BIOLOGICAL MONITORING STUDY OF AIRPORT RUNWAY EXPANSION SITE MOEN, TRUK, EASTERN CAROLINE ISLANDS

PART B: CONSTRUCTION PHASE

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UNIVERSITY OF GUAM MARINE LABORATORY

Technical Report No. 74

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EXECUTIVE SUMMARY

This report covers the second phase of a study designed to monitor the effects of construction activities on the marine environment surrounding the airport runway on Moen Island, Truk. The baseline environmental conditions which existed in the area prior to the commencement of construction activities were surveyed in May 1978 and the results of those surveys are detailed by Amesbury et al. (1978). In April 1979, the first of the during-construction monitoring surveys was performed (Amesbury et al., 1979); the second during-construction monitoring survey was carried out in May-June 1980 (Amesbury et al., 1980); this report summarizes the earlier monitoring studies and presents the results of the third monitoring survey carried out in April 1981.

The monitoring studies consisted of transect counts of the abundance and species richness of marine plants, corals, macroinvertebrates, and fishes at a series of monitoring stations located near the water quality boundary along the length of the runway and dredge sites, as well as a control station located at some distance from construction activities.

Turbidity levels (measured near the bottom) increased at all monitoring stations after construction began, although major increases in turbidity occurred only at the stations located adjacent to the runway. Two stations located at the southwest end of the runway were heavily impacted by the accumulation of fine sediments: one station was partially covered with sediments and the other was completely covered. One station near the north end of the runway was covered with large rocks.

The transect surveys of marine plants showed a decrease in species richness and percent cover over the period of study. These trends were most notable at the southwest end of the runway where siltation was heaviest.

Percent cover of corals has shown variation throughout the period of study. The stations covered with silt have shown considerable decline in coral coverage, with no evidence of new colonization.

There seems to have been little change in the macroinvertebrate fauna within the study area over the period of study. The dominant macroinvertebrates in the area are filter feeders which may be able to withstand siltation stress.

Reef fish diversity and density declined at those monitoring stations which were inundated with sediments, but the other stations showed little change in fish assemblages which could be attributed solely to turbidity.

Ciguatoxin analyses of fish specimens collected from the study area do not indicate an increase in toxicity of fish as a result of construction activities.

In conclusion, the monitoring study indicates that turbid water conditions generated by construction activities have had little measurable effects on nearby marine communities; however, the accumulation of the sediments at the southwest end of the construction area has eliminated coral substrates and their associated biota. It is suggested that the placement of artificial reefs of some durable material in this area of sediment accumulation may permit recolonization of this area by reef organisms.

INTRODUCTION

This report covers the second phase of a study designed to monitor the effects of construction activities on the marine environment surrounding the airport runway on Moen Island, Truk. The baseline environmental conditions which existed in the area prior to the commencement of construction activities were surveyed in May 1978 and the results of those surveys are detailed by Amesbury et al. (1978). In April 1979, the first of the during-construction monitoring surveys was performed (Amesbury et al., 1979); the second during-construction monitoring survey was carried out in May-June 1980 (Amesbury et al., 1980); this report summarizes the earlier monitoring studies and presents the results of the third monitoring survey carried out in April 1981. The third phase of the study, a post-construction survey, will be performed in 1982 after the construction activities have ceased.

During the same period of time that the environmental monitoring surveys were being carried out, but at monthly rather than annual intervals, the physical and chemical characteristics of the seawater in the area of construction activities were monitored by the University of Guam Water Resources Research Center (now Water and Energy Research Institute). Among the various factors which were measured, turbidity was felt to be the factor most likely to change as a result of the dredging and filling activities involved in the lengthening and widening of the airport runway. The purposes of the environmental monitoring, then, were to examine the effects of increased turbidity, caused by dredging and filling, on the marine communities adjacent to the construction site, and to determine whether these communities were adversely impacted by turbidity and associated sediment accumulation.

METHODS

The impact of construction-generated sediments was assessed by monitoring the biotic communities at a series of monitoring stations established just beyond the water quality boundary adjacent to the construction area. Each station consisted of an isolated or semi-isolated coral mound surrounded by coarse Halimeda sand. Twelve of these stations were established in 1978, six near the dredge site (stations 1, 2, 3A, 3B, 4A, and 4B) and six near the airport expansion site (stations 5, 6A, 6B, 7, 8A, and 8B). An additional station (st. 9) was established approximately 1 km offshore to serve as a control. Descriptions of these sites and their locations are given by Amesbury et al. (1978). A fourteenth station (st. 10) was established in 1979 to assess the affects of silt carried by currents southward from the construction site. This station is described by Amesbury et al. (1979).

A transect line was placed across each monitoring station and the biota was quantified along this line. Where time permitted, replicate transects were run at the monitoring stations. For each census the transect was laid anew and so replicate transects did not invariably cross the monitoring station along the identical path. After each quantitative transect census, the mound was searched for additional species not seen along the transect line.

Marine plants along the transect were quantified by a point-quadrat method which consisted of setting a 25 cm x 25 cm gridded quadrat with 16 internal points on the transect line every meter. Percent cover was calculated by dividing the number of points at which each species was seen by the total number of points (16 times the number of tosses) and multiplying by 100.

Two methods were used to census the stony corals communities at the station. The point-quarter method (Cottam et al., 1953) was applied along transects where scattered, discreet colonies of several species of coral were encountered. In zones of extensive coverage of a single species, a line-intercept method described in Smith (1974) was used, since the point-quarter method proved to be inefficient in terms of time. These zones included large patches of Acropora sp. and mounds of Porites sp.

Generally, for transects where the point-quarter method was applied, a series of 10 points at equal intervals along the transect line was selected. A second line was laid perpendicular to the transect line at each point. The area around each point was thus divided into four equal quadrants. In each quadrant, the coral closest to the point was located, and the diameter and distance of the colony center from the transect point was measured. A sample of the coral was taken and color and

growth form were noted for later positive determination in the laboratory. If no coral was observed within a maximum distance of 1 m from the transect point in any quadrant, a point-to-coral distance of 100 cm (1 m) and a diameter of zero was recorded. From these data, the following quantities were calculated:

$$\text{Total Density of All Species} = \frac{\text{Unit Area}}{(\text{Mean point to point distance})^2}$$

$$\text{Relative Density} = \frac{\text{Individuals of a species}}{\text{Total individuals of all species}} \times 100$$

$$\text{Density} = \frac{\text{Relative density of a species}}{100} \times \text{Total density of all species}$$

$$\text{Percent Cover} = \text{Density of species} \times \text{Average dominance value for species}$$

$$\text{Relative Percent Cover} = \frac{\text{Percent cover for a species}}{\text{Total percent cover for all species}} \times 100$$

$$\text{Frequency of Occurrence} = \frac{\text{Number of points at which species occurs}}{\text{Total number of points sampled}}$$

$$\text{Relative Frequency of Occurrence} = \frac{\text{Frequency value for a species}}{\text{Total of frequency values for all species}} \times 100$$

The sum of the values for Relative Percent Cover, Relative Dominance and Relative Frequency of Occurrence equals the Importance Value for each species on each transect.

The line-intercept method was applied at some stations. Species names and lengths of the invervals intercepted were recorded for each coral colony lying beneath the transect line. The line was considered to be a belt one cm wide extending along one side of the tape. The data was summarized in the following manner: (1) the number of times each individual species appeared along the line; (2) "relative occurrence" as determined by the dividing number of intervals occupied by each species by the total number of intervals occupied by all species, the result multiplied by 100; (3) the total linear distance (cm) of each species per length of transect. Percent cover and relative percent cover was calculated from the latter two quantities.

The abundances of macroinvertebrate were quantified by swimming the lengths of the transects and counting the number of invertebrates within one meter to either side of the line. A meter stick was held perpendicular to the line with one end touching the line as the observer swam along the transect. Since the biological monitoring stations were discrete coral/rubble mounds, the area along the entire length of one

side of the transect line was recorded as one transect count. Therefore, each station or station site had two invertebrate transects. In order to facilitate comparisons between stations, the number of species per m^2 was computed.

Random swims were conducted around the monitoring stations for the presence of invertebrate species not associated with the monitoring mounds.

Fishes were censused by swimming the length of the transect line counting the number of each fish species seen within a meter of either side of the line. A list was also made of fish species seen on the mound but not encountered in the transect census.

RESULTS AND DISCUSSION

Turbidity

The airport runway construction commenced in early October 1978. Prior to construction, mean turbidity levels (measured near the bottom) at the monitoring stations ranged from 0.25 to 0.58 NTU (Table 1). Mean turbidity increased at all monitoring stations after construction began, but major increases occurred only at stations located adjacent to the runway, stations 5, 6A, 6B, 7, 8A, and 8B. At the latter two stations, water circulation was such that suspended silt settled from the water column and accumulated on the bottom in a layer exceeding a meter in thickness in some areas. This resulted in the complete covering of station 8B and the partial submergence of station 8A in fine sediments.

Monitoring Stations

The fate of the monitoring stations over the period of study affects the analysis of construction-relation impacts on the biota discussed below. Station 5 was inadvertently covered with large rocks sometime between the 1980 and the 1981 surveys. This had the effect of completely destroying the existing communities on this coral mount (as well as others in the area). Although this is a construction-related impact, the loss of biota cannot be attributed to turbidity or silt accumulation.

Station 6B presented problems. It was not possible to locate this station during the 1979 surveys because of lack of water clarity and strong currents. A coral mound in the area of 6B was located and surveyed in 1980 and in 1981, but either the mound had been badly damaged by dynamite or some other agent or it was not the original mound. For this reason, the changes in the surveyed biota at station 6B may not relate to turbidity or silt accumulation.

Station 8A and 8B were, respectively, partially and wholly submerged in fine sediments prior to the 1980 survey, and this condition persisted during the 1981 survey. The reduction in biota at these stations was a direct result of the accumulation of sediments generated by the construction activities.

Station 10 was established during the 1979 survey and was located near the base of a large harbor entrance buoy. This station was surveyed again in 1980, but it may not have been the same coral mound. Prior to the 1981 survey, the channel buoy was lost and there was no way to locate this station and it was not resurveyed in 1981. This station has been eliminated from analyses on the effects of turbidity and sediment accumulation on reef organisms.

Marine Plants

A list of all species of marine plants observed or collected during the 1981 survey and their respective percent coverages are listed in Table 2. Overall percent covereages and species richness of each station reported between 1978 and 1981 are presented in Table 3 and percent cover of dominant species or species groups for each year are presented in Table 4.

Numerous changes within the study area occurred from year to year. The most obvious were the disappearance of two stations. Station 5 was covered by fill material used in construction activities between 1980 and 1981 and station 8B was completely inundated by silt between 1979 and 1980. Station 10 could not be located in 1981 due to the disappearance of a harbor entrance buoy used to locate the site. Average species richness on transects and percent cover were lower in 1981 than in all previous years, but highest in 1980. Only station 8A exhibited an increase in percent cover between 1980 and 1981, however, both figures are drastically lower than in previous years. Were it not for the 1980 figures the decline in percent coverage for most stations would have been constant from year to year. It is possible that this discrepancy may be due to variation in sampling techniques complicated by the fact that each annual marine plant survey was conducted by a different worker. Decreases in percent cover observed at most stations between 1978 and 1979 are well documented in Amesbury et al. (1979). Percent cover was lower in 1981 than in 1978 and 1979 for all stations, except 3A, 3B, 4B, and 6A. The most drastic reductions were observed at stations 7 and 8A which were under the influence of the heaviest siltation.

Perhaps more meaningful than species richness observed on transects is species richness observed at sites, if based on collections identified later in the laboratory. A total of at least 55 species were observed or collected furing the 1981 survey. This figure is comparable to those for 1980 and 1978, though a good deal higher than the 39 species reported in 1979. Fifty two species were reported in the area encompassing stations 1 through 8 both in 1979 and 1978, respectively. This may be a result of discrepancies in sampling techniques or collecting efforts. The same pattern was observed at most individual stations with 1980 and 1981 figures being fairly close and higher than in previous years.

Changes in algal composition from year to year are more difficult to explain. Coralline red algae increased in dominance steadily from 1978 to 1980, then decreased slightly at all but two stations in 1981, while still remaining the dominant group at more stations than any other species or species group. This overall increase in dominance may be a result of lower light levels due to increased siltation, a situation that may favor the growth of coralline red algae over other groups (Gordon, 1975). The most obvious algal components of most stations throughout the study area were several species of Halimeda, chiefly H. opuntia over solid substrates and H. cylindracea on sand or mud. In 1978 Halimdea spp. and Dictyota patens were the dominant species at 6 and 5 sites, respectively. Halimeda opuntia remained a very important component at most sites throughout the study period, while Dictyota

patens diminished greatly in abundance and tended to be replaced by the easily overlooked, low profile D. friabilis. Percent cover of Polysiphonia turf increased in 1979 and remained an important component throughout the study period.

In terms of both species composition and total percent cover, 1981 results most closely resembled the 1978 results. Were it not for higher values obtained during the 1980 survey, the 1981 results would reflect a continuation of a trend toward lower percent cover with increasing siltation.

Corals

Coral species encountered at the monitoring stations are listed in Table 5. Parameters of coral communities from 1978 to 1981 are compared in Table 6. Tables 7 through 16 detail the results of the 1981 surveys.

Station 1

This station was composed of a mound of Porites (S.) iwayamaensis and adjacent thickets of Acropora formosa. Areas dominated by A. formosa had a relatively low species diversity except where the Acropora had died and collapsed, and new corals were able to settle. Because of the small size of the new corals, coral cover was low in these areas, although colony density was high.

Porites (S.) iwayamaensis and Acropora formosa have remained the dominant coral species at station 1 throughout the monitoring study. No impacts resulting from construction activities were detectable at this station. Thirty-six coral species were recorded from the station.

Station 2

This station consists of a small mound of Porites lutea with a perimeter of scattered corals. The community structure had remained relatively constant over the period of study (Table 6), with such variation as has occurred attributable to sampling artifacts. New recruits were seen, and sedimentation was not an apparent problem. There were 20 species of corals recorded at the station.

Station 3A and 3B

The coral composition of these two mounds had not changed throughout the study. Percent live coral cover has remained relatively stable also. Recruits were seen at both stations. Eventhough both stations were small, each had a rich collection of coral species; 29 species and 34 species, for station 3A and 3B respectively.

Station 4A

This station consists of scattered patches of Acropora formosa and small mounds of Porites (S.) iwayamaensis. The species composition of the station has not changed greatly over the period of study. In 1981,

40 species of corals were found at the station, five more than previously reported. The increase was due to recruitment, as well as an increase in search effort.

Station 4B

A large (4 m high; 9 m long) mound of Porites lutea makes up this station. A cave at the base of the mound contains many colonies of the ornate Distichopora violacea and Stylaster elegans. Around the perimeter of the mound some 40 species of corals were found. The species composition and percent cover has remained relatively stable. Recruits were seen at the station, and construction activities did not seem to have altered the coral community.

Station 5

Since 1978, there has been a steady decline in the percent coral cover at this station as well as a trend towards smaller class sizes of corals. The 1980 survey noted heavy siltation on the mound and the presence of suspended sediments in the water column. Station 5 has now been covered with rocks.

Station 6A

A Porites lutea mound stands at one end of the station and adjacent to that is a thicket of Acropora formosa. The corals on the upper surface of the Acropora have collapsed, and on the broken branches, other corals have recruited, principally Pocillopora damicornis. From the sides of the thicket, live A. formosa colonies were growing up. The large Acropora hyacinthus colony, which once marked the station, had fallen from its pedestal, but it was still alive.

Both suspended materials and veneering sediments were apparent, a condition reported in the previous surveys. The community composition has remained stable, and coral recruitment and growth were apparent. In 1981, 15 species of corals were noted.

Station 7

This station is composed principally of a single large mound of Pavona maldivensis standing 4 m high with a diameter of 10 m. On the mound itself, in areas that had been disturbed, other species of corals have settled (e.g., Acropora formosa, Fungia fungites, Fungia rapands, Pocillopora damicornis). At opposite ends of the longest axis of this oblong mound, most of the 59 species of corals at the station are found. These corals rent on an adjacent platform. The community on the platform has a high coral density, but a low percent cover. Within a relatively small area there was a high species richness. Although there was silt on the mound, the effects on the coral community were not significant.

Stations 8A and 8B

Station 8B was still buried under a layer of find sediment and no corals could be found.

Station 8A is partially covered with a thick layer of sediments, and a thin veneer of silt lies on exposed surfaces. A few scattered coral colonies are visible, most of these being remnants of larger colonies partially buried in silt. There were no signs of recruitment of new corals to the station. Nine coral species were observed during the 1981 survey.

Station 9

This station served as control. It consisted of a large mound of Acropora formosa. The mound, though predominantly formed by A. formosa, had a species richness of 69 coral species. The rich collection of species was found around the apron of the mound and in niches formed by the slumping of A. formosa. These niches are clearings within the thicket which allow new recruits to settle. The system was rather dynamic, since there were examples where the once open space was recaptured by an overtopping A. formosa.

Macroinvertebrates

The abundances of macroinvertebrates along the transect lines, expressed as numbers of individuals per m^2, are presented in Table 17. Other invertebrates occurring in the vicinity of each station but not counted on transects were also recorded. All invertebrates encountered at each station are shown in Table 18.

Invertebrates assemblages within the study area consist primarily of filter feeders. Most noticeable are many species of sponges, bivalves, and tunicates. Hermit crabs and gastropods were the most commonly encountered nonfilter feeders at the study site.

The four organisms selected by Amesbury et al. (1979) as indicators were again the predominant noncoral macroinvertebrates. Both alcyonaceans and arcrid bivalves were present on 82 percent of the transects. The bear claw clam Pycnodonte hyotis was found on 73% of the transects and the tunicate Phallusia julinea on 95% of the transects.

