showed cryptic behaviour at some stages of infestation of a reef but not at others, attempts to estimate starfish numbers on transects were abandoned.

Initial infestation of a reef in the region investigated appeared to occur at some point or points at the foot of the seaward slopes around the perimeter of the reef. At this stage starfish numbers were relatively small and coral damage was patchy. However, it was possible to follow the trails of dead coral left by the starfish, the earlier parts of the trails being several weeks old. Indeed, location of the starfish often depended upon observing the trail of dead coral as the starfish were cryptic at this stage. It is significant that juvenile starfish were not found among the early invaders in the deep water around reefs. Yamato, Tabias, Mid, Dolphin, Centipede, and Tiger Reefs appeared to be at this early stage of infestation when visited in 1970.

Apparently the ranks of the early invaders are swollen by later arrivals and the starfish begin to ascend the seaward slopes of the reef. In July, 1970 starfish were observed in deep water around the perimeters of Dip and Coil Reefs but were not found in shallow water areas of these reefs. Only in the areas where the starfish were observed was there evidence of marked coral destruction. At Trout Reef in December, 1969 large numbers of adult starfish were congregated in water about 33 metres deep near the foot of the seaward slopes on one sector of the reef. Marked coral damage was confined to this sector. When the reef was visited approximately 4 weeks subsequently it was noted that many of the starfish had moved through distances of several metres up the reef slope. Their paths of ascent could be traced readily by the trails of recently killed corals which they left behind. Coral damage on other regions of Trout Reef examined at the time was slight and no adult specimens of *A. planci* were observed in these other areas. Trails of freshly killed coral which marked the paths of ascent of seaward slopes by starfish were observed on other reefs and were especially prominent at Glenda and Seeker Reefs when these were visited in May, 1971.

When John Brewer Reef and Lodestone Reef were examined in January, 1970 the bulk of starfish and the bulk of coral damage were confined to the deeper regions of the seaward slopes around the perimeters of the reefs and to the lower parts of the vertical or near-vertical faces of coral pinnacles. Coral on the reef crests, upper parts of the seaward slopes and on the reef flats was largely undamaged at this time. By July, 1970 starfish had invaded the upper parts of the seaward slopes at both localities and were observed on vertical and near vertical faces near the tops of coral pinnacles on the lee side of each reef. At John Brewer Reef adult starfish were observed to be eating the coral in the upper 3 m on some sectors on the windward side of the reef despite exposure to wave action.

In October, 1970 large numbers of A. planci were observed attacking corals on the seaward slopes of Glow Reef. By January, 1971 they had killed the bulk of the coral on the slopes and were congregated on the upper parts of the seaward slopes near the reef edge. In October, 1970 A. planci was observed attacking corals on the vertical and near vertical seaward slopes of Grub Reef. By January, 1971 destruction of corals on the seaward slopes was well advanced and adult starfish were concentrated near the reef edge.

After killing the bulk of coral on the seaward slopes around the perimeter of a reef the starfish may invade the reef flat in very large numbers. In September, 1969 a large herd of starfish was encountered on the reef flat near the sand cay at Taylor Reef. The herd appeared to be completing the destruction of thick beds of branching acropores. Twelve months later it was found that most of the dead branching corals in the shallow water near the cay had been broken to form piles of rubble. In July, 1970 very large numbers of starfish were observed to be massed on the reef flat at Slashers No.1 Reef. The main group occupied an area of several thousand square metres. It was surrounded by smaller groups of starfish and other groups of starfish were observed to be moving into the area from the north and the west. A second visit two weeks later revealed that the centre of the main group was about 200 m to the south of its previous position. Starfish occurred on the reef flat at densities as high as 15 per square metre over thousands of square metres. Areas of coral which were alive but in the path of the feeding starfish at the time of the first visit were dead at the time of the second visit. The trail of dead corals left by the migrating starfish herds could be followed readily. It extended northwards for at least 800 m. Freshly killed coral in the vicinity of the feeding starfish was stark white while skeletons to the north showed progressive fouling by algae.

When the bulk of hard corals on a reef flat have been killed starfish move back into deeper water. In early 1970 large numbers of A. planci were observed moving across the devastated reef flats to the reef edges of Bramble Reef and Trunk Reef. However, adult starfish do not usually invade the reef crest area or the tops of coral pinnacles and reef flats subject to emersion at low tide. For example, although large numbers of starfish caused almost total destruction of hard corals on the seaward slopes of Lodestone Reef, adult starfish departed from the reef in 1970 without invading the reef flat to any great extent.

Infestation of some outer patch reefs may follow a different course. Large numbers of juvenile starfish and a few adults were found on some coral pinnacles in the lee of Nathan Reef in 1969 and 1970 but invasion of the seaward slopes or reef flat had not occurred. The juveniles were confined to shallow water. A few juveniles but no adults were found in shallow water at Birthday Reef in 1969. In this connection it should be noted that small juvenile specimens of A. planci were found only in shallow water near reef crests and on the tops of coral pinnacles despite intensive searches for them in a variety of habitats. Data on size frequencies of starfish in population samples taken from nine reefs are incorporated in Table 4 and in Figs 18, 19 and 20.

Fig. 18 A shows the size structure of an A. planci population consisting entirely of juveniles found on the reef crest of Slashers No.4 Reef in January, 1971. Their mean size would indicate that they were approximately 12 months old (Pearson and Endean, 1969). Fig. 18 B shows the size structure of a population sample of juvenile A. planci taken from the reef crest at Glow Reef in January, 1971 and the structure of a sample of A. planci taken from the seaward slopes of Glow Reef at the same date. Obviously the small juveniles tend to keep together during their first year.

Figs. 18 C and 18 D show the size frequency of two samples of a population of A. planci associated with a large coral pinnacle in a back reef area at Nathan Reef. The first sample was taken in September, 1969 and the second in January, 1970. It was noted that the larger starfish in each sample occurred in deeper water around the perimeter of the pinnacle but unfortunately records were not kept of the exact sites from where representatives of each size group in the population sampled were collected. It was of interest that other coral pinnacles in the area which were examined carried few or no starfish and the infestation observed appeared to be a localized one.

According to Pearson and Endean (1969) juvenile A. planci grow at the rate of about 1 cm per month. However, it is not known whether this growth rate is maintained after the end of their second year when most probably mature. Strong domination by certain size groups and apparent year groups characterizes the populations sampled at Big Sand Cay, Bramble Reef and Slashers No.1 Reef (Figs.19 A-C). However, different year groups could be represented and are almost certainly represented in Fig.19 D, Fig. 20 A and Fig. 20 B. Indeed, small juveniles are included in the population sampled from Trunk Reef (Fig. 20 B).

The fact that starfish were observed to be aggregated on reefs during all seasons of the year rules out the possibility that the starfish aggregations are breeding aggregations (Pearson and Endean (1969) have shown that A. planci breeds during the summer months).

During this survey 22 adult and two large juvenile specimens of the giant triton (Charonia tritonis) were found (Figs. 21 and 22). All except two were lying fully exposed among corals when found (Table 3). They occurred on windward and lee sides of reefs and in lagoons. Five specimens of C. tritonis were eating A. planci when encountered. Four of the A. planci specimens were large juveniles about 20 cm in diameter, the other was adult. Two tritons were eating holothurians when found. One large recently dead specimen of C. tritonis was encountered. Its shell was intact but its flesh was putrefying. The cause of death was not ascertained.

Pieces of discs and arms from adult specimens of A. planci which had been recently killed and torn apart were observed at Broadhurst Reef (two specimens), John Brewer Reef (one specimen) and Slashers No.4 Reef (two specimens). A large hump headed wrasse (Cheilinus undulatus) was observed mouthing a macerated specimen of A. planci at Slashers No.4 Reef but it is not known whether the wrasse had seized and dismembered the starfish initially.

DISCUSSION

This study was hampered by the great extent of the region of the Great Barrier Reef which has been affected by the A. planci infestations and hence warranted detailed investigation. It was hampered too by the small number of personnel involved and by the limited period of time (a few hours) which could be spent on each of the many reefs visited, most of which were several square kilometres in extent. All of this restricted the amount of quantitative data which could be obtained. Moreover, numerous difficulties attend attempts to carry out quantitative transect work on coral reefs. Some of these difficulties have been discussed recently by Stoddart (1969). In particular, because of the variation in growth form assumed by different coral colonies the accuracy of methods involving quadrats in the sampling of the percentage area of reef surface covered by each major category of reef cover may well be questioned. Inevitably, the projection onto a flat surface (film) of the images of corals which branch extensively in all planes from the point of attachment gives rise to problems if the projection is used to assess the extent of the reef surface covered by corals. Furthermore, some corals such as the common plate coral Acropora hyacinthus tend to grow out on a tubular "stalk" from the region of attachment before expanding to form a "plate" in a horizontal or near horizontal plane. When photographed from a point at right angles to a reef face these corals usually appear to occupy a much smaller area of the reef surface if they grow out from a vertical or near vertical reef face than is the case when they arise from a horizontal or near horizontal reef Then too, the sampling frequency along the transect line when it is placed on parts of those reefs where seaward slopes are steep requires detailed study in order to select an optimal frequency for subsequent statistical analysis.

Likewise, the optimal number of stations for transect work that should be set up on a coral reef of mean size for the region of the Great Barrier Reef visited if the surface cover of the reef is to be satisfactorily sampled has still to be determined. It will be appreciated that the limited amount of time which could be spent on any reef during the present investigation prevented the establishment of an adequate number of sampling stations. In view of all this the transect data obtained could not be used to provide accurate estimates of the surface cover of any of the reefs visited. Indeed, if reliance were placed solely on such transect data the estimates obtained could be misleading. However, the transect data obtained enabled checks to be made at particular reef sites on visual estimates of the total coral cover and of relative amounts of dead and living coral in the total coral cover. Much greater areas of reef were viewed when visual estimates were being obtained than were involved in the transect work undertaken thereby enabling a better assessment of the overall picture at each reef visited to be made.

Although the degree of accuracy which could be attained when making visual estimates is limited, difficulty was rarely experienced in referring visual estimates of total coral cover and of the extent of recently killed coral in the total coral cover of a reef to appropriate categories among those illustrated in Figs. 4-9. Particularly was this so with visual estimates of the extent of recently killed coral in the total coral cover. Indeed, it emerged from the present study that on those reefs or areas of reefs investigated which are as yet unaffected by the feeding activities of *A. planci* the number of skeletons of recently killed hard corals remaining *in situ* normally constitutes a minor percentage (certainly less than 10%) of the total coral cover. In fact, dead coral skeletons *in situ* were rarely seen on the seaward slopes of those reefs visited which have not been invaded by *A. planci*. The marked increase in the percentage of coral skeletons *in situ* on reefs which have been invaded by *A. planci* is apparent from analysis of the figures given in Table 2 and from the visual estimates listed in Table 1. Although the proliferation of soft corals which follows destruction of hard corals in some reef areas has masked, to some extent, the actual magnitude of the destruction which has occurred in many areas, particularly sheltered areas of inner patch reefs devastated during the mid 1960's, the results obtained are unequivocal. On the reefs visited which had already been invaded by *A. planci* it is apparent that massive destruction of hard corals has occurred and that living hard corals now form a remarkably small percentage of the total reef cover. Precise figures for the extent of the hard coral cover killed by *A. planci* on the reefs are not available but the new data obtained support earlier estimates made by Pearson and Endean (1969) that the great majority of hard corals on these reefs have been killed by *A. planci*. Indeed, there is no question that almost every coral colony in an extensive area of reef under attack by large numbers of A. planci can be killed by the starfish in a short period of time. Such destruction has been witnessed and photographed at the reefs of the Slashers complex for example. There is also no doubt that a massive destruction of corals owing to the feeding activities of A. planci can occur over a whole reef. Such destruction was observed, for example, to occur within a few months at John Brewer Reef after the reef had been invaded by large numbers of starfish.

Available information would indicate that the bulk of the hard corals on many reefs of the Great Barrier Reef investigated was killed within 2-6 years after large numbers of starfish were observed on the reefs. Many factors would influence the rate of destruction of the corals at a particular reef. However, as a reef of mean size in the area investigated normally carries many square kilometres of coral and as each adult starfish kills about 6 sq m of coral per year (Pearson and Endean, 1969) it is apparent that tens of thousands of adult starfish must be involved in the destruction of coral at each reef.

On some reefs such large numbers of A. planci were undoubtedly present. Densities as high as 15 adult starfish per sq m over an area of several thousand square metres have been observed (and photographed). However, it has become apparent that the location of feeding starfish and, to a large extent, the degree of aggregation of starfish are dependent on the stage of infestation of a reef reached and on the distribution of corals, particularly acropores, on the reef. Because of this the data on starfish densities obtained at sectors of each reef examined (particularly those obtained during transect work involving only small areas of reef) cannot be extrapolated to give figures for the density of starfish over the reef as a whole. Also, it would be easy for divers, even divers experienced with A. planci, to visit briefly a portion of a reef which was devoid of starfish and to miss completely large concentrations of starfish present on other areas of the same reef. Then again, once they have killed the bulk of corals on a coral reef (except those in very shallow water on reef crests and the tops of coral pinnacles) adult starfish depart from the reef. It may have been the operation of factors such as these which caused Weber and Woodhead (1970) and Vine (1970) to underestimate seriously the extent and severity of the starfish infestations of reefs in the central region of the Great Barrier Reef.

Pearson and Endean (1969) have arbitrarily selected a figure of 40 starfish seen per 20 minute swim as constituting an infestation. This figure is arrived at by making certain assumptions. The first assumption is that in one year a 25% kill of hard corals in an area completely covered by corals is significant. The second assumption is that an adult starfish kills about 6 sq m of coral per year. The third assumption is that 1000 sq m of reef can be examined in 20 minutes by a diver.

It is possible that the figure of 40 starfish seen per 20 minute swim as an indicator of an infested reef may be set too high. The hard coral cover of a reef would rarely exceed 50% of the total reef cover. Then again, Chesher (1969) maintained that an adult A. planci killed about 12 sq m of coral per year. Moreover, A. planci tends to be cryptic during the early stages of invasion of a reef, normally hiding during the day. T. Brown (personal communication) has counted 22 adult starfish hidden beneath one large tabular acropore. In view of all this it is of interest to note that Chesher (1969) has selected a figure of 20 A. planci seen per 20 minute swim as indicating the possible existence of a starfish infestation. This raises the question of the manner in which reefs become infested by starfish.

The available evidence indicates that large numbers of A. planci appeared suddenly on those reefs of the Great Barrier Reef which have recently become infested by the starfish. Two mechanisms can be invoked to account for the sudden appearance of A. planci on these reefs. One mechanism involves the carriage of large numbers of pelagic starfish larvae to a reef by currents, the other involves the migration of starfish across the sea floor from one reef to another. It seems likely that juvenile starfish settle principally in shallow water near reef crests and the tops of coral pinnacles. Certainly these were the only regions where juvenile starfish were found during the present investigation despite an intensive search for them in a wide selection of the major habitats provided by a coral reef. Only rarely were large numbers of juvenile starfish found on a reef in the apparent absence of substantial numbers of adult starfish on the same reef. Indeed, of the reefs visited only Nathan Reef appeared exceptional in this regard. At this locality large numbers of juvenile starfish were present on the tops of a few coral pinnacles in the lee of the main reef which appeared to be free of A. planci. However, a few large adult starfish were found in deeper water around the pinnacles carrying the juvenile starfish and the juveniles could have been the progeny of these adults.

On the other hand, large numbers of adult starfish were found on some reefs which appeared to be free of juvenile starfish. It is significant that initially the adult starfish on these reefs were found principally in the deeper water around the peripheries of the reefs and that the bulk of the coral in shallow water on such reefs showed little damage which could be attributed to A. planci. Indeed, the weight of evidence obtained during the present investigation indicates that those reefs which have recently become infested by starfish have been invaded by adults which have migrated to the reefs across the sea floor. The invasion pattern would appear to involve the following sequence of events. Adult starfish arrive at one or more points at the foot of the seaward slopes around the perimeter of a reef. As numbers of invaders increase and the coral in the deeper water around the perimeter of the reef is killed the starfish ascend the seaward slopes of the reef. Initially, the adult starfish tend to avoid shallow reef areas exposed to wave action and they move peripherally around the reef following the contours of its seaward slopes. Amalgamation of groups of feeding starfish becomes more pronounced as coral destruction increases. Eventually coral on the reef edge is attacked and the starfish may then move onto the reef flat and the tops of coral pinnacles, hunger probably overcoming their erstwhile photonegative behaviour. Very large herds of migrating starfish are frequently seen during the day by the casual observer at this stage. When the bulk of the available coral has been exhausted the migrating starfish then move into deeper water and depart from the reef.

Normally, large numbers of juvenile starfish appear on a reef subsequent to the arrival of large numbers of adults on the reef and it is probable that the juveniles are the progeny of the invading adults. *A. planci* breeds only during the summer months and it would seem that the extent of the participation of juvenile starfish in destruction of coral at a particular reef would depend upon the season when adults invade the reef as well as on the rapidity with which the adults kill the reef's coral. This, in turn, depends on the number of adults present and the amount of coral present (assuming that the adults feed at a constant rate throughout the year). It is significant that juvenile starfish are found in shallow water on the reef crest and on the tops of coral pinnacles, regions normally avoided by adult starfish.

