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

PART C: POST-CONSTRUCTION SURVEY

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EXECUTIVE SUMMARY

This report covers the third and final 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); the third monitoring survey was carried out in April 1981 (Amesbury et al., 1981). This report discusses the results of the final monitoring study carried out in July 1982 after construction activities had ceased.

Results of studies of current patterns, turbidity, and sedimentation provide a backdrop for the biological monitoring studies.

The monitoring studies consist 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.

The transect surveys of marine plants showed fluctuation in species richness and percent cover over the period of study, but, except for the southwest end of the runway where siltation was heaviest, no clearcut trends were seen.

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 the 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.

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.

INTRODUCTION

Background

The reef communities in the vicinity of the Moen, Truk, airport runway have been the subject of a five-year biological monitoring study. The purpose of the study has been to determine the impacts of construction activities, principally dredging and filling, on the marine plants, corals, macroinvertebrates, and reef fishes which are the most conspicuous components of these biotic communities. The first set of surveys was carried out in 1978, before construction activities began, and serves to provide baseline information on the status of the communities (Amesbury et al., 1978). Subsequent surveys have been carried out annually to monitor the effects of construction activities (Amesbury et al., 1979, 1980, and 1981). Major dredging and filling activities ceased by 1982 and the present set of surveys was carried out to determine whether such impacts as had been noted during the earlier surveys had ameliorated since construction work ceased or whether any delayed affects of the construction work could be detected.

The earlier surveys (the results of which are summarized by Amesbury et al., 1981) indicated that the major impact due to construction activities was the deposition of a thick blanket of fine sediments at the southwest end of the study area. Monitoring stations in this area were partially or completely buried by the sediments, and, where the reef was covered, no corals, marine plants, macroinvertebrates, or fishes were able to maintain themselves. Attached organisms have no doubt died and motile ones have either died or moved to other areas.

In other parts of the study area, there were obvious and measurable increases in the turbidity of the water due to the presence of suspended ~~silt~~ solids derived from the filling operations associated with the runway expansion.

Despite this marked change in water clarity, the impacts on the diversity and standing stocks of reef organisms were minimal, and such changes as were measured during the surveys could be attributable to variations in placement of the transect line from year to year.

This report consists of the results of a resurvey of the monitoring stations with particular attention paid to the condition of the monitoring stations in the area of major sediment deposition to determine whether the sediments are dispersing from this area since construction ceased or whether new communities, adapted to the new conditions, are becoming established.

Water Circulation

Water current movements were determined in the Part C monitoring program at water quality and biological monitoring stations from July 19 to 30, 1982. Surface water flow patterns were determined by fluorescein dye studies. Directions of flow and relative speeds were recorded for the water quality (Figure 1; Table 1) and biological programs (Figures 2 and 3; Table 2).

Part A water circulation patterns were quantified with drift drogue studies (Amesbury et al., 1978). Water column movements were determined at depths of 1 m and 6 m below the water surface. Throughout the Part B monitoring program, surface water flow directions were measured with fluorescein dye studies (Figure 4). These dye studies correlated with the Part A drift drogue patterns. Surface water flow was usually significantly affected by wind direction and speed. Tidal changes were periodically responsible for the water circulation patterns. Part A drogue studies showed that surface and bottom waters generally moved in the same direction. However, there were differences in water speeds. Although surface water dye studies could not measure large flow or water column patterns, they could ascertain flow trends.

Since movements of turbidity plumes in surface waters were a major concern of Part B monitoring, dye studies were sufficient to measure these surface flow trends. In Part B monitoring, there was a significant correlation between turbidity plume flows and wind characteristics. This was particularly evident in periods of increased winds or seas (swell activity). Current flow directions were shown to affect turbidity levels at the shallow water stations. Wind flow which moved the water mass away from fringing reefs and construction zones produced increased turbidity levels. Wind flow which moved the water mass toward land resulted in minimum turbidities.

Major Part B monitoring flow directions were southwest through west (30%) and west through northwest (20%) (Figure 4). For the Part C monitoring, the dominantly southwest winds (Table 3) caused water currents to trend toward the north to northeast. These water circulation patterns were atypical when compared with the Part B monitoring current patterns. Water movement toward the northeast occurred only 7% of the time in the Part B monitoring. These northeast trending water flows were associated with increased turbidities. This trend was evident for the Part C monitoring program.

There is no apparent major alternation of water circulation patterns as a result of construction activities. Minor flow alternations have occurred near water quality and biological stations 3, 4, and 5. These Changes are a result of outflow water, particularly in periods of tidal flushing, from the dredged reef flat areas (Figure 1). The restricted nature of entrance/exit points for these dredge zones produces increased water velocities at these points. These higher velocity waters modify the near-reef current patterns. The extent of modification could not be determined under the prevailing weather conditions of Part C monitoring.

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Turbidity and Sedimentation

Environmental stress on marine biological communities due to excessive discharges of dredge spoil into near-shore lagoon waters was anticipated in the Part A monitoring program as the major potential threat to the marine environment beyond the water quality boundary (Amesbury et al., 1978). The impact of dredge-generated sediment fill materials on marine receiving waters was monitored in the Part B program by monthly measurements of nephelometric turbidity at 10 water quality stations (WERI, 1982). Turbidity was measured at these stations for the Part C water quality monitoring program (Table 4) (WERI, 1982).

The Part C post-construction monitoring program showed a degradation of marine water quality, which could have affected marine communities, around the airport runway due to increased turbidity levels. These increased turbidities were attributed to past and ongoing construction operations. Accumulations of lime mud deposited in shallow waters adjacent to the runway were easily resuspended into the water column by tropical storm-related wind and surf conditions. These turbidity plumes may have impacted large areas of lagoon water around the construction zone, including the off-shore control station.

Natural sedimentation rates were determined at biological stations prior to dredge effluent discharges (Table 5). Sediment fallout or "rain" ranged between 43 ml/m^2/day at the control station to 143 ml/m^2/day at station 5 (Figure ~~4~~ 5). The dry weight of these sediments ranged from 10.1 g/m^2/day (station 4) to 18.8 g/m^2/day (station 5) with an organic content of 8.2 to 14.3 percent. The organic content of the lagoon sediments at biological stations was about 3 percent. Dredge effluent discharges produced increased sedimentation rates with a 900 percent increase at station 6 (Figure ~~4~~ 5). There was no significant change in sediment "rain" at station 9 for the Part B construction

Station label on fig. 5

period (Figure ~~4~~5). Part C post-construction sedimentation rates were measured at stations 6 and 9 (Table 5). Station~~s~~ 6 sediment "rain" was still occurring at a rate of 256 ml/m^2/day which was 200% higher than the initial natural conditions (Figure ~~4~~5). Station 9 had a mean sediment "rain", based on 20 sedimentation traps, of 23.6 ml/m^2/day (12.5 g/m^2/day) which was consistent with both the Parts A and B measurements (Figure 1).