Abundances of these four indicators were compared statistically with those of previous studies. First, abundance of each indicator was compared from year to year using Friedman's method for randomized blocks (Sokal and Rohlf, 1969). In this analysis the stations were used as the randomized blocks and the years studied as the treatments. Results of these analyses showed no significant difference in abundances between years.

Second, each station at which at least three of the indicators were present was analyzed for possible changes in abundances between years. Friedman's method was again used. In this case the indicator organisms were the randomized blocks and the years studied were the treatments. Stations 1, 3A, 3B, 4A, and 7 showed no significant changes in abundances during the four years studied. Station 4B($X^2 = 8.1^*$; $X^2_{.05[3]} = 7.815$) and station 5($X^2 = 9.3^*$; $X^2_{.05[3]} = 7.815$) each underwent significant changes in abundances of the indicator organisms. The change at sta-

tion 4B is difficult to explain. Station 5 declined somewhat in 1980 as compared to 1978 and 1979 and then was buried completely before the 1981 study.

Stichodactylid sea anemones were observed in the study area. One of these anemones, in the vicinity of station 6B, was observed to have a procellanid crab, Neopetrolisthes maculatus, associated with it. This crab is an obligate anemone associate.

Two genera of filter-feeding polychaete worms were common in the study area. Most common were the feather dusters (Sabellastarte). Christmas tree worms (Spirobranchus) were also observed. Cryptic polychaete species were not quantified or collected.

Trochids were the most frequently counted gastropods, occurring at six stations. Two species of Tectus (T. pyramis, T. triserialis) were found. Previously these were listed together as T. pyramis and are considered as Tectus spp. in the quantitative portion of this report.

At five stations, vermetid gastropods were observed. This gastropod, which was reported as Dendropoma sp. in Amesbury et al. (1980), was probably Petaloconchus keenae, as species which "forms fingerlink protuberances" in massive corals such as Porites (Kay, 1979)

Strombid gastropods were common in the study area. Lambis lambis and Strombus luhuanus were the most common. A beautiful strombid, L. scorpius, listed as uncommon by Cernohorsky (1972) was fairly common at stations 2 and 3.

Muricids were well presented. Chicoreus brunneus occurred at 4 stations and an aggregation of 6-8 individuals of this species was noticed at station 3B.

Sandy areas adjacent to four stations harbored several species of mitrid and costellariid gastropods, of which Vexillum discolorium was the most widespread. Several terebrid snails were also found in sand near stations.

Bivalve molluscs occurred on every transect. Arcids were the most widespread and abundant reaching almost $11/m^2$. One specimen of the pearl oyster, Pinctada margaritifera, was found to contain an irregularly shaped pearl.

Several crustacean records were noteworthy. Several speciemsn of the spiny lobster, Panulirus ornatus were seen near the otherwise deapuperate station 8A.

Hermit crabs were frequently encountered. Calcinus minutus and C. pulcher were the most common diogenids. Several Dardanus were observed. Several specimens of Diogenes gardineri (identified by J. Haig, University of Southern California) were collected. These constitute the first record of the genus in the Carolines. Small pagurid hermit crabs were collected and will be sent to Dr. P. A. McLaughlin at Florida International University for identification.

Hapalocarcinid crabs are obligate coral associates. The gall crab, Hapalocarcinus marsupialsis, was found commonly on Pocillopora and Seriatopora. Associated with the large Pavona maldivensis mound at station 7 was Pseudocryptochirus crescentus. This species was found in burrows within the coral skeleton and also in tunnel-like "dens" formed by a coral roof which has grown above the normal surface of the coral.

Although not found in abundance on transects, holothurians were encountered at every station except station 8A. Holothuria atra was the most widespread species. Five species of holothurians were recorded from station 8A in 1978 and 1979 (Amesbury et al., 1978; 1979). None were found in 1980 (Amesbury et al., 1980) nor during the present study. This disappearance is directly related to the replacement of the Halimeda-sand substrate present in earlier years by very fine silt which is not physically able to support holothurians. Also holothurians are known to prefer food particles of a certain species specific size (Bakus, 1973) which may not have been present after siltation thus forcing the animals to move to more suitable habitats.

Several invertebrates were collected from sites outside the study area. Littorinid gastropods were collected at the Boat Pool dock. Intertidal gastropods and anomuran crustacenas were collected from the rocky jetty near the Blue Lagoon Dive Shop. At Sepuk, on the northwest side of Moen, sandy and hard bottom gastropods were collected in the vicinity of or on the old Japanese pier. Intertidal collections were made from under small volcanic boulders along the shore. All of these animals seen or collected outside the study area are included in Table 18.

Generally there seems to have been little change in the invertebrate fauna within the study area during the four years. The area is characterized by many filter feeders which typically have mechanisms for foreign particle rejection. These animals thus may be better able to handle siltation stress. If this is true, the indicator organisms, all filter feeders, used in this study may not have accurately reflect the effects of siltation on the entire invertebrate community.

With respect to the invertebrate fauna, the monitoring stations should have included a greater portion of the sandy substrate adjacent to each mound. Many organisms, living on or in the sand, may be affected by sedimentation as evidenced by the holothurian changes at station 8A.

Fish

As mobile rather than sessile organisms, fish are much more variable in abundance at the monitoring stations than other biota. This makes it more difficult to determine whether changes in fish diversity and abundance at the stations is related to natural variability or to environmental impacts. In order to reduce this variability, a subset of fish species, designated "conspicuous residents," was selected. This subset consists of those species which, when observed on one member of a replicate census pair, were also seen on the other member at least 50%

of the time. This procedure eliminated those species that visit the monitoring station occasionally but are not consistently found there as well as those cryptic species which are seen from time to time but which are easily overlooked even when they are present. The 40 species which met the criterion for membership in this subset are principally the more conspicuous species which are more or less permanent residents of the monitoring stations.

The full fish census results are presented in Tables 19-32. Conspicuous residents are indicated by asterisks. General patterns of species richness and fish density are shown in Tables 33 and 34.

A noticeable decline in species richness occurred at station 8A where the number of species dropped to about half the number originally seen (Table 33). The number of fish species seen at station 8B dropped abruptly to 0 on the 1980 census as a result of the coral mound being completely covered with sediments. Station 5 was inadvertently covered with large rocks during construction activities prior to the 1981 survey. Station 1 also exhibited a decline in species richness over the study period. None of the other stations exhibited noteworthy reductions in species richness.

Fish density, based on enumeration of fishes along the transect lines, proved to be quite variable, not only from year to year but also between replicate transects run during the same census period (Table 34). The most consistent decline in density occurred at station 1. Fish density declined to 0 at stations 5 and 8B which were completely covered with rocks and fine sediments, respectively. Although the total number of fish counted at station 8A declined during the course of the study, density was less noticeably affected as the size of the coral mound also diminished.

Fish could potentially serve as useful early indicators of environmental stress because their mobility permits them to escape areas where environmental quality is declining. Sessile organisms, on the other hand, are constrained to remain in their original habitats until environmental degradation becomes severe enough to result in their death (or changed conditions). Thus, if sessile organisms are used as indicators of environmental stress, the need for ameliorative action may not become apparent until environmental degradation becomes irreversible.

The results of this study suggest that reef fish species, particularly those species which hold territories or confine their activities to limited home ranges, continue to occupy habitats subject to high levels of water turbidity. Only at sties where significant amounts of sediment accumulated and coral substrates were buried did reef fish assemblages suffer major impacts. The decline in species richness and fish density at station 1 cannot be related to either turbidity or sediment accumulation, however, as turbidity levels at this station were among the lowest of all the stations, and no noticeable sediment accumulation occurred.

Other investigators have reported reduction in abundance and species richness of reef fishes subject to siltation (e.g., Brock et al., 1966). The relative stability in fish abundance and diversity exhibited at those stations subject to high turbidity levels, but where silt did not accumulate, suggests that suspended sediment (at least at the level and duration observed during this study) may not, by itself, cause fish to abandon their places of residence.

Several studies have indicated that a fairly wide variety of reef fish species habitually remain within rather limited areas of the reef (Bardach, 1958; Randall, 1961; Springer and McErlean, 1962; Low, 1971; Sale, 1971; Reese, 1973; Amesbury, 1979). In some cases these species hold and defend specific territories and aggressively repel invading individuals of the same species (or of ecologically similar species). Other home ranging species also remain within circumscribed areas wherein are contained their necessary food resources and predator refuges. The persistence exhibited by several species of reef fishes in this study in remaining at their residence locations under conditions of substantial environmental deterioration suggests that selective pressures favor provincialism in residence patterns of these fish. The likelihood of a fish successfully establishing itself at a new location, when faced by possible predation or aggression from competing territory-holders, may be sufficiently small to select against adventuresome individuals.

Although reef fish species have the potential to emigrate from areas where environmental quality is deteriorating, the results of this work indicate that this option may not be exercised by territorial and home ranging species until stresses are such that other, less variable and more easily quantified, sessile species become impacted. Thus, reef fish assemblages may have no particular value as indicators of early stages of environmental degradation caused by turbidity and siltation.

Ciguatoxin Analysis

Fish tissue samples were analyzed for ciguatera toxicity by Dr. Y. Hokama's laboratory at the John A. Burns School of Medicine in Honolulu. The assay technique used by his lab is a radioimmunoassay, and three levels of toxicity are recognized: positive (<400,000 counts per gram), borderline (between 400,000 and 350,000 counts per gram), and negative (<350,000 counts per gram). The results of the analyses performed on the fish specimens collected in 1981 are shown in Table 35. The surgeonfish *Ctenochaetus striatus* and the various snappers (*Lutjanus* spp.) are the most consistently ciguatoxic. These results accord well with the presently accepted hypothesis that ciguatoxin is produced by a benthic dinoflagellate (*Gambierdiscus toxicus* and others) which is eaten by certain herbivorous fish species, especially *C. striatus* which has long, comb-like teeth with which these epiphytic dinoflagellates can be scraped off their macroalga substrates. The toxin passes up the food chain as carnivorous fishes feed on *C. striatus*, and is often found most concentrated in large predatory fish, such as species of *Lutjanus*. The

1981 results are hard to compare meaningfully with earlier ciguatoxin analyses because of variation in the sizes and species sampled. The analyses of the fishes collected prior to the beginning of construction also showed toxicity in C. striatus and lutjanids. It is worth noting that large lutjanids caught in the same area as those used in the ciguatoxin analysis (adjacent to the airport runway) were cooked and eaten by several people with no detectable effects.

CONCLUSIONS

Despite the high levels of turbidity which occurred over a period of nearly three years, the biota at the monitoring stations has apparently been little affected by suspended silt generated by construction activities. The most significant adverse impact on the marine ogranisms in the area has occurred where suspended sediments have settled out of the water column and accumulated on the bottom. In these areas, living coral substrates have been submerged in fine silt, and the habitats of coral-associated plants and animals have been eliminated. As long as this fine-grained sediment covers the reef, there is little likelihood that benthic animals or plants (with the possible exception of the blue-green algae) will be able to establish themselves here. In the absence of benthic organisms for food and topographic relief for shelter, fishes are not expected to maintain residence in this area either. Although the fine sediments are easily disturbed by the activities of divers at the bottom, the thick layer of sediment in the area of station 8A and 8B has remained stable for more than a year. It is possible that a major storm could remove the sediment from this area and redeposit it elsewhere, but so far this has not happened. As long as these sediments remain in place, the area at the southwest end of the runway will remain a biological wasteland.

In the interest of providing some firm substrate for the attachment of benthic organisms, and more topographic relief to attract fishes, it would be worth considering the possibility of placing surplus concrete "dolosse" throughout the area where the fine sediments have accumulated. The persistence of some marine organisms on the upper parts of station 8A which have not been completely covered with fine sediments indicates that some fish and invertebrates (including spiny lobsters) can survive these conditions if hard substrate is available.

If surplus dolosse are not available, other permanent, hard substrate such as concrete blocks would serve as well. Old automobile bodies would not be suitable as they deteriorate rather rapidly in tropical marine waters and would not provide a permanent substrate.

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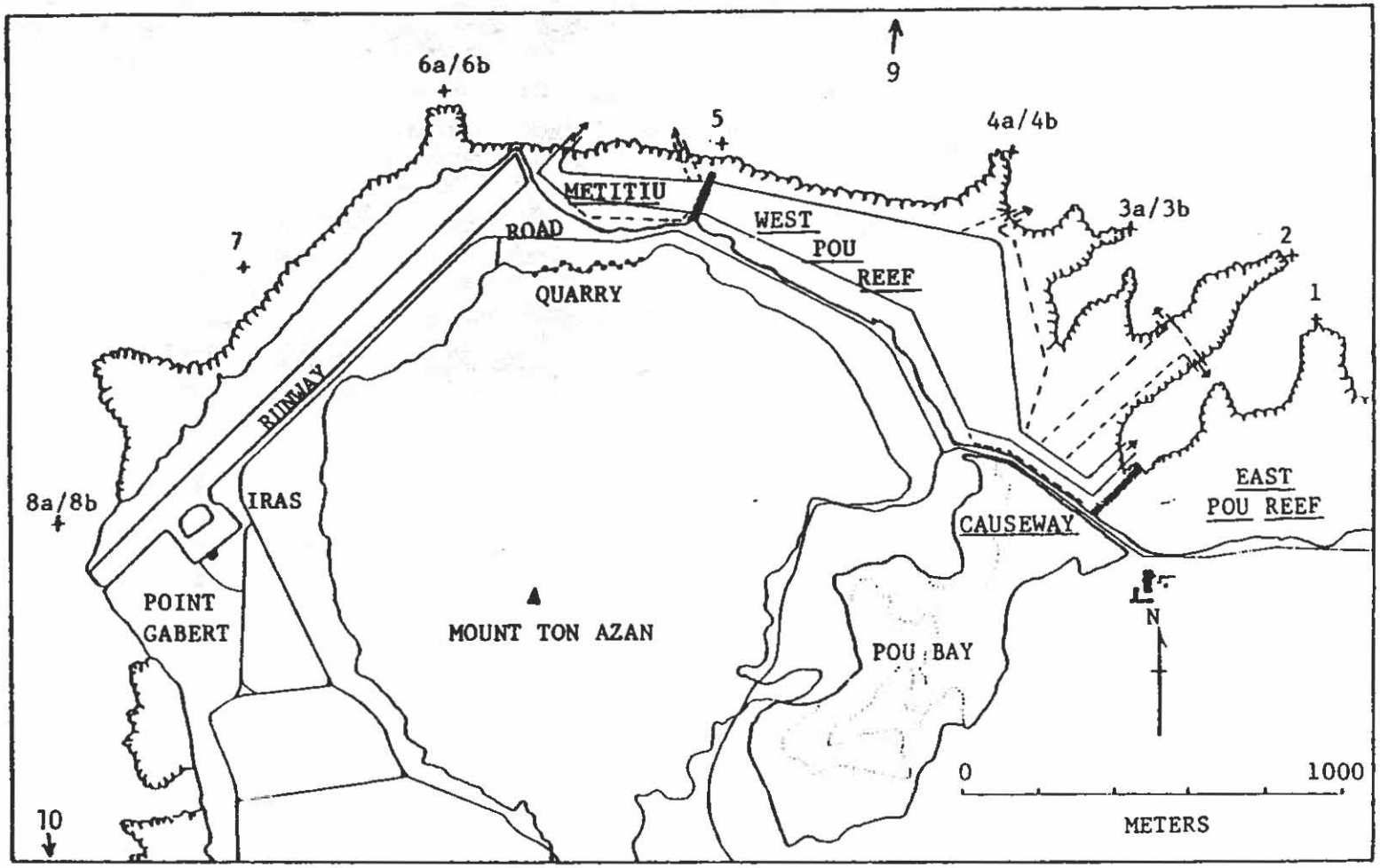

Figure 1. Airport expansion study area and biological monitoring stations.

Table 1. Turbidity levels (NTU) at the monitoring stations, averaged over various time periods.

	20 May-1 Sept 78 (prior to construction)			4 Oct 78-3 Apr 79 (beginning construction to 2nd fish survey)			7 May 79-28 May 80 (2nd fish survey to 3rd fish survey)			27 June 80-9 Apr 81 (3rd fish survey to 4th fish survey)		
Stations	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N
1	.47	.125	6	.81	.393	6	.79	.341	14	.65	.251	10
2	.45	.122	6	.57	.201	6	.70	.457	14	.54	.146	10
3A/3B	.45	.096	6	.64	.212	6	.97	.573	14	.51	.159	10
4A/4B	.41	.095	5	.48	.223	6	.80	.407	14	.51	.185	10
5	.33	.031	6	1.05	.721	6	1.17	.544	14	.94	.558	10
6A/6B	.32	.055	6	1.01	.658	6	1.43	.667	14	1.33	1.201	10
7	.39	.114	6	.73	.295	6	1.17	.466	14	1.04	.320	10
8A/8B	.58	.243	6	.86	.368	7	1.51	1.410	12	3.74	3.506	10
9	.25	.047	6	.47	.233	5	.46	.189	14	.39	.104	10

Table 2. Checklist of Marine Plants recorded from monitoring stations. Numerical entries are the percent cover measured on the transect line. Other species observed at each station are indicated by the symbol X.

	TRANSECT =																					
SPECIES	1	1'	2	2'	3a	3a'	3b	3b'	4a	4a'	4b	4b'	6a	6a'	6b	6b'	7	7'	8	8'	9	9'
Cyanophyta																						
Hormothamnion sp.	X																					
Microcoleus lyngbyaceus	X		?		X		X		X				1.7				X					0.8
Schizothrix calcicola	X				X		X		0.8				X		X		?			0.4	1.2	
S. mexicana					X		X		X													
Unid. spp. as thin fuzz or in red turf	X		X		X		X		X		X		X		X		X				X	
Chlorophyta																						
Borgesenia forbesii																	X					
Caulerpa cupressoides																				X		
C. racemosa																				X		
C. serrulata							0.6										X			1.7		
C. urvilliana					X		X															
C. verticillata	0.6	1.4	0.7	1.8	0.8		X				1.2						0.4		0.4			X
Chladophoropsis sp.					X		X		X				X							X		X

Table 2 Continued.