Recent charts of the region of the Barrier Reef lying between Lat. 16° 34' S. and 19° 20' S. (the region embraced by the present survey) show the positions of approximately 150 recognizable reefs (fringing reefs of mainland islands are excluded). Of these 150 reefs 82 were visited between August, 1969 and May, 1971. Another 8 reefs in the region (Oyster, an unnamed reef at Lat. 16° 39' S., Elford, Briggs, Maori, Scott, Stevens, and Rib Reefs) were visited during 1966-1968 by Pearson (Pearson and Endean, 1969). These 90 reefs visited include all the larger reefs in the region. Most of the remaining 60 are very small. A study of the results of Pearson and Endean (1969) will reveal that by December, 1966 most, if not all, the inner platform reefs between Michaelmas Reef (Lat. 16° 34' S.) and Beaver Reef (Lat. 17° 51' S.) were already heavily infested with starfish. By 1970-71 starfish were absent from these reefs and the bulk of the hard corals present on these reefs appeared to have been killed by the starfish. As evidenced by the paucity of living hard corals and the abundance of skeletons of recently killed corals still *in situ* destruction of corals had been extremely heavy and in many cases was almost total. Further to the south, Otter Reef and Rib Reef were at least partially infested by the end of 1966 (as was the fringing reef at the Palm Islands) but, as far as can be ascertained, other patch reefs south of Beaver Reef carried few or no starfish at the end of 1966. None was seen at Britomart Reef and John Brewer Reef and only 2 specimens at the reef complex known as The Slashers and 2 specimens at Trunk Reef when these were examined at the end of 1966 (Pearson and Endean, 1969). John Brewer Reef and Lodestone Reef were both free of starfish in 1968 (T. Brown, personal communication). Britomart, John Brewer, Lodestone, Trunk and the reefs of the Slashers complex all carried starfish in plague proportions during 1969 and 1970. Other reefs still further to the south were observed to be invaded by starfish during 1969, 1970 or 1971 as were some of the outer patch reefs (Trout, Josephine, Big Sand Cay) east of Otter Reef during this period.

In general there appears to have been a southward spread of the starfish plague to inner patch reefs between Lat. 18° S. and 19° S. and to many outer patch reefs between Lat. 17° S. and 19° S. during the latter half of the 1960's. On some reefs lying in these regions such as Yamacutta, Taylor, Beaver, John Brewer, the reefs of The Slashers, Lodestone, Britomart and Bramble, the bulk of the hard coral cover had been killed by early 1971 and it can be expected that these reefs will be free or vitually free of adult starfish in the near future. Indeed, starfish numbers have already declined markedly on some of these reefs (e.g. Taylor, John Brewer, Lodestone, reefs of The Slashers). Other reefs such as Glow, Grub, Dip, Coil and Keeper have only recently come under attack by large numbers of A. planci and areas of rich growths of living coral still remained when these reefs were last visited.

It would appear that starfish invasions of Centipede, Dolphin, Yamato, Tabias, Tiger, Pollux, and Mid Reefs had just begun in August, 1970 and it is possible that most of the reefs between Lat. 19° S. and 20° S. will come under attack by starfish during the 1970's. Twenty-six of the 90 reefs visited in the area surveyed were free of starfish and the condition of their hard coral cover would indicate that they had not been invaded by large numbers of A. planci in recent years. However, some of these reefs are near reefs already infested and it is to be expected that invasion of some of these reefs is imminent.

Of interest was the finding that some of the outer patch reefs in the region between Lat. 16° 34' S. and 19° S. were still free of starfish in 1970 and 1971. In some cases the lagoons or back reef areas of the outer patch reefs had been invaded but the seaward slopes on the weather sides had escaped infestation. Adult A. planci appear to avoid areas exposed to heavy wave action and this may provide an explanation for the virtual absence of A. planci from some of the outer patch reefs. It is also of interest that, with one apparent exception, juvenile starfish are not present on these outer patch reefs even though some of them are close to reefs which carry or carried large numbers of A. planci.

Some information was obtained about predators of A. planci. Charonia tritonis, a formidable predator of the starfish (Endean, 1969) was found among coral on seaward slopes and on coral pinnacles in lagoons. Because of its large size, its characteristic shape and colouration and because it usually lies completely exposed among corals, the giant triton is readily detected by experienced divers. In view of this, the fact that only 24 specimens were encountered during visits made to 81 reefs would indicate that C. tritonis is a somewhat rare species, at least on the reefs visited. Five of the giant tritons seen were feeding upon specimens of A. planci and two were feeding upon holothurians when found. It is of interest that 4 of the specimens of A. planci being eaten were large juveniles about 20 cm in diameter. Possibly A. planci of this size are preferred by the tritons. No juvenile Charonia tritonis less than 14 cm in length were encountered.

Not a single specimen of the giant helmet, Casis cornuta, a possible predator of A. planci (Endean, 1969) was encountered during the trips to 82 reefs. It is known that shell collectors have found giant helmets in the lagoons of two of the reefs visited (Sudbury Reef and Taylor Reef) in recent years.

While the hump headed wrasse was not observed to seize and dismember A. planci one large specimen of this fish (the species attains a length of approximately 2 metres) was observed mouthing fragments of a specimen of A. planci. It is possible that this species is a predator of A. planci.

No information pinpointing the causes of the A. planci plagues in Barrier Reef waters was obtained during the investigation. Indeed, the initial causes of the population explosions of A. planci may no longer be operative. However, a study of the results of the earlier investigation (Endean, 1969; Pearson and Endean, 1969) in conjunction with a study of those of the present investigation suggest that the starfish infestations can be traced back to several foci--accessible inner platform reefs near the major centres of human population on the coast of Queensland between Cooktown and Townsville. If the Great Barrier Reef starfish plagues did begin on these accessible reefs it is possible that the plagues are man-induced. A release of predator pressure on adult and large juvenile starfish as a result of intensive collecting of Charonia tritonis by shell collectors operating on accessible reefs could have triggered the plagues as suggested by Endean (1969). C. tritonis is a predator of high trophic status and can be regarded as a keystone species in the sense used by Paine (1969). It is possible that other factors could have contributed to a decline in numbers of C. tritonis. For example, toxic residues from pesticides or other pollutants emanating from centres of human population on the Queensland coast could have accumulated in the tissues of specimens of C. tritonis until levels which were lethal or levels which interfered with reproduction were attained. Also, it is possible that factors other than a reduction in numbers of C. tritonis on accessible reefs could have triggered the plagues.

Whatever the causes of the increases in starfish numbers on accessible reefs near major centres of population on the Queensland coast between Cooktown and Townsville, it would appear that the increases occurred almost simultaneously on those reefs during the early 1960's. Subsequently, as food supplies on these reefs became exhausted, adult starfish migrated from these initial centres of infestation to adjacent reefs. This process has continued throughout the last decade. It is apparent that massive damage to the corals of most reefs in the region of the Great Barrier Reef investigated (the region between Lat. 16° 34' S. and 19° 20' S.) during the present study has already occurred. Also, it would seem likely that similar destruction has been caused to the coral cover of most reefs in the region of the Great Barrier Reef lying between Lat. 15° 18' S. and 16° 34' S. where starfish infestations were reported earlier (Pearson and Endean, 1969). It is possible that migrating starfish could encounter unfavourable conditions on the reefs now being invaded and that the starfish plagues will attenuate during the 1970's. However, no evidence for the occurrence of such an attenuation has so far been obtained. On the contrary, additional reefs of the Great Barrier Reef are coming under attack and a recruitment of juveniles to the *A. planci* populations of at least some of the reefs currently under attack is occurring. Obviously, measures should be adopted to control the starfish plagues while their causes are investigated and their probable consequences assessed.

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TABLE 1. REEFS VISITED WITH DETAILS OF AREAS SAMPLED, NUMBER AND DISTRIBUTION OF *ACANTHASTER PLANCI*, ESTIMATES OF TOTAL HARD CORAL COVER AND RECENT DESTRUCTION

Reef and date visited	Type*	Position of area examined[x]	Depth range (m)	Estimated area sampled (m^2)	Number and distribution of *A. planci***	Total hard coral cover+	Hard coral skeletons *in situ* ++
Michaelmas 3.5.70	IP	N. tip, back reef area	0-5	10,000	1 A on massive coral	S-M	H
Remarks:	Hard coral mostly dead. Obvious damage by starfish. Soft coral cover extensive.						
Michaelmas 3.5.70	IP	N. tip, seaward slope	0-10	2,000	Nil	D	L
Remarks:	Hard coral well developed. No damage by starfish.						
Upolo 3.5.70	IP	E. side, seaward slope	0-5	3,000	Nil	M	H
Remarks:	Hard coral mainly dead. Obvious damage by starfish. Water turbid.						

* OP = outer patch reef; IP = inner patch reef.
x N. = north; E. = east; S. = south; W. = west.
** A = adult; J = juvenile.
\+ S = sparse (c.f. Fig. 4); M = moderate (c.f. Fig. 5); D = dense (c.f. Fig. 6).
++ L = low (c.f. Fig. 7); M = marked (c.f. Fig. 8); H = high (c.f. Fig. 9).

Table 1 cont'd.

Arlington 5.11.70	IP	S.E. tip, seaward slope	0-5	10,000	Nil	D	H
<u>Remarks:</u>	Massive destruction of hard coral. Large areas of soft coral. Obvious starfish damage to hard coral.						
Arlington 5.11.70	IP	S.W. side, seaward slope	0-5	10,000	Nil	D	H
<u>Remarks:</u>	Massive destruction of hard coral. Soft coral cover extensive. Obvious starfish damage to hard coral.						
Green 2.5.70	IP	W. of cay, reef flat	0-5	10,000	Nil	S	H
<u>Remarks:</u>	Hard coral mostly dead. Soft coral cover extensive. Obvious damage by starfish.						
Green 6.11.70	IP	N.W. side, reef flat	0-3	5,000	Nil	S	H
<u>Remarks:</u>	Coral destruction almost total. Soft coral cover extensive. Obvious starfish destruction of corals.						
Green 6.11.70	S.W. side, seaward slope		0-15	5,000	Nil	S	H
<u>Remarks:</u>	Coral destruction almost total. Mostly dead coral rubble plus algal covered coral skeletons <u>in situ</u>.						
Green 6.11.70	IP	S.W. side, seaward slope	0-15	5,000	Nil	S-M	H
<u>Remarks:</u>	Extensive destruction of hard coral. Mostly dead coral rubble plus algal covered coral skeletons <u>in situ</u>.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
Green 6.11.70	IP	S. side, seaward slope	0-15	5,000	Nil	M	H
Remarks:	Extensive destruction of hard corals. Mostly dead coral rubble plus algal covered coral skeletons *in situ*.						
Green 6.11.70	IP	S.E. side, submerged reef	3-10	10,000	Nil	M	H
Remarks:	Patches of soft coral interspersed with hard coral which had survived starfish invasion. Marked development of few species of coral.						
Flynn 5.11.70	OP	S.E. side, seaward slope	0-15	1,500	1 J near reef crest	M	L
Remarks:	Hard coral cover extensive but many colonies stunted.						
Flynn 5.11.70	OP	N.W. side, back reef area	0-10	10,000	15 A hiding under plate corals	D	L
Remarks:	Hard coral growth luxuriant. Starfish present but not conspicuous.						
Thetford 2.5.70	IP	S.E. side, seaward slope	0-10	2,000	Nil	M-D	L
Remarks:	Hard coral growth luxuriant. No damage by starfish.						
Thetford 2.5.70	IP	S. tip, seaward slope	0-5	5,000	Nil	M	L
Remarks:	Hard corals well developed. No damage by starfish.						

Table 1 cont'd.

Milln 4.11.70	OP	Right around perimeter, seaward slopes	0-15	40,000	Nil	D	L
Remarks:	Hard coral growth luxuriant particularly on lee side. No starfish seen and no damage attributable to starfish observed.						
Moore 2.5.70	IP	S.W. tip, back reef area	0-5	2,000	5A on vertical faces of bombies	M-D	L-M
Remarks:	Corals on tops of bombies alive. Corals on sides of bombies damaged by starfish.						
Pellowe 4.11.70	OP	W. side, seaward slope	0-10	3,000	Nil	M-D	L
Remarks:	Hard corals well developed. Brain corals conspicuous. No damage by starfish.						
North West 4.11.70	OP	Middle, submerged reef	5-10	1,000	Nil	M	L
Remarks:	Hard corals patchy but well developed. No damage by starfish.						
Channel 4.11.70	OP	S. tip, seaward slope	0-5	5,000	Nil	M	L
Remarks:	Hard corals well developed. Few soft corals seen. No damage by starfish.						
Channel 4.11.70	OP	N. tip, seaward slope	0-5	5,000	Nil	M	L
Remarks:	Hard corals well developed. Few soft corals seen. No damage by starfish.						
Sudbury 2.5.70	IP	N.W. side, seaward slope	0-5	10,000	Nil	S-M	H
Remarks:	Obvious starfish damage. Few corals had survived.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
Sudbury 6.11.70	IP	N.W. of cay, reef flat	0-3	10,000	Nil	S	H
Remarks:	Coral destruction appeared total. Much coral rubble. Soft coral cover extensive.						
Sudbury 6.11.70	IP	W. side, seaward slope	0-10	7,000	Nil	M	H
Remarks:	Massive destruction of hard corals. Obvious damage by starfish. Dark algae on coral skeletons remaining *in situ*.						
Noggin 3.11.70	OP	S.E. tip, seaward slope	0-15	5,000	Nil	M	L
Remarks:	Some coral damage not obviously caused by starfish. Hard coral patchy.						
Noggin 3.11.70	OP	N. tip, seaward slope	0-10	5,000	Nil	M	L
Remarks:	Hard coral patchy. No damage attributable to starfish.						
Flora 7.11.70	IP	S.E. side, seaward slope	0-5	10,000	Nil	M	H
Remarks:	Coral destruction almost total. Black algal covered coral skeletons.						
Flora 7.11.70	IP	S.W. side, seaward slope	0-5	7,000	Nil	S	H
Remarks:	Coral destruction almost total. Black algal covered coral skeletons. Few soft corals.						
Hedley 3.11.70	OP	S.E. tip, seaward slope	0-15	10,000	Nil	M	L
Remarks:	Patchy damage to hard corals near reef crest.						

Table 1 cont'd.

Hedley 3.11.70	OP	N.E. tip, seaward slope	0-15	10,000	Nil	M	L
Remarks:	Patchy damage to hard coral near reef crest.						
Gibson 3.11.70	IP	S.E. side seaward slope	0-10	5,000	Nil	S-M	H
Remarks:	Extensive destruction of hard corals. Soft corals common.						
McCulloch 3.11.70	IP	W. side, seaward slope	0-5	3,000	Nil	S-M	H
Remarks:	Massive destruction of hard corals. Coral skeleton *in situ* covered with black algae. Soft corals common.						
McCulloch 3.11.70	IP	N.E. tip, seaward slope	0-15	5,000	Nil	M	H
Remarks:	Massive destruction of hard corals. Coral skeletons *in situ* covered with black algae. Soft corals common.						
Howie 1.5.70	IP	S. tip, lagoon bombie	0-5	500	Nil	M	H
Remarks:	Extensive destruction of coral by starfish. Soft corals common. Water turbid.						
Howie 2.11.70	IP	W. side, lagoon near centre of reef	0-5	500	Nil	S	H
Remarks:	Coral destruction appeared to be total. Water turbid.						
Cayley 2.11.70	IP	S.W. tip, seaward slope	0-10	2,000	Nil	M	M
Remarks:	Large *Porites* common and most had survived starfish invasion of reef.						
Cayley 2.11.70	IP	W. side, seaward slope	0-10	5,000	Nil	M	M
Remarks:	Small clumps of coral had survived starfish invasion.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
Peart 23.9.69	IP	S.W. side, back reef area	0-2	24,000	Nil	S-M	H
Remarks:	Massive destruction of hard corals. Some corals regenerating.						
Feather 22.9.69	IP	N. tip, crest and reef flat	0-1	4,000	Nil	S	H
Remarks:	Extensive destruction of hard corals by starfish. Soft coral cover extensive.						
Feather 22.9.69	IP	N. tip, back reef area	0-5	5,000	Nil	S	H
Remarks:	Soft corals abundant. Hard corals obviously killed by starfish.						
Feather 23.9.69	IP	E. side, seaward slope	0-5	4,000	Nil	S-M	H
Remarks:	Soft coral cover extensive. Hard corals obviously killed by starfish.						
Feather 23.9.69	IP	S. tip, seaward slope	0-5	10,000	Nil	M	H
Remarks:	Extensive destruction of hard corals. Soft coral cover extensive.						
Feather 2.11.70	IP	N. tip, seaward slope	0-12	5,000	Nil	S-M	H
Remarks:	Extensive destruction of hard corals. Soft coral cover extensive.						
Feather 2.11.70	IP	E. side, seaward slope	0-12	5,000	Nil	M	H
Remarks:	Coral destruction extensive. Soft coral cover extensive.						

Table 1 cont'd.