To maintain fine sand in the suspended sediment load, the average water current must be about 50 cm/sec. Water velocities, measured with drift drogues, at station 6 in 1978 (pre-construction) ranged from 3 to 11 cm/sec; subsequent velocities, measured with dye tracks for both Parts A and B monitoring, have been in the same range. Only in periods of tropical storm induced heavy surf and wind, have current velocities been measured near 50 cm/sec. Therefore, most of the suspended load deposited along the water quality boundary is silt- and clay-sized particles. These silt- and clay-sized deposits are lime muds. Once these lime muds are deposited in the quieter and deeper lagoon water, they are difficult to remove by water currents. It is these muds which can have the greatest impact on biological communities near the water quality boundary.

In order to assess the volume of deposited mud resuspended by water currents, flat exposure plates were placed at station 6 from February to June, 1979. Accumulation of lime mud occurred at a rate of 15 ml/m^2/day. Therefore, most of the suspended sediment load "rained" onto station 6 was removed by currents. Visual inspection at this station during the sedimentation plate collection and at the conclusion of Part B monitoring (December 1981) showed a 4 to 5 cm veneer of mud overlying ~~on the~~ lagoon sands. Pockets of mud were found with thicknesses ranging up to 20 cm. Analyses of the plate muds for grain size distribution showed 10-15% fine to very fine sands with the remainder as silts and clay. In Part C monitoring, visual inspection at this station showed an apparent decrease in veneered muds; but pockets of mud were still common throughout the area. However, the sediments were primarily composed of Halimeda debris. There was an anaerobic sediment layer composed of fine mud and sand at a depth of 15-20 cm. This layer was compact and generally stable. Pockets of mud were not stable and were easily disturbed by diver activities.

There are extensive accumulations of lime mud deposited in the vicinity of station 8 beyond the water quality boundary. These muds were measured to depths in excess of 2 m.

There was minimal stabilization of these muds by biological or physical processes. In periods of increased current velocities, these muds are resuspended into the water column producing turbidity plumes. These plumes were maximized in the Part C monitoring program when winds originated from the southwest with speeds in excess of 11 knots.

The Part C monitoring has shown large scale dredge and fill operations can cause long term changes in marine water quality which can cause potential stress to marine biological communities. It can be anticipated that future resuspension of dredge deposited lime muds will occur in the vicinity of the runway as a result of normal tropical storm conditions.

METHODS

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Marine Plants

Marine plants at monitoring stations were quantified by the point quadrat method along selected transect lines originally designated by Amesbury et al. (1978). A 0.25 m^2 quadrat with a 16 point grid was randomly tossed every meter and the marine plant species or bare substratum found under each point recorded. Replicate transects were run at each station. Percent cover was calculated by dividing the number of points recorded for each species by the total number of points (16 times the number of tosses) and multiplying by 100. In addition, a qualitative list of marine plants was compiled by recording species observed during random swims at each station. Several stations were not consistently or accurately located in each survey: stations 5, 6B, 8B and 10. Station 5, presumed lost in 1981 (Amesbury et al., 1981) was located in 1982. Station 6B was located as described by Amesbury et al. (1978) in 1978, 1979 and 1982. In 1980 and 1981 station 6B was located on a Porites mound half way between station 6A and the original location of 6B. Because of this location discrepancy, the data from station 6B were not included in the statistical analysis. Station 8B was covered by dredged discharge in 1979 and subsequently has not been included as a monitoring station. Station 10 was extensively modified by movement of a harbor bouy chain in 1980 and therefore it was not surveyed in 1981 and 1982.

A 2-way ANOVA (Sokal and Rohlf, 1969) was used to analyze the survey data (1978-1982). Replicate transects were averaged. The 1978 survey data was not presented in a manner useful for statistical analysis. The information from this Part A pre-construction survey was only included in the comparison of total percent coverage between surveys. Marine plants were surveyed by a different scientist each year; therefore, variations in results may reflect differences in the technical skills of each individual.

Corals

Two methods were used to census the stony corals at 10 different stations. The point quarter method (Cottam et al., 1953) was applied along transects where scattered, discreet colonies were encountered. On transects where there

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was extensive coverage of a single colony or species, a line intercept method (Smith, 1974) was used.

The point quarter method was applied to survey stations 1, 3, 4A, half of 6B and 8 in 1982. A series of 10 points of equal intervals along the transect line was selected. The area around each of the points was divided into quadrants by placing a second line perpendicular to the transect line. In each quadrant the living coral closest to the point was located, and the diameter and distance of the colony center to the transect point was measured. Where necessary, a sample of the coral colony was removed for later positive identification in the laboratory. If no coral was observed within 1 m of the transect point in any quadrant, a point to coral distance of 100 cm and a diameter of zero were recorded for that quadrant. From these data, the following quantities were calculated: density, percent cover and frequency, as well as relative values for each parameter (see Amesbury et al., 1978 for calculations). An importance factor for each coral species was calculated by summing all ~~the~~ relative values. Table 2 contains ~~the~~ parameters for all corals at each station with each coral ranked by their importance value.

The line intercept method was used ~~in~~ at stations 2, 4B, 5, 6A, half of 6B, 7 and 9 (1982). A transect line was laid across the station and species names and lengths of the line intercepted by the coral were recorded for each coral found lying above or below the line. ~~Using these data~~, Percent and relative percent cover were calculated from this data (calculations as in Amesbury et al., 1978).

Each station was surveyed during a 15-min swim to record additional coral species not found during transect work.

Macroinvertebrates

Macroinvertebrate densities were quantified by swimming along transects and counting the number of exposed invertebrates within 1 m to either side of the line. This method was the same as used in Amesbury et al. (1978, 1979, 1980, 1981). 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 mounds, the area along the entire length of one side of the transect line was recorded as a single transect count. In order to facilitate comparisons between stations the number of species or invertebrate groups per m^2 were computed.

Fishes

At each of the monitoring stations, fish were censused along a transect line which was laid along the long axis of the coral mound. Fish within one meter of either side of the transect line were enumerated by species. Following the transect census, the investigator swam around the coral mound listing all species of fish seen. A replicate transect was run at each monitoring station.

RESULTS AND DISCUSSION

Marine Plants

In 1982, the stations surveyed, at locations described by Amesbury et al. (1978), were 1, 2, 3A, 3B, 4A, 4B, 5, 6A, 7, 8A and 9. The data on percent coverage for each species and transect replicates are presented in Table 6, along with a list of species observed during random swims at each station. The species data from previous surveys are presented in Amesbury et al., 1978, 1979, 1980, and 1981.