SPECIES	1	1'	2	2'	3a	3a'	3b	3b'	4a	4a'	4b	4b'	6a	6a'	6b	6b'	7	7'	8	8'	9	9'
Chlorodesmis fastigiata	?		?										?									
Dictyosphaeria sp.	X																					
Halimeda cylindracea	X				X		X						X		X		X			0.4		
H. discoidea[1]	6.9	1.2			1.6	3.1	X		X					5.7	2.5	0.7		0.4	X		X	
H. gigas	0.6		X		?		?		X								X		2.3			
H. macroloba			X							0.8							X					
H. macrophysa[2]		1.4	X	0.9	X		X		X		X		1.0	1.1		2.1					0.4	0.8
H. micronesica[3]		3.0	0.7						0.4		0.3	0.4		0.6	X						3.3	2.5
H. opuntia[4]	11.9	6.9	1.4		3.1	5.5	X		1.2	5.5	6.3	7.0	14.6	5.7	8.8	18.8	X		0.8		4.5	2.7
Halimdea spp.[5]	X		X		X		1.9			0.4	1.5		1.0									
Neomeris annulatus																				X		
Rhipilia orientalis	X		X												0.4		X					
Tydemania expeditionis	X											X				0.7					2.5	
Udotea argentea					X		X				2.1		X				X				X	
Valonia aegagropila																					X	
V. ventricosa																0.7						

Table 2 Continued.

SPECIES	1	1'	2	2'	3a	3a'	3b	3b'	4a	4a'	4b	4b'	6a	6a'	6b	6b'	7	7'	8	8'	9	9'
Phaeophyta																						
Dictyota bartayresii									1.6		0.9		0.5		2.9		0.8			X		
D. patens	X				X		X			X		X									X	
D. friabilis		1.6	1.4	0.9	7.8	7.0	8.8	11.9		1.2	5.1	4.0				5.6					0.2	
Lobophora vaiegata	4.4	0.2			X		1.3	1.3				0.4	X		3.8			1.2				
Padina jonesii	X				X		X		0.4	1.6							X		13.7	7.9	X	
Ralphsia sp.			X		X		X		2.7				1.0		4.2		X				X	
Sphacelaria sp.	X																					
Turbinaria ornata	X																					
Rhodophyta																						
Amphiroa spp.[6]	X		X							X											1.0	3.1
Asparagopsis taxiformis													13.0	5.1								
Centroceros sp.					X		X					X	X				X					
Ceramium sp.													X				X					
Galaxaura fasciculata																			0.4	1.7		
Hypnea pannosa	X		X		X		X						X								X	

Table 2 Continued.

SPECIES	1	1'	2	2'	3a	3a'	3b	3b'	4a	4a'	4b	4b'	6a	6a'	6b	6b'	7	7'	8	8'	9	9'
Jania capillacea					X		X		X		X		X				X				0.2	
Laurencia papillosa			X		?		?												?			
Lithophyllum kotschyanum	X								X													
Negoniolithon frustescens																					X	
Peysonellia rubra		3.4	2.8	4.5	2.4	3.9	15.0	16.3	2.8	4.3	1.2	1.5	6.8	1.7	1.3	11.8	3.3				1.8	1.6
Porolithon spp.		1.2		0.9	0.8		X		3.5	2.7	0.6	X	5.7	0.6	14.6	2.1	3.3				0.2	
Polysiphonia spp.					X		X						X				X				X	
Tolipiocladia glomerulata	X				X		X		X											0.4	X	
Unid. thin, filamentous strands and epiphytes	X		X		X		X		X		0.6		X						X			
Red turf	5.1	2.4	1.4	2.6	14.1	10.9	6.9	5.0	0.4		11.6	5.1		1.2	0.8	2.8	4.6	0.8	2.0		5.6	10.0
Unid. fleshy red (thick)			X																X			
Total percent cover	29.4	25.4	8.3	12.5	30.5	29.7	34.4	34.4	12.9	17.2	31.3	18.4	43.8	23.3	39.2	45.1	12.1	2.7	19.5	12.5	20.9	21.9
No. species observed at station	29		20		29		29		25		19		24		17		24		19		24	
No. species observed on transect	7	11	6	7	8	5	6	4	8	8	13	7	8	10	9	9	4	4	6	6	12	8

Table 2 continued.

Mean % cover: 23.9%

Mean no. species/station: 23.0

Mean no. species/transect: 7.5

Total species all stations: .55

Footnotes:

1. Percent coverages of this species may also include the superficially similar H. taenicola.
2. Percent coverages of this species may also include the superficially similar H. fragilis.
3. Percent coverages of this species may also include the superficially similar H. incrassata.
4. Percent coverages of this species may also include the superficially similar H. copiosa.
5. Includes two species at station 48; one species elsewhere.
6. Includes two species at station 9, one species elsewhere.
7. Identified in the laboratory from samples of red turf taken from the station.
8. Composed of small red algae (e.g. Ceramium, Centroceros, Polysiphonis) and species of blue green or green algae.

Table 3. Species richness and percent cover of marine plants recorded on the monitoring transects, 1978-1980. Replicate transects are averaged.

Station No.	Number of Species* on transect			Number of Species** at each site				Percent Cover			
	1979	1980	1981	1978	1979	1980	1981	1978	1979	1980	1981
1	15.5	16	9	15	19	24	29	50	34.6	63.1	27.4
2	12	16	6.5	9	15	25	20	24	29.2	31.3	10.4
3A	11.5	15.5	6.5	21	17	23	29	45	18.2	54.5	30.1
3B	10	10.5	5	6	17	23	29	38	32.4	48.8	34.4
4A	10	19	8	6	10	30	25	45	46.1	46.8	15.1
4B	11.5	24	10	12	14	22	19	20	31.0	38.1	24.9
5	12.5	13	--	15	14	18	--	51	39.6	44.1	--
6A	12	17	9	10	14	24	24	41	31.8	68.2	33.6
6B	--	17.5	9	20	--	23	17	51	--	54.3	42.2
7	11	16	4	14	13	22	24	41	23.8	27.4	7.4
8A	11	8	6	17	12	10	19	71	49.9	7.5	16.0
8B	13	--	--	17	19	--	--	25	23.0	0	--
9	19.5	17.5	10	17	23	25	24	30	31.2	44.2	21.4

Table 3 Continued.

Station No.	Number of Species* on transect			Number of Species** at each site				Percent Cover			
	1979	1980	1981	1978	1979	1980	1981	1978	1979	1980	1981
10	19.0	15.5	--	--	31.9	44.4	--	--	21	23	--
Mean	13.0	15.8	7.5	13.8	15.9	22.4	23.0	40.9	32.5	44.1	23.9
Cumulative no. species observed at all sites:				47	39	53	55				
Cumulative no. species observed at Sta. 1-8 only:				35	34	52	52				

*This figure is not available for 1978.

**Due to close proximity and similarities between Transects 3A and 3B, algae reported in their vicinities in 1981 are based on a single collection encompassing both transects. For comparative purposes figures for previous years are also lumped.

Table 4. Dominant marine plant species at the study sites, 1978-1981. Numerical entry is percent cover. The 1978-1980 data were obtained from Amesbury, et al. (1980).

Site #	1978		1979		1980		1981	
1	Halimeda opuntia	12%	Coralline	8.3%	Coralline	18.9	H. opuntia	9.4%
			H. opuntia	5.6	H. opuntia	10.9	H. discoidea	4.1
			Lobophora	3.8	Lobophora	6.9	Polysiphonia turf	3.3
2	Dictyota patens	12	Coralline	6.9	Coralline	6.2	Coralline	4.1
			H. gigas	6.4	Lobophora	6.8	Polysiphonia turf	2.6
			H. opuntia	4.0	H. opuntia	5.2	Caulerpa verticillata	1.3
3A	D. patens	20	Coralline	4.9	Dictyota sp.	20.1	Polysiphonia turf	12.5
			H. opuntia	4.1	Coralline	12.0	Dictyota friabilis	7.3
					Lobophora	8.0	Coralline	3.6
3B	D. patens	14	Lobophora variegata	18.4	Lobophora sp.	18.7	Coralline	15.7
			Coralline	5.2	Dictyota sp.	18.4	D. friabilis	10.4
			Polysiphonia/ Celidiopsis turf	5.2	Coralline	9.4	Polysiphonia turf	6.0
4A	H. opuntia	11	H. opuntia	19.6	Coralline	14.2	Coralline	6.7
			Coralline	9.9	Dictyota sp.	9.2	H. opuntia	3.4
			Polysiphonia/ Gelidiopsis turf	4.6	H. opuntia	7.9		
					Lobophora	6.0		
4B	D. patens		Coralline	9.6	H. opuntia	11.5	Polysiphonia turf	8.3
			Lobophora variegata	5.9	Coralline	11.3	H. opuntia	6.7
			H. opuntia	5.8	Dictyota	5.4	D. friabilis	4.6
					Lobophora	4.2		

Table 4 Continued.

Site	1978		1979		1980		1981	
5	Microcoleus lyngbyaceus	15	Polysiphonia/ Gelidiopsis turf	15.3	Polysiphonia turf	11.2	--	
			Coralline	14.8	Coralline	12.8		
					Lobophora	5.4		
					Caulerpa filicoides	5.4		
6A	H. opuntia	22%	H. opuntia	20.8	Coralline	21.7	H. opuntia	10.2
					Polysiphonia turf	12.8	Asparagopsis taxiformis	9.1
					Lobophora	12.5	Coralline	7.5
					H. opuntia	7.0		
6B	H. cylindracea	17	--		Polysiphonia turf	16.7	Halimeda opuntia	13.8
					Coralline	13.0	Coralline	15.0
					H. opuntia	5.0	Dictyota friabilis	2.8
					Dictyota sp.	5.0		
7	D. patens	16	Polysiphonia/ Gelidiopsis turf	12.8	Coralline	14.4	Coralline	3.3
			Coralline	7.2	Polysiphonia turf	5.0	Polysiphonia turf	2.7
8A	Padina jonesii	40	Polysiphonia/ Gelidiopsis turf	12.7	Coralline	6.5	Padina jonesii	10.8
			Coralline	1.24			Halimeda gigas	1.2
			H. opuntia	10.3			Galaxaura fascilulata	1.1
			P. jonesii	7.2				
8B	H. cylindracea	7	Polysiphonia/ Gelidiopsis turf	11.4	--		--	
			Coralline	5.4				

Table 4 Continued.

Site = 1978			1979		1980		1981	
9	H. opuntia	11	Coralline	8.1	Coralline	13.6	Polysiphonia turf	7.9
			H. opuntia	4.1	H. opuntia	11.2	H. opuntia	3.6
			Polysiphonia/ Gelidiopsis turf	5.1			H. micronesica	2.9
							Coralline	1.7
10			Polysiphonia Geilidiopsis turf	15.2	Coralline	18.5	--	
					Polysiphonia turf	8.1		
			Coralline	10.1	Lobophora	5.4		
			L. variegata	6.2	Dictyota	4.2		

Table 5. List of corals observed in the various study areas, 1980-1981 survey.

	1	2	3A	3B	4A	4B	5++	6A	6B*	7	8A	8B+	9	10*
CORALS														
Class Anthozoa														
Order Scleractinia														
Family Astrocoeniidae														
Stylococniella armada (Ehrenberg)	X		X	X	X					X			X	X
Family Thamnasteriidae														
Psammocora contigua (Esper)										X				
Psammocora digitata Milne Edwards & Haime			X				0			X			X	
Psammocora nierstrazi van der Horst						X				X			X	
Psammocora sp. 1											X			X
Family Pocilloporidae														
Stylophora mordax (Dana)													X	
Seriatopora hystrix (Dana)	X		X	X	X					X			X	
Pocillopora damicornis (Linnaeus)	X	X	X	X	X		0	X	X	X	0		X	X
Pocillopora elegans Dana													X	
Pocillopora verrucosa (Ellis & Solander)	X				X	X	0	X					X	
Pocillopora sp. 1													X	
Family Acroporidae														
Acropora acuminata Verrill			X	X				X					X	
Acropora affinis Crossland	X		X	X				X						
Acropora aspera (Dana)					X									
Acropora brueggemanni (Brook)	X						0							X
Acropora clathrata (Brook)	X		X	X	X		0	X	X	X			X	
Acropora cythrata (Dana)													X	
Acropora divaricata (Dana)					X	X	0		X	X				
Acropora diversa (Brook)	X				X								X	
Acropora echinata (Dana)			X										X	
Acropora elseyi (Brook)	X		X	X	X		0		X	X			X	

Table 5 continued.

	1	2	3A	3B	4A	4B	5++	6A	6B*	7	8A	8B*	9	10*
Acropora cf. A. grandulosa (Milne Edwards & Haime)	X		X	X	X			X		X			X	
Acropora formosa (Dana)	X	X	X	X		X	0	X	X	X			X	
Acropora humilis (Dana)			X	X	X		0		X	X			X	
Acropora hyacinthus (Dana)	X	X	X		X	X	0	X		X			X	
Acropora irregularis (Brook)													X	
Acropora longicyathus (Milne Edwards & Haime)					X								X	
Acropora polymorpha (Brook)	X		X	X	X		0						X	X
Acropora quelchi (Brook)	X			X					X				X	
Acropora samoensis (Brook)					X									
Acropora squarrosa (Ehrenberg)	X	X		X	X		0		X	X			X	
Acropora tenuis (Dana)	X		X	X	X				X	X				
Acropora valida (Dana)										X			X	
Acropora variabilis (Klunzinger)	X				X			X					X	
Acropora virgata (Dana)		X												X
Acropora sp. 1			X		X			X						
Acropora sp. 2				X	X								X	
Acropora sp. 3													X	
Acropora sp. 4													X	
Astreopora eliptica Yabe & Sugiyama														X
Astreopora gracilis Bernard	X									X				X
Astreopora myriophthalma (Lamarck)	X				X	X				X			X	
Montipora acanthella Bernard								X						X
Montipora conicula Wells	X	X	X		X	X				X				
Montipora elschneri Vaughan		X				X				X				
Montipora foliosa (Pallas)													X	
Montipora foveolata (Dana)										X				
Montipora hoffmiesteri Wells			X	X		X				X				
Montipora hobulata Bernard		X					0						X	
Montipora tuberculosa (Lamarck)													X	
Montipora verrilli Vaughan	X		X			X			X	X			X	
Montipora verrucosa (Lamarck)			X							X				

Table 5 continued.

	1	2	3A	3B	4A	4B	5++	6A	6B*	7	8A	8B+	9	10*
Family Agariciidae														
Pavona multivensis (Gardiner)										X				
Pavona varians Verrill		X			X		0		X	X			X	
Pavona sp. 1													X	X
Pachyseris rugosa (Lamarck)				X		X				X			X	X
Family Fungidae														
Fungia echinata (Pallas)				X									X	
Fungia fungites (Linnaeus)	X			X	X			X	X	X	X		X	
Fungia repanda Dana	X			X						X			X	
Herpentoglossa simplex (Dana)	X									X				
Herpolitha limax (Esper)				X									X	
Polyphyllia talpina (Lamarck)										X				X
Parahalmitra robusta (Quelch)					X									
Family Poritidae														
Goniopora arbuscula Umbgrove	X									X			X	
Goniopora lobata Milne Edwards & Haime														X
Goniopora sp. 1											0			
Porites andrewsi Vaughan	X		X	X	X					X	X		X	X
Porites lichen Dana					X		0				X			
Porites lobata Dana	X									X			X	
Porites lutea Milne Edwards & Haime	X	X	X	X		X		X		X	X		X	
Porites murrayensis Vaughan													X	X
Porites sp. 1								X						
Porites (Synaraea) horizontalata Hoffmeister		X								X				
Porites (Synaraea) iwayamaensis Eguchi	X	X		X	X					X			X	
Stylaraea punctata Klunzinger													X	
Alveopora sp. 1				X	X	X	0	X	X	X	X		X	
Family Faviidae														
Favia favus (Forskal)	X		X				0			X	X		X	X

Table 5 continued.

	1	2	3A	3B	4A	4B	5++	6A	6B*	7	8A	8B+	9	10*
Favia matthai Vaughan		X			X									
Favia pallida (Dana)		X	X		X		0						X	X
Favia stelligera (Dana)							0				0		X	
Favites abdita (Ellis & Solander)		X		X		X	0			X	0		X	
Favites flexuosa (Dana)				X									X	
Favites russelli (Wells)													X	
Oulophyllia crispa (Lamarck)														X
Goniastrea edwardsi Chevalier		X				X								
Goniastrea pectinata (Ehrenberg)						X				X	0		X	
Goniastrea sp. 1														X
Platygyra lamiellina (Ehrenberg)					X								X	X
Leptoria phrygia (Ellis & Solander)										X				
Montastrea curta (Dana)	X	X		X	X	X				X			X	
Montastrea sp. 1					X	X								X
Diploastrea heliopora (Lamarck)				X						X				
Leptastrea purpurea (Dana)	X			X	X	X				X				
Leptastrea transversa Klunzinger					X	X				X	X		X	X
Cyphastrea chalcidicum (Forskal)										X				
Cyphastrea serailia (Forskal)										X			X	
Family Merulinidae														
Clavarina scrabicula (Dana)	X		X							X				
Merulina ampliata (Ellis & Solander)										X			X	
Family Oculinidae														
Galaxea fascicularis (Linnaeus)													X	
Acrhelia horrescens (Dana)			X											X
Family Mussidae														
Lobophyllia corymbosa (Forskal)					X				X	X				
Lobophyllia costata (Dana)	X			X	X		0			X	X		X	X
Lobophyllia hemprichii (Ehrenberg)										X			X	X

Table 5 continued.