Feather 2.11.70	IP	E. side, seaward slope	0-12	5,000	Nil	S-M	H
Remarks:	Massive destruction of hard corals. Soft coral cover extensive.						
Feather 2.11.70	IP	E. side, seaward slope	0-12	5,000	Nil	M	H
Remarks:	Massive destruction of hard corals. Soft coral cover extensive.						
Nathan 26.9.69	OP	E. side, seaward slope	0-10	26,000	Nil	D	L
Remarks:	Hard coral growth luxuriant. No damage caused by starfish.						
Nathan 26.9.69	OP	Middle, reef flat	0-2	18,000	Nil	M	L
Remarks:	Hard corals well developed. No damage caused by starfish.						
Nathan 26.9.69	OP	N.W. side, bombie in lee	0-5	8,000	700 small J. collected in 2 hrs. from coral on top and sides of bombie	S-M	M
Remarks:	Mostly Acropora under attack.						
Nathan 27.1.70	OP	N.W. side, bombie in lee	0-10	10,000	182 J seen in 20 mins. on top and sides of bombie	S-M	M
Remarks:	Mostly Acropora under attack.						
Gilbey 25.9.69	OP	E. side, seaward slope	0-20	14,000	Nil	D	L
Remarks:	Hard coral growth luxuriant.						
Gilbey 25.9.69	OP	W. side, lagoon edge	0-10	12,000	Nil	S-M	L
Remarks:	Some coral destruction but corals had been dead for long time. Suspected storm damage.						
Hall-Thompson 24.5.71	IP	S. side, lagoon	0-10	10,000	Nil	M	H
Remarks:	Massive destruction of hard corals. Estimated 30% soft coral cover.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
Hall-Thompson 24.5.71	IP	E. side, seaward slope	0-15	5,000	Nil	M-D	H
Remarks:	Massive destruction of hard corals from reef crest to sea floor. Estimated 15% soft coral cover.						
Adelaide 24.5.71	IP	Middle N. side lagoon	0-6	10,000	Nil	S-M	H
Remarks:	Dead corals *in situ*. Coral destruction appeared to be almost total.						
Adelaide 24.5.71	IP	N.E. tip, seaward slope	0-15	7,000	Nil	M	H
Remarks:	Extensive destruction of coral. Dead corals *in situ* mostly massive species. Acropores broken up.						
Potter 25.9.69	OP	Middle E. side, seaward slope	0-10	12,000	Nil	M-D	L
Remarks:	Hard corals well developed.						
Potter 25.9.69	OP	Middle of reef, lagoon	0-5	10,000	1 A on vertical face of bombie. 1 J on brain coral	M	L-M
Remarks:	Some coral damage possibly due to storms.						
Potter 24.5.71	OP	Middle of reef, lagoon	0-10	10,000	Nil	M	H
Remarks:	Destruction of coral almost total. Damage obviously caused by starfish.						

Table 1 cont'd.

Potter 24.5.71	OP	N.E. side, seaward slope	0-20	15,000	1 A near crest	M-D	L
Remarks:	No damage obviously caused by starfish.						
Ellison 28.5.71	IP	S.W. side, back reef area	3-10	10,000	1 J on dead coral	M-D	H
Remarks:	Destruction of massive and branching corals almost total.						
Eddy 28.12.70	IP	W. side, seaward slope	0-3	5,000	1 A on rubble	M	H
Remarks:	Destruction of hard coral almost total. Much rubble among dead skeletons in situ. Some regeneration of Acropora and Pocillopora tips.						
Eddy 28.12.70	IP	S. tip, seaward slope	0-10	5,000	Nil	M-D	H
Remarks:	A few large Porites had survived.						
Farquharson 12.12.69	IP	N. side, seaward slope	0-5	5,000	Nil	M	H
Remarks:	Coral mostly dead. Obvious damage caused by starfish.						
Farquharson 28.5.71	IP	S.E. corner, seaward slope	0-15	7,000	Nil	M	M-H
Remarks:	Obvious damage by starfish. Some corals missed by starfish, others partially eaten but regenerating.						
Taylor 28.9.69	IP	S. side of cay, reef flat	0-2	16,000	68 A on hard corals seen in 20 minutes	M	H
Remarks:	Destruction of corals almost total. Dead corals mostly acropores.						
Taylor 28.9.69	IP	W. side of cay, reef flat	0-1	8,000	30 A and J eating soft coral	S	H
Remarks:	Destruction of corals almost total. Soft corals common.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons in situ
Taylor 28.9.69	IP	Middle of lagoon, bombies	0-5	6,000	1-2 A per bombie found on sides of bombies	S-M	M-H
Remarks:	Massive corals mostly undamaged.						
Taylor 28.1.70	IP	S. of cay, reef flat	0-2	10,000	2 A on hard coral	S-M	H
Remarks:	Destruction of corals almost total. Dead acropores had been smashed since previous visit.						
Taylor 30.12.70	IP	N.W. side, lagoon near cay	0-3	15,000	1 A, 3 J on soft corals	S	H
Remarks:	Coral destruction almost total. A few living clumps of Pocillopora seen. Extensive soft coral cover.						
Taylor 31.12.70	IP	N. side, seaward slope	0-5	20,000	Nil	S	H
Remarks:	Extensive coral destruction. Some large Porites and a few coral colonies on tops of coral pinnacles had survived.						
Taylor 31.12.70	IP	S. side, seaward slope	0-15	15,000	2 J on crest	D	M
Remarks:	Corals on exposed reef crest had survived. Corals dead from 3-4 metres below crest to sea floor.						
Taylor 1.1.71	IP	S.W. tip, lagoon	0-5	30,000	2 A on Acropora	S-M	H
Remarks:	Coral destruction almost total. Recent starfish feeding scars on surviving corals.						

Table 1 cont'd.

Taylor 1.1.71	IP	E. side, lagoon	0-5	15,000	20 A collected from sides of 10 bombies	S-M	H
Remarks:	Coral destruction appeared total.						
Taylor 25.5.71	IP	W. side, lagoon near cay	0-6	10,000	10 J on soft corals	S	H
Remarks:	Coral destruction appeared total.						
Beaver 23.9.69	IP	E. of cay, reef flat	0-2	12,000	70 A in 20 minutes on Acropora	M	M-H
Remarks:	Extensive coral destruction. Soft corals common.						
Beaver 23.9.69	IP	N. of cay reef flat	0-5	10,000	25 A seen in 20 minutes on reef flat and tops of bombies	M	M-H
Remarks:	Coral under attack by starfish. Soft corals common.						
Beaver 29.12.70	IP	W. of cay, seaward slope	0-10	10,000	Nil	S	H
Remarks:	Coral destruction almost total. Extensive soft coral cover. Some regeneration of tips of staghorn coral.						
Beaver 29.12.70	IP	N.E. tip, seaward slope	0-15	10,000	Nil	D	M-H
Remarks:	Clumps of corals on tops of coral pinnacles survived.						
"Yamacutta"* 2.1.71	IP	N. side, seaward slope	0-3	5,000	Nil	S	H
Remarks:	Some Pocillopora colonies had survived but most corals were dead.						
"Yamacutta" 2.1.71	IP	Centre of reef, lagoon bombies	0-5	10,000	4 J, 8A, at bases of staghorn corals	M	L
Remarks:	Starfish feeding on staghorn Acropores. Remainder of corals untouched.						

* quotes denote that name of reef is unofficial.

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
"Yamacutta" 2.1.71	IP	S. tip, seaward slope	0-15	5,000	Nil	D	L
Remarks:	No damage caused by starfish.						
"Yamacutta" 25.5.71	IP	N. side, lagoon	0-15	10,000	2 A on sides of bombies	M	H
Remarks:	Extensive coral destruction. Live coral confined to tops of bombies.						
"Yamacutta" 25.5.71	IP	N. E. tip, seaward slope	0-15	15,000	Nil	M	M-H
Remarks:	Corals in upper 3 metres mostly alive; mostly dead in deeper water.						
"Yamacutta" 25.5.71	IP	E. side, seaward slope	0-20	500	Nil	M	H
Remarks:	Coral destruction apparently total.						
"Yamacutta" 25.5.71	IP	E. side, seaward slope	0-20	500	Nil	M	M-H
Remarks:	Patchy destruction of corals on upper 6 metres of reef. Below this region destruction almost total.						
"Yamacutta" 25.5.71	IP	S. E. side, seaward slope	0-20	5,000	Nil	M	L-M
Remarks:	Slight damage in upper 15 metres of reef. Below this region coral destruction almost total.						
"Horseshoe" 25.5.71	OP	Middle W. area, lagoon	0-15	5,000	2 A on staghorn corals	M	H
Remarks:	Coral destruction extensive. Estimated 20 per cent soft coral cover.						

Table 1 cont'd.

"Horseshoe" 25.5.71	OP	Middle E. side, seaward slope	0-15	10,000	Nil	M	L-M
Remarks:	Patches of algal covered coral skeletons *in situ*.						
"Judy" 26.5.71	OP	Middle lagoon	0-15	10,000	10 A on top of reef platform	M	M
Remarks:	Obvious damage caused by starfish.						
"Doll" 26.5.71	OP	Middle lagoon	0-15	7,000	12 A on top of reef platform	M	H
Remarks:	Extensive coral destruction. Obvious damage caused by starfish.						
"Trout" 15.12.69	OP	W. side, seaward slope	0-30	15,000	1 per 3 m^2 on coral in deep water around perimeter	M	M
Remarks:	Coral dead in deep water but progressively alive towards shallow water.						
"Trout" 28.1.70	OP	W. side, seaward slope	0-3	12,000	87 counted in 20 minutes	M	M
Remarks:	Branching and massive corals under attack. Starfish ascending seaward slope.						
"Trout" 26.5.71	OP	N. tip, seaward slope	0-20	15,000	50 A seen in 20 minutes on coral platforms	M-D	M
Remarks:	Branching and massive corals under attack in shallow water.						
"Trout" 26.5.71	OP	S.W. tip, seaward slope	0-20	16,000	35 A seen in 20 minutes on coral platforms	M	H
Remarks:	Coral destruction almost total. Blackish algae growing on dead coral skeletons *in situ*.						

Table 1 cont'd

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons in situ
"Josephine" 29.1.70	OP	W. side seaward slope	3-10	2,000	Nil	D	L
Remarks:	Hard coral growth luxuriant. Reef not exposed at low tide.						
"Zeta" 26.5.71	OP	N. side, seaward slope	0-20	50,000	25 A seen in 20 minutes on upper region of slope	M	M-H
Remarks:	Massive and branching corals under attack. Coral in deeper water eaten.						
Otter 13.12.69	IP	N. side, back reef area	0-3	5,000	12 A seen near tops of bombies	S	H
Remarks:	Massive destruction of coral. Patches of soft coral on rubble strewn bottom.						
Otter 13.12.69	IP	Middle back reef area	0-3	10,000	1 A per 10 m^2 on tops of squat bombies	M	H
Remarks:	Massive destruction of coral. Coral obviously killed by starfish.						
"Big Sand Cay" 15.12.69	OP	N. side of cay, seaward slope	0-10	5,000	Nil	M	M
Remarks:	Coral probably killed by shifting sand of cay.						
"Big Sand Cay" 26.5.71	OP	W. side, back reef area	0-15	25,000	128 A per 20 minutes on coral in shallow water	M	M-H
Remarks:	Coral in water deeper than 3 metres almost all dead. Starfish attacking corals in shallow water.						
"Glenda" 27.5.71	OP	W. side seaward slope	0-20	5,000	42 A per 20 minutes on coral in shallow water	M-D	M
Remarks:	Extensive but patchy destruction of corals in water deeper than 3 metres. Starfish attacking corals on reef flat.						

Table 1 cont'd.

"Seeker" 27.5.71	OP	S.E. side, seaward slope	0-20	10,000	38 A per 20 minutes on coral in shallow water	D	M
Remarks:	Coral destruction in swathes from deep water to reef flat obviously caused by starfish.						
"Birthday" 14.12.69	OP	S. tip, crest and seaward slope	0-10	15,000	6 J seen on crest	D	L
Remarks:	Hard corals well developed.						
Britomart 13.12.69	IP	N. tip, seaward slope	0-10	10,000	Adults abundant on coral in shallow water but not counted	M	H
Remarks:	Massive coral destruction obviously caused by starfish.						
Pith 15.12.69	OP	S. tip, seaward slope	0-10	5,000	Nil	D	L
Remarks:	Hard corals well developed.						
Trunk 14.12.69	IP	S.W. corner, seaward slope	0-10	20,000	Abundant but cryptic and not counted - on coral in shallow water	M	L-M
Remarks:	Coral under attack by starfish. White coral skeletons exposed.						
Bramble 13.12.69	IP	S. tip, seaward slope	0-10	25,000	Abundant but not counted - on coral in shallow water	D	M-H
Remarks:	Extensive coral destruction. Starfish in plague proportions.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
Bramble 14.12.69	IP	W. side, lagoon	0-3	2,000	100 collected in 1 hour from corals on edge of lagoon	D	H
Remarks:	Extensive coral destruction. Large areas of freshly killed coral and very large numbers of starfish present.						
Slashers No. 1 29.7.70	IP	W. of cay, reef flat	0-2	25,000	Abundant on branching and massive corals	M	M-H
Remarks:	Starfish densely packed over thousands of square metres of reef flat.						
Slashers No. 1 17.8.70	IP	W. of cay, reef flat	0-2	80,000	Abundant, frequently over-lapping - on branching and massive corals	M	M-H
Remarks:	Starfish densely packed over thousands of square metres of reef flat.						
Slashers No. 1 30.10.70	IP	W. of cay, reef flat	0-2	45,000	134 per 20 minutes on branching and massive corals	M	H
Remarks:	Destruction of hard corals almost total. Coral skeletons covered with dark algae.						
Slashers No. 2 27.1.71	IP	W. side, reef flat	0-2	70,000	2 A on hard coral	S-M	H
Remarks:	Coral destruction almost total. Coral skeletons covered with black algae.						

Table 1 cont'd.

Slashers No. 2 27.1.71	IP	E. side, reef flat	0-3	130,000	Nil	S	H
Remarks:	Coral destruction almost total. Coral skeletons covered with black algae.						
Slashers No. 3 27.1.71	IP	W. side, reef flat	0-2	120,000	Nil	S-M	H
Remarks:	Destruction of hard corals almost total. Coral skeletons covered with dark algae.						
Slashers No. 3 27.1.71	IP	W. side, bombies in back reef area	0-10	80,000	2 A on vertical faces of bombies	S	H
Remarks:	Destruction of hard corals almost total. Coral skeletons covered with dark algae.						
Slashers No. 4 27.1.71	IP	W. side, reef flat	0-2	30,000	65 A per 20 minutes on coral of all types	S	M
Remarks:	Starfish attacking branching and massive corals.						
Slashers No. 4 27.1.71	IP	W. side, crest	0-2	2,000	107 J collected from low acropores	S	M
Remarks:	Juvenile starfish among acropores on crest.						
Dip 30.7.70	OP	Middle E. side, seaward slope	0-20	7,000	20 A seen in deeper parts of reef slopes around periphery of reef	M	L
Remarks:	Corals in deep water under attack.						
Coil 30.7.70	OP	Middle E. side, seaward slope	0-20	7,000	12 A seen in deeper parts of reef slopes	M-D	L
Remarks:	Corals in deep water under attack.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons <u>in situ</u>
Glow 31.7.70	OP	Middle E. side, seaward slope	0-20	10, 000	60 specimens seen on low acropores	M	L-M
<u>Remarks:</u>	Coral stunted, some damage caused by starfish.						
Glow 31.7.70	OP	N. W. side, back reef area	0-10	5, 000	40 specimens seen on coral on sides of bombies	S-M	L-M
<u>Remarks:</u>	Coral damage patchy but obviously due to starfish.						
Glow 30.10.70	OP	S. E. side, seaward slope	0-15	20, 000	118 A seen in 20 minutes on all types of coral.	M	M-H
<u>Remarks:</u>	Hard corals in deep water mostly dead. Skeletons <u>in situ</u>.						
Glow 28.1.71	OP	S. E. side, seaward slope	0-10	10, 000	14 J and 94 A seen in 20 minutes on coral near crest	M	H
<u>Remarks:</u>	Hard corals mostly dead from sea floor to crest. Corals on crest being attacked.						
Glow 28.1.71	OP	N. W. side, coral pinnacles	0-5	10, 000	15A per 20 minutes on coral near tops of coral pinnacles	S-M	H
<u>Remarks:</u>	Hard corals mostly dead. Few live coral colonies on tops of pinnacles.						
Bowl 30.10.70	OP	S. E. side, seaward slope	0-30	10, 000	Nil	S-M	L
<u>Remarks:</u>	Hard corals stunted but showing no obvious signs of recent damage. Below 24 metres sponges and gorgonians were common.						

Table 1 cont'd.

Bowl 30.10.70	OP	Middle of reef lagoon	0-5	5,000	1 J on top of coral pinnacle	S	L
Remarks:	Hard corals stunted and patchy. Some corals damaged possibly by juvenile starfish.						
"Grub" 25.5.70	IP	S. tip, back area	0-10	4,000	15 A seen on sides of bombies	S	L
Remarks:	Starfish present but little coral damage.						
"Grub" 18.8.70	IP	N. tip, seaward slope	0-20	10,000	26 A counted on vertical and near vertical faces of reef	M	L-M
Remarks:	Hard corals well developed. Some coral damage obviously caused by starfish.						
"Grub" 29.1.71	IP	E. side, seaward slope	0-15	10,000	526 A seen in 20 minutes on vertical and near vertical reef faces near reef edge	M	M
Remarks:	Large amounts of freshly killed hard corals noted. Most of the remaining live coral under attack.						
John Brewer 29.1.70	IP	N.W. side, seaward slope	0-15	120,000	36 A seen in 20 minutes on corals growing on vertical and near vertical faces	D	L
Remarks:	Corals mostly tabular acropores. Obvious damage by starfish to corals in deeper water.						
John Brewer 29.1.70	IP	N.W. side, reef flat	0-2	20,000	Nil	S	L
Remarks:	Coral cover patchy. No damage by starfish observed.						
John Brewer 28.7.70	IP	W. side, seaward slope	0-10	3,000	Common but not counted - on corals growing on vertical and near vertical faces.	M	H
Remarks:	Coral destruction heavy and continuing.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
John Brewer 16.8.70	IP	W. side, seaward slope	0-5	3,000	2 A seen on coral near crest	M	H
Remarks:	Corals in deeper water mostly dead. Corals in shallow water under attack.						
John Brewer 26.1.71	IP	S.E. side seaward slope	0-15	100,000	5 A on vertical faces and reef crest	M	H
Remarks:	Most corals on reef crest had survived but almost all corals in deeper water except massive *Porites* and *Astreopora* had been killed.						
John Brewer 26.1.71	IP	E. side, seaward slope	0-15	10,000	4 A on vertical faces and 3 J on reef crest	M	H
Remarks:	Most coral colonies on reef crest had survived. Corals in deeper water had been killed.						
John Brewer 26.1.71	IP	W. tip, seaward slope	0-15	5,000	7 A seen in 20 minutes on vertical and near vertical faces of reef	M	H
Remarks:	Most coral colonies on reef crest had survived. Corals in deeper water mostly killed						
John Brewer 26.1.71	IP	N.W. side, seaward slope	0-15	5,000	Nil	M	H
Remarks:	Most coral colonies on reef crest had survived. Corals in deeper water mostly dead.						
Lodestone 29.1.70	IP	W. side, seaward slope	0-5	10,000	18 A seen in 20 minutes on vertical and near vertical faces	M	L
Remarks:	Mostly tabular acropores on vertical and near vertical faces. Corals under attack in deeper water.						