A total of 49 marine plant species was observed with a mean number of species per station of 16.2. The grea~~s~~test number of species (55) was observed in 1981 (Table 7). There was no trend in the number of species observed between survey years. Variance in total number of species observed may have

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been an artifact of field and laboratory identification techniques, as well as the amount of time devoted to random searches at each station.

The percent coverage of marine plants varies significantly between surveys (P>0.05) (Table 7). In 1982 the mean percent cover per station was 44.3%. This is the highest marine plant coverage found in the 5 surveys. Peaks in percent coverage occur in alternate survey years: 1978, 1980 and 1982. Figure 6 ~~8~~ presents percent coverage of marine plants in each survey.

The abundance of marine plant species varied between surveys. Table 8 presents the most abundant marine plant species found at each station in each survey. The calcareous green alga Halimeda opuntia and filamentous red algae (turf) are the most consistently important species. The trend toward increased abundance of encrusting coralline algae reported between 1979 and 1981 was not observed in 1982.

Halimeda opuntia was selected as an indicator species because of its importance in terms of percent coverage and its contribution to marine sediment in the form of calcareous plates. Table 9 and Figures 7 ~~6~~ and 9 ~~8~~ present the percent coverage of H. opuntia. The trends in percent cover at all stations appear to follow the natural trend in community dynamics as quantified at station 9. There is no statistical difference (P>0.05) in the percent coverage of H. opuntia between surveys. A statistical difference (P>0.05) was found between stations which reflects the variation in substratum types (coral mounds and patch reefs). The greatest coverages occur at stations 1, 6A and 9 which are primarily composed of the branching coral Acropora.

In order to assess general trends in community dynamics, rather than variation for a particular species, marine plants are lumped into 4 functional groups: encrusting, fuzz (turf), calcareous, and fleshy. These groups span all traditional taxonomic phyla. The functional group data are presented in

Table 10 and Figure ~~7~~8. There is no significant difference (P>0.05) in percent coverage of each functional group between stations within each survey. The percent cover of three functional groups (encrusting, calcareous, and fuzz) is significantly different between surveys (P>0.05).

The percent coverage of the fleshy component increased between 1979 and 1980 (23.7-74.0%), but declined continually after 1980 to a point in 1982 (20.7%) where the coverage was approximately equal to the coverage in 1979. The 1980 increase may result from increased recruitment space available in conjection with the decrease in the calcareous group. However, the differences in percent coverage between years and between stations within years is not statistically significant.

The percent coverage of the encrusting group fluctuates significantly between surveys (P>0.05). In 1980 coverage increased by 30% over the 1979 figure. This rise may be a result of an increase in the available space. In 1980 there was significant decline in encrusting types. This trend in decreasing coverage is apparent for all functional groups. At the time of the 1981 survey, construction was still underway. The post-construction survey in 1982 showed a slight increase in coverage of encrusting types. The total percent coverage (66.3%) in 1982 did not recover to the 1979 (126.6%) pre-construction coverage. Field identification of encrusting type algae is difficult; the encrusting foraminiferan Gypsina sp., was often identified as a coralline algae. However, in terms of an encrusting calcareous functional group designation, Gypsina can be considered with calcareous algae.

Both calcareous (nonencrusting types) and fuzz (turf) algal types showed a post-construction increase (1982) in percent coverage to a point where the percent coverage was greater than in 1979. This trend also occurs at the control station 9 (Table 10 and Figure ~~7~~8) which was not influenced by runway

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construction (at least not by parameters surveyed in the water quality monitoring programs). It is therefore possible that the changes in the calcareous, encrusting, fleshy and fuzz functional groups reflected a natural fluctuation in community dynamics.

The marine plant population at station 8A was selected as an example of the resiliancy of the algal community. Station 8A sustained a continuous influx of dredge discharge during the 3 years of construction. An accumulation of fine silty sediment buried most of the coral mound, reducing the percent coverage of marine plants from 49.9% in 1978 (before construction) to 7.5% in 1979 (one year of construction), and 16.0% after two years of construction. However, in 1982, the post-construction survey data showed an increase in percent coverage for all functional groups (Table 10). The total percent coverage in 1982 (51.0%) was greater than the pre-construction coverage.

Based on the comparison between survey years and survey stations, the marine plant community adjacent to the Truk airport was not adversely affected by construction activities. Observed trends in percent coverage and species dominance in the construction impact area reflected natural fluctuations found to occur in a pristine environment outside the construction influence.

Corals

Table 11 presents the qualitative results of the 1982 coral transect surveys at the study sites. A checklist of all coral species observed at the monitoring stations in 1982 is given in Table 12.

There was a general decrease in coral cover from 1978 to 1979 or 1980 (Phase A to Phase B) and then an increase during the next years (late Phase B and Phase C), returning to approximately the original values or higher (Table 13, Figures ~~9~~ 10 and ~~10~~ 11). Station 8A is the only station which decreased consistently from 1978 through 1982. This is also the only station where visible

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damage was caused by the extreme turbidity levels. Sediment settled on the substrata, making a soft and changing surface which corals are unable to settle on. In addition, the constant "rain" of particles covered and killed many corals.

Figure ~~8~~ 10 shows no trend, although, except for stations 2 and 3A, no major changes are apparent. Most of the values, after undergoing fluctuations through the study, returned to values close to the originals.

Taken as a whole, only stations 3A and 8A suffered a major decrease in coral cover, and stations 2 and 7 showed a marked increase. All other stations showed only slight increases or decreases. No statistical analysis of variance between years was performed because the method used was not always consistent at a station through all the years. This discounted most of the stations, leaving too few to perform a valid test.

The coral survey did not show any major detrimental effects caused by the higher turbidity values associated with the airport runway expansion. It should be noted that, although using a coral survey will show major changes in a community, slight changes would be masked by the often great variance between samples, as seen in the ranges. This great variance shows the extreme variability of a coral community even within a small area, as the transect lines were never moved more than a few feet in any direction. Where slight changes in a community need to be measured with more certainty, either permanent transects, or fewer stations with numerous replicate samples would be necessary.

Macroinvertebrates

The densities and distributions of larger and more conspicuous macroinvertebrates (excluding corals) were quantified at the biological monitoring stations (Table 14). The biological stations which were transected included stations 1, 2, 3A, 3B, 4A, 4B, 5, 6A, 6B, 7, 8A, and 9. Two stations not transected were station 8B, which was previously covered by dredge fill discharge and station 10, which had been severely damaged by a buoy chain. Station 6B was the same mound as quantified in the 1978 survey, while the 1979, 1980 and 1981 surveys were conducted at a different coral mound. Uncommon macroinvertebrates found at monitoring stations, but not located along transect lines, were recorded (Table 15). The four previous surveys provided extensive checklists of macroinvertebrates which were located at and around monitoring stations. There were only a few new gastropods found in this survey. Filter-feeders were the dominant invertebrates associated with the mounds. The most abundant invertebrate groups were sponges, hydrozoans, ascidian tunicates, bivalves, and alcyonaceans. The indicator groups (alcyonaceans, *Arca*/*Barbatia* spp., *Hyotissa hyotis* (=*Pycnodonte hyotis*) and *Phallusia julinea*) were still dominant fauna at the monitoring stations.