		1	2	3A	3B	4A	4B	5++	6A	6B	7	8A	8B+	9	10*
Lobophyllia (Palauphyllia) hataii Yabe, Sugiyama & Eguchi							X				X				X
Symphyllia valenciennesii Milne Edwards & Haime										X	X				X
Family Pectiniidae															
Echinophyllia aspera (Ellis & Solander)				X							X			X	
Oxypora lacera (Verrill)				X											
Pectina lactuca (Pallas)				X							X	X			X
Family Caryophyllidae															
Euphyllia glabrescens (Chamisso & Eysenhardt)			X		X		X				X			X	
Plerogyra sinuosa (Dana)							X								
Physogyra lichtensteini (Milne Edwards & Haime)		X									X				X
Class Hydrozoa															
Order Milleporina															
Family Milleporidae															
Millepora exaesa Forskaal			X			X					X			X	X
Millepora dichotoma Forskaal					X					X					
Family Stylasteridae															
Distichopora violacea (Pallas)		X	X			X	X	0		X	X				X
Stylaster elegans Verrill							X								
TOTAL GERNERA	45	17	12	13	17	18	17	0	6	10	32	7	0	31	24
TOTAL SPECIES	115	36	20	29	34	40	24	0	16	17	59	9	0	69	31

* Station not sampled in 1981 study
\+ Station buried in sediment 1980 ++ Station buried in sediment 1981
0 Coral found in 1980 survey, but absent in 1981 survey.

Table 6. Mean percent coral cover ($\overline{Y}$) and range (w) at the monitoring stations from 1978 to 1981.

STATION	1978		1979		1980		1981	
	$\overline{Y}$%	w%	$\overline{Y}$%	w%	$\overline{Y}$%	w%	$\overline{Y}$	$\overline{w}$
1	13.00	-	48.02	46.82-49.22	61.44	49.05-73.83	46.43	43.93-48.93
2	10.15	-	15.89	12.78-18.99	65.02	60.00-70.04	60.42	57.78-63.05
3A	53.31	-	17.40	13.64-21.15	14.13	12.27-15.99	19.75	15.25-24.25
3B	*	-	29.99	29.29-30.68	14.93	9.51-20.35	21.67	19.83-23.50
4A	33.11	-	37.58	-	43.5	27.93-49.07	46.23	39.55-52.91
4B	46.6	-	70.41	65.75-75.06	60.59	56.47-64.7	62.63	61.24-64.02
5	18.06	-	17.15	8.73-25.56	1.54	.39- 2.69	0	0
6A	75.4	63.07-97.73	55.85	33.3 -78.4	36.67	30.16-43.07	50.71	36.40-65.02
6B	32.36	1.82-62.90	-	-	47.77	62.72-32.81	-	-
7	38.62	-	27.93	25.25-30.6	53.75	49.35-58.14	71.02	66.51-75.54
8A	2.71	-	2.75	2.74- 2.76	.125	0.101- .15	.58	.05- 1.11
8B	26.45	-	22.87	18.12-27.62	0	0	0	0
9	80.4	-	60.1	59.81-60.39	69.40	63.50-75.29	73.39	62.83-83.96
10	-	-	19.3	18.58-20.02	25.73	21.00-30.45	-	-

*Station 3A and 3B combined in the 1978 coral analysis.

Table 7A. Parameters of coral distribution, Station 1, 1981. Symbols are as follows: n = number of corals, $\bar{Y}$ = mean colony diameter cm, s = standard deviation, w = range. Point-quarter method.

Species	Size Distribution of Colonies Diameters (cm) N	Y	S	W	Frequency	Relative Frequency	Density per m^2	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Acropora formosa	12	63.3	76.7	9.5-144.7	.60	23.08	1.212	30.00	38.12	86.77	139.85
Porites (S.) iwayamaensis	13	19.4	21.3	3. - 37.5	.60	23.08	1.313	32.50	3.87	8.81	64.39
Pocillopora damicornis	2	11.2	3.1	9.0- 13.4	.20	7.69	.202	5.00	.21	.47	13.27
Seriatophora hystrix	2	2.7	3.2	2.5- 2.8	.20	7.69	.202	5.00	.02	.04	12.73
Acropora quelchi	1	20.4			.10	3.85	.101	2.5	.30	.75	9.42
Porites lutea	1	26.5			.10	3.85	.101	2.5	.56	1.27	7.62
Acropora hyacinthus	2	12.1	9.8	9.3- 14.9	.10	3.85	.202	5.0	.24	.57	6.92
Fungia fungites	1	16.0			.10	3.85	.101	2.5	.20	.46	6.81
Acropora diversa	1	12.5			.10	3.85	.101	2.5	.12	.27	6.62
Fungia rapanda	1	12.0			.10	3.85	.101	2.5	.11	.25	6.60
Acropora tenuis	1	10.9			.10	3.85	.101	2.5	.09	.20	6.55
Acropora cf. A. grandulosa	1	7.5			.10	3.85	.101	2.5	.04	.09	6.44
Lobophyllia costata	1	3.4			.10	3.85	.101	2.5	.01	.02	6.37
Stylocoeniella armada	1	3.0			.10	3.85	.101	2.5	.01	.02	6.37

Overall Density 4.04 corals/m^2 Percent cover 43.93%

Table 7B. Parameters of coral distribution, Station 1, 1981. Line-intercept method.

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Acropora formosa	36.06	73.69	35.71
Porites (S.) iwayamaensis	10.06	20.55	28.57
Acropora elseyi	.71	1.45	13.57
Fungia repanda	.87	1.78	10.71
Acropora diversa	.32	.65	3.57
Seriatopora hystrix	.32	.65	3.57
Acropora clathrata	.19	.39	3.57
Acropora quelchi	.16	.33	3.57
Pocillopora damicornis	.23	.47	7.14

Total length = 3100
Percent cover = 48.93%

Table 8A. Parameters of coral distribution, Station 2, 1981. Line-intercept method.

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Porites lutea	48.89	84.61	66.66
Montipora conicula	4.44	7.68	11.11
Porites (S.) iwayamaensis	3.89	6.73	11.11
Acropora formosa	.55	.97	11.11

Percent coverage 57.78%
Total Distance 900 cm

Table 8B. Station 2 (Replicate).

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Porites lutea	49.44	78.41	66.67
Porites (S.) iwayamaensis	12.00	19.03	11.11
Acropora hyacinthus	1.33	2.11	11.11
Acropora squarrosa	.28	.44	11.11

Percent coverage 63.05%
Total Distance 900 cm

Table 9A. Parameters of coral distribution, Station 3A, 1981. Symbols are as follows: n = number of corals, $\bar{Y}$ = mean colony diameter cm, s = standard deviation, w = range. Point-quarter method.

Species	Size Distribution of Colonies Diameters (cm)				Frequency	Relative Frequency	Density per m^2	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
	N	Y	S	W							
Porites lutea	10	39.3	55.1	3.0- 99.8	.86	27.56	1.33	35.71	16.11	66.42	126.69
Acropora hyacinthus	3	33.4	40.1	1.6- 56.1	.43	13.78	.40	10.71	4.38	18.06	42.55
Acropora formosa	2	16.2	13.7	6.5- 25.9	.14	4.49	.27	7.14	.75	3.09	14.67
Porites andrewsi	2	10.7	4.5	7.5- 13.91	.14	4.49	.27	7.14	.26	1.07	12.70
Acropora clathrata	1	41.9			.14	4.49	.13	3.57	1.80	7.42	15.48
Acropora elseyi	2	2.9	2.4	1.1- 4.5	.29	9.29	.27	7.14	.02	.08	16.51
Psammocora digitata	1	24.5			.14	4.49	.13	3.57	.61	2.52	10.58
Favia favus	1	10.5			.14	4.49	.13	3.57	.11	.45	8.51
Montipora hoffmiesteri	1	9.4			.14	4.49	.13	3.57	.09	.37	8.43
Montipora verrucosa	1	7.7			.14	4.49	.13	3.57	.06	.25	8.31
Acropora cf. grandulosa	1	5.0			.14	4.49	.13	3.57	.03	.12	8.18
Acheilia horrescens	1	3.9			.14	4.49	.13	3.57	.02	.08	8.14
Acropora (unknown)	1	3.2			.14	4.49	.13	3.57	.01	.04	8.10
Pocillopora damicornis	1	2.0			.14	4.49	.13	3.57	.004	.02	8.08

Overall Density 3.728 Corals/m^2 Percent Cover 24.254%

Table 9B. Station 3A (Replicate)

Species	N	Size Distribution of Colonies Diameters (cm) Y	S	W	Frequency	Relative Frequency	Density per m^2	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Porites lutea	7	43.8	59.8	4.1- 99.8	.21	23.86	.73	25.00	11.00	72.13	120.99
Acropora formosa	3	22.9	24.3	9.5- 34.6	.07	7.96	.31	10.71	1.28	8.39	27.06
Acropora hyacinthus	2	32.2	-	-	.04	4.55	.21	7.14	1.71	11.21	22.90
Psammocora digatata	1	24.5	-	-	.04	4.55	.10	3.57	.47	3.08	11.20
Acropora elseysi	2	3.0	2.0	1.6- 4.4	.04	4.55	.21	7.14	.02	.13	11.82
Pocillopora damicornis	1	15.9	-	-	.04	4.55	.10	3.57	.20	1.31	9.43
Seriatopora hystrix	1	13.0	-	-	.04	4.55	.10	3.57	.13	.85	8.97
Favia favus	1	10.5	-	-	.04	4.55	.10	3.57	.09	.59	8.71
Pectina lactuca	1	10.4	-	-	.04	4.55	.10	3.57	.09	.59	8.71
Porites andrewsi	1	9.8	-	-	.04	4.55	.10	3.57	.08	.52	8.64
Montipora verrilli	1	7.7	-	-	.04	4.55	.10	3.57	.05	.33	8.45
Montipora hoffmiesteri	1	9.4	-	-	.04	4.55	.10	3.57	.07	.46	8.58
Acropora cf. A. grandulosa	1	5.0	-	-	.04	4.55	.10	3.57	.02	.13	8.25
Acropora clathrata	1	4.1	-	-	.04	4.55	.10	3.57	.01	.07	8.19
Acrhelia horrescens	1	3.9	-	-	.04	4.55	.10	3.57	.01	.07	8.19
Echinophyllia aspera	1	3.4	-	-	.04	4.55	.10	3.57	.01	.07	8.19
Stylocoeniella armada	1	2.5	-	-	.04	4.55	.10	3.57	.01	.07	8.19

Overall Density 2.91 corals/m^2 Percent cover 15.25%

Table 10A. Parameters of coral distribution, Station 3B, 1981. Symbols are as follows: n - number of corals, $\bar{Y}$ = mean colony diameter cm, s = standard deviation, w = range. Point-quarter method.

Species	Size Distribution of Colonies Diameters (cm) N	Y	S	W	Frequency	Relative Density	Density per m^2	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Porites lutea	10	38.2	33.8	5.4- 62.9	.50	17.86	1.042	32.36	11.94	50.81	101.03
Porites (S.) iwayamaensis	3	58.4	31.6	23.7- 85.5	.25	8.93	.312	9.68	8.36	35.57	54.18
Acropora hyacinthus	5	5.2	3.8	2.0- 8.0	.50	17.86	.519	16.13	.11	.47	34.46
Seriatopora hystrix	3	23.5	17.0	3.9- 34.3	.25	8.93	.312	9.68	1.35	5.75	24.31
Acropora elseyi	1	26.8	-	-	.13	4.64	.104	3.23	.59	2.51	10.38
Acropora formosa	1	26.1	-	-	.13	4.64	.104	3.23	.56	2.38	10.25
Acropora polymorpha	1	14.5	-	-	.13	4.64	.104	3.23	.17	.72	8.59
Acropora affinis	1	14.2	-	-	.13	4.64	.104	3.23	.16	.68	8.55
Pocillopora damicornis	1	12.7	-	-	.13	4.64	.104	3.23	.13	.55	8.42
Acropora clathrata	1	7.5	-	-	.13	4.64	.104	3.23	.05	.21	8.08
Fungia repands	1	7.0	-	-	.13	4.64	.104	3.23	.04	.17	8.04
Acropora cf. A. grandulosa	1	4.2	-	-	.13	4.64	.104	3.23	.02	.09	7.96
Euphyllia glabrescens	1	3.0	-	-	.13	4.64	.104	3.23	.01	.04	7.91
Acropora (unknown)	1	2.0	-	-	.13	4.64	.104	3.23	.01	.04	7.91

Overal Density 3.22 corals/m^2 Percent cover 23.50%

Table 10B. Station 3B (Replicate).

Species	N	Size Distribution of Colonies Diameters (cm) Y	S	W	Frequency	Relative Density	Density per m^2	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Porites lutea	9	41.	40.7	6.0- 86.8	.38	14.90	1.021	32.14	13.74	62.29	116.33
Seriatopora hystrix	3	22.2	17.9	1.6- 34.35	.13	5.10	.340	10.71	1.89	9.53	25.34
Acropora hyacinthus	4	11.7	15.1	2.0- 21.97	.13	5.10	.454	14.29	.49	2.47	21.86
Acropora clathrata	2	15.3	18.8	2.0- 28.6	.13	5.10	.227	7.14	.73	3.68	15.92
Porites andrewsi	2	14.2	6.2	10.2- 18.9	.25	9.80	.227	7.14	.41	2.07	19.01
Porites (S.) iwayamaensis	1	44.4	-	-	.13	5.10	.113	3.57	1.75	8.83	17.50
Fungia fungites	2	3.0	1.3	2.0- 3.9	.25	9.80	.227	7.14	.02	.10	17.04
Stylocoeniella armada	2	2.3	1.0	1.6- 3.0	.25	9.80	.227	7.14	.01	.10	17.04
Montipora hoffmeisteri	1	12.3	-	-	.13	5.10	.113	3.57	.53	2.67	11.34
Acropora squarrosa	1	8.0	-	-	.13	5.10	.113	3.57	.13	.66	9.33
Acropora quelchi	1	4.4	-	-	.13	5.10	.113	3.57	.06	.30	8.97
Acropora (unknown)	2	4.4	2.0	3.0- 6.9	.25	9.80	.227	7.14	.04	.20	17.14
Acropora formosa	1	7.3	-	-	.13	5.10	.113	3.57	.05	.25	8.62
Acropora cf. A. grandulosa	1	3.0	-	-	.13	5.10	.113	3.57	.01	.05	8.42

Overall Density 3.18 coral/m^2 Percent cover 19.83%

Table 11A. Parameters of coral distribution, Station 4A, 1981. Line-intercept method.

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Porites (S.) iwayamaensis	24.81	46.89	36.36
Acropora formosa	23.84	45.06	31.82
Seriatopora hystrix	2.07	3.91	13.63
Pocillopora damicornis	.91	1.72	4.56
Acropora variabilis	1.22	2.31	4.56
Acropora clathrata	.06	.11	4.56

Percent coverage 52.91%
Total distance 1640 cm

Table 11B. Station 4A (Replicate).

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Acropora formosa	24.30	61.44	11.11
Porites (S.) iwayamaensis	5.00	12.64	14.81
Porites andrewsi	4.15	10.49	37.04
Seriatopora hystrix	1.55	3.92	7.41
Pocillopora verrucosa	1.35	3.41	3.70
Acropora longicyathus	1.15	2.90	3.70
Acropora elseyi	.70	1.77	3.70
Montipora conicula	.50	1.26	3.70
Fungia fungigets	.50	1.26	3.70
Alveopora sp. 1	.25	.63	3.70
Lobophyllia costata	.10	.25	3.70

Percent coverage 39.55%
Total distance 2000 cm

Table 12A. Parameters of coral distribution, Station 4B, 1981. Line-Intercept method.

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Porites lutea	59.68	97.45	92.86
Acropora formosa	1.56	2.55	7.14

Percent coverage 61.24%
Total distance 1550 cm

Table 12B. Station 4B (Replicate).

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Porites lutea	62.77	.98	87.5
Acropora formosa	1.29	.02	12.5

Percent coverage 64.06%
Total distance 1150 cm

Table 13A. Parameters of coral distribution, Station 6A, 1981. Line intercept method.

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Acropora formosa	20.83	57.23	50.00
Porites lutea	10.00	27.47	10.00
Acropora hyacinthus	4.17	11.46	10.00
Pocillopora damicornis	1.40	3.85	30.00

Percent coverage 36.40%
Total distance 1200 cm

Table 13B. Station 6A (Replicate).

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Acropora formosa	64.95	.99	91.00
Acropora hyacinthus	.07	.01	9.00

Percent coverage 65.02%
Total distance 1070 cm

Table 14A. Parameters of coral distribution, Station 7, 1981. Line-intercept method.

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Pavona multivensis	50.00	75.18	25.00
Porites (S.) iwayamaensis	3.97	5.97	5.00
Acropora elseyi	3.97	5.97	10.00
Porites lutea	2.64	3.97	10.00
Acropora hyacinthus	1.32	1.98	5.00
Acropora cf. A. gradulosa	1.32	1.98	5.00
Acropora formosa	.66	.99	5.00
Pavona varians	.66	.99	5.00
Euphyllia glabrescens	.66	.99	5.00
Pacillopora damicornis	.33	.50	5.00
Fungia fungites	.33	.50	5.00
Psammacora nierstrazi	.33	.50	5.00
Montipora foveolata	.33	.50	5.00
Acropora clathrata	.33	.50	5.00

Percent coverage 66.51%
Total distance 1510 cm

Table 14B. Station 7 (Replicate).

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Pavona multivensis	59.07	78.20	27.20
Porites lutea	10.00	13.24	9.09
Porites (S.) iwayamaensis	2.53	3.35	9.09
Pavona varians	1.47	1.96	9.09
Pocillopora damicornis	.67	.87	9.09
Fungia fungites	.60	.79	9.09
Symphyllia valenciennesii	.60	.79	9.09
Acropora cf. A. grandulosa	.40	.53	9.09
Astreopora myriopthalma	.20	.26	9.09

Percent coverage 75.54%
Total distance 1500 cm

Table 15A. Parameters of coral distribution, Station 8A, 1981. Symbols are as follows: n = number of corals, $\bar{Y}$ = mean colony diameter cm, s = standard deviation, w = range. Point-quarter method.