Table 1 cont'd.

Lodestone 29.5.70	IP	N. tip, seaward slope	0-5	40,000	132 A seen in 20 minutes on vertical and near vertical faces	M	M
Remarks:	Mostly tabular acropores on vertical and near vertical faces. Coral under attack in deeper water.						
Lodestone 31.10.70	IP	E. side, seaward slope	0-15	30,000	12 A seen in 20 minutes on dead coral	M	H
Remarks:	Coral near crest mostly alive. Remainder of coral on slope mostly dead.						
Lodestone 31.10.70	IP	S.E. side, seaward slope	0-10	3,000	Nil	M	H
Remarks:	Coral near crest alive, remainder mostly dead.						
Lodestone 31.10.70	IP	S. side, seaward slope	0-15	3,000	3 A seen in 20 minutes on dead coral	M	H
Remarks:	Coral near crest alive, the remainder mostly dead.						
Lodestone 31.10.70	IP	S.W. side, seaward slope	0-10	3,000	7 A seen in 20 minutes on vertical faces of reef	M	H
Remarks:	Only coral in shallow water alive, remainder mostly dead.						
Lodestone 31.10.70	IP	N.W. side back reef area	0-10	9,000	22 A seen in 20 minutes on tops of bombies	M	M-H
Remarks:	Coral on tops of bombies mostly alive, remainder mostly dead.						
"Dolphin" 29.10.70	OP	N. tip, seaward slope	0-15	10,000	14 A seen in 20 minutes in deep water on slopes	S-M	L
Remarks:	Some recent damage to hard corals by starfish in deeper water on seaward slopes.						
"Dolphin" 29.10.70	OP	N.W. side, reef flat	0-2	3,000	Nil	S	L
Remarks:	Some coral damage but cause not ascertained.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
"Centipede" 25.5.70	IP	Middle of lagoon	0-3	10,000	2 A on sides of bombie	S	L
Remarks:	Hard corals stunted.						
"Centipede" 19.8.70	IP	N. tip, seaward slope	0-20	3,000	Nil	S-M	L
Remarks:	No damage caused by starfish observed.						
"Centipede" 27.1.71	IP	Centre of lagoon	0-10	10,000	4 A on vertical and near vertical faces of reef	S	L
Remarks:	Hard corals stunted and patchy. Some fresh damage due to starfish.						
"Centipede" 27.1.71	IP	S. side, seaward slope	0-15	100,000	12 A on coral in deep water	S-M	L
Remarks:	Corals somewhat stunted. Some damage apparently due to starfish in deep water.						
Keeper 30.1.70	IP	N. tip, seaward slope	0-5	5,000	80 A seen in 20 minutes on coral on vertical and near vertical faces of reef	M	L-M
Remarks:	Coral in deeper water dead. Starfish ascending slope.						
"Watkins" 18.8.70	IP	N. tip, seaward slope	0-20	7,500	Nil	M	L
Remarks:	No damage caused by starfish observed.						
"Watkins" 18.8.70	IP	N. tip, back reef area	0-5	5,000	Nil	M	L
Remarks:	Some coral damage but cause not ascertained.						

Table 1 cont'd.

"Watkins" 29.10.70	IP	N. E. side, seaward slope	0-15	27,000	Nil	D	L
Remarks:	Coral growth luxuriant.						
"Watkins" 29.10.70	IP	W. side, bombies in back reef area	0-10	5,000	Nil	S	M
Remarks:	Coral stunted and some colonies dead. Cause of death not established.						
"Watkins" 30.1.71	IP	S.W. side, bombies in back reef area	0-10	3,000	1 A seen on side of bombie	S	L
Remarks:	Some fresh coral damage possibly caused by starfish.						
Wheeler 31.1.70	IP	N. tip, seaward slope	0-10	5,000	Nil	D	L
Remarks:	Tabular acropores well developed. No coral damage.						
Wheeler 31.1.70	IP	W. of cay, back reef area	0-5	5,000	Nil	S-M	L
Remarks:	Slight coral damage possibly due to siltation.						
Wheeler 30.1.71	IP	N. & W. sides, seaward slope	0-10	200,000	Nil	M-D	L
Remarks:	Hard coral growth luxuriant. No obvious damage to corals.						
Wheeler 30.1.71	IP	S. E. tip, seaward slope	0-20	3,000	1 A seen on coral in deep water	M	L
Remarks:	Hard coral growth luxuriant. No obvious damage observed.						
Davies 1.2.70	IP	N. tip, seaward slope	0-10	2,000	Nil	S-M	L
Remarks:	No damage caused by starfish.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons in situ
"Lynch" 19.8.70	IP	N. tip, seaward slope	0-5	5,000	Nil	M	L
Remarks:	No damage attributable to starfish.						
"Lynch" 29.10.70	IP	S.W. side, seaward slope	0-10	5,000	Nil	S	M
Remarks:	Corals near crest alive but mostly dead in deeper water. Cause of death not ascertained.						
"Lynch" 30.1.71	IP	W. side, seaward slope	0-10	20,000	Nil	S	L
Remarks:	Extensive areas devoid of hard or soft corals.						
Broadhurst 1.2.70	IP	N. tip, seaward slope	0-10	10,000	Adults common on coral on vertical faces of reef	M	H
Remarks:	Extensive coral destruction. Coral on vertical faces mostly tabular acropores.						
Broadhurst 3.2.70	IP	N. tip, seaward slope	0-10	7,000	38 A collected in 20 minutes from coral on steep seaward slope	S-M	H
Remarks:	Extensive coral destruction. Coral on seaward slope of reef mostly tabular acropores.						
Broadhurst 20.8.70	IP	N. tip, reef crest	0-1	5,000	6 A seen in 20 minutes on coral near crest	D	L
Remarks:	Hard coral well developed on crest and showing little starfish damage.						

Table 1 cont'd.

Broadhurst 31.1.71	IP	S.E. side, seaward slope	0-10	2,000	Nil	S	L
Remarks:	Coral sparse but undamaged.						
Broadhurst 31.1.71	IP	W. side, seaward slope	0-10	2,000	Nil	S	L
Remarks:	Coral sparse but undamaged.						
Broadhurst 31.1.71	IP	N. side, seaward slope	0-10	14,000	32 A seen in 20 minutes	M	H
Remarks:	Most of hard coral from sea floor to crest has been killed by starfish.						
"Elaine" 20.8.70	IP	N. tip, seaward slope	0-20	7,000	Nil	D	L
Remarks:	Hard coral well developed. No damage obviously caused by A. planci.						
Shrimp 28.10.70	IP	W. side, lagoon	0-5	8,000	Nil	S	L
Remarks:	Hard corals sparse and stunted. Sponges abundant. No damage obviously caused by A. planci.						
Castor 21.8.70	IP	N. tip, seaward slope	0-10	11,000	Nil	M	L
Remarks:	Some coral damage probably due to storms.						
Pollux 21.8.70	IP	Middle W. side, seaward slope	0-10	12,000	4 A on coral on sides of bombies	M	L-M
Remarks:	Patches of coral damage caused by starfish.						
Prawn 2.2.70	IP	Middle E. side, seaward slope	0-10	70,000	Nil	M-D	L
Remarks:	Coral growth luxuriant.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons in situ
Prawn 28.10.70	IP	Middle E. side, seaward slope	0-10	15,000	Nil	M	L
Remarks:	Hard corals well developed. Large massive corals prominent. No obvious damage caused by starfish.						
Prawn 28.10.70	IP	W. side, pinnacles in lee	0-5	5,000	Nil	S	L
Remarks:	Hard corals well developed in patches. No obvious damage caused by starfish.						
Bowden 3.2.70	IP	N. tip, seaward slope	0-10	30,000	Nil	S-M	L
Remarks:	Coral undamaged but stunted.						
Mid 22.8.70	IP	Middle E. side, seaward slope	0-20	13,000	3 A on corals in deep water	M	L
Remarks:	Coral damage patchy and obviously caused by starfish.						
Shell 28.10.70	IP	S.E. side, seaward slope	0-10	7,000	Nil	M	L
Remarks:	Hard corals well developed. Staghorn corals abundant in deeper water.						
Shell 28.10.70	IP	N.W. side, lagoon	0-2	3,000	Nil	S	L
Remarks:	Hard corals well developed in patches. No damage obviously caused by A. planci.						
Tabias 21.8.70	IP	Middle W. side, back reef area	0-10	5,000	6 A seen on coral on sides of bombies	S	L
Remarks:	Some patchy coral damage obviously caused by starfish.						

Table 1 *cont'd*.

"Hades" 28.10.70	IP	W. side, lagoon	0-2	1,000	Nil	S	L
Remarks:	Hard corals well developed in patches. Soft corals and sponges common.						
"Yamato" 22.8.70	IP	Middle E. side, seaward slope	0-20	15,000	5 A seen on coral in deep water around perimeter	M	L
Remarks:	Hard corals well developed. Damage to corals patchy but obviously caused by starfish.						
Tiger 27.10.70	IP	N. E. side, seaward slope	0-10	14,000	5 A seen on corals in deep water around perimeter	M-D	L
Remarks:	Hard corals luxuriant but some recent damage caused by starfish apparent.						
Tiger 27.10.70	IP	W. side, back reef area	0-2	6,000	Nil	S	L
Remarks:	Hard coral colonies well developed in patches.						
Darley 26.5.70	IP	N. tip, back reef area	0-10	150,000	Nil	S-M	L
Remarks:	Coral stunted but undamaged.						
Jacqueline 27.10.70	OP	E. side, seaward slope	0-10	12,000	Nil	S	L
Remarks:	Hard corals stunted and showing patchy distribution. No damage obviously caused by *A. planci*.						
Jacqueline 27.10.70	OP	W. side, back reef area	0-5	10,000	Nil	S	L
Remarks:	Hard corals stunted. Soft corals and sponges common.						

Table 1 cont'd.

Reef Date	Type	Position	Depth	Area	No. specimens	Cover	Skeletons *in situ*
Elizabeth 26.10.70	OP	S.E. side, seaward slope	0-15	10,000	1 A on coral near crest	M	L
Remarks:	Hard corals well developed. No damage obviously caused by *A. planci*.						
Elizabeth 26.10.70	OP	W. side, reef flat	0-2	8,000	Nil	S	L
Remarks:	Hard coral colonies well developed in patches. Soft corals and sponges common.						
Old 31.1.71	IP	W. side, seaward slope	0-10	10,000	Nil	S-M	L
Remarks:	Hard corals stunted but showing little damage. No damage obviously caused by *A. planci*.						
Old 31.1.71	IP	Middle of back reef area	0-5	2,000	Nil	S	L
Remarks:	Hard corals stunted. Soft corals and sponges common.						
Old 1.2.71	IP	E. side, seaward slope	0-10	15,000	Nil	S-M	L
Remarks:	Hard corals well developed in patches.						

TABLE 2. POSITION OF TRANSECTS AND DATA ON REEF COVER OBTAINED FROM QUADRAT SAMPLING.

Reef and date examined	Type	Position of transect	Number of quadrat prints	% LHC* cover (mean)	% DHC** cover (mean)	% total hard coral cover (mean)	Number colonies per print (mean)	% DHC in total hard coral cover (mean)	% SC+ cover (mean)	% ADS++ (mean)
Flynn 5.11.70	OP	N.W. side, back reef area	11	15.4	1.0	16.4	6.0	5.9	9.1	74.5
Thetford 2.5.70	IP	S.E. side, seaward slope	16	22.7	1.6	24.3	5.8	6.4	7.2	68.5
Moore 2.5.70	IP	S. tip, back reef area	11	8.9	9.3	18.2	4.0	51.3	32.0	49.8
Channel 4.11.70	OP	S. tip, seaward slope	9	24.1	0.7	24.8	7.2	2.7	4.9	70.3
Channel 4.11.70	OP	N. tip, seaward slope	10	10.7	0.7	11.4	5.5	6.5	3.6	84.9
Potter 24.5.71	OP	N.E. side, seaward slope	13	47.2	2.1	49.3	9.6	4.2	4.0	46.7
Farquharson 28.5.71	IP	S.E. side, seaward slope	20	16.0	10.1	26.1	2.5	38.8	20.1	54.0

* LHC = Live hard coral. ** DHC = Dead hard coral.
\+ SC = Soft coral. ++ ADS = Algal dominated substratum.

Table 2 cont'd.

"Yamacutta" 25.5.71	IP	N.E. tip, seaward slope	7	26.2	16.4	42.6	10.0	38.5	18.6	38.9
"Horseshoe" 25.5.71	OP	Middle east side, seaward slope	10	30.2	15.6	45.8	4.3	34.0	3.9	50.3
"Judy" 26.5.71	OP	W. side, back reef area	15	11.9	57.2	69.1	3.7	82.8	2.7	28.3
"Doll" 26.5.71	OP	W. side, back reef area	11	7.9	61.6	69.5	3.6	88.6	4.3	23.6
"Trout" 26.5.71	OP	N. tip, back reef area	12	10.9	39.9	50.8	5.0	78.5	2.3	46.8
"Big Sand Cay" 26.5.71	OP	W. side, back reef area	21	8.4	58.3	66.7	2.8	87.5	7.3	26.0
Slashers No. 1 28.7.70	IP	E. of cay, seaward slope	4	53.6	6.9	60.5	6.0	11.4	5.8	33.7
Slashers No. 1 28.7.70	IP	E. of cay, seaward slope	6	1.7	7.0	8.7	6.3	80.0	0	91.3
Slashers No. 1 28.7.70	IP	E. of cay, seaward slope	7	46.9	3.6	50.5	9.8	7.2	2.7	46.8
Slashers No. 1 17.8.70	IP	W. of cay, reef flat	16	4.6	43.4	48.0	5.9	90.5	0	52.0

Table 2 cont'd.

Reef Date	Type	Transect	No. prints	% LHC	% DHC	% total h. c.	Colonies per print	% DHC in total h. c.	% SC	% ADS
Dip 30.7.70	OP	E. side, seaward slope	8	31.1	4.3	35.4	8.3	12.1	0	64.6
Coil 30.7.70	OP	E. side, seaward slope	4	51.5	0	51.5	9.7	0	6.3	42.2
"Grub" 18.8.70	IP	N. tip, seaward slope	10	21.4	11.0	32.4	6.0	34.0	1.9	65.7
"Grub" 29.1.71	IP	E. side, seaward slope	20	7.3	11.4	18.7	2.5	60.8	3.3	78.0
John Brewer 28.7.70	IP	W. side, seaward slope	7	6.6	56.9	63.5	5.0	89.6	0.4	36.1
John Brewer 16.8.70	IP	W. side, seaward slope	18	2.7	11.2	13.9	4.7	80.5	0.3	85.8
John Brewer 26.1.71	IP	E. side, seaward slope	3	3.0	31.8	34.8	5.6	91.3	0	65.2
John Brewer 26.1.71	IP	E. side, seaward slope	6	0	44.6	44.6	3.6	100	1.5	53.9
John Brewer 26.1.71	IP	E. side, seaward slope	6	0.7	17.9	18.6	3.3	96.2	0	81.4
Lodestone 26.7.70	IP	E. side, seaward slope	11	19.9	26.0	45.9	5.5	56.6	5.6	48.5

Table 2 cont'd.

Lodestone 26.7.70	IP	E. side, seaward slope	10	20.8	26.5	47.3	4.5	56.0	7.5	45.2
Lodestone 26.7.70	IP	E. side, seaward slope	10	2.9	49.5	52.4	3.8	94.4	0	47.6
Lodestone 26.7.70	IP	S.E. side, seaward slope	9	4.3	20.2	24.5	5.0	82.4	0.2	75.3
Lodestone 26.7.70	IP	S.E. side, seaward slope	9	14.9	22.3	37.2	5.0	59.9	1.5	61.3
Lodestone 26.7.70	IP	S.E. side, seaward slope	9	29.5	19.7	49.2	4.0	40.0	0	50.8
Lodestone 26.7.70	IP	S.E. side, seaward slope	9	24.2	27.4	51.6	3.7	53.1	0.4	48.0
Lodestone 26.7.70	IP	S.E. side, seaward slope	9	23.6	26.3	49.9	8.0	52.7	0	50.1
Lodestone 26.7.70	IP	S.E. side, seaward slope	6	12.5	31.1	43.6	6.6	71.3	0.8	55.6
Lodestone 26.7.70	IP	S. side, seaward slope	5	3.0	26.2	29.1	5.8	89.9	0	70.9
Lodestone 27.7.70	IP	W. side, seaward slope	6	16.9	30.9	47.8	8.0	64.6	1.1	51.1
Lodestone 27.7.70	IP	W. side, seaward slope	6	19.2	25.1	44.3	11.5	56.6	4.3	51.4
Lodestone 27.7.70	IP	W. side, seaward slope	8	30.3	12.9	43.2	9.0	29.9	0	56.8

Table 2 cont'd.