Mean densities of macroinvertebrate indicator groups were tabulated for monitoring stations from 1978 to 1982 (Table 16). Stations 5 and 6B had missing data for the 1979 and 1981 surveys, respectively, and were not used in statistically analysis. The mean data were analyzed with a one-way ANOVA to ascertain if changes had occurred at stations between surveyed years. At a significant level of $P = 0.05$, there were no significant differences in mean densities for indicator groups between years.

The 1978 and 1982 surveys were conducted by the same marine biologist. There was, generally, no change in mean densities of indicator groups at monitoring stations between these surveys. For alcyonaceans (soft corals), stations 3A and 4A had increased densities. There was an introduction of *Sarcophytum* and increased densities of *Sinularia* at these stations. These changes may have been caused by alterations in water circulation patterns caused by the dredged reef-flat channel entrances. Differences in densities of *Arca*/*Barbatia*, which inhabit massive coral heads, were probably due to placements of the transect lines. The decrease of *Arca*/*Barbatia* spp. at station 5 was caused by reduction in habitat. The coral at this station was broken into large boulders by construction activities. There were no significant changes in densities of *H. hyotis* between the 1978 and 1982 surveys. The tunicate *Phallusia julinea*, which was associated with topographic features that produced reduced-light conditions, had similar densities between survey years, except at station 8A. At this station, there was an apparent increase in density. *P. julinea* were clustered around the dead coral boulder tract in the central portion of the mound. Most of the invertebrates encountered at station 8A were also located at this isolated outcrop of hard substratum.

The total number of species or macroinvertebrate groups quantified on transects was tabulated for survey years 1978 to 1982 (Table 17). The 1978, 1980 and 1982 surveys included generic subdivision of the alcyonacean group. Therefore, these surveys had higher total group counts compared with the 1979 and 1981 surveys, by a maximum of 5 groups. These invertebrate groups (Table 17) were found to be significantly different (P = 0.05) between survey years. The mean ± standard deviation of invertebrate groups for the survey years were:

1978	10.3	3.1
1979	8.4	3.2
1980	21.7	7.0
1981	10.0	4.1
1982	17.9	5.0

The survey had a greater number of quantified invertebrates. This was caused by a marked increase in the number of bivalves recorded, including some inconspicuous species. The variability in the number of encountered groups on transects was related, in part, to the personnel conducting the surveys. Comparison of the 1978 and 1982 data for total encountered groups (these surveys were conducted by the same person) showed an increase at all 1982 monitoring stations (Table 17). There were apparent increases in the numbers of gastropods and bivalves. These changes were caused by a more careful scrutiny of the monitoring stations for smaller invertebrates for the 1982 survey. However, there were also decreases in species encountered for some invertebrate groups (ie. Asteroidea or seastars). There was no measurable decline in diversity of macroinvertebrate groups which could be attributed entirely to constuction activities.

Replicate surveys were conducted at all monitoring stations with either 3 or 4 transects made at each station (Table 17). There was considerable variation for specific invertebrate groups between replicate transects, particularly for rare or uncommon fauna. Transect lines set at stations for all survey years were oriented in similar directions. Differences in invertebrate densities between replicate surveys generally corresponded with small changes in transect line orientation. This method of semifixed transect location had the potential to influence invertebrates quantified. Motile fauna were recorded only when they moved within this transect measurement zone, while many groups of sessile fauna exhibited patchy distribution. This patchiness could result in one transect having a large number of individuals while the replicate had few individuals. The more dominant invertebrate groups, including the indicator groups, had comparable densities between replicate transects.

Sessile groups were best quantified with the fixed transect method. Motile groups would have been better quantified by a random transect orientation method. In relation to a monitoring strategy, assessment of dominant sessile fauna would be the most useful in ascertaining major changes in environmental quality. The dominant sessile fauna at stations were filter-feeders with the capacity to adapt to a wide range of environmental stresses, including increased particulate loads. These suspended sediments loads were measured by nephelometric turbidity units, and were seen to increase in relation to construction activities (WERI, 1982). These increased turbidities had no measurable affect on sessile fauna at stations, except where sediment burial occurred over a prolonged time period.

Station 8A was subjected to extensive sedimentation by dredge fill discharging procedures. These discharges caused burial of many topographic features beyond the water quality boundary around station 8A. In the vicinity and at station 8A there was a loss of most suitable habitat for sessile invertebrate tebrate attachment, particularly for suspension-feeders that cannot colonize silt-clay substrata. Additionally, most of the soft sediments deposited around this station were not suitable for benthic motile fauna (i.e. gastropods and holothurians). There were no holothurian species found around this station within a searched area of about 300 m^2. The gastropod *Pyrene deshayesii* was found on exposed hard substrata. No gastropods were found in soft sediments around the station. The bivalve *Atrina vexillum* was found in soft sediments, which had dredge deposits of less than 0.25m. Several specimens of the spiny lobster *Panulirus ornatus* were found near the central boulder tract. The density and diversity of sponges was reduced compared with the 1978 survey.

Soft sediments in the vicinity of station 8A have been observed to be readily disturbable. This disruption, which produces high turbidity levels, can cause frequent stress on the suspension-feeder community (Gray, 1981). Although this environmental stress has not significantly decreased invertebrate species diversity, it has the potential to alter natural growth and reproduction cycles. Therefore, the addition of new hard substrata would enhance the survival of suspension-feeder sessile fauna. Stabilization of the sediments would be required before benthic motile fauna (i.e. holothurians) could reinhabit this area. Sediment stabilization and habitat enhancement could be accomplished by creating artificial reefs.

There was a moderate diversity of holothurians at monitoring stations, but with low densities. In 1978, there were 17 species of holothurians recorded, while only 10 species were found in 1982. The species not found in 1982 were relatively uncommon. *Holothuria atra*, *H. edulis*, and *Stichopus variegatus* were the most commonly encountered species. The sandy area around the stations usually had the highest densities of holothurians. The two stations, 6A and 8A, which had heavy sediment deposition from construction fill discharges, had no observable holothurians. Holothurians were rare around stations 5 and 7, which had high densities on adjoining sands in 1978. There was an apparent decrease in density of holothurians around stations impacted by dredge discharges. Since invertebrates on the flats adjoining the stations were not quantified, the magnitude in change for holothurians could not be determined.