Species	Size Distribution of Colonies Diameters (cm) N	Y	S	W	Frequency	Relative Frequency	Density per m^2	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Porites lutea	20	13.0	11.8	1.1- 19.2	.80	34.78	.558	50.00	.74	67.27	152.05
Favia favus	11	5.9	4.9	1.1- 7.7	.80	34.78	.307	27.50	.08	7.27	69.55
Fungia fungites	2	18.0	-	-	.20	8.70	.056	5.00	.14	12.72	26.42
Lobophyllia costata	2	9.8	2.9	7.7- 11.8	.10	4.35	.056	5.00	.04	3.64	12.99
Leptastrea transversa	2	1.1	-	-	.10	4.35	.056	5.00	.0001	.01	9.36
Alveopora sp. 1	1	19.5	-	-	.10	4.35	.028	2.50	.08	7.27	14.12
Pectima lactuca	1	9.4	-	-	.10	4.35	.028	2.50	.02	1.82	8.67
Porites andrewsi	1	2.5	-	-	.10	4.35	.028	2.50	.001	.09	6.94

Overall Density 1.12 corals/m^2 Percent cover 1.10%

Table 15B. Station 8A (Replicate).

Species	Size Distribution of Colonies Diameters (cm) N	Y	S	W	Frequency	Relative Frequency	Density per m^2	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Favia favus	19	6.4	5.6	1.1- 10.0	.9	56.25	.35	47.20	.01	20.83	124.58
Porites lutea	11	14.3	15.7	3.9- 29.6	.6	37.50	.20	27.50	.03	62.5	127.50
Alveopora sp. 1	3	6.1	2.7	3.0- 7.7	.3	18.75	.06	7.5	.002	4.17	62.97
Porites lobata	3	8.4	-	-	.3	18.75	.06	7.5	.003	6.25	32.55
Lobophyllia costata	3	7.5	1.9	5.3- 9.0	.3	18.75	.06	7.5	.002	4.17	30.42
Pectina lactuca	1	8.4	-	-	.1	6.25	.02	2.5	.001	2.08	10.83

Overall Density 6.73 corals/m^2 Percent cover .048%

Table 16A. Parameters of coral distribution, Station 9, 1981. Line-intercept method.

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Acropora formosa	65.50	78.01	31.82
Porites (S.) iwayamaensis	11.02	13.13	13.64
Porites andrewsi	1.60	1.90	4.55
Acropora squarrosa	1.60	1.90	4.55
Montipora lobulata	1.60	1.90	4.55
Goniopora lobata	.64	.76	4.55
Acropora elseyi	.32	.38	4.55
Acropora diveroa	.32	.38	4.55
Fungia fungites	.32	.38	4.55
Pocillopora damicornis	.32	.38	4.55
Acropora quelchi	.32	.38	4.55
Favia favus	.16	.19	4.55
Seriatopora hystrix	.16	.19	4.55
Cyphastrea serailia	.08	.10	4.55

Percent coverage 83.96%
Total distance 3130 cm

Table 16B. Station 9 (Replicate).

Species	Percent Cover	Relative Percent Cover	Relative Frequency
Acropora formosa	54.91	87.39	40.0
Psammocora nierstrazi	1.98	3.15	8.0
Pocillopora elegans	.73	1.16	4.0
Acropora clathrata	.69	1.09	4.0
Leptastrea transversa	.66	1.05	4.0
Seriatopora hystrix	.63	1.00	4.0
Acropora squarrosa	.59	.94	4.0
Pachyseris rugosa	.41	.65	4.0
Galaxea fascicularis	.38	.60	4.0
Acropora hyacinthus	.35	.56	4.0
Acropora longicyathus	.47	.75	4.0
Pocillopora damicornis	.31	.49	4.0
Acropora quelchi	.28	.45	4.0
Montipora verrelli	.28	.45	4.0
Favia favus	.16	.25	4.0

Percent coverage 62.83%
Total distance 3170 cm

Table 17. Densities of benthic macroinvertebrates encountered on transects of the monitoring stations. Densities are in individuals/m^2.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'	#	%
CNIDARIA																								
Alcoyonacea																								
Alcyonacean spp.	2.98	2.90	0.06		1.26	1.92	1.50	1.55	1.70	0.59	0.06	0.26			0.14	0.72	0.33	1.17	0.03	0.87		0.03-	18	82
Gorgonacea																								
gorgonacean spp.	0.02										0.06													
Cirripathes aguina	0.15			0.11							0.25	0.13			0.03		0.13							
ANNELIDA																								
Polychaeta																								
Sabellastarte cf. sanctijosephi							0.06	0.05				0.03												
Sabellastarte sp.		0.02			0.07	0.07					0.03	0.10						0.07						
MOLLUSCA																								
Gastropods																								
Tectus spp.							0.06	0.05			0.03	0.03	0.04				0.03				0.02	0.02-	8	36
Trochus niloticus									0.02															
Lambis scorpus					0.07	0.07																		
Strombus luhuanus							0.28	0.15		0.06														
Cypraea erosa							0.06	0.05																
Chicoreus brunneus							0.33	0.40			0.03				0.07	0.06								
C. ramosus										0.03														
Drupella elata									0.02															
Conus marmoreus		0.02													0.03									

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
+ Cerithium echinatum (Lamarck)	X											
+ C. morus Bruguiere											X	
+ Rhinoclavis aspera (Linnaeus)				X					X	X		
Lambis lambis (Linnaeus)	X	X		X	X	X	X					
+ L. scorpius (Linnaeus)		X	X									
+ Strombus gibberulus (Roeding)									X	X		
+ S. luhuanus Linnaeus	X	X	X	X					X			
+ S. variablis Swainson			X			X			X			
+ Cypraea annulus Linnaeus										X		
+ C. arabica Linnaeus										X		
C. argus (linnaeus)			*									
+ C. eglantina (Duclos)				*						X		
C. erosa Linnaeus			X						*			
+ C. helvola Linnaeus				*								
C. mappa Linnaeus			*									
C. moneta Linnaeus										X		
C. talpa Linnaeus				*								
C. tigris Linnaeus					*							
+ Cypraea sp. 1										X		
+ Cypraea sp. 2 ("maculifera arabica")										X		
+ Casmaria ponderosa (Gmelin)				*								
+ Cassis cornuta (Linnaeus)						X						
+ Phalium sophia (Brazier)						*						
+ Tonna perdix (Linnaeus)						*						
+ Gyrineum gyrinum (Linnaeus)			X	*				*				

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
+ Colubraria tortuosa (Reeve)				*								
+ Chicoreus brunneus (Link)			X	X		X	X					
C. ramosus (Linnaeus)				X			X					
+ Drupa ricinus (linnaeus)										X		
+ D. rubusidaeus Roeding				X								
+ Drupella elata Blainville				X					X			
+ Homalocantha anatomica (Perry)				X								
+ Morula granulata (Duclos)										X		
+ M. fiscella (Gmelin)			X	X					X	X		
+ Pterynotus triqueter (Born)								*				
+ Coralliophila violacea (Keiner)		X	X	X			X					
+ Rapa rapa Linnaeus			*									
+ Mitrella ligula (Duclos)			X			*						
+ Pyrene deshayesii (Crosse)	X	X	X	X		X	X					
+ P. ocellata (Link)											X	
+ P. punctata (Bruguiere)				X								
+ P. testudinaria (Link)				X								
+ Pisania gracilis (Reeve)						X						
+ Cantharus fumosus Dillwyn										X	X	
+ Engina alveolata (Kiener)										X		
+ Nassarius distortus (A. Adams)										X		
+ N. graniferus (Kiener)				X						X		
+ N. pauperus (Gould)					X							
+ Latirus polygonus (Gmelin)				X								
+ Peristernia cf. incarnata (Kiener)				X								
+ Oliva carneola Gmelin						X				X		

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
+ O. miniacea Roeding					X							
Vasum turbinellus (Linnaeus)			X									
Imbricaria conularis (Lamarck)				*								
+ Mitra ferruginea Lamarck				*								
+ M. fraga Quoy & Gaimard				X								
+ M. lugubris Swainson					X							
+ M. tabanula Lamarck				X								
Vexillum cadaverosum (Reeve)									X			
+ V. discolorium (Reeve)			X	X	X							
+ V. exasperatum (Gmelin)									X			
+ V. granosum (Gmelin)									X			
+ V. sanguisugum (Linnaeus)										X		
Vexillum sp.										X		
+ Conus aureus Hwass			*									
+ C. imperialis Limnaeus	X								X			
+ C. lividus Hwass									X			
+ C. magus Linnaeus							*					
+ C. marmoreus Linnaeus	X					X				X		
+ C. pulicarius Hwass			X	X					X			
+ C. scabriusculus Dillwyn				*								
+ C. sponsalis Hwass				X						X		
+ C. vexillum Gmelin				X								
Terebra affinis Gray				X								
+ T. felina (Dillwyn)			X									
+ T. guttata (Roeding)				X						X		
T. maculata (Linnaeus)			X							X	X	
+ T. subulata (Linnaeus)						X						

Table 17 continued.

	1 1'	2 2'	3A 3A'	3B 3B'	4A 4A'	4B 4B'	6A 6A'	6B 6B'	7 7'	8A 8A'	9 9'	#	%
Bivalvia													
Arcidae	0.03 0.03	10.72 10.94	1.43 2.21	1.00 1.70	0.10	4.34 5.27	0.27 0.15	0.03	0.17 0.30	0.23 0.07		-18	82
Pteria cypsellus					0.02				0.07				
Pincatada margaritifera	0.02					0.09		0.03		0.03			
Pedum spondyloideum		0.22 0.22	0.14 0.14	0.22 0.30		0.03		0.03	0.07			- 9	
Pycyndonte hyotis		0.28 0.22	0.14	0.17	0.10 0.15	0.06 0.23		0.13 0.33	0.13 0.07	0.20 0.07	0.02 0.06	-16	73
Chama sp.										0.03 0.03			
ECHINODERMATA													
Asteroidea													
Culcita novaeguineae						0.03							
Echinaster luzonicus				0.05									
Fromia milleporella			0.07 0.07										
Linckia multifora			0.07			0.03							
Echinoidea													
Echinostrephus aciculatus						0.06 0.07		0.03 0.06					
Holothuroidea													
Bohadschia graeffei	0.03 0.03				0.02	0.03					0.02		
Holothuria atra	0.03 0.05		0.07	0.06 0.05									
H. edulis	0.02 0.03				0.02						0.02		

Table 17 continued.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'	#	%
Holothuroidea (continued)																								
Stichopus chloronotus		0.02			0.07	0.07			0.08															
S. variegatus																		0.03						
Crinoidea																								
Comanthus bennetti	0.03	0.05	0.06				0.06				0.03	0.03												
C. multifidus	0.02	0.02																						
CHORDATA																								
Ascidacea																								
Phallusia julinea	0.25	0.23	0.06	0.06	0.36	0.29	0.22	0.10	0.02	0.15	0.12	0.43		0.05	0.63	0.28	0.80	0.47	0.63	0.40	0.06	0.34	-21	95
Ascidacean sp.																	0.27	0.17						

Table 18. Checklist of all macroinvertebrates observed or collected during the present study. This list includes species encountered on transects, near monitoring stations, and at sites outside the study area. Live specimens are denoted by "X", and dead speciments by "*". + denotes specimen in the collection at the University of Guam Marine Lab. (S = Sepuk; BL = Blue Lagoon Dive Shop Jetty; BD = Boat Pool dock.)

	1	2	3	4	5	6	7	8	9	S	BL	BD
PORIFERA												
Cinachyra sp.							X					
porifera sp. (blue vase)	X	X		X		X						
CNIDARIA												
Anthozoa												
Stichodactylid spp.						X		X		X		
Alcyonacea												
Neptheid spp.	X	X				X						
Lobophytum sp.					X				X			
Sacrophytum sp.	X	X	X	X		X	X		X			
Sinularia sp.	X		X	X		X	X	X	X			
Xeniid spp.	X	X	X	X		X						
Cirripathes anguina Dana	X	X		X			X	X				
Gorgonian spp.	X			X		X						
ANNELIDA												
Polychaeta												
Sabellastarte cf. *sanctijosephi* (Gravier)			X	X		X						
Sabellastarte sp.	X		X	X		X	X		X			
Spirobranchus sp.		X		X						X		

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
MOLLUSCA												
Gastropods												
+ Haliotis ovina Gmelin		*	*							X		
+ Euchelus atratus (Gmelin)										X		
+ Tectus pyramis (Born)	X		X	X		X	X		X			
+ Tectus triserialis				X								
+ Trochus incrassatus Lamarck	X	X	X							X		
+ T. maculatus Linnaeus										X		
T. niloticus Linnaeus	X	X		X		X			X			
+ Leptothyra haninia (Souverbie)											X	
Turbo petholatus Linnaeus						*						
Turbo sp.						*						
+ Nerita plicata Linnaeus										X	X	
+ N. reticulata Karsten										X	X	
+ N. squamulata (Le Guillou)?											X	
+ N. undata Linnaeus										X	X	
+ Neritopsis radula (linnaeus)											*	
+ Littorina scabra (Linnaeus)											X	X
+ L. undulata Gray											X	X
+ Nodolittorina millegrana (Phillipi)											X	
Pedaloconchus cf. keenae Hadfield & Kay		X	X	X		X	X					
+ Planaxis sulcatus (Born)										X		
+ Quoyia decollata (Quoy & Grimard)										X		

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
+ Turridrupa bijubata (Reeve)			X									
Bivalvia												
Arca ventricosa Lamarck		X	X	X			X	X				
Barbatia sp.	X	X	X	X		X	X	X				
Atrina sp.			X									
+ Pteria cypsellus (Dunker)				X			X					
+ Pinctada margaritifera (Linnaeus)	X			X		X		X				
Pedum spondyloideum (Gmelin)		X	X	X		X	X					
Lopha cristagalli (Linnaeus)						X						
Ostrea sp.			X									
+ Pycnodonte hyotis		X	X	X		X	X	X	X			
Chama sp.								X				
Hippopus hippopus (Linnaeus)										X		
Tridacna squamosa Lamarck		X						X				
+ Periglypta puerpera (Linnaeus)				*								
+ Gastrochaena cuneiformis Spengler						X						
ARTHROPODA												
Crustacea												
+ Gonodactylus cf. ternatensis DeMan				X		X						
Saron neglectus DeMan				X								
Saron sp.	X											
Panulirus ornatus (Fabricius)								X				
Callianassid sp.	X											

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
+ Galathea affinis Ortmann				X								
+ Neopetrolisthes masculatus H. Milne Edwards						X				X		
+ Petrolisthes asiaticus (Leach)											X	
+ Petrolisthes sp.										X	X	
Anriulus sp.				X								
+ Calcinus laevimanus Randall											X	
+ C. minutes Buitendijk				X		X	X		X			
+ C. pulcher Forest	X		X	X								
+ Clibanarius virescens (Krauss)											X	
+ Dardanus guttatus (Olivier)				X		X	X					
+ D. lagopodes (Forskaal)			X			X						
+ D. cf. woodmasoni (Alcock)			X				X					
+ Diogenes cf. gardineri Alcock			X	X								
Pagurid spp.						X	X					
Dromiid sp.				X								
+ Huenia proteus deHaan				X								
Majid spp.				X								
+ Hapalocarcinus marsupialis Stimpson				X					X			
+ Pseudocryptochirus crescentus (Edmundson)							X					
+ Thalamita pilumnoides Borradaile								X				
+ Thalamitoides quadridens A. Milne Edwards	X								X			
+ Etisus utilis Lucas									X			
+ Tetralia glaberrima (Herbst)				X								
+ Tetralia sp.						X			X			
+ Trapezia cymodoce (Herbst)						X					X	
Grapsus tenuicrustatus (Herbst)											X	

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
ECHINODERMATA												
Crinoidea												
Comanthus bennetti (J. Müller)	X	X	X	X								
C. multifidus (J. Müller)	X											
Asteroidea												
Culcita novaeguineae Müller and Troschel				X		X				X		
+ *Echinaster luzonicus* (Gray)			X							X		
+ *Fromia milleporella* (Lamarck)			X						X			
Linckia laevigata (linnaeus)		X								X		
L. multifora (Lamarck)			X	X						X		
Ophiuroidea												
+ *Ophiocoma fusca* Brock							X					
Echinoidea												
Echinometra mathaei (deBlainville)							X					
Echinostrephus aciculatus A. Agussiz				X		X						
Echinothrix calamaris (Pallas)	X		X									
+ *Eucidaris metularia* (Lamarck)						X						
Holothuroidea												
Bohadschia argus Jaeger				X								
B. graeffei (Semper)	X		X	X		X			X			
B. marmorata Jaeger				X								
Holothuria atra Jaeger	X	X	X	X	X	X			X	X		
H. edulis Lesson	X	X		X			X		X			
H. hilla Lesson									X	X		
H. pervicax Selenka									X			

Table 18 Continued.