Reef Date	Type	Transect	No. prints	% LHC	% DHC	% total h. c.	Colonies per print	% DHC in total h. c.	% SC	% ADS
Lodestone 27.7.70	IP	W. side, seaward slope	11	16.4	8.3	24.7	7.4	33.6	0.1	75.2
Lodestone 27.7.70	IP	N. tip, seaward slope	19	29.0	23.8	52.8	13.4	42.9	0.8	46.4
Lodestone 31.10.70	IP	E. side, seaward slope	3	19.7	15.0	34.7	4.6	43.3	0	65.3
Lodestone 31.10.70	IP	E. side, seaward slope	4	0.7	38.5	39.2	3.2	98.1	14.6	46.2
Lodestone 31.10.70	IP	S. E. side, seaward slope	3	0	19.8	19.8	4.3	100	6.3	73.9
Lodestone 31.10.70	IP	S. E. side, seaward slope	3	0	47.1	47.1	4.3	100	0	52.9
Lodestone 31.10.70	IP	S. side, seaward slope	3	0.5	62.1	62.6	6.3	99.1	0	37.4
Lodestone 31.10.70	IP	S. side, seaward slope	3	1.2	43.6	44.8	6.0	97.2	6.8	46.4
Lodestone 31.10.70	IP	W. side, back reef area	2	0	37.0	37.0	5.5	100	0	63.0
"Centipede" 19.8.70	IP	N. tip, back reef area	12	12.5	2.5	15.0	6.0	16.7	0	85.0

Table 2 cont'd.

"Centipede" 19.8.70	IP	N. tip, seaward slope	7	29.0	0.9	29.9	11.0	2.9	0.6	69.5
"Watkins" 18.8.70	IP	N. tip, seaward slope	8	43.0	0.2	43.2	7.1	0.5	0.6	56.2
"Watkins" 18.8.70	IP	N. tip, back reef area	9	20.7	0.9	21.6	6.0	4.0	2.4	76.0
"Lynch" 19.8.70	IP	N. tip, back reef area	7	63.3	0.5	63.8	8.1	0.8	0.2	36.0
"Lynch" 19.8.70	IP	N. tip, back reef area	18	28.7	2.3	31.0	5.9	7.3	1.1	67.9
Broadhurst 20.8.70	IP	N. tip, seaward slope	34	3.8	19.3	23.1	5.5	83.6	0.6	76.3
Broadhurst 28.10.70	IP	N. side, seaward slope	10	31.4	8.7	40.1	6.2	21.7	0	59.9
"Elaine" 20.8.70	IP	N. tip, seaward slope	4	52.7	0	52.7	6.2	0	0	47.3
Prawn 28.10.70	IP	E. side, seaward slope	3	46.1	0	46.1	4.0	0	2.4	51.5

TABLE 3. OCCURRENCE OF *CHARONIA TRITONIS*

Reef	Date	Habitat	Remarks
Noggin	3.11.70	On coral, windward seaward slope of reef.	Adult. No *A. planci* seen in vicinity.
Noggin	3.11.70	On coral at northern tip of reef.	Juvenile. No *A. planci* seen in vicinity.
Nathan	26.9.69	In gutter, windward seaward slope of reef.	Adult. No *A. planci* seen in vicinity.
Nathan	27.1.70	Among coral on top of coral pinnacle in lee of reef.	Adult. Eating a specimen of *Acanthaster planci* approx. 20 cm in diameter.
Gilbey	25.9.69	In gutter on windward seaward slope of reef.	Adult. No *A. planci* seen in vicinity.
Gilbey	25.9.69	On coral, reef flat.	Adult. No *A. planci* seen in vicinity.
Potter	25.9.69	In gutter on windward seaward slope of reef.	Adult. No *A. planci* seen in vicinity.
Taylor	1.1.71	On coral, windward seaward slope. Water 2 m deep.	Adult. Eating *Holothuria leucospilota*. No *A. planci* in immediate vicinity.
Taylor	1.1.71	On coral, windward seaward slope. Water 5 m deep.	Adult. Eating brown holothurian. No *A. planci* in immediate vicinity.
Taylor	1.1.71	Under coral, windward seaward slope of reef. Water 6 m deep.	Adult. No *A. planci* seen in immediate vicinity.
Taylor	25.5.71	On soft coral in water 2 m deep near cay	Juvenile. Numerous small specimens of *A. planci* in vicinity.

Table 3 cont'd.

"Yamacutta"	2.1.71	Exposed on top of coral pinnacle in 2 m water in lagoon.	Adult. A. planci in vicinity.
"Horseshoe"	25.5.71	On top of submerged coral pinnacle in lagoon.	Adult. A. planci vicinity.
"Trout"	15.12.69	On coral on platform in lee of reef.	Adult. A. planci in vicinity.
"Trout"	29.1.70	Among coral on platform in lee of reef.	Adult. Eating a specimen of A. planci estimated to be 18 cm in diameter.
Bramble	14.12.69	On plate coral.	Adult. Eating A. planci about 30 cm in diameter.
John Brewer	26.1.71	Exposed on top of coral pinnacle out from windward side of reef. Water about 3 m deep.	Adult. No A. planci seen in immediate vicinity.
John Brewer	26.1.71	Exposed on top of coral pinnacle out from windward seaward slope of reef.	Adult. No A. planci seen in immediate vicinity.
Lodestone	29.5.70	In small cave on seaward slope, lee side of reef. Water about 3 m deep.	Adult. Eating specimen of A. planci about 22 cm in diameter.
Lodestone	31.10.70	On platform, windward seaward slope on reef.	Adult. Eating specimen of A. planci estimated to be 18 cm in diameter.
Glow	28.1.71	In cave in coral pinnacle in lagoon.	Adult. Recently killed. Flesh putrefying. Cause of death not apparent.

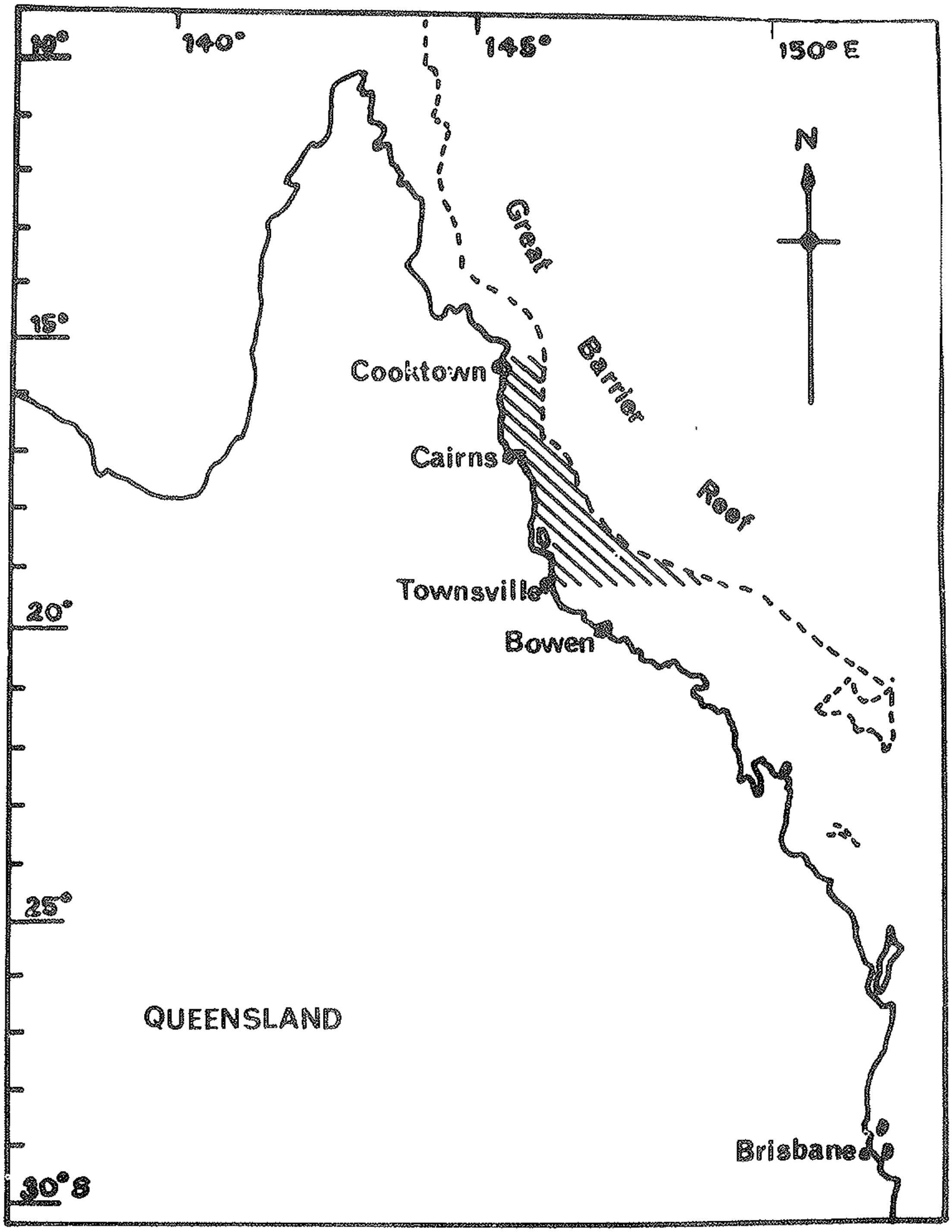
Table 3 cont'd.

Reef	Date	Habitat	Remarks
"Centipede"	25.5.70	On top of coral pinnacle in lagoon.	Adult. No A. planci seen in immediate vicinity.
Shell	28.10.70	On top of coral pinnacle in lee of reef.	Adult. No A. planci seen in immediate vicinity.
Tabias	21.8.70	Among coral on floor of lagoon.	Adult. A few A. planci seen in vicinity.

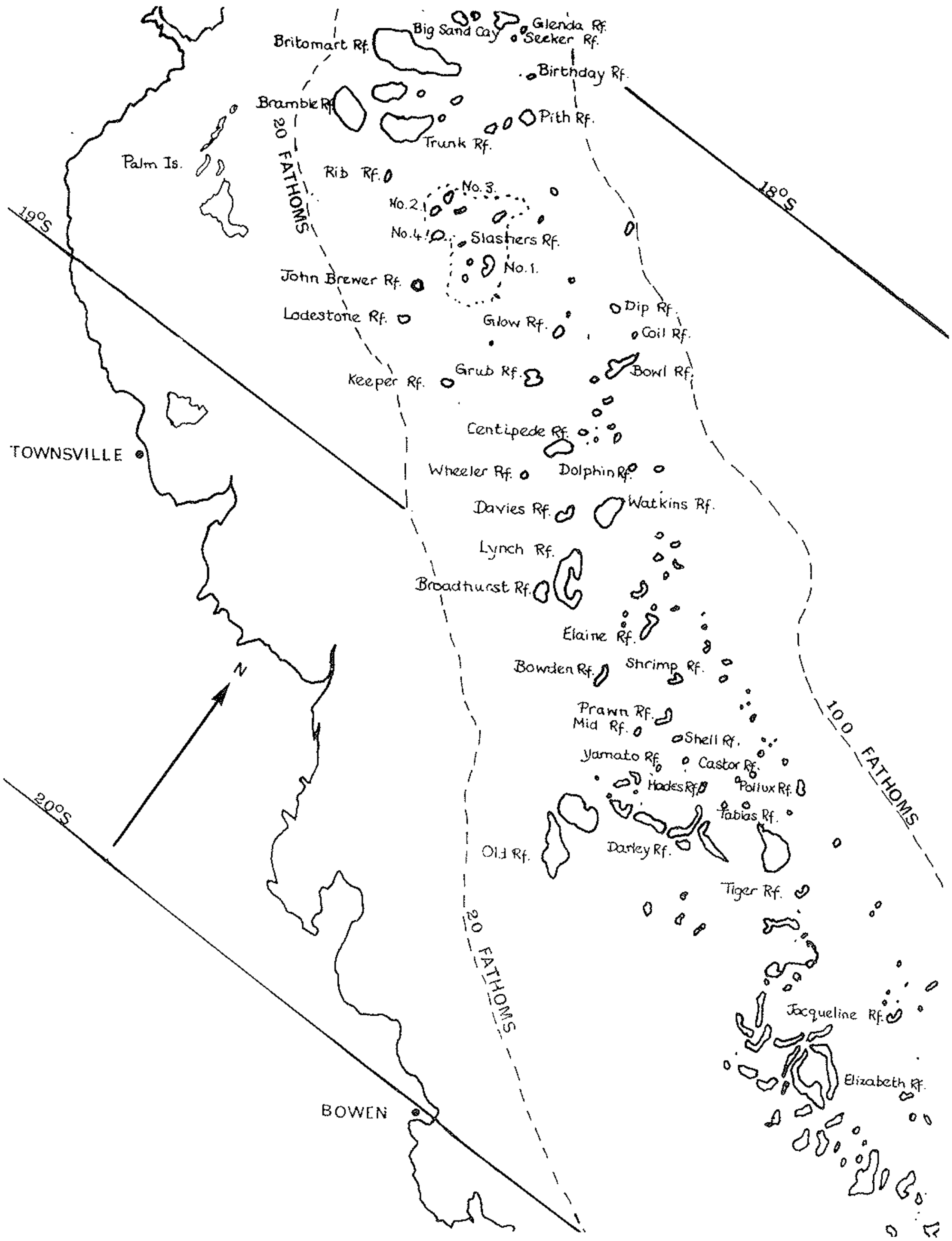
TABLE 4. SIZE FREQUENCY OF A. PLANCI POPULATION SAMPLES

Reef	Date	Number of specimens	Total diameter (cm)*		
			Mean ± S.E.**	Range	S.D.***
Slashers No. 4	27.1.71	102	10.9 ± 0.2	7 - 15	1.8
Glow	28.1.71	28	9.2 ± 0.2	7 - 12	1.1
Glow	28.1.71	74	23.2 ± 0.5	17 - 36	4.7
Nathan	26.9.69	635	16.4 ± 0.3	4 - 31	7.1
Nathan	27.1.70	145	17.7 ± 0.5	8 - 32	5.6
Lodestone	29.5.70	89	31.2 ± 0.6	17 - 43	5.9
Trunk	14.12.69	296	26.7 ± 0.5	8 - 43	8.2
"Big Sand Cay"	26.5.71	44	25.7 ± 0.7	20 - 32	4.6
Slashers No. 1	17.8.70	65	39.2 ± 0.5	31 - 47	3.9
Broadhurst	1.2.70	95	37.9 ± 0.6	19 - 50	5.6
Bramble	13.12.69	145	32.0 ± 0.4	14 - 39	4.2

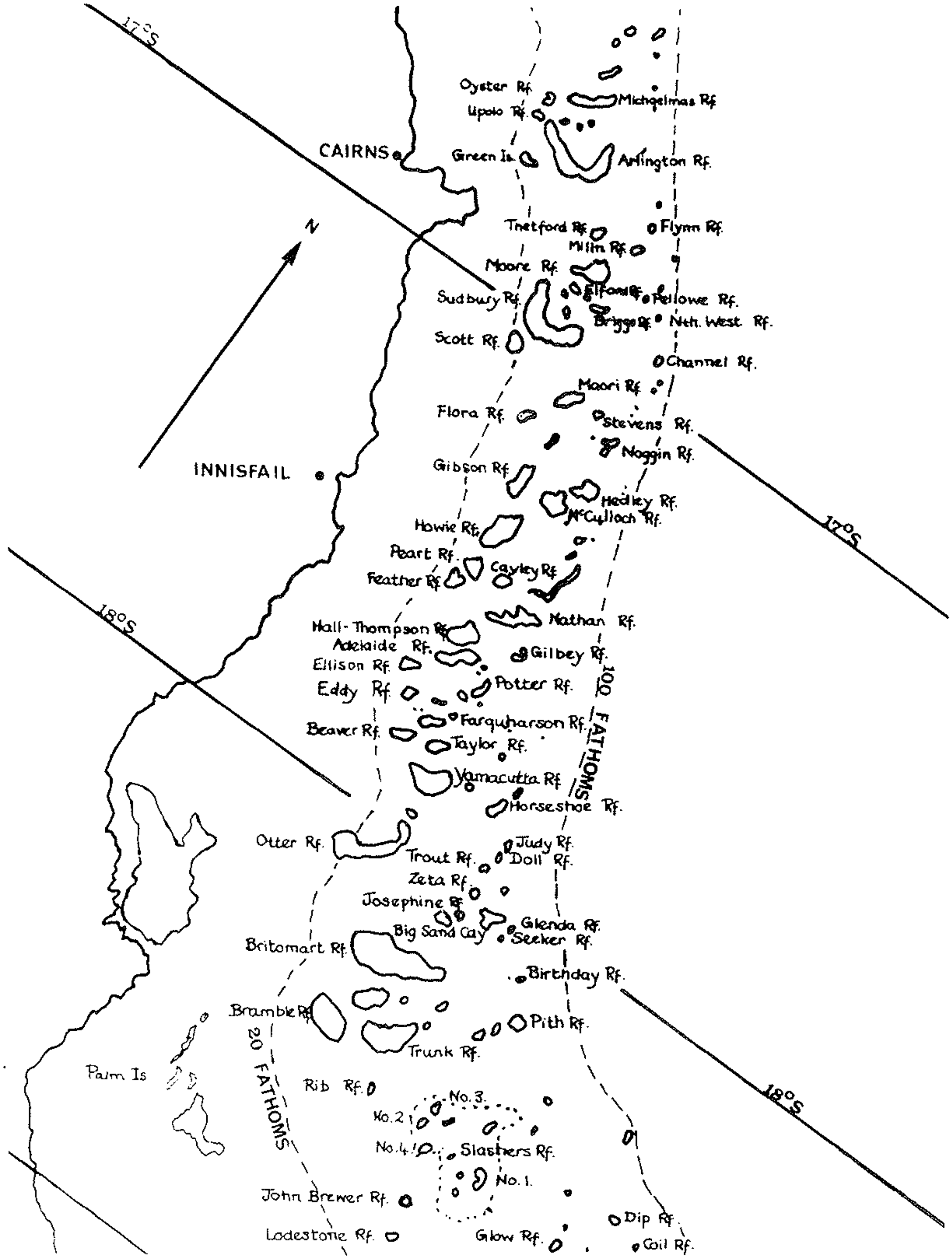
* Twice maximum radius (centre of disk to tip of longest arm)
** Standard error
*** Standard deviation