Two species of asteroid, *Culcita novaeguineae* and *Linckia multifora*, which were previously common at monitoring stations, were rare in the 1982 survey. There was a distinct lack of Asteroidea species with only the seastar *Acanthaster planci* found on a transect at station 9. There were also reductions in Echinoidea and Crinoidea at specific stations. These groups were common around stations 5, 6A and 6B in 1978, but were not found at these stations in 1982. The sand dollar *Brissidae latecarinatus* was found in sediments around station 1, 2, 3A, 5, 6A, 6B and 7. It was particularly common in sediments around station 5. The sea urchin *Diadema setosum*, which was quantified at 8 stations in 1978, was found at stations 1, 2 and 4B.

The vermetid gastropod *Petaloconchus* sp. was found at 10 stations, with a high density of 6 individuals/m^2 at station 2. The muricid gastropod *Chicoreus brunneus* was quantified at 5 stations and found at 7 stations. The most abundant large motile gastropod was *Tectus pyramis*, which was quantified at 8 stations. *Trochus niloticus* was quantified on 9 transects in 1978, but was found at only 2 stations (1 and 3A) in 1982. There was a distinct decrease in density of *T. niloticus* around the stations in 1982, as compared with previous years. The small gastropod *Pyrene deshayesii* was both abundant and widespread at monitoring stations. It was most often found on exposed hard substrata. The gastropod *Corolliophila violacea*, which feeds on corals, was found at all stations with massive coral heads. In the 1981 survey, extensive gastropod collections were made for the monitoring statons. These collections may have altered the densities of the uncommon gastropods recorded for the 1982 survey.

Two genera of filter-feeding polychaete worms were quantified at monitoring stations. These were the *Sabellastrarte* feather dusters and *Spirobranchus* christmas tree worms. These genera were usually associated with the massive coral heads.

The Anthipatharia black coral *Cirripathes anquina* was found at 10 stations. The densities ranges from 0.2 (station 4A) to .28 (station 4B) per m^2. The deeper stations generally had higher *C. anquina* densities.

Didemnum tunicates were a dominant faunal component of monitoring station communities. *Didemnum ternatanum* was found at all stations, except 3A, with maximum densities in excess of 16 individuals per m^2. *Didemnum moseleyi* showed a similar distribution with lower densities. The solitary ascidian *Polycarpa* sp. reported in Amesbury et al. (1980) was found at 6 stations. *Phallusia julinea*, an indicator species, was found on all stations with densities ranging from 0.08 to 1.23 individuals per m^2.

Bivalves were a conspicuous faunal component of monitoring station communities. There were 13 species found at the stations. Two bivalve species, which live as suspension-feeders inbedded in coral framework, were *Arca* sp. and

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Barbatia sp. These bivalves are difficult to distinguish in the field and were combined in transect counts as a single group. This indicator group was found at all stations with densities ranging from 0.03 to 9.01 individuals per m^2. The pearl oyster Pteria cypsellus, which readily attached to buoy lines (Amesbury et al., 1979), was uncommon after the loss of buoy lines. Pteria loveni, which was associated with gorgonian fan corals, was not observed at the stations. The loss of this species, particularly at station 4B, was caused by collections made in the 1981 survey. The large bear-claw clam Hyotissa (=Pycnodante) hyotis was found in low densities at all stations. This species has been identified as a member of the compound-coral biocoenosis. A specimen of the giant clam Tridacna squamosa located near station 6A in 1978 was measured in 1982. It was found to have increased in value length by about 17 cm (1978-28 cm; 1982-45 cm). This specimen was located on a patch of elevated hard substrata.

In terms of overall diversity and density of macroinvertebrates at the biological monitoring stations, there has been no substantial change in communities. The filter-feeding fauna, which characterize the stations, have mechanisms for foreign partical removal and can tolerate, to a point, increased levels of suspended sediments. An assessment of the frequency of bottom sediment disruption at station 8A would be necessary to ascertain the long term impacts of siltation on the existing faunal community.

Fishes

The fish census counts at the monitoring stations are presented in Table 18. Species richness ranged from 38 species on transect 4A' to 11 species on transect 8A'. (Station 8B continued to be covered with sediments and no fish were seen there.) Transect 4A had the highest fish density (59.3 fish/m^2) primarily because of an abundance of fusiliers of the genus Caesio schooling

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around the coral mound, aggregations of cardinalfish (Apogonidae) at the base of the mound and numerous blue damselfish (*Pomacentrus pavo*) hovering about the surface of the mound. The lowest fish density (again excepting station 8B which had no fish) was seen on transect 9'. This station was our control station and has not been subject to any appreciable stress from the construction work; the low fish density reflects the natural condition of the fish assemblage at this site.

Trends in fish species richness and density are shown in Tables 19 and 20. Most stations exhibited variations in species richness from year to year with little overall change or some slight increase. Station 2 showed the most consistent and notable increase, with the number of species seen doubling over the five years of surveys. Declines were most notable at stations 8A and 8B; at the former station, which was partially covered in silt, species richness dropped to less than half its original level; fish completely disappeared from station 8B which was covered with silt prior to the 1980 census. Fish density was even more variable than was species richness (Table 19). At some stations there were rather remarkable increases in fish density (stations 4A, 5, and 7). Most others varied but with smaller differences from year to year. Station 8B again stands out by the loss of its fish fauna due to sedimentation.

The results of the fish censuses over the course of the construction indicate that the increased water turbidity by itself had no great impact on fish communities. Only when sediment accumulated on the substrate and buried the food and shelter sites of the coral-associated fishes did fish communities dwindle or disappear.

CONCLUSIONS

The only significant and obvious impact on the reef communities adjacent to the runway which was clearly a result of construction activities was the covering of the southwestern part of the study area with a blanket of fine sediments which smothered benthic plants, corals, and attached macroinvertebrates and eliminated habitats for reef fishes. This considerable deposit of sediments has not diminished noticeably in the more than two years that it has been present. Neither has any marine species of plant or animal been able to establish itself on the surface of the sediment blanket. It seems likely that in the years to come these sediments will become resuspended and moved by water currents to other areas, but whether this will take 5, 50, or 500 years is an open question.

Although the sediment deposition is the most dramatic phenomenon documented during these surveys, perhaps the most interesting one is the apparent minimal impact of high turbidities (due to suspended silt) on the other reef areas adjacent to the construction site. If these results are generally applicable to tropical reefs, it is heartening to know that suspended silt production from shoreside dredging and filling operations may not be environmentally harmful if the silt is not allowed to settle.