	1	2	3	4	5	6	7	8	9	S	BL	BD
Stichopus chloronotus Brandt	X		X	X	X					X		
S. variegatus Semper			X	X		X	X					
CHORDATA												
Asideacea												
Didemnum ternatanum (Gottschaldt)		X		X		X	X	X	X	X		
+ *Phallusia julinea* Sluiter	X	X	X	X	X	X	X	X	X			

Table 19. Fish census data, Station 1. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus nigrofuscus		1	2	1	✓		
A. xanthopterus		1	✓		✓		
* Ctenochaetus striatus	10	19	16	9	18	6	23
Naso vlamingi	2				✓		
Zebrasoma scopas					1		✓
Z. veliferum	3	✓	✓		✓	✓	
APONGONIDAE							
Apongon novemfasciatus		✓					
Cheilodipterus macrodon			1				
Paramia quinquelineata	2		✓	84		✓	
* sp. A				2			
BALISTIDAE							
Sufflamen chrysoptera	✓			✓			
BLENNIIDAE							
* Meiacanthus atrodorsalis		1	1	6	2	2	19
CANTHIGASTERIDAE							
Canthigaster valentini						✓	

Table 19 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
CENTRISCIDAE							
Aeoliscus sp.							✓
CHAETODONTIDAE							
Chaetodon auriga					✓		
C. ephippium		✓			✓		
C. kleini	1		✓			✓	✓
C. trifascialis							✓
C. trifasciatus	1	✓	✓				
C. ulietensis			✓		✓		
Heniochus acuminatus	✓						
H. chrysostomus						✓	
ELEOTRIDAE							
Ptereleotris tricolor	✓						
GOBIIDAE							
sp. A (pale)				✓			
sp. B (brown stripe, orange tail spot)						✓	
LABRIDAE							
Cheilinus diagrammus	2	3	6		1		
* C. fasciatus	✓		2	✓			
C. rhodochrous		✓					
Cirrhilabrus cyanopleura				✓	1		

Table 19 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
LABRIDAE (continued)							
* Coris variegatus		✓	✓	1	✓	✓	
Epibulus insidiator		1	✓				
* Halichoeres hoeveni	12	18	10	16	12	2	13
H. marginatus	2						
Hemigymnus melapterus		✓			✓		
* Labrichthys uniliniata	2	6	7	5	9	4	6
* Labroides dimidiatus	5	2	✓	4	3	1	1
Macropharyngodon meleagris	3						
Stethojulis bandanensis				2	3		
juvenile		4					
unidentified	2			2	1		
LUTJANIDAE							
Caesio caerulaureus			✓		✓	✓	
* Lutjanus fulvus			✓	✓			
Lutjanus sp.			✓				
MULLIDAE							
Parupeneus barberinus				✓			
P. trifasciatus		✓		✓			1
POMACANTHIDAE							
Centropyge vroliki	1		✓				
POMACENTRIDAE							
* Amblyglyphidodon curacao	70	37	26	12	13	1	4

Table 19 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
POMACENTRIDAE (continued)							
* Chromis atripectoralis	2		100	✓	1	✓	✓
* C. ternatensis(?)	4	3	5				
* C. xanthura(?)	23				✓		
* Dascyllus aruanus		1	2				
* Glyphidodontops traceyi	5	2	2	2		✓	✓
Pomacentrus molluccensis(?)				✓	✓		✓
* P. pavo	65	135	40	23	82		
* P. vaiuli	2	2					✓
sp. A		7	7	1	3	8	3
sp. B					1		2
* sp. C		2	4	✓	1	2	2
* sp. D	7	6	3	1	5	1	
* sp. E		24	25				
unidentified	1						
SCARIDAE							
Cetoscarus bicolor	2			✓			
Scarus ghobban	✓	✓	✓				
* S. troscheli			✓				
* S. venosus		✓	1	✓	✓	✓	1
sp. A	✓	✓	✓	✓			✓
juv. scarids	1	12		1	✓	6	3
SERRANIDAE							
Epinephelus merra		✓					
Epinephelus sp.					✓		

Table 19 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
SIGANIDAE							
Siganus puellus	1		✓				
S. spinus			✓				
S. virgatus	4	✓	✓				
* S. vulipinus	5						
SYNGANATHIDAE							
Corythoichythys intestinalis					✓	2	✓
SYNODONTIDAE							
Synodus variegatus				1	✓		
ZANCLIDAE							
Zanclus cornutus		✓	✓		✓		✓
Total No. Species	34	35	39	31	35	22	23
No. Species on Transect	28	21	20	18	17	11	13
No. Individuals on Transect	240	287	261	173	157	35	79
Transect Length(M)	30	31	31	32	32	30	31
No. Individuals/M^2	4.00	4.63	4.21	2.70	2.45	0.58	1.27
No. Conspicuous Resident Species	16	16	20	16	13	13	12
Density Conspic. Res. (NO./M^2)	3.57	4.16	4.02	1.25	2.28	0.32	1.08

Table 20. Fish census data, Station 2. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus nigrofuscus						✓	1
A. xanthopterus			1				
* Ctenochaetus striatus	3	1		1	6	3	3
Zebrasoma veliferum			1				
APOGONIDAE							
Cheilodipterus macrodon					✓		
Paramia quinquelineata	2						
BLENNIIDAE							
* Meiacanthus atrodorsalis			1			✓	✓
CHAETODONTIDAE							
Chaetodon auriga						✓	
C. ephippium			1				
* C. kleini	1						✓
* C. trifasciatus	1	1					
C. ulietensis						✓	1
Heniochus acuminatus			1				
GOBIIDAE							
unidentified		✓			2		

Table 20 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
HOLOCENTRIDAE							
* Adioryx spinifer			1	1	1	✓	✓
* Flammeo operculare						1	1
Myripristis sp.				1	1	1	✓
LABRIDAE							
* Coris variegatus			1	✓		1	1
Halichoeres centiquadrus					✓		
* H. hoeveni	4	2	7	2	7	2	6
* Labroides dimidiatus	2	3	4	1	1	1	1
sp. A						1	
LUTJANIDAE							
Caesio caerulaureus				3	✓		
Caesio sp.				125	✓		
MULLIDAE							
Parupeneus trifasciatus		1	1				
POMACENTRIDAE							
* Amblyglyphidodon curacao				✓			
* Chromis margaritifer		1	1	1	4	2	
* C. ternatensis(?)					✓		
* C. xanthura(?)	3			1	2	6	6
* Dascyllus aruanus						✓	✓
* Glyphidodontops traceyi	1	1	1	1	✓		

Table 20 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
POMACENTRIDAE (continued)							
* Pomacentrus pavo	57	72	33	35	101	42	41
sp. A					5		
* sp. C		2	3	4	6	1	1
* sp. E				5	12		
juveniles	1						
SCARIDAE							
sp. B				✓			
juveniles		1					
SYNODONTIDAE							
Synodus variegatus				✓		✓	
Total No. Species	10	13	15	16	17	18	15
No. Species on Transect	10	11	15	12	11	11	10
No. Individuals on Transect	75	90	69	176	148	61	62
Transect Length (M)	9.5	9.5	9.5	10.0	9.6	9.0	9.0
No. Individuals/M^2	3.95	4.74	3.63	8.80	7.71	3.39	3.44
No. Conspicuous Resident Species	8	8	9	12	11	12	12
Density Conspic. Res. (NO./M^2)	3.79	4.37	2.74	2.60	7.29	3.28	3.33

Table 21. Fish census data, Station 3A. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus nigrofuscus	✓						2
* Ctenochaetus striatus	4	6	1	3	7	4	5
juveniles	1						
APONGONIDAE							
Paramia quinquelineata				1			
BLENNIIDAE							
Ecsenius bicolor	✓	1		1			
* Meiacanthus atrodorsalis	2		1	1		1	1
CHAETODONTIDAE							
Chaetodon auriga						1	
C. ephippium							
* C. kleini						1	1
* C. trifasciatus							
HOLOCENTRIDAE							
Adioryx diadema				✓			
LABRIDAE							
Cheilinus diagrammus		2				1	

Table 21 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
LABRIDAE (continued)							
* C. fasciatus	1			✓	✓		✓
Cheilinus sp.							✓
* Coris variegatus		1	✓	✓	1	1	✓
* Halichoeres hoeveni	11	6	5	1	3	4	✓
* Labrichthys unilineata				1		1	1
* Labroides dimidiatus		✓	1	3	2	2	2
Macropharyngodon meleagris							1
Stethoulis bandanensis	2			✓			
LETHRINIDAE							
Monotaxis grandoculis		✓	1				
MULLIDAE							
Parupeneus trifasciatus			1				
POMACENTRIDAE							
* Amblyglyphidodon curacao		1	2	3	3	2	1
* Chromis atripectoralis			7			2	14
* C. xanthura(?)				1	1	2	1
* Glyphidodontops traceyi	1	3	✓	✓	1		
Pomacentrus molluccensis(?)					✓		
* P. pavo	17			45	40	15	19
* P. vaiuli	1		✓				
sp. A	1				2		1
sp. B	1		2		✓	✓	
* sp. C		3	8	✓			✓

Table 21 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
POMACENTRIDAE (continued)							
* sp. E juveniles	1	2	4				
SCARIDAE							
juveniles			✓				
SYNGNATHIDAE							
Corythoichthys intestinalis				✓		✓	
Total No. Species	14	12	15	18	13	15	17
No. Species on Transect	12	9	12	10	9	13	12
No. Individuals on Transect	43	25	35	60	60	37	47
Transect Length (M)	6.6	6.6	6.6	7.0	7.0	6.8	7.0
No. Individuals/M	3.26	1.89	2.65	4.29	4.29	2.72	3.36
No. Conspicuous Resident Species	7	8	11	12	10	11	13
Density Conspic. Res. (No./M^2)	2.80	1.67	2.20	4.14	4.14	2.57	3.21

Table 22. Fish census data, Station 3B. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus nigrofuscus	1	✓					
* Ctenochaetus striatus	10	3	4	7	8	9	2
Zebrasoma scopas		✓	✓		✓		
Z. veliferum		✓				✓	
juveniles	1				1		
APONGONIDAE							
Paramia quinquelineata	3					✓	✓
BLENNIIDAE							
Ecsenius bicolor		1					
* Meiacanthus atrodorsalis	1			✓	1	✓	
CHAETODONTIDAE							
Chaetodon auriga				✓	✓		
C. ephippium		✓					
* C. kleini		1					
C. melannotus			✓		✓		
* C. trifasciatus	1			1			
C. ulietensis				✓			
Heniochus chrysostomus					✓	1	1
H. varius				✓			

Table 22 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
HOLOCENTRIDAE							
Adioryx diadema		✓					
* Flammeo operculare						✓	
Myripristis sp.		2	2	3	1	5	1
MULLIDAE							
Parupeneus trifasciatus				1	✓	1	✓
LABRIDAE							
Cheilinus diagrammus			✓		✓		✓
* C. fasciatus			✓		1	1	1
* Coris variegatus	1	✓					
Epibulus insidiator			1				
* Halichoeres hoeveni	10	8	3	3	5	6	4
* Labrichthys unilineata			1				
* Labroides dimidiatus	1	1	3	3		1	
Macropharyngodon meleagris		✓					
Stethojulis bandanensis	2						
sp. A				1	✓	1	
LUTJANIDAE							
* Lutjanus fulvus				1	✓	1	
PLECTORPHNCHIDAE							
Plectorhynchus goldmanni		✓					

Table 22 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
POMACANTHIDAE							
Centropyge vroliki				1			1
POMACENTRIDAE							
* Amblyglyphidodon curacao	10	3	3	4	4	7	4
* Chromis atripectoralis		1	7	30			
* C. xanthura(?)	14			2	1	7	1
* Dascyllus aruanus	✓	3	2	5	6	✓	5
D. reticulatus					✓		
* Glyphidodontops traceyi	2	2	2	1	4	3	3
Pomacentrus molluccensis(?)		✓			3	1	1
* P. pavo	48	30	12	50	21	65	7
* P. vaiuli						1	1
sp. A					3	1	
sp. B					1		
* sp. C							1
* sp. E		4	4				
juveniles	2						
unidentified	4						
SCARIDAE							
Scarus ghobban						✓	
sp. A		✓	✓				
sp. B				1	2		✓
SERRANIDAE							
Variola louti		✓					

Table 22 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
SIGANIDAE							
Siganus virgatus							
SYNGNATHIDAE							
Corythoichthys intestinalis		✓		2		✓	2
ZANCLIDAE							
Zanclus cornutus						✓	
Total No. Species	19	24	19	21	24	24	19
No. Species on Transect	16	12	12	17	15	16	15
No. Individuals on Transect	111	59	44	116	62	111	35
Transect Length (M)	11.8	9.3	9.3	10.5	11.0	9.5	10.0
No. Individuals/M^2	4.70	3.17	2.37	5.52	2.82	5.84	1.75
No. Conspicuous Resident Species	11	11	11	12	10	13	10
Density Conspic. Res. (No./M^2)	4.15	2.20	3.01	5.10	2.32	5.32	1.45

Table 23. Fish census data, Station 4A. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus nigrofuscus				1			
* Ctenochaetus striatus	4	✓	3	3	7	6	6
Zebrasoma scopas					✓		
juveniles		2				✓	
APOGONIDAE							
* Apogon leptacanthus			21				
* Archamia fucata	9	25	20	10	1	100	50
Cheilodipterus macrodon						1	
Paramai quinquelineata						✓	
juveniles	220	300	200	✓	220	✓	✓
unidentified			25				
BLENNIIDAE							
Ecsenius bicolor			✓				
* Meiacanthus atrodorsalis		✓	✓	✓	1		
* Plagiotremus rhinorhynchus		✓				1	1
CANTHIGASTERIDAE							
Canthigaster solandri	1						
CARANGIDAE							
Caranx sp.							1

Table 23 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
CHAETODONTIDAE							
Chaetodon auriga					✓		
C. ephippium					✓	✓	
* C. kleini	2		✓		✓	1	2
C. lunula						✓	
* C. trifasciatus	✓						
C. ulietensis						✓	
Heniochus acuminatus		✓					
H. varius							✓
GOBIIDAE							
Amblygobius decussatus							1
HOLOCENTRIDAE							
Adioryx caudimaculatus					✓		
A. diadema					✓		
* A. spinifer						1	
Myripristis sp.		✓	✓	✓	✓	✓	✓
LABRIDAE							
Cheilinus diagrammus		✓		1	✓		✓
* C. fasciatus	1	✓	1		✓		
Cirrhilabrus					1		
* Coris variegatus		1	✓		✓	✓	
Epibulus insidiator					✓		
Gomphosus varius						✓	
* Halichoeres hoeveni	7	6	10	3	2	4	4

Table 23 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
LABRIDAE (continued)							
Hemigymnus melapterus					1		
* Labrichthys unilineata					✓	1	✓
* Labroides dimidiatus	3			2	✓	1	1
Stethojulis bandanensis			2				✓
Thalassoma lutescens					✓	1	1
Thalassoma juv.	1						
sp. A							✓
unidentified	1	1					
LETHRINIDAE							
* Gnathodentex aureolineatus	2	✓	✓	✓	✓	80	40
Monotaxis grandoculis	1	✓		1		✓	1
LOTJANIDAE							
Caesio caerulaureus		25				1	25
C. xanthonotus		✓			✓		
Caesio sp.		12	10	10	✓		
Lutjanus bohar							1
MUGILOIDIDAE							
Parapercis cephalopunctatus			✓				
MULLIDAE							
* Mulloidichthys vanicolensis		✓					
Parupeneus barberinus		1				✓	

Table 23 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
MULLIDAE (continued)							
P. trifasciatus							
PEMPHERIDAE							
* Pempheris ovalensis	3						
PLECTORHYNCHIDAE							
Plectorhynchus goldmanni							
POMACANTHIDAE							
Centropyge vroliki	3		1	1		2	2
POMACENTRIDAE							
* Amblyglyphidodon curacao	5	2	2	1	3	1	1
A. leucogaster							
* Chromis atripecteralis	1		2		20	9	
C. lepidolepis					1		
* C. margaritifer				1	1	1	1
* C. xanthura(?)	1	1		2	9		5
* Dascyllus aruanus							
D. retieulatus							
* Glyphidodontops traceyi	4	2	1	5	7	4	2
Pomacentus molluccensis(?)							
* P. pavo	47	207	106	127	105	145	130
P. vaiuli					1		
sp. A	1			3	7	2	

Table 23 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
POMACENTRIDAE (continued)							
* sp. C		1	1		1		
* sp. E		2	3			2	
SCARIDAE							
Cetoscarus bicolor							
Scarus ghobban				1			
* S. venosus							
Scarus sp. C							
juveniles							
SERRANIDAE							
* Cephalopholis urodelus						1	1
Epinephelus sp.							
SIGANIDAE							
Siganus virgatus							
* S. vulpinus							
SYNGNATHIDAE							
Corythoichthys intestinalis						2	1
SYNODONTIDAE							
Synodus variegatus							

Table 23 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ZANCLIDAE							
Zanclus cornutus							
Total No. Species	22	30	29	22	40	41	32
No. Species on Transect	20	15	16	16	16	22	21
No. Individuals on Transect	319	588	408	172	168	367	277
Transect Length (M)	14.4	16.0	16.0	17.5	17.0	16.0	15.5
No. Individuals/M^2	11.08	18.38	12.75	4.91	4.94	11.47	8.94
No Conspicuous Resident Species	15	16	18	12	19	20	16
Density Conspic. Res. (NO/M^2)	3.16	7.72	5.31	4.40	4.65	11.19	7.87

Table 24. Fish census data, Station 48. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979	1980A	1980B	1981A	1981B
ACANTHURIDAE						
Acanthurus nigrofuscus			✓	1	2	✓
A. xanthopterus				✓		
* Ctenochaetus striatus		9	11	11	12	24
* Naso literatus		✓			✓	✓
N. vlamingi				✓	1	✓
Zebrasoma scopas					1	
BALISTIDAE						
Sufflamen chrysoptera			1			
BLENNIIDAE						
Ecsenius bicolor		✓				
* Meiacanthus atrodorsalis			✓	1		
* Plagiotremus rhinorhynchus						✓
P. tapeinosoma		2				
CHAETODONTIDAE						
Chaetodon auriga					✓	✓
C. citrinellus					✓	
C. ephippium				✓		
* C. kleini		✓	1	✓	✓	✓
C. trifascialis					✓	
* C. trifasciatus		✓	✓			
C. ulietensis			✓		✓	

Table 24 continued.