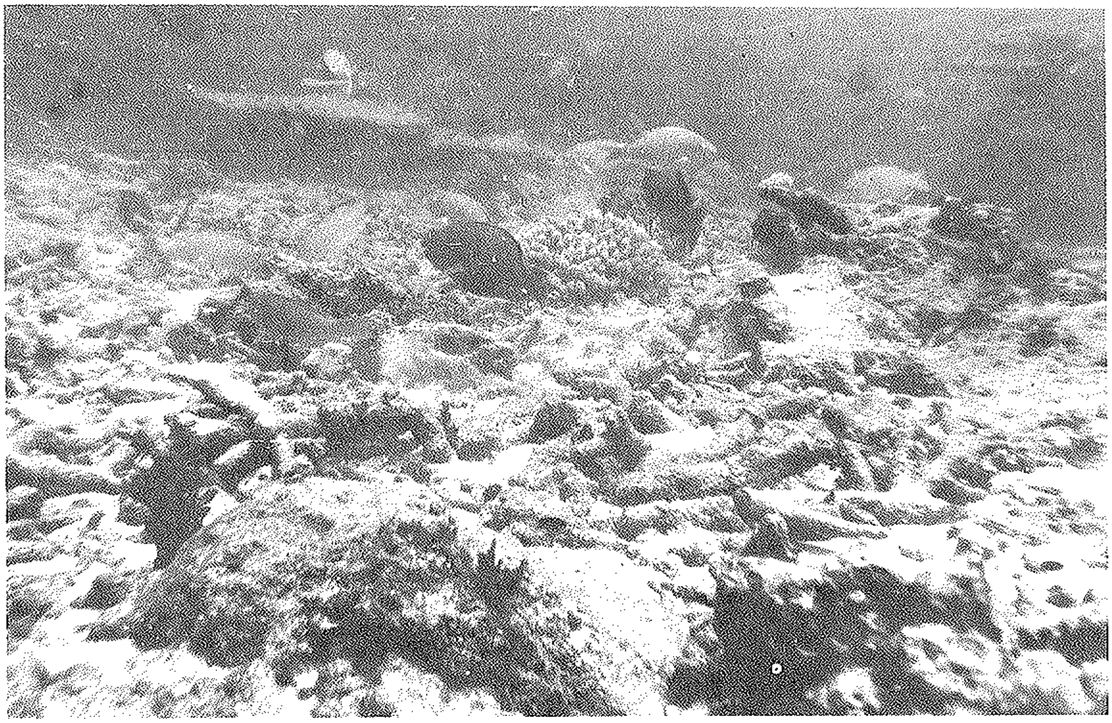
1 Map of Queensland and the Great Barrier Reef. The shaded area represents the region of the Great Barrier Reef affected by the *A. planci* plagues.



2 Map of portion of the Great Barrier Reef showing the positions of some of the reefs visited during the present investigation. The positions of 8 reefs referred to in this paper but not visited during this investigation are also shown.

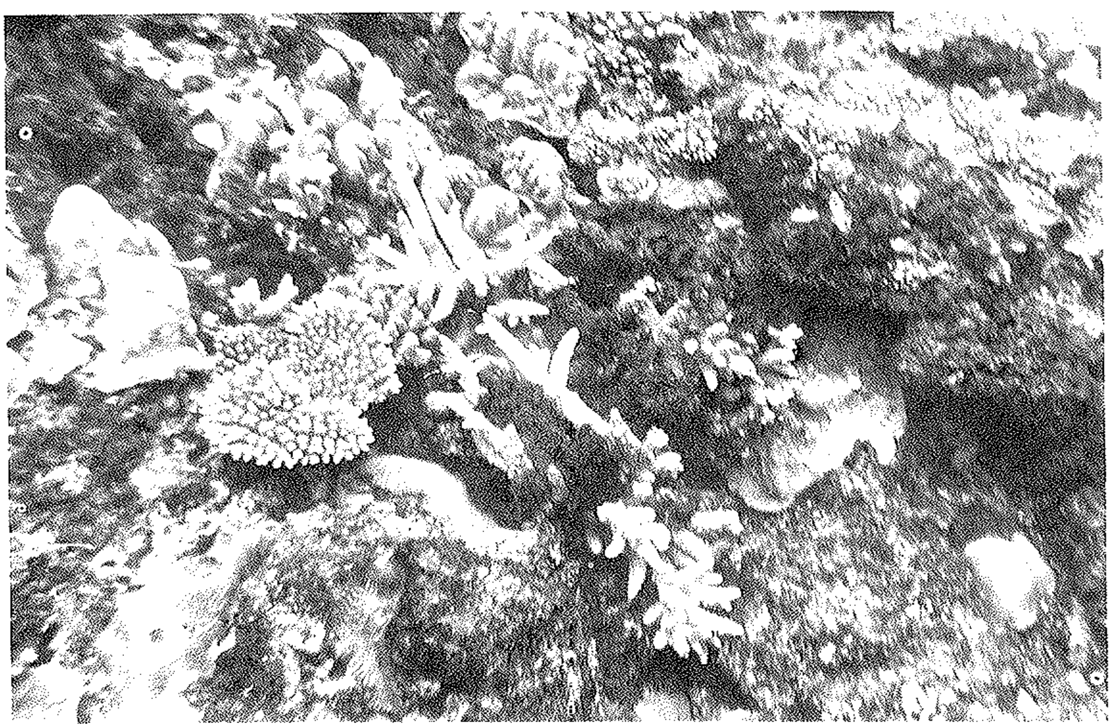


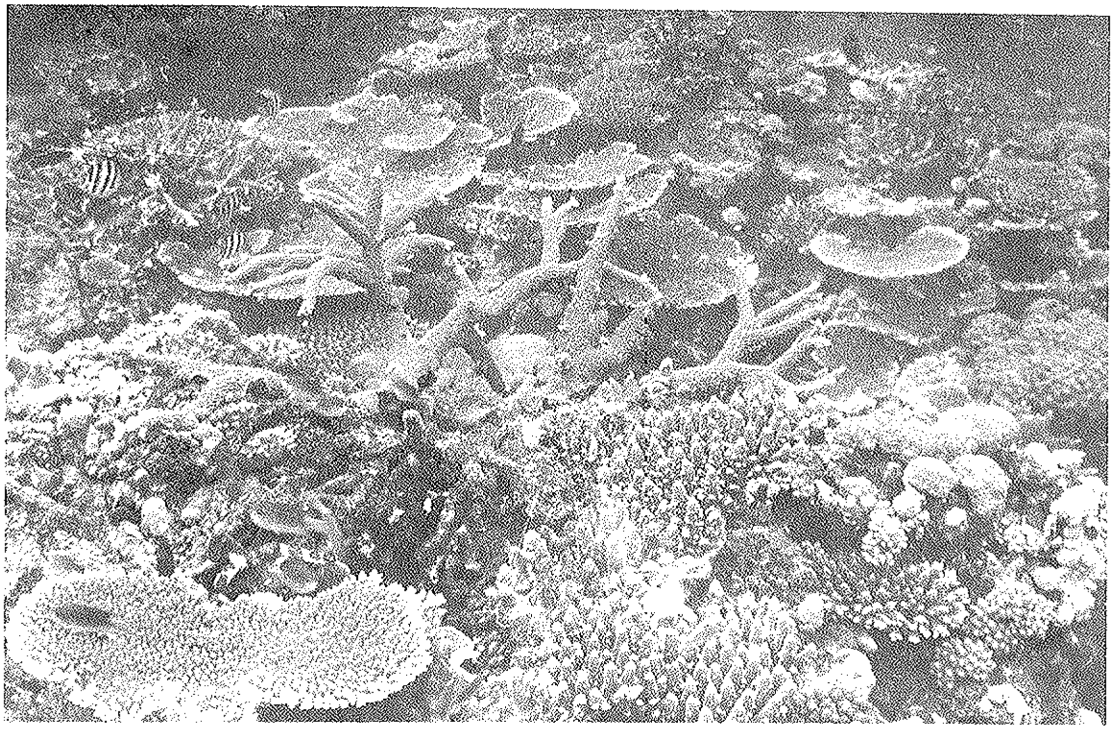
3 Map of portion of the Great Barrier Reef showing the positions of the remainder of the reefs visited during the present investigation.



4 Portion of back reef area west of sand cay at Beaver Reef illustrating sparse hard coral cover (December, 1970).

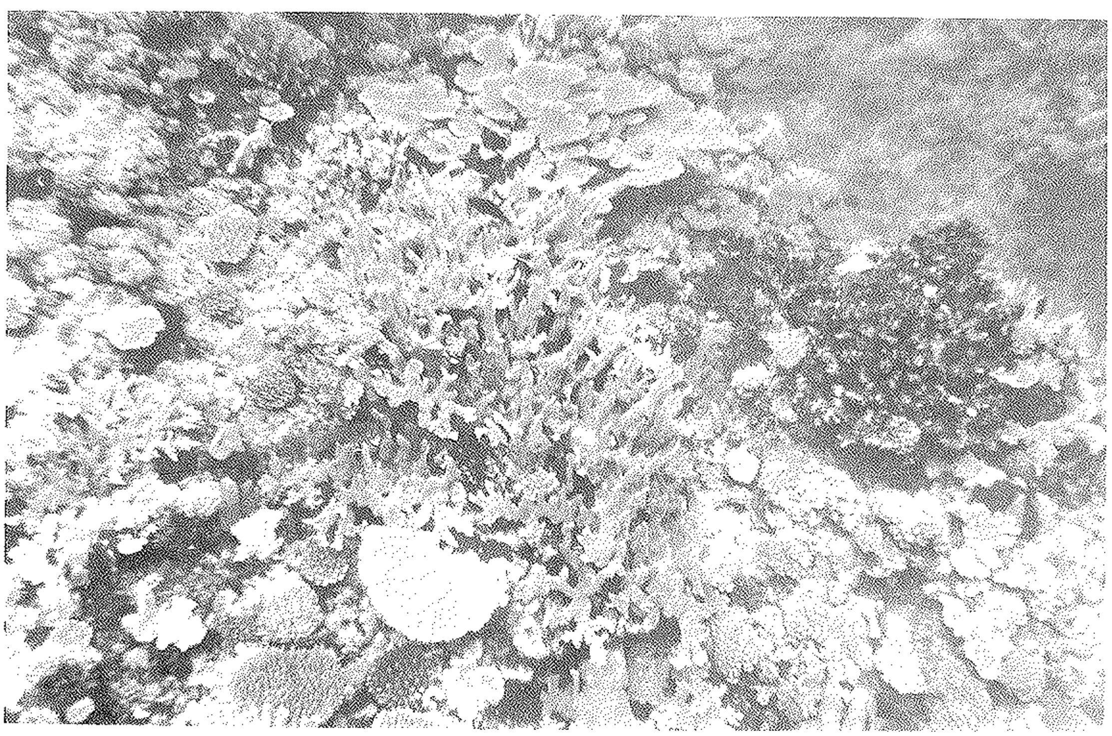
5 Portion of seaward slope on south-east side of Glow Reef illustrating moderate hard coral cover (January, 1971).

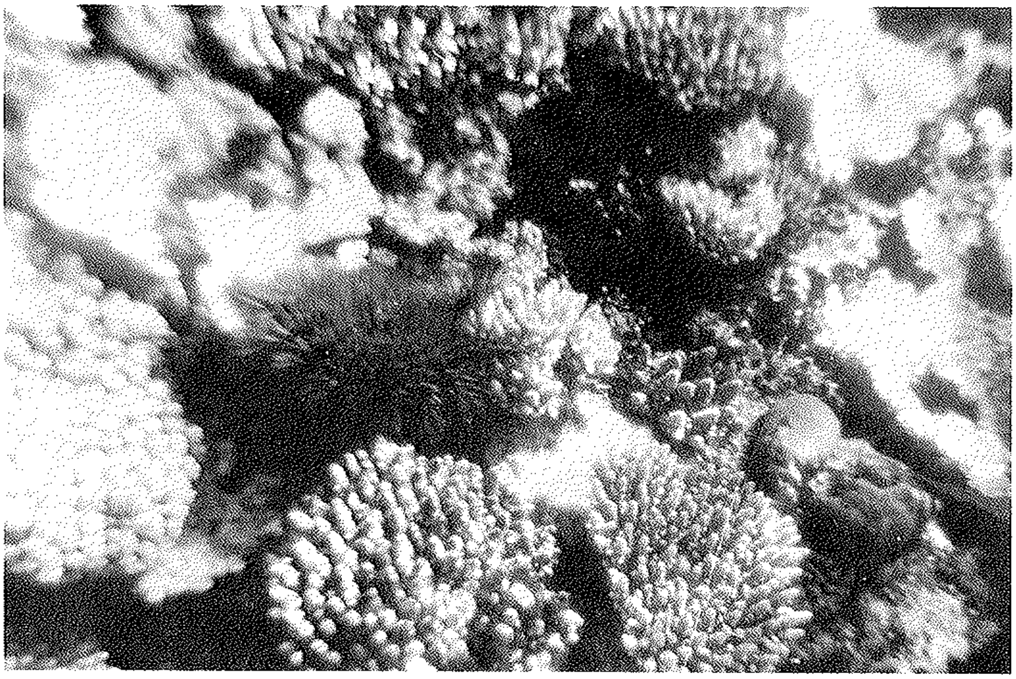




6 Portion of seaward slope on north-east side of Potter Reef illustrating dense hard coral cover (May, 1971).

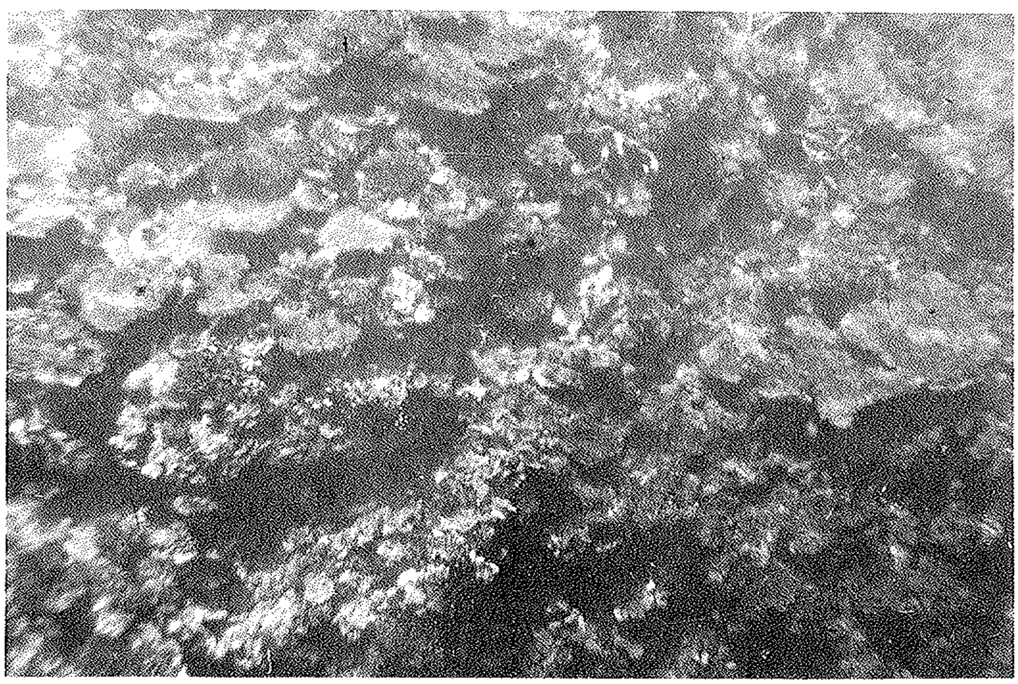
7 Portion of seaward slope on east side of Coil Reef illustrating low damage to hard corals caused by A. planci.