Notwithstanding the lack of measurable biological impact of suspended sediments, there is no question that they have major aesthetic impacts. In some areas underwater visibility is extremely limited and there is little pleasure in snorkeling or diving in these areas (unless one entertains some rather arcane interests). Aesthetic considerations are important and should not be ignored when shoreside construction activities are planned.

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We wish to thank the Truk Division of Health and Sanitation for their support and the District Boat Pool for providing us with boat transportation. Our boat operators over the years have been very helpful and this year was no exception. A great deal of appreciation goes to Lucy Lacsamana who transformed piles of virtually illegible manuscripts into a flawless final draft.

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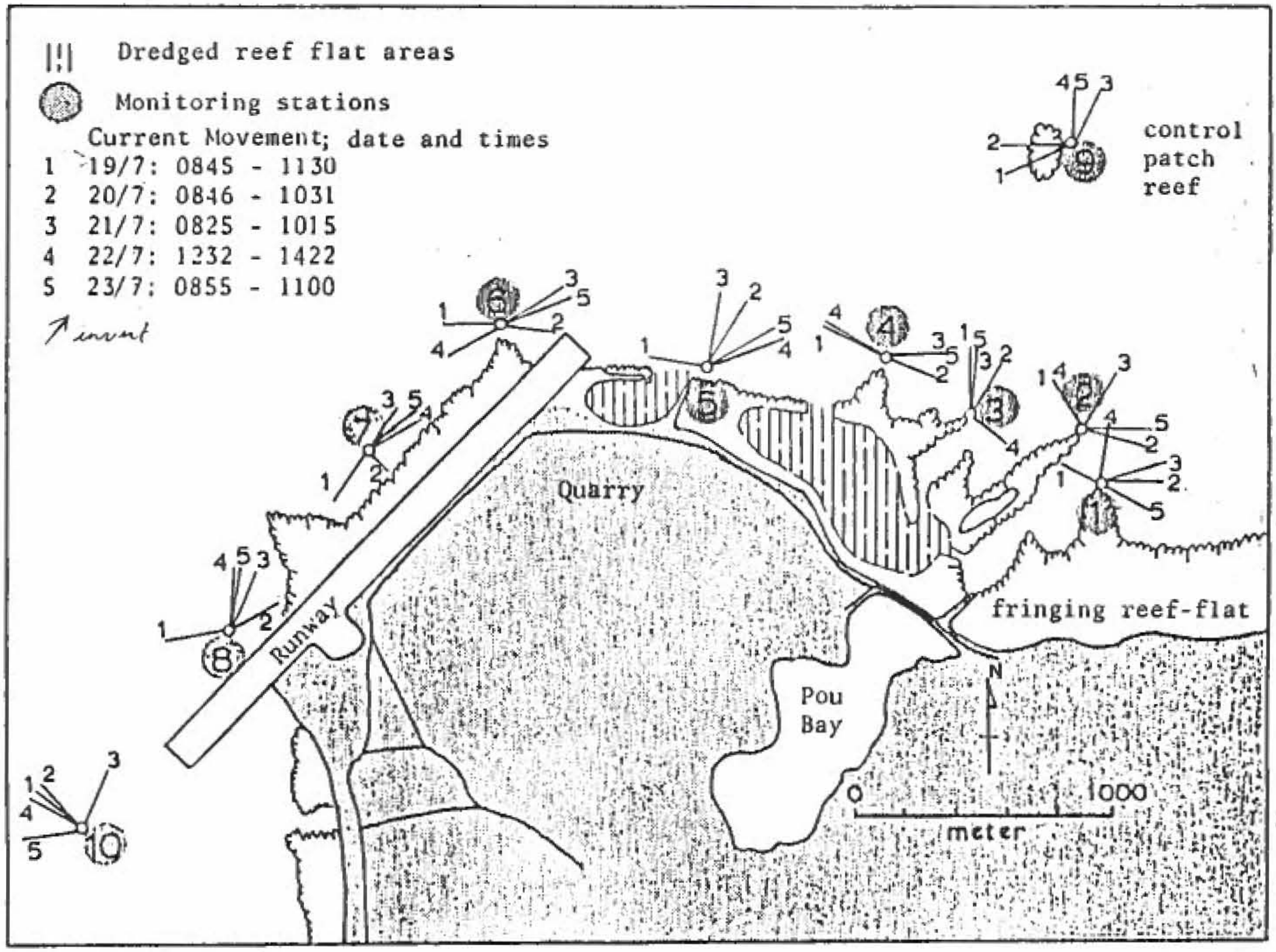

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Figure 1. Water flow measurements at water quality stations, July 19 to 23, 1982.