	1978	1979	1980A	1980B	1981A	1981B
FISTULARIIDAE						
Fistularia commersonii			✓			
HOLOCENTRIDAE						
Myripristis		1	2	1		2
LABRIDAE						
Cheilinus diagrammus		2		1	9	
* C. fasciatus			✓	✓	2	✓
C. rhodochrous						✓
Cheilinus sp.						1
Cirrhilabrus cyanopleura		1		✓		
* Coris variegatus		✓			✓	✓
Epibulus insidiator						✓
Gomphosus varius		1		2	1	✓
* Halichoeres hoeveni	15	8	2	9	3	6
Hemigymnus melapterus			✓	✓	1	✓
* Labrichthys unilineata	1	1	✓	✓	1	3
* Labroides dimidiatus	1	4	✓	✓		✓
Macropharyngodon meleagris						✓
Stethojulis bandanensis			1	2		
Thalassoma amblycephala		1				
T. lutescens	1	✓		✓	3	✓
Thalassoma juveniles	1					
LETHRINIDAE						
Monotaxis grandoculis					✓	✓

Table 24 continued.

	1978	1979	1980A	1980B	1981A	1981B
LUTJANIDAE						
Caesio sp.				40		
Lutjanus sp.					✓	
MONACANTHIDAE						
Oxymonacanthus longirostris	1			✓		✓
MULLIDAE						
Parupeneus barberinus					✓	✓
P. trifasciatus	1		✓	✓		
OSTRACIONTIDAE						
Ostracion cubicus					1	
POMACANTHIDAE						
Centropyge vroliki			✓	✓	✓	
POMACENTRIDAE						
* Amblyglyphidodon curacao	2	52	28	15	39	21
* Chromis atripectoralis		100	26	200	6	27
C. caerulea						3
* C. margaritifer		1	1			1
* C. ternatensis(?)		10	✓	✓	4	
* C. xanthura(?)	24		2	4	4	39

Table 24 continued.

	1978	1979	1980A	1980B	1981A	1981B
POMACENTRIDAE (continued)						
* Dascyllus aruanus	2	1	10	7	12	24
* Glyphidodontops traceyi	1	8	2	1	✓	2
Pomacentrus molluccensis(?)				✓		
* P. pavo	51	90	29	51	✓	
* P. vaiuli	2	1	2	3	3	2
sp. A	1		1			
sp. B		6			9	5
* sp. C	11		7	8	9	8
* sp. D				4		
* sp. E		31				
unidentified	1					
SCARIDAE						
Scarus ghobban		✓		✓		✓
* S. venosus		✓			✓	1
Scarus sp. A		✓				✓
juveniles	12	1				
SERRANIDAE						
Epinephelus merra		✓	✓			1
SIGANIDAE						
Siganus virgatus				✓	✓	
* S. vulpinus					✓	

Table 24 continued.

	1978	1979	1980A	1980B	1981A	1981B
SYNGNATHIDAE						
Corythoichthys intestinalis					1	
ZANCLIDAE						
Zanclus cornutus		1				
Total No. Species	17	32	29	35	37	37
No. Species on Transect	17	22	16	18	21	17
No. Individuals on Transect	128	332	126	330	124	170
Transect Length(M)	19.0	22.0	21.0	19.0	20.0	17.0
No. Individuals/M^2	3.37	7.55	3.00	8.68	3.10	5.00
No. Conspicuous Resident Species	10	18	17	17	18	18
Density Conspic. Res. (NO/M^2)	2.89	7.18	2.88	8.26	2.38	4.62

Table 25. Fish census data, Station 5. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B
ACANTHURIDAE					
Acanthurus nigrofuscus					✓
A. xanthopterus				1	
* Ctenochaetus striatus	1	3	2	3	
APOGONIDAE					
* Apogon leptacanthus	65	79	45		
* Archamia fucata	32	11	4	58	51
Paramia quinquelineata	7			4	1
juveniles				535	370
BLENNIIDAE					
Ecsenius bicolor	2	✓	1		
* Meiacanthus atrodorsalis					1
* Plagiotremus rhinorhynchus				1	1
CANTHIGASTERIDAE					
Canthigaster solandri		✓	✓	✓	
CHAETODONTIDAE					
Chaetodon citrinellus				✓	✓
* C. kleini	✓	2	2		
C. trifascialis	1				

Table 25 continued.

	1978	1979A	1979B	1980A	1980B
ELEOTRIDAE					
Ptereleotris juveniles				8	
GOBIIDAE					
Amblygobius albimaculatus				✓	✓
Gobiodon citrinus	1				
LABRIDAE					
Cheilinus diagrammus	✓	1			
* Coris variegatus		3	1	1	1
* Halichoeres hoeveni	7	9	8	3	
* Labroides dimidiatus	1	4	1	2	
Stethojulis juveniles		2	1		✓
LETHRIDIDAE					
Monotaxis grandoculis			✓	1	
LUTJANIDAE					
Caesio juveniles	15			200	✓
Lutjanus sp. unidentified				✓	✓
MULLIDAE					
Parupeneus pleurostigma	✓		✓		✓
P. trifasciatus			✓	1	✓

Table 25 continued.

	1978	1979A	1979B	1980A	1980B
POMACENTRIDAE					
* Amblyglyphidodon curacao		✓		✓	
* Chromis xanthura(?)		1			
* Pomacentrus pavo	133	75	21	200	8
* P. vaiuli	1				✓
sp. A				1	
* sp. C					✓
unidentified	1				
SCARIDAE					
juveniles		✓			✓
SYNODONTIDAE					
Synodus variegatus				✓	✓
Total No. Species	16	15	14	21	19
No. Species on Transect	13	11	10	15	7
No. Individuals on Transect	267	190	86	1019	433
Transect Length(M)	9.0	9.0	9.0	9.0	8.0
No. Individuals/M^2	14.83	10.56	4.78	56.61	27.06
No. Conspicuous Resident Species	8	10	8	8	7
Density Conspic. Res. (NO./M^2)	13.33	10.39	4.67	14.89	3.88

Table 26. Fish census data, Station 6A. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978A	1978B	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE								
Acanthurus nigrofuscus	1	3				3	✓	✓
A. xanthopterus			1	✓		✓	✓	✓
* Ctenochaetus striatus	4	2	1	2	10	4	5	16
Naso vlamingi						1		
Zebrasoma scopas						✓		
APOGONIDAE								
Apogon novemfasciatus						4		
Cheilodipterus macrodon						✓		
CHAETODONTIDAE								
Chaetodon auriga						✓	✓	
C. ephippium		✓			✓			
* C. kleini		✓			✓	✓	4	✓
C. trifascialis	✓		1			✓		
* C. trifasciatus						✓	1	✓
FISTULARIIDAE								
Fistularia commersonii						✓		
HOLOCENTRIDAE								
Myripristis sp.		1				✓	✓	✓

Table 26 continued.

	1978A	1978B	1979A	1979B	1980A	1980B	1981A	1981B
LABRIDAE								
Cheilinus diagrammus		2			✓			2
Cheilinus sp.								1
Cirrhilabrus cyanopleura	✓	1	✓					
* Coris variegatus	1			✓	✓			
Epibulus insidiator		✓						
Gomphosus varius	✓							
* Halichoeres hoeveni	5	7	13	3	4	6	✓	12
* Labrichthys unilineata	✓					✓	1	4
* Labroides dimidiatus	2	2	2					
Stethojulis bandanensis		2			1	✓		2
juvenile labrids			1				1	
LETHRINIDAE								
Monotaxis grandoculis	✓						✓	
LUTJANIDAE								
Caesio caerulaureus		4	3			✓	1	✓
Caesio sp. A						✓	50	
Caesio sp. B					✓	✓		✓
* Lutjanus fulvus								
MONACANTHIDAE								
Paraluteres prionurus					✓			

Table 26 continued.

	1978A	1978B	1979A	1979B	1980A	1980B	1981A	1981B
MULLIDAE								
Mulloidichthys flavolineatus						✓		
Parupeneus barberinus			✓					
P. trifasciatus					✓			1
POMACENTRIDAE								
* Amblyglyphidodon curacao	10	3	1	3	15	9	18	11
* Chromis atripectoralis	1		✓	✓		1	1	✓
* C. ternatensis(?)			✓					
* C. xanthura(?)	2	2	3		3	1	✓	✓
* Dascyllus aruanus	✓	3						
* Pomacentrus pavo			1					
* P. vaiuli	3	2		✓	1	1	1	3
sp. A	5	3						
sp. B			1		1	2		
* sp. C		2	1	1	2	✓	1	✓
* sp. D	1	3						
sp. E				✓				
juveniles		✓						
SCARIDAE								
Scarus ghobban	2							✓
* S. venosus	1	✓	1			✓	✓	✓
juveniles								
ZANCLIDAE								
Zanclus cornutus	✓		1		1		✓	

Table 26 continued.

	1978A	1978B	1979A	1979B	1980A	1980B	1981A	1981B
Total No. Species	20	21	18	9	16	28	20	22
No. Species on Transect	13	16	14	4	9	11	11	10
No. Individuals on Transect	38	42	31	9	38	34	84	55
Transect Length(M)	11.0	12.5	11.0	10.0	23.3	12.0	12.0	10.7
No. Individuals/M^2	1.73	1.68	1.41	0.45	1.54	1.42	3.50	2.57
No. Conspicuous Resident Species	11	10	9	7	9	12	10	12
Density Conspic. Res. (NO./M^2)	1.32	1.04	1.00	0.45	1.42	1.00	1.33	2.29

Table 27. Fish census data, Station 6B. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978A	1978B	1980A	1980B	1981A	1981B
ACANTHURIDAE						
Acanthurus nigrofuscus		3	4	✓	1	1
* Ctenochaetus striatus	7	11	9	2	4	7
Naso vlamingi	1			✓		✓
Zebrasoma scopas		✓	1			
APOGONIDAE						
Cheilodipterus macrodon					✓	1
Paramia quinquelineata		✓		✓		
unidentified		✓				
BLENNIIDAE						
* Meiacanthus atrodorsalis	1				1	
unidentified	1					
CATHIGASTERIDAE						
Canthigaster valentini		✓				
CHAETODONTIDAE						
Chaetodon auriga	✓			3		
C. citrinellus	1	1				
* C. kleini		2	1	✓	✓	✓
C. lunula				1		
C. trifascialis				✓		

Table 27 continued.

	1978A	1978B	1980A	1980B	1981A	1981B
CHAETODONTIDAE (continued)						
C. vagabundus						1
Heniochus chrysostomus	1					
H. varius			✓			
CIRRHITIDAE						
unidentified				1		
ELEOTRIDAE						
Ptereleotris tricolor		2				
GOBIIDAE						
unidentified		1				
HOLOCENTRIDAE						
* Adioryx spinifer		1	1			
Myripristis sp.	2	1	1			
LABRIDAE						
Cheilinus diagrammus	1	4	1		2	
* C. fasciatus			1			
Cheilinus sp.						1
Cirrhilabrus cyanopleura	15	2				
* Coris variegatus		✓				✓

Table 27 continued.

	1978A	1978B	1980A	1980B	1981A	1981B
LABRIDAE (continued)						
Epibulus insidiator		1				
* Halichoeres hoeveni	7	7	7	4	1	4
Hemigymnus melapterus			✓	1	✓	
* Labrichthys unilineata				✓		1
* Labroides dimidiatus	1	1	✓		✓	1
Thalassoma juveniles	2					
LETHRINIDAE						
Monotaxis gradoculis						✓
LUTJANIDAE						
Aphareus furcatus						1
Caesio caerulaureus			✓		10	
Caesio sp.			40			
Macolor niger					✓	
MONACANTHIDAE						
Oxymonacanthus longirostris					✓	
MULLIDAE						
Parupeneus barberinus						1
P. bifasciatus	1					
P. trifasciatus			1			✓

Table 27 continued.

	1978A	1978B	1980A	1980B	1981A	1981B
POMACANTHIDAE						
Centropyge vroliki	4					
POMACENTRIDAE						
* Amblyglyphidodon curacao	47	17	8	3		4
A. leucogaster					19	
* Amphiprion clarki	✓	2				
* Chromis atripectoralis		1	9		1	8
* C. margaritifer			2	1		
* C. ternatensis(?)	1	✓	✓	10		2
* C. xanthura(?)	10	13	1	1	2	2
* Dascyllus aruanus		✓				
D. reticulatus		✓				1
D. trimaculatus	✓	6				
* Glyphidodontops traceyi	1	✓	✓	✓	7	✓
* Pomacentrus pavo	61	18	37	26	7	3
* P. vaiuli	7	3	4	1	✓	
sp. A	2	5	2			
sp. B			✓	✓		✓
* sp. C	5	4				
* sp. D	1					
juveniles		1				
SCARIDAE						
juveniles	9	4	✓	✓		

Table 27 continued.

	1978A	1978B	1980A	1980B	1981A	1981B
SIGANIDAE						
Siganus puellus			✓			
S. virgatus						✓
* S. vulipinus				✓		
SYNGNATHIDAE						
Corythoichthys intestinalis					1	
ZANCLIDAE						
Zanclus cornutus			1	✓	✓	
Total No. Species	27	33	28	23	20	24
No. Species on Transect	24	24	19	12	]2	16
No. Individuals on transect	189	111	131	82	56	39
Transect Length	12.0	13.2	15.0	12.0	15.0	9.0
No. Individuals/M²	7.88	4.11	4.37	3.42	1.87	2.17
No. Conspicuous Resident Spcies	13	16	14	12	10	12
Density Conspic. Res. (NO./M²)	6.21	3.03	2.67	2.00	0.77	1.78

Table 28. Fish census data, Station 7. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus nigrofuscus					1	2	
* A. pyroferus						✓	✓
A. xanthopterus		✓	✓	✓	✓		
* Ctenochaetus striatus	5	4	5	6	9	10	4
Naso vlamingi		1	1		1		
Zebrasoma scopas					1		✓
Z. veliferum					1		
APOGONIDAE							
Cheilodipterus macrodon					✓	1	1
Paramia quinquelineata	4	✓	1	18	25	✓	✓
* sp. A				8	5		
unidentified					✓		
BLENNIIDAE							
Ecsenius bicolor	1			1			
* Meiacanthus atrodorsalis	1						
Plagiotremus tapeinosoma	1						
unidentified				1			
CHAETODONTIDAE							
Chaetodon auriga					✓		1
C. citrinellus		✓					
* C. kleini	1	✓	✓	1	3	5	2

Table 28 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
CHAETODONTIDAE (continued)							
C. lunula			✓				
C. trifascialis	1						
* C. trifasciatus	3	✓	✓	1	✓	8	4
Heniochus acuminatus			1				
H. chrysostomus	✓			✓		1	
H. varius	✓	1		✓	✓		✓
HOLOCENTRIDAE							
* Adioryx spinifer	✓						
Flammeo samara	4				✓	1	✓
Myripristis sp.	1		2			✓	✓
LABRIDAE							
Cheilinus diagrammus	1				2	1	
C. rhodochrous					1		
Cheilinus sp.							1
Cirrhilabrus cyanopleura					1		
* Coris variegatus		1	✓	4	1		1
Epibulus insidiator					✓		2
Gomphosus varius		✓					
* Halichoeres hoeveni	6		6	6	7	1	5
Hemigymnus melapterus	✓						
* Labrichthys unilineata	1	1	1	1	✓	4	2
* Labroides dimidiatus	4	1	1	4	4	3	3
Thalassoma juveniles	2			✓		1	
sp. A				✓			
unidentified					1		

Table 28 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
LETHRINIDAE							
Monotaxis grandoculis	1		✓	✓	✓	✓	1
LUTJANIDAE							
Caesio caerulaureus		4		75	75		✓
Caesio sp.		25	20	16	25	✓	
Lutjanus bohar				✓			
MUGILOIDIDAE							
Parapercis cephalopunctatus			✓				
MULLIDAE							
Mulloidichthys flavolineatus			✓				
* M. vanicolensis						6	
Parupeneus barberinus	✓		✓				
P. cyclostomus					✓		
P. pleurostigma			✓				
P. trifasciatus	1		✓	✓		✓	✓
MURAENIDAE							
Gymnothorax sp.					✓		
POMACANTHIDAE							
Centropyge vroliki	✓			✓			

Table 28 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
POMACENTRIDAE							
* Amblyglyphidodon curacao	10	10	6	10	35	13	38
* Chromis atripectoralis	23				5		6
C. caerulea	✓			10		✓	
* C. margaritifer			3	1	✓	✓	1
* C. ternatensis(?)		✓	2	✓	10	✓	4
* C. xanthura(?)	10	✓		8	4	3	5
* Dascyllus aruanus							✓
* Glyphidodontops traceyi	3	1	✓	1	2	1	
Plectroglyphidodon lachrymatus	2	1			1	1	1
Pomacentritus molluccensis(?)				1	✓		✓
* P. pavo	39	36	12	21	21	62	10
* P. vaiuli	6	1	1	1		1	✓
sp. A	2				1		
sp. B			1		1	1	1
* sp. C		1			1		✓
* sp. E		4	13				
SCARIDAE							
Scarus ghobban			✓	✓			
* S. venosus			✓				
sp. A			✓	✓			✓
juveniles				1		✓	✓
SIGANIDAE							
Siganus guttatus(?)					1		

Table 28 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
SYNGNATHIDAE							
Corythoichthys intestinalis	2			1			
SYNODONTIDAE							
Synodus variegatus					✓		
ZANCLIDAE							
Zanclus cornutus		✓		✓	✓		
Total No. Species	33	24	31	36	42	33	33
No. Species on Transect	26	15	16	24	26	23	19
No. Individuals on Transect	135	92	76	197	243	129	92
Transect Length	15.0	15.0	15.0	16.0	15.0	15.0	15.0
No. Individuals/M^2	4.50	3.07	2.53	6.16	8.10	4.30	3.07
No. Conspicuous Resident Species	14	14	15	15	16	15	17
Density Conspic Res. (NO./M^2)	3.73	2.00	1.67	2.28	3.57	3.90	2.70