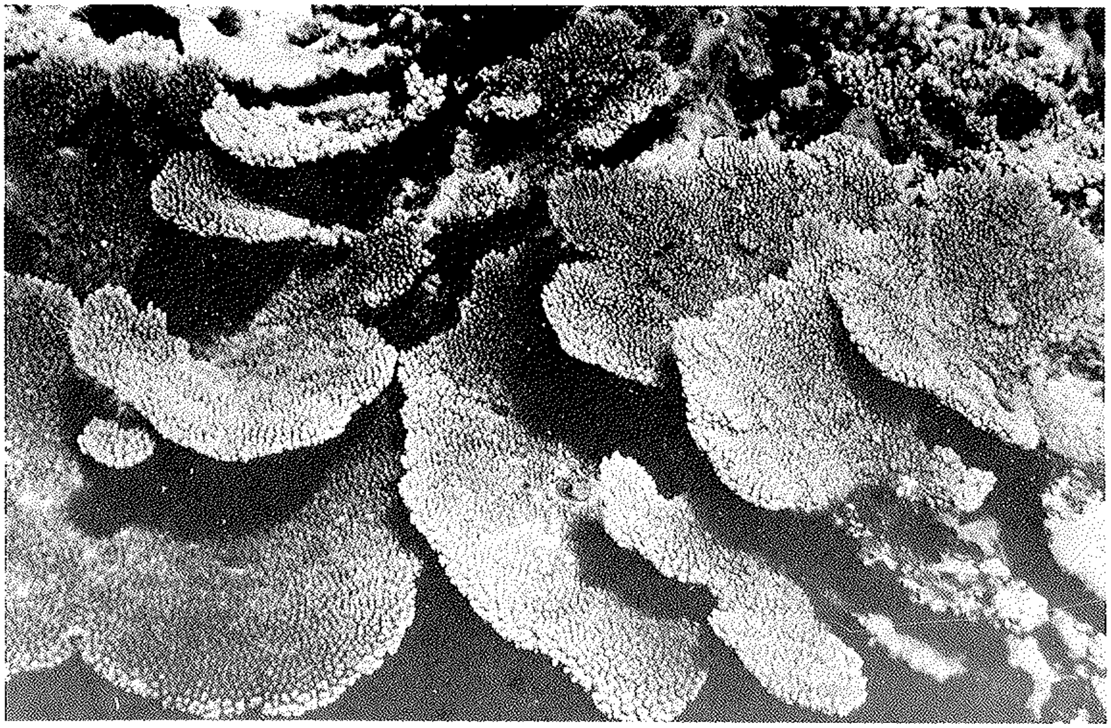




8 Portion of seaward slope on west side of Trout Reef illustrating marked damage to hard corals caused by *A. planci*. A specimen of *A. planci* is visible near the centre of the photograph (December, 1969).

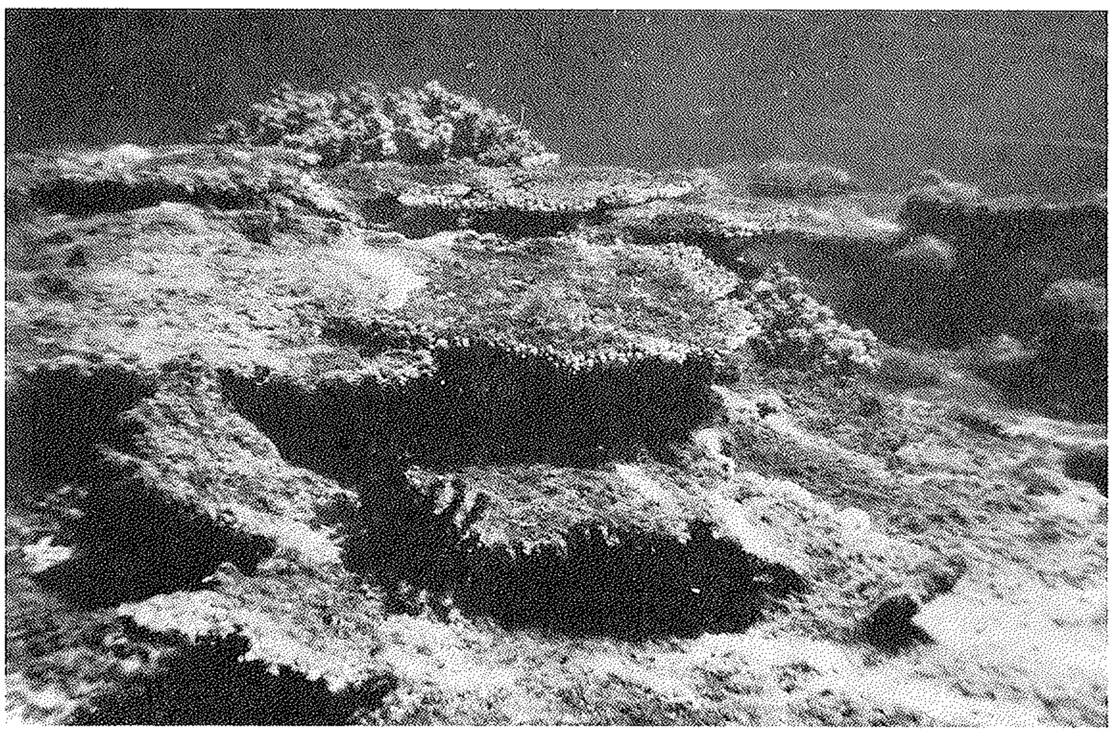
9 Portion of seaward slope on east side of John Brewer Reef illustrating heavy damage to hard corals caused by *A. planci* (January, 1971).

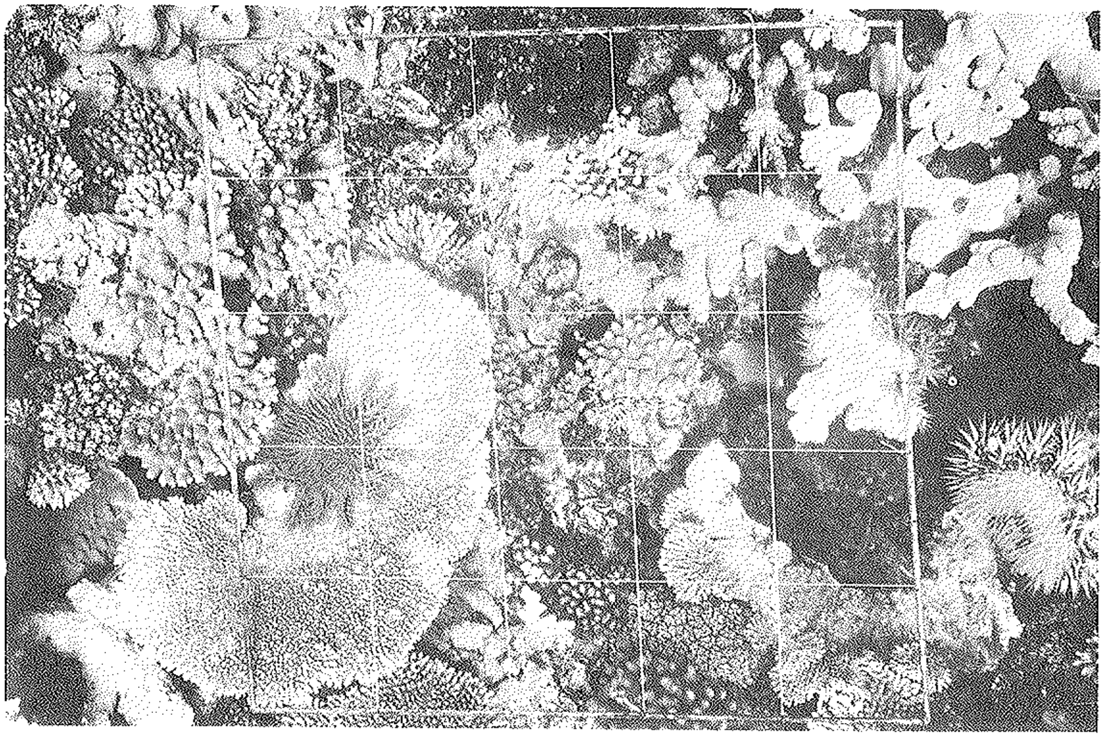




10 Living tabular acropores on reef crest on north side of Broadhurst Reef (October, 1970).

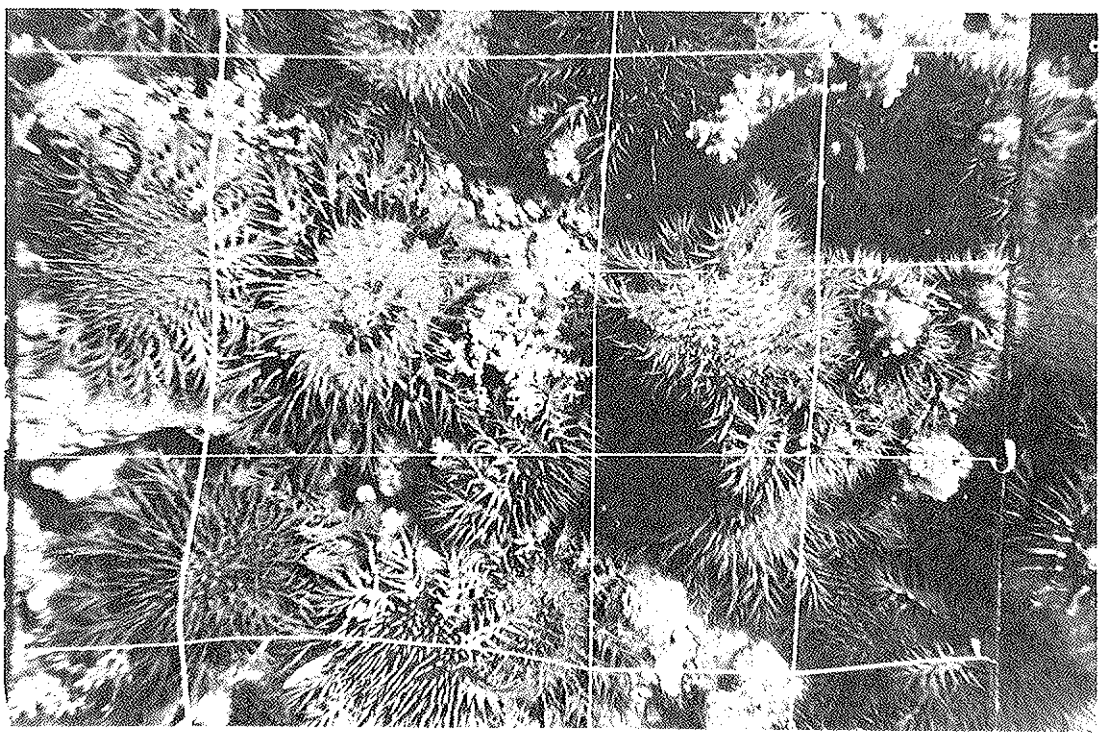
11 Skeletons of tabular acropores killed by A. planci on seaward slopes on north side of Broadhurst Reef (February, 1970).

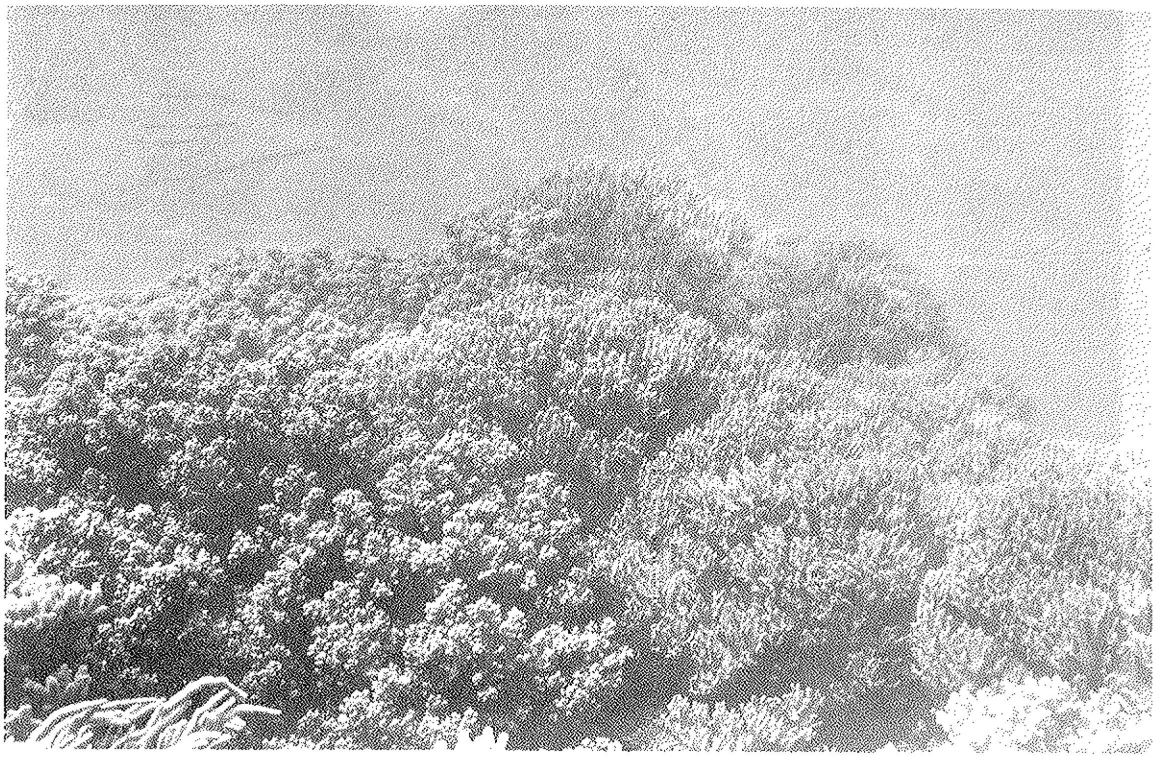




12 Photograph of quadrat in position on seaward slope at northern tip of Lodestone Reef (July, 1970). Analysis of reef cover in quadrat yields 26.3% LHC, 37.3% DHC, 0% SC and 36.4% ADS.

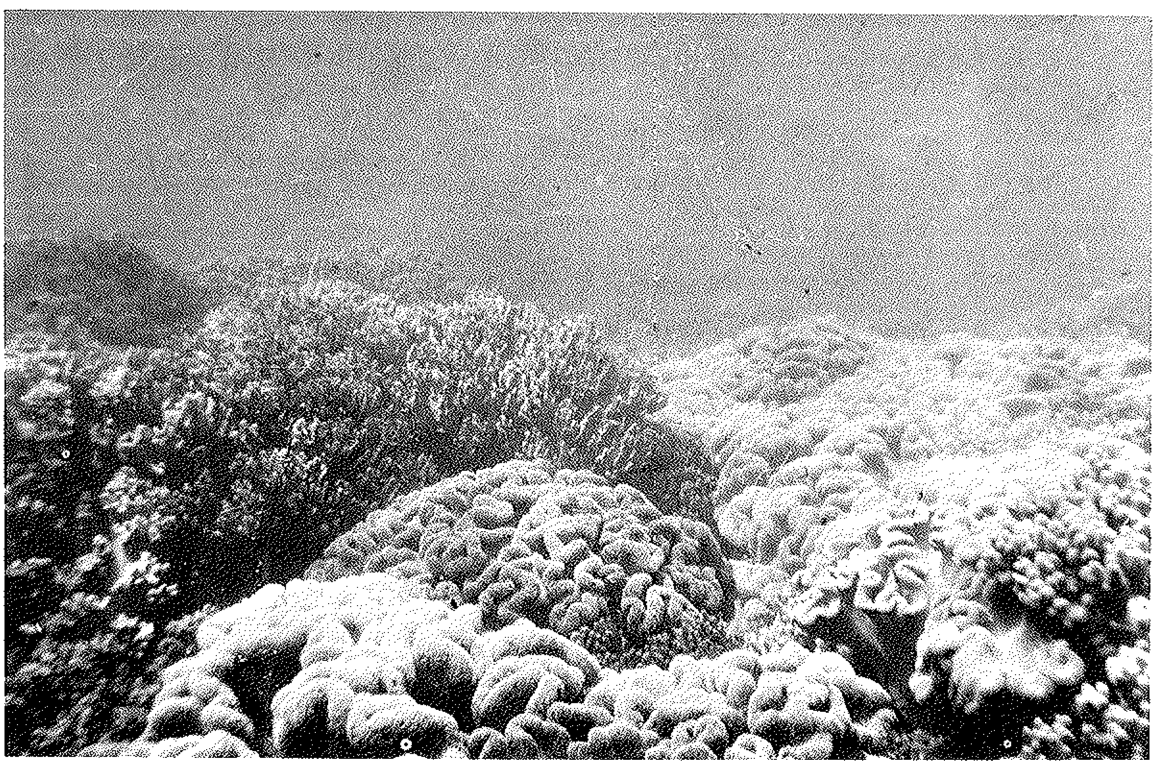
13 Massed specimens of A. planci underlying part of a quadrat on the reef flat at Slashers No.1 Reef (August, 1970).