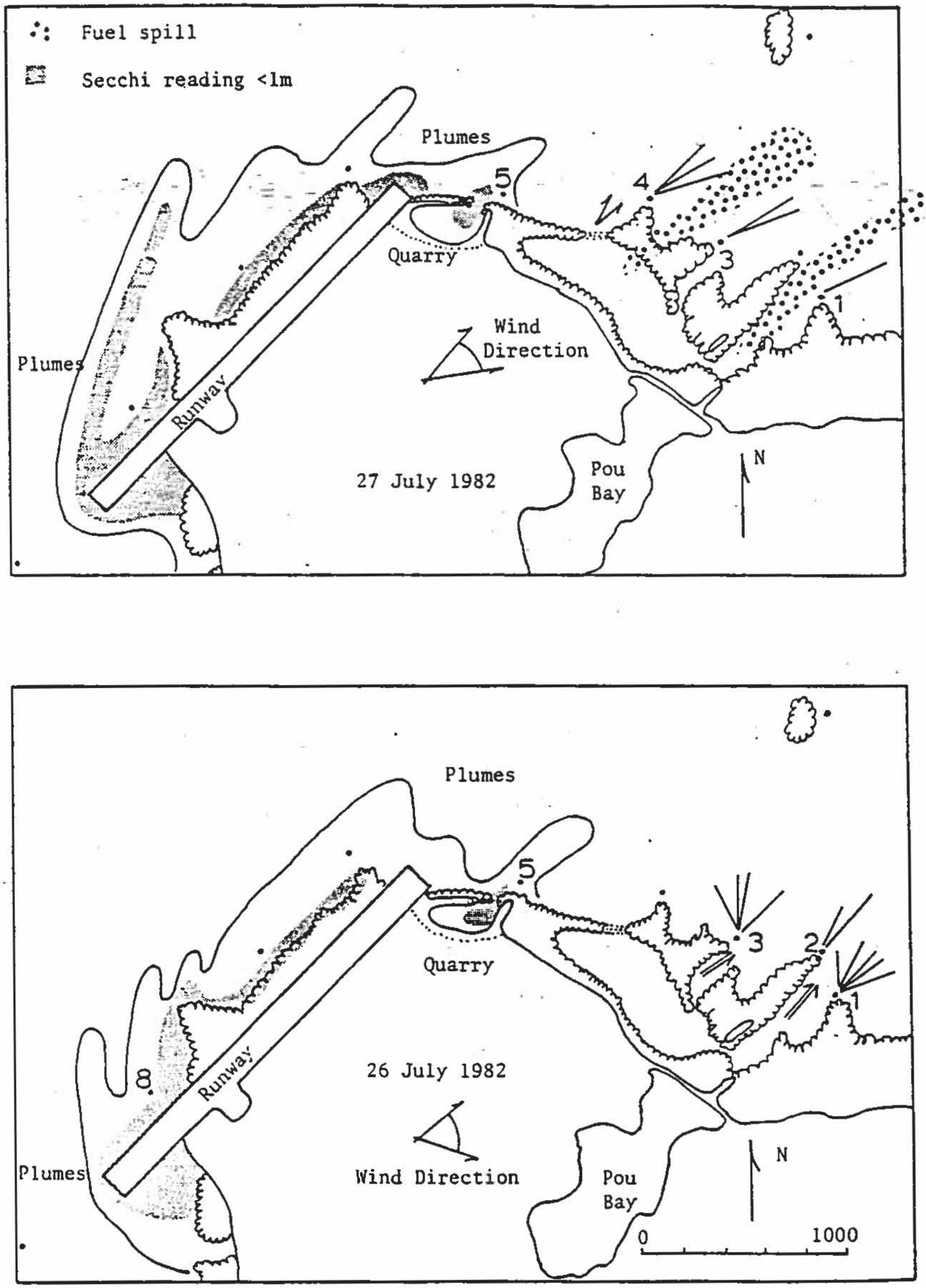

Figure 2. Water flow movements and turbidity plumes at biological stations July 26 and 27, 1982.

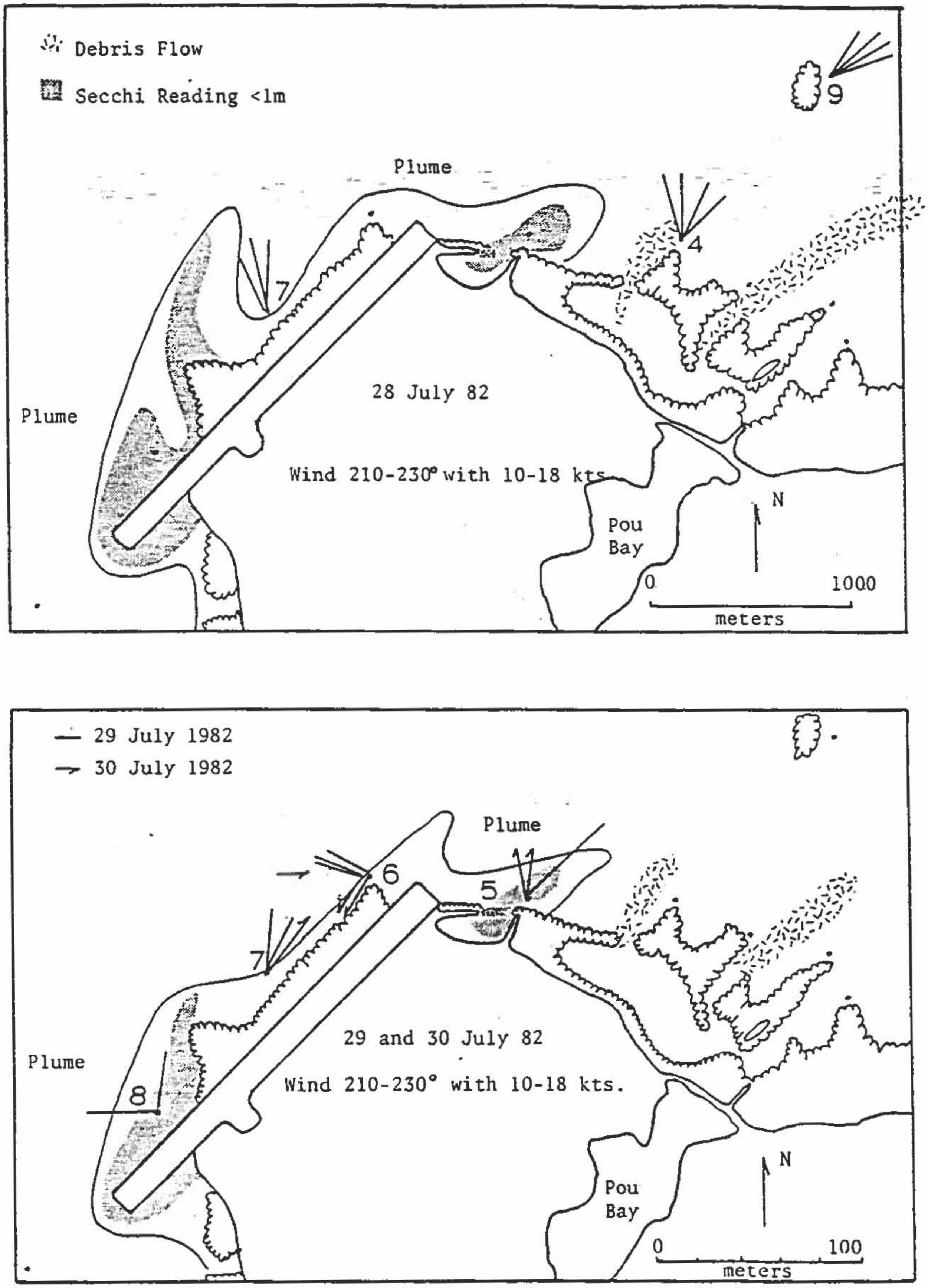

Figure 3. Water flow movement and turbidity plumes at biological stations July 28, 29 and 30, 1982.