Table 29. Fish census data, Station 8A. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus nigrofucus		12	4				✓
A. olivaceous	✓	✓					
A. xanthopterus				✓	1	✓	
* Ctenochaetus striatus	9		1				
juveniles		1	✓		1		
APOGONIDAE							
Paramia quinquelineata	8	✓					
unidentified							✓
BALISTIDAE							
Sufflamen chrysoptera	1	1					
CATHIGASTERIDAE							
Canthigaster solandri	4		✓				✓
CHAETODONTIDAE							
Chaetodon auriga	2	✓			1		
* C. kleini	4	4	4				
Heniochus accuminatus							1
H. chrysostomus						1	

Table 29 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ELEOTRIDAE							
Ptereleotris microlepis	1	2					
GOBIIDAE							
Amblygobius albimaculatus	5	1	2				
unidentified	4	1		✓	✓		
HOLOCENTRIDAE							
Adioryx diadema							1
Flammeo sammara							1
LABRIDAE							
Cheilin diagrammus	1						
* Coris variegatus	✓						
* Halichoeres hoeveni	17	8	7		2		
* Labroides dimidiatus		✓		✓			
Stethojulis bandanensis		✓					
LETHRINIDAE							
Monotaxis grandoculis		✓					
LUTJANIDAE							
* Lutjanus fulvus	✓			2	1	✓	5
* Lutjanus sp. A					1	✓	1

Table 29 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
MULLIDAE							
Parupeneus barberinus	1						
P. pleurostigma	✓		1				
P. trifasciatus	✓	5	5				
POMACENTRIDAE							
* Amblyglyphidodon curacao	1						
* Amphiprion clarkii	2					1	✓
Dascyllus trimaculatus	4	✓					2
Pomacentrus molluccensis(?)	12	2	1				
* P. pavo	26	174	105	41	23	30	26
* P. vaiuli	1						
* sp. C	33	3	13			2	1
SCARIDAE							
Cetoscarus bicolor		✓	1				
sp. A	✓						
juveniles	1	28	8			✓	
SERRANIDAE							
Epinephelus sp.					✓		
SIGANIDAE							
Siganus spinus	1						

Table 29 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
Total No. Species	27	21	14	5	9	8	13
No. Species on Transect	21	13	12	2	7	4	9
No. Individuals on Transect	138	242	152	43	30	34	39
Transect Length(M)	35.0	14.0	25.0	18.0	15.0	15.0	15.0
No. Individuals/M^2	1.97	8.64	3.04	1.19	1.00	1.13	1.30
No. Conspicuous Resident Species	10	5	5	3	4	5	5
Density Conspic. Res. (NO./M^2)	1.33	6.75	2.60	1.19	0.90	1.10	1.10

Table 30. Fish census data, Station 8B. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B
ACANTHURIDAE			
* Ctenochaetus striatus	11	✓	2
juveniles		1	
APOGONIDAE			
Apogon novemfasciatus		✓	
Paramia quinquelineata	1		
BALISTIDAE			
Sufflamen chrysoptera	✓		
BLENNIIDAE			
* Meiacanthus atrodorsalis		1	
CHAETODONTIDAE			
* Chaetodon kleini	✓	1	✓
Heniochus acuminatus		1	
H. chrysostomus	✓	1	
H. varius		1	
HOLOCENTRIDAE			
Myripristis sp.	1		

Table 30 continued.

	1978	1979A	1979B
LABRIDAE			
* Coris variegatus	✓		
* Halichoeres hoeveni	13	2	1
* Labroides dimidiatus	1		
Stethojulis bandanensis	1		1
LETHRINIDAE			
Monotaxis grandoculis	1		✓
LUTJANIDAE			
Caesio caerulaureus	25		
C. chrysozonus(?)	✓		
MULLIDAE			
Parupeneus bifasciatus	1		
P. trifasciatus			1
POMACENTRIDAE			
* Amblyglyphidodon curacao	6	3	6
* A. ternatensis		✓	
* Dascyllus aruanus	1		
Pomacentrus molluccensis(?)	3		
* P. pavo			3
* P. vaiuli	3	✓	
sp. A	1		
sp. B		✓	

Table 30 continued.

	1978	1979A	1979B
POMACENTRIDAE (continued)			
* sp. C	36	8	11
* sp. E			2
SCARIDAE			
Scarus ghobban	✓		
juveniles	7		✓
Total No. Species	22	14	11
No. Species on Transect	16	9	8
No. Individuals on Transect	112	19	27
Transect Length(M)	16.0	13.5	14.0
No. Individuals/M^2	3.50	0.70	0.96
No. Conspicuous Resident Species	8	8	7
Density Conspic. Res. (NO./M^2)	2.22	0.56	0.82

Table 31. Fish census data, Station 9. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
ACANTHURIDAE							
Acanthurus xanthopterus	✓		✓		✓		✓
* Ctenochaetus striatus	1	✓	4	2	3	8	4
Naso vlamingi					✓	4	1
Zebrasoma flavescens		1					
Z. scopas	2	✓	✓	✓			
Z. veliferum		✓		✓	1	✓	
APOGONIDAE							
Paramia quinquelineata	41	2		40			
AULOSTOMIDAE							
* Aulostomus chinensis	✓					✓	1
BALISTIDAE							
Balistapus undulatus	✓						
Sufflamen chrysoptera							✓
BLENNIIDAE							
* Meiacanthus atrodorsalis	1	3	40	1	9	3	21
sp. A	1		2				

Table 31 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
CARANGIDAE							
Caranx melampygus							
Scomberoides lysan							
CHAETODONTIDAE							
Chaetodon auriga						1	
C. bennetti							
C. citrinellus							
C. ephippium							
* C. kleini							
C. melannotus							
C. punctatofasciatus							
C. trifascialis	1	1				2	1
* C. trifasciatus	2	3	1	2		1	
C. ulietensis			1				
H. chrysostomus				1			2
H. varius							
ELEOTRIDAE							
Ptereleotris tricolor							
GOBIIDAE							
Gobiodon citrinus							

Table 31 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
HOLOCENTRIDAE							
Flammeo sammara							
Myripristis sp.				2			
LABRIDAE							
Cheilinus diagrammus		2		1	1	1	
* C. fasciatus	1	1	1		1		
C. undulatus							
* Coris variegatus		1	1	3			
Gomphosus varius	1						1
* Halichoeres hoeveni	38	15	29	15	2	8	1
Hemigymnus melapterus							1
* Labrichthys unilineata	4	1	8	5	8	13	9
* Labroides dimidiatus		2	2	5	2	2	3
Stethojulis bandanensis							
Thalassoma juveniles				5			
LETHRINIDAE							
Monotaxis grandoculis							
LUTJANIDAE							
Caesio caerulaureus		15	1	20			
Caesio sp. A				8			
Caesio sp. B						50	
Caesio juveniles		30					

Table 31 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
MULLIDAE							
Mulloidichthys flavolineatus						10	
* M. vanicolensis							
Parupeneus barberinus	1						
P. chryseredros							
P. trifasciatus							
PEMPHERIDAE							
* Pempheris ovalensis	2						
POMACENTRIDAE							
Abudefduf sexfasciatus							
* Amblyglyphidodon curacao	11	82	50	100	28	69	61
A. leucogaster							
* Amphiprion clarkii							
* Chromis atripectoralis	8			16	29	5	5
* C. margantifer			2				
* C. ternatensis(?)		35		10		18	5
* C. xanthura(?)	9	8		10	5	8	33
* Dascyllus aruanus							
* Glyphidodontops traceyi	13	5	13	2	1	5	1
Plectroglyphidodon lachrymatus	2	2					
Pomacentrus molluccensis(?)							
* P. pavo	1	20			12	3	7
* P. vaiuli	1		5	1	1		
sp. A	1			8			
sp. B		11	9	1	4	7	9
* sp. C		1		1	9	2	2

Table 31 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
POMACENTRIDAE (continued)							
* sp. D			9	3	3		
sp. F							2
juveniles			60				
unidentified			1				
SCARIDAE							
Cetoscarus bicolor			1				
Scarus sordidus	2			1		2	
* S. troscheli							1
* S. venosus							2
sp. A							
sp. B							
sp. C						1	
juveniles	2					5	1
SERRANIDAE							
Epinephelus merra							
Epinephelus sp.	1						
Variola louti							
SIGANIDAE							
Siganus argenteus		1					
S. puellus	1						
S. virgatus	4					3	4
* S. vulpinus	3					1	1

Table 31 continued.

	1978	1979A	1979B	1980A	1980B	1981A	1981B
SYNODONTIDAE							
Synodus variegatus							
ZANCLIDAE							
Zanclus cornutus	✓	✓				1	1
Total No. Species	48	38	39	43	35	41	43
No. Species on Transect	30	22	19	25	17	26	26
No. Individuals on Transect	224	242	197	263	119	233	180
Transect Length(M)	30.0	30.0	30.0	34.0	30.0	31.0	31.0
No. Individuals/M^2	3.73	4.03	3.28	3.87	1.98	3.76	2.90
No. Conspicuous Resident Species	19	19	22	21	20	19	19
Density Conspic. Res. (NO./M^2)	1.72	2.95	2.88	2.59	1.88	2.37	2.52

Table 32. Fish census data, Station 10. Numbers are transect counts; checks denote presence at the station. Conspicuous residents indicated by asterisk.

	1979A	1979B	1980A	1980B
ACANTHURIDAE				
Acanthurus nigrofuscus	1			
A. xanthopterus		✓		
* Ctenochaetus striatus	15	3	1	5
Zebrasoma scopas	1			
Z. veliferum		✓		
APOGONIDAE				
Paramia quinquelineata	2		✓	✓
BALISTIDAE				
Sufflamen chrysoptera		✓		
BLENNIIDAE				
* Meiacanthus atrodorsalis			1	✓
CHAETODONTIDAE				
Chaetodon auriga			3	
C. bennetti	✓	1		
C. kleini	✓			
* C. trifasciatus	2	1		
C. ulietensis	✓			
Heniochus acuminatus	✓			
H. chrysostomus	2	2		
H. varius	✓	1		

Table 32 continued.

	1979A	1979B	1980A	1980B
GOBIIDAE				
unidentified			1	
HOLOCENTRIDAE				
Adioryx diadema				
* A. spinifer				
LABRIDAE				
Cheilinus diagrammus		2		
* C. fasciatus	3	1		
Cirrhilabrus cyanopleura				
* Coris variegatus		1		1
* Halichoeres hoeveni	2	8		1
Hemigymnus melapterus		2		
* Labroides dimidiatus		2		
sp. A				1
juveniles				
LETHRINIDAE				
Monotaxis grandoculis				
unidentified				
MULLIDAE				
Parupeneus chryseredros		1		
P. trifasciatus		2		

Table 32 continued.

	1979A	1979B	1980A	1980B
POMACENTRIDAE				
* Amblyglyphidodon curacao	11	54	4	2
* Chromis atripectoralis	10	14		
* Dascyllus aruanus	7	2	4	9
Stegates nigricans	1	1		
* Glyphidodontops traceyi	1	5		
Pomacentrus molluccensis(?)				1
* P. pavo	15	125	30	28
sp. A			1	1
sp. B			1	
* sp. C	6	15	1	1
* sp. E	14	12		
SCARIDAE				
Scarus ghobban		✓		
* S. troscheli		✓		
* S. venosus		✓		
juveniles	✓	22		
SERRANIDAE				
Epinephelus merra	1			
SIGANIDAE				
Siganus puellus		3		
S. virgatus	✓	4		

Table 32 continued.

	1979A	1979B	1980A	1980B
ZANCLIDAE				
Zanclus cornutus	2	1		
Total No. Species	28	32	15	16
No. Species on Transect	18	25	10	10
No. Individuals on Transect	86	285	47	50
Transect Length	19.0	19.0	11.0	11.0
No. Individuals/M^2	2.26	7.50	2.14	2.27
No. Conspicuous Resident Species	11	14	7	9
Density Conspic. Res. (NO./M^2)	2.00	6.39	1.86	2.14

Table 55. Mean number of fish species observed at monitoring stations, with range of replicates in parentheses. "Conspicuous residents" is defined in text.

	1978		1979		1980		1981	
Station	All Species	Conspicuous Residents	All Species	Conspicuous Residents	All Species	Conspicuous Residents	All Species	Conspicuous Residents
1	34	16	37(35-39)	18.5(17-20)	33(31-35)	14(13-15)	22.5(22-23)	12.5(12-13)
2	10	8	14(13-15)	8.5(8- 9)	16.5(16-17)	11.5(11-12)	16.5(15-18)	12(12-12)
3A	14	7	13.5(12-15)	9.5(8-11)	15.5(13-18)	11(10-12)	16(15-17)	12(11-13)
3B	19	11	21.5(19-24)	11(11-11)	22.5(21-24)	11.5(11-12)	21.5(19-24)	11.5(10-13)
4A	22	15	29.5(29-30)	17(16-18)	31(22-40)	15.5(12-19)	36.5(32-41)	17.5(15-20)
4B	17	10	32	18	32(29-35)	17.5(17-18)	37(37-37)	18(18-18)
5	16	8	14.5(14-15)	9(8-10)	20(19-21)	7.5(7- 8)	0	0
6	20.5(20-21)	10.5(10-11)	13.5(9-18)	8.5(8- 9)	22(16-28)	10.5(9-12)	21(20-22)	11(10-12)
7	33	14	27.5(24-31)	14.5(14-15)	39(36-42)	15.5(15-16)	33(33-33)	16(15-17)
8A	27	10	17.5(14-21)	5(5- 5)	7(5- 9)	3.5(3- 4)	10.5(8-13)	5(5- 5)
8B	22	8	12.5(11-14)	7.5(7- 8)	0	0	0	0
9	48	19	38.5(38-39)	20.5(19-22)	39(35-43)	20.5(20-21)	42(41-43)	19(19-19)

Table 34. Mean fish density (no./m^2) on the monitoring station transects, with range of replicates in parentheses. "Conspicuous residents" is defined in text.

	1978		1979		1980		1981	
Station	All Species	Conspicuous Residents	All Species	Conspicuous Residents	All Species	Conspicuous Residents	All Species	Conspicuous Residents
1	4.00	3.57	4.42(4.21-4.63)	4.09(4.02-4.16)	2.58(2.45-2.70)	1.77(1.25-2.28)	0.93(0.58-1.27)	0.70(0.32-1.08)
2	3.95	3.79	4.19(3.63-4.74)	3.56(2.74-4.37)	8.26(7.71-8.80)	4.95(2.60-7.29)	3.42(3.39-3.44)	3.31(3.28-3.35)
3A	3.26	2.80	2.27(1.89-2.65)	1.94(1.67-2.20)	4.29(4.29-4.29)	4.14(4.14-4.14)	3.04(2.72-3.36)	2.89(2.57-3.21)
3B	4.70	4.15	2.77(2.37-3.17)	2.61(2.20-3.01)	4.17(2.82-5.52)	3.71(2.32-5.10)	3.80(1.75-5.84)	3.39(1.45-5.32)
4A	11.08	3.16	15.57(12.75-18.38)	6.52(5.31-7.72)	4.93(4.91-4.94)	4.53(4.40-4.65)	10.21(8.94-11.47)	9.53(7.87-11.19)
4B	3.37	2.89	7.55	7.18	5.84(3.00-8.68)	5.57(2.88-8.26)	4.05(3.10-5.00)	3.50(2.38-4.62)
5	14.83	13.33	7.67(4.78-10.56)	7.53(4.67-10.39)	41.84(27.06-56.61)	9.39(3.88-14.89)	0	0
6	1.71(1.68-1.73)	1.18(1.04-1.32)	0.93(0.45-1.41)	0.73(0.45-1.00)	1.48(1.42-1.54)	1.01(1.00-1.02)	3.04(2.57-3.50)	1.81(1.33-2.29)
7	4.50	3.73	2.80(2.53-3.07)	1.84(1.67-2.00)	7.13(6.16-8.10)	2.93(2.28-3.57)	3.69(3.07-4.30)	3.50(2.70-4.30)
8A	1.97	1.33	5.84(3.04-8.64)	4.68(2.60-6.75)	1.10(1.00-1.19)	1.05(0.90-1.19)	1.22(1.13-1.30)	1.10(1.10-1.10)
8B	3.50	2.22	0.83(0.70-0.96)	0.69(0.56-0.82)	0	0	0	0
9	3.73	1.72	3.66(3.28-4.03)	2.92(2.88-2.95)	2.93(1.98-3.87)	2.24(1.88-2.59)	3.33(2.90-3.76)	2.45(2.37-2.52)

Table 35. Results of ciguatoxin analysis. Negative = 0; borderline = *; Positive = **; not tested = —.

Species	Standard length (cm)	Sex	Tissue Tested: Dorsal Muscle	Ventral Muscle	Gonad
ACANTHURIDAE					
Ctenochaetus striatus	12	?	0	*	**
C. striatus	9	?	whole fish: *		
C. striatus	8	?	whole fish: *		
C. striatus	9	?	whole fish: *		
C. striatus	9	?	whole fish: *		
C. striatus	11	?	whole fish: *		
HOLOCENTRIDAE					
Adioryx spinifer	24	?	0	0	—
LABRIDAE					
Cheilinus fasciatus	18	F	0	0	—
LETHRINIDAE					
Lethrinus sp.	20	?	0	0	—
Lethrinus sp.	21	?	0	0	0
Lethrinus sp.	33	M	*	**	0
Lethrinus sp.	25	?	0	0	0
Lethrinus sp.	44	M	0	0	0
Monotaxis grandoculis	18	?	0	0	—
LUTJANIDAE					
Lutjanus bohar	21	?	0	**	—
L. bohar	57	M	*	*	—
L. gibbus	29	?	0	0	0
L. gibbus	22	?	**	0	—
L. lutjanus	23	F	*	0	*
L. lutjanus	26	M	*	*	—
SERRANIDAE					
Cephalopholis urodelus	23	M	0	0	*
Epinephelus microdon	32	?	0	0	0
E. microdon	33	?	0	0	0
E. microdon	30	?	0	*	—
Variola louti	25	?	**	0	—
SIGANIDAE					
Siganus argenteus	22	?	*	0	—