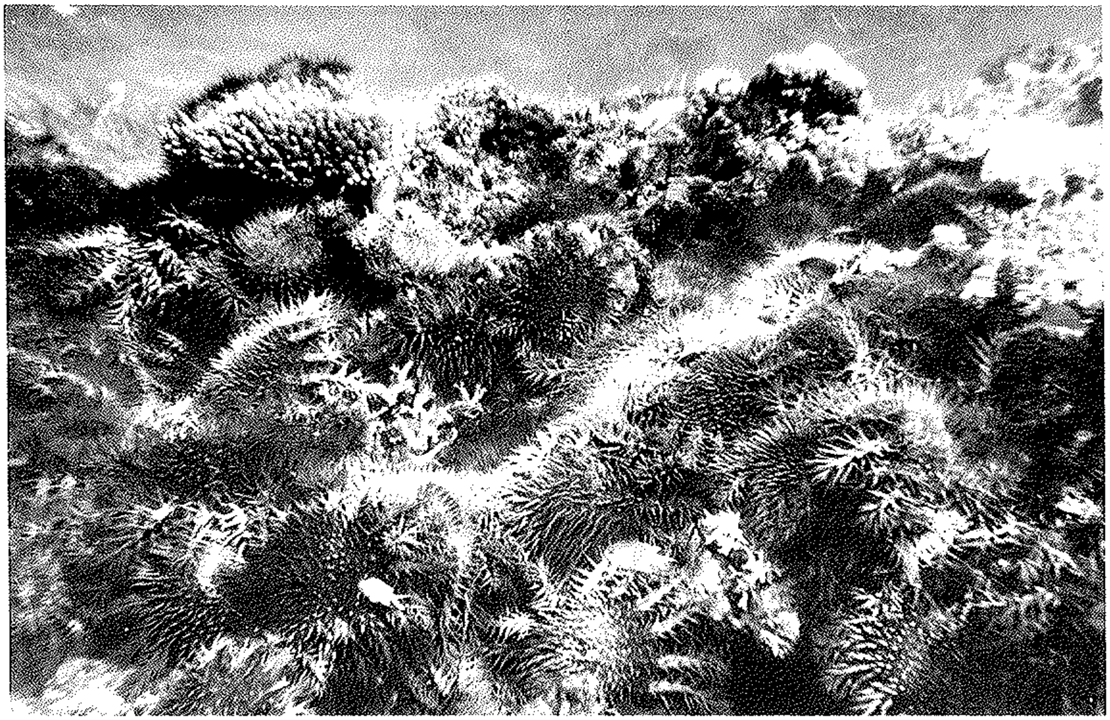




14 Soft coral cover on reef flat near sand cay at Taylor Reef (May, 1971).

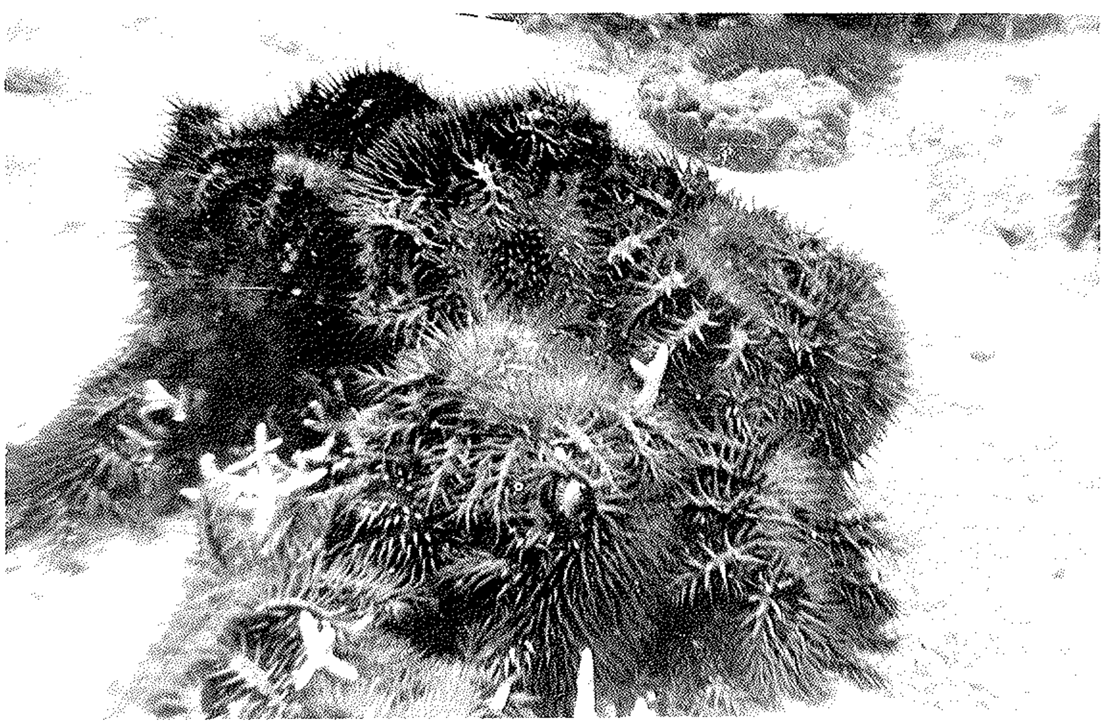
15 Soft coral cover on reef flat near sand cay at Taylor Reef (May, 1971).

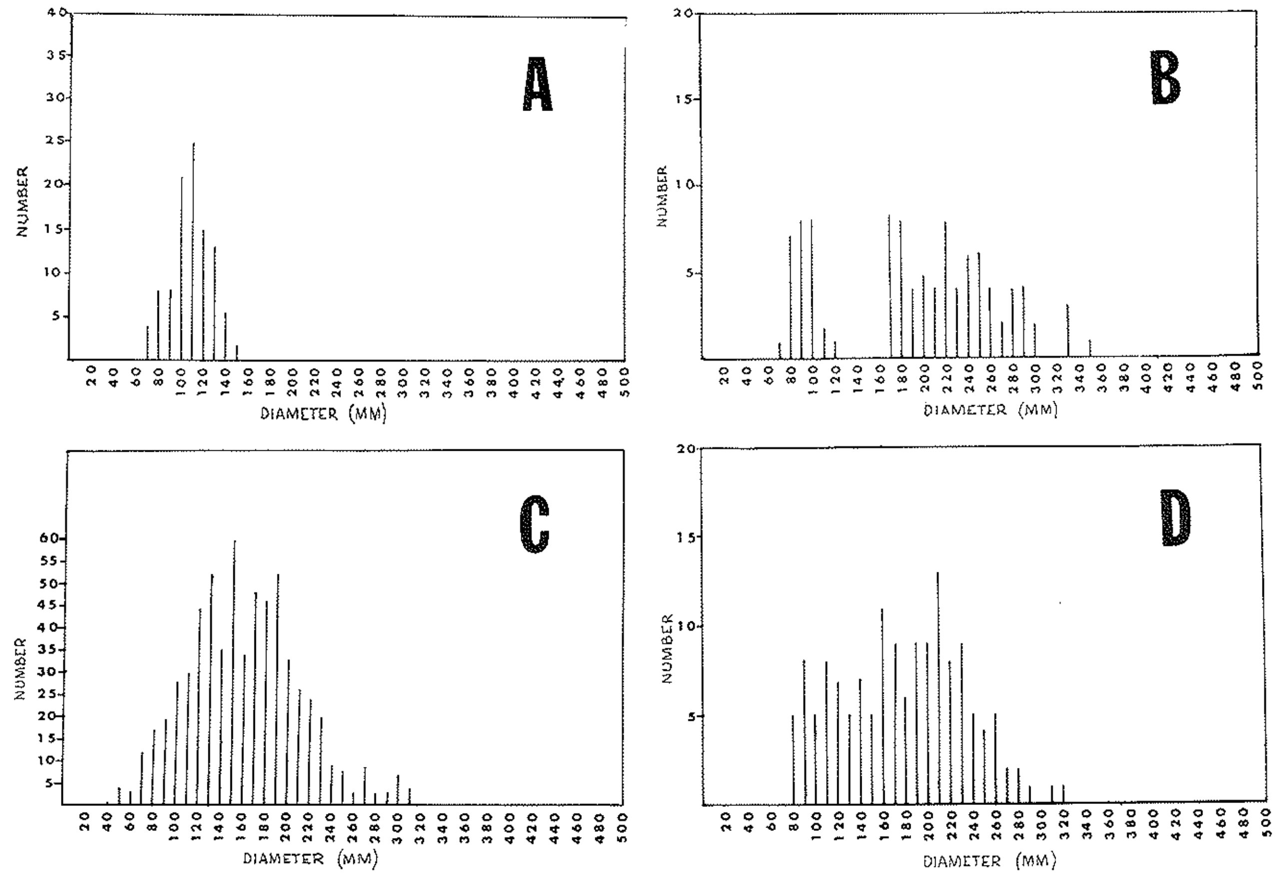




16 Large numbers of A. planci on hard corals on reef flat at Slashers No.1 Reef (August, 1970).

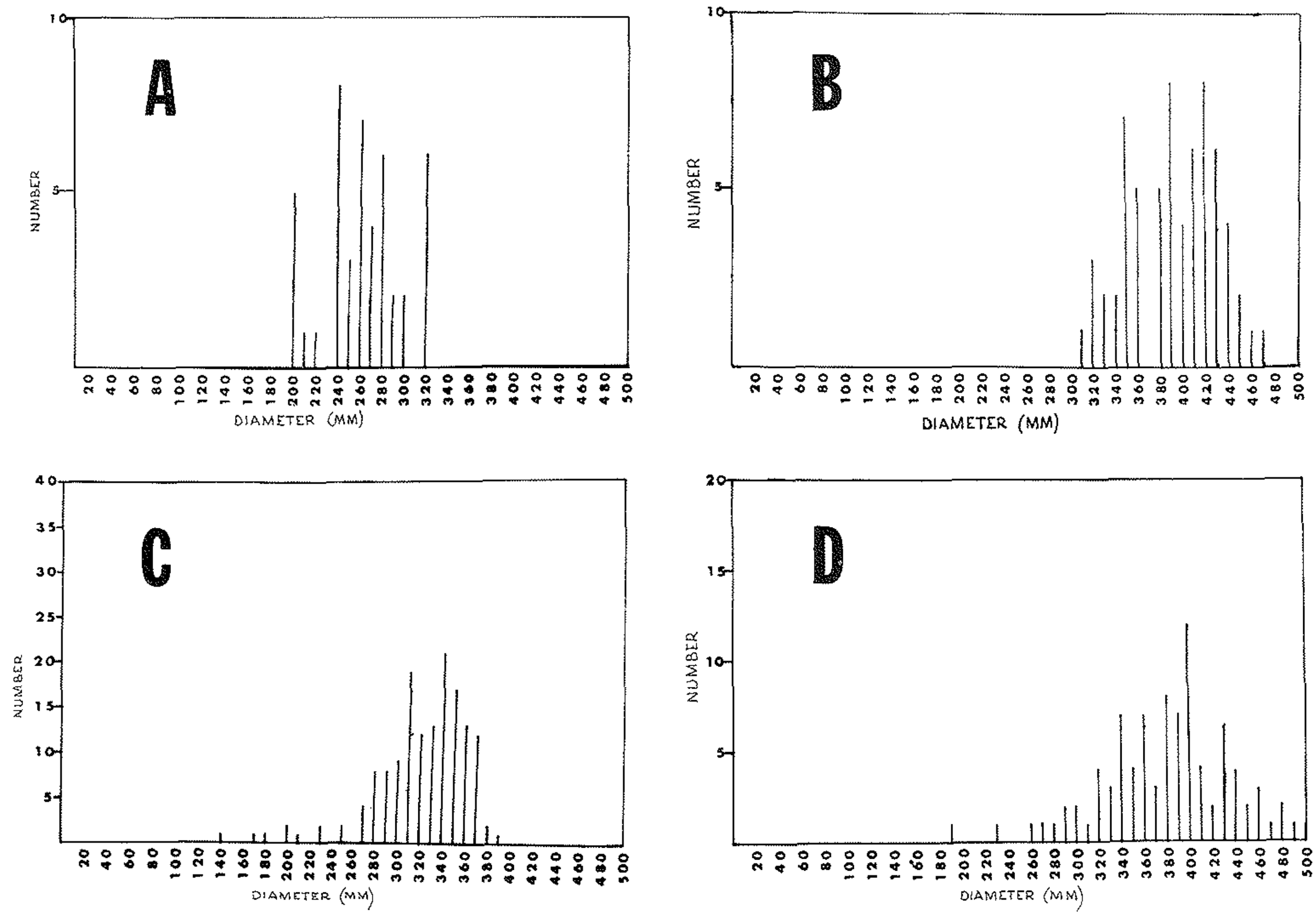
17 A colony of staghorn coral almost completely enveloped by a mass of feeding A. planci at Slashers No.1 Reef (August, 1970).





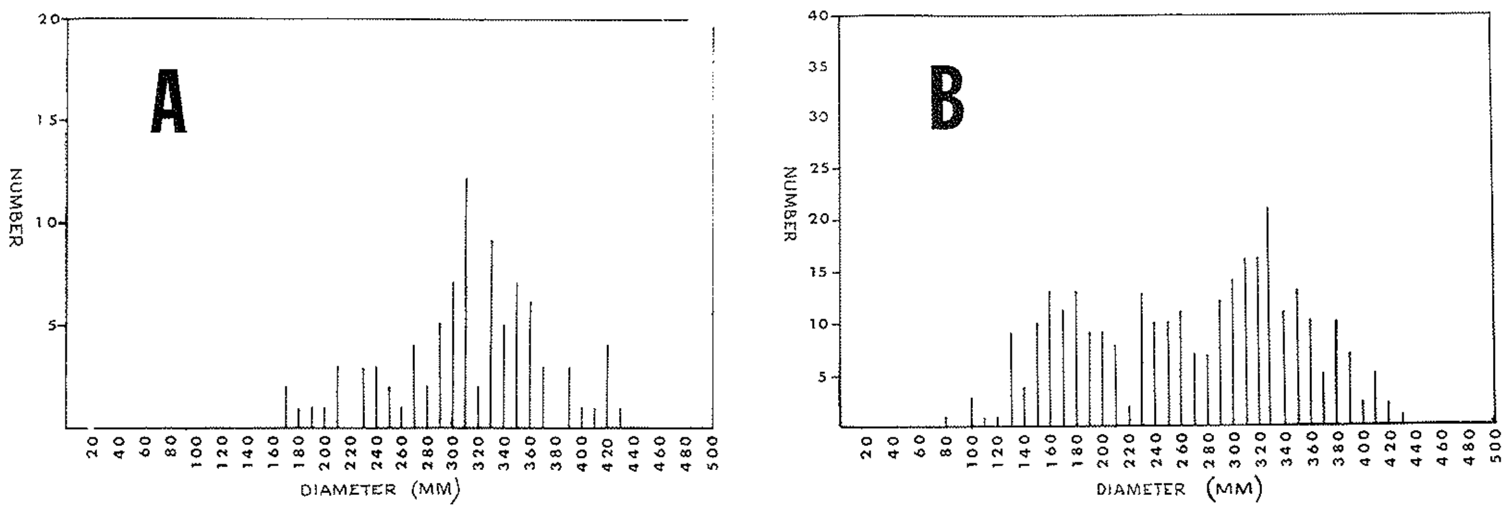
18 Graphs showing size frequencies of populations of A. planci.

A. Population sample from reef crest at Slashers No.4 Reef on 27.1.71.
B. Population sample from reef crest and seaward slope south east of Glow Reef on 28.1.71. Specimens in the size range 70-120 mm were collected on the reef crest, the remainder from the reef slope.
C. Population sample from a coral pinnacle in the back reef area at Nathan Reef on 26.9.69.
D. Population sample from a coral pinnacle in the back reef area at Nathan Reef on 27.1.70.



19 Graphs showing size frequencies of populations of A. planci.

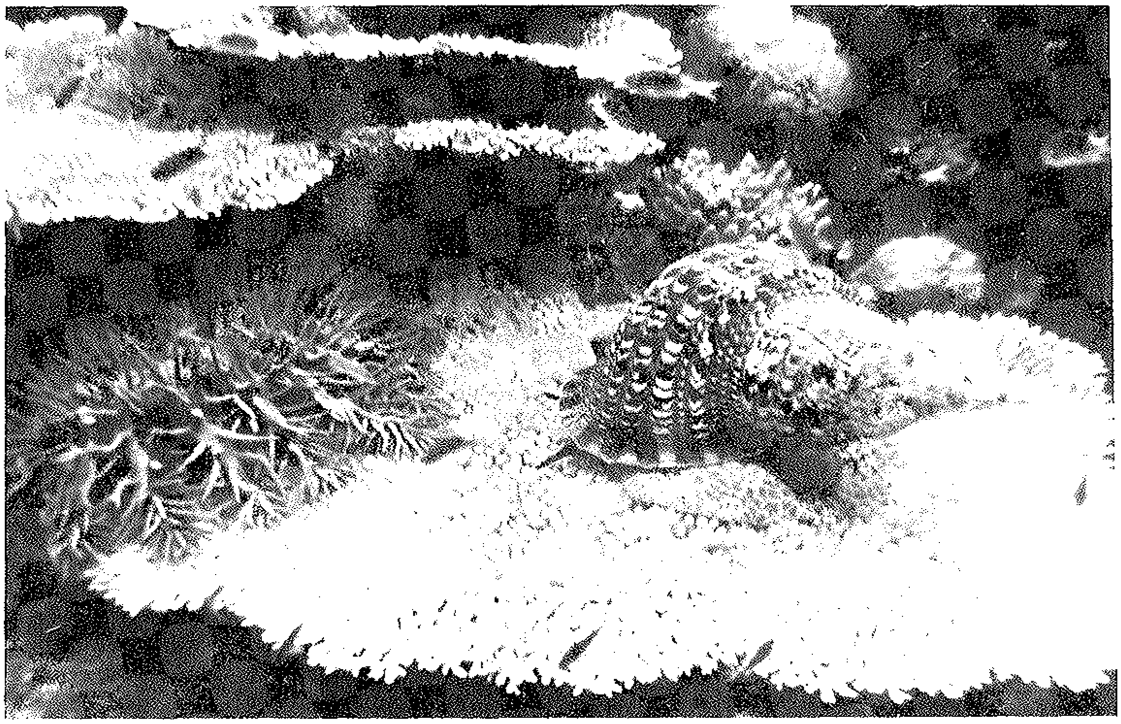
A. Population sample from back reef area at Big Sand Cay Reef on 26.5.71.
B. Population sample from the reef flat at Slashers No.1 Reef on 17.8.70.
C. Population sample from west side of lagoon at Bramble Reef on 13.12.69.
D. Population sample from seaward slope, northern tip of Broadhurst Reef on 1.2.70.



20 Graphs showing size frequencies of populations of A. planci.

A. Population sample from seaward slope, northern tip of Lodestone Reef on 29.5.70.

B. Population sample from reef crest and seaward slope, south west corner of Trunk Reef on 14.12.69.



21 The giant triton, Charonia tritonis, approaching a specimen of A. planci which is feeding on a tabular acropore at Lodestone Re (May, 1970).

22 Charonia tritonis captured while eating a specimen of A. planci at Nathan Reef (January, 1970).