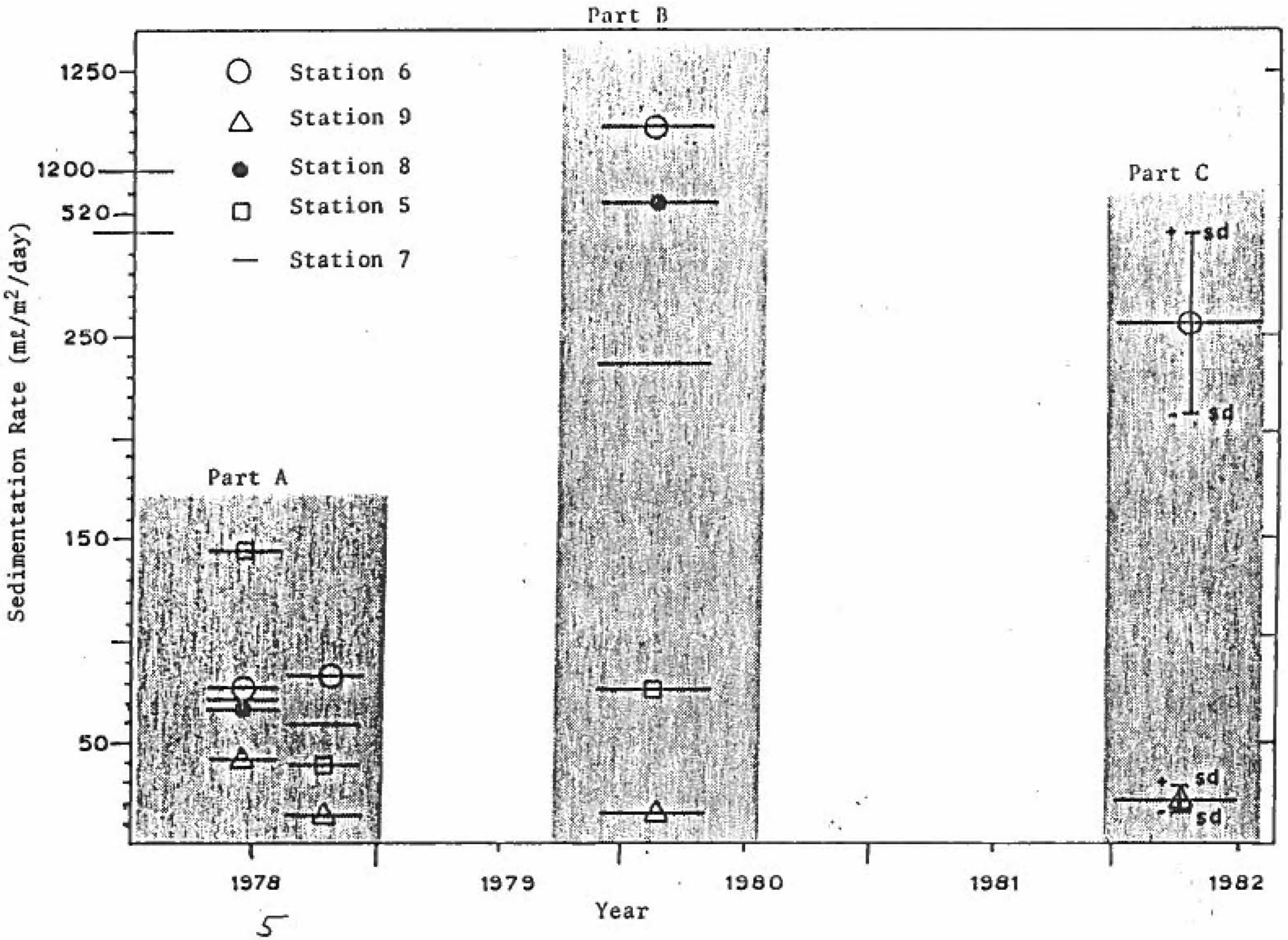

Figure ~~4~~ 5. Sedimentation rates at construction impacted stations 5, 6, 7 and 8 compared with the control station 9.

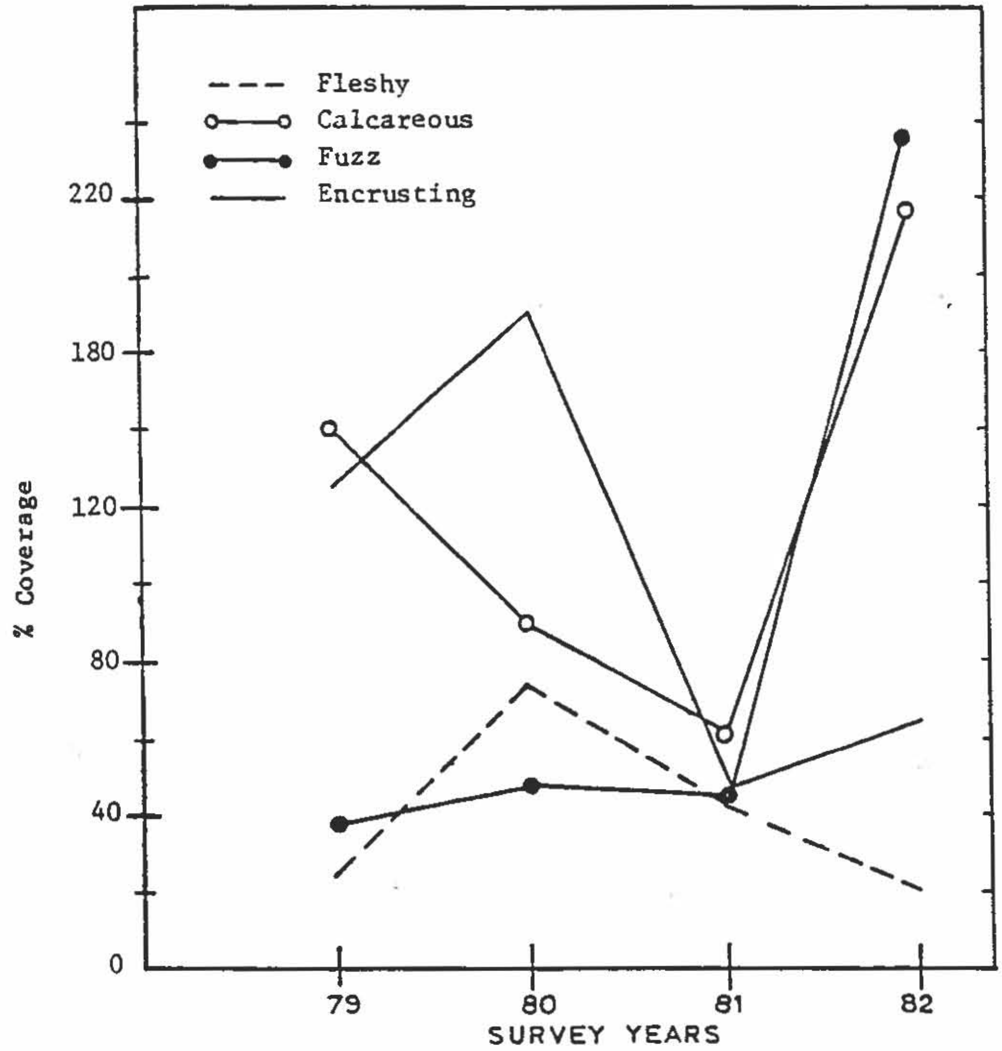

Figure ⑤ 6. Percent coverage of marine plant functional groups; encrusting, fleshy, calcareous and fuzz (turf), for the survey year 1979-1982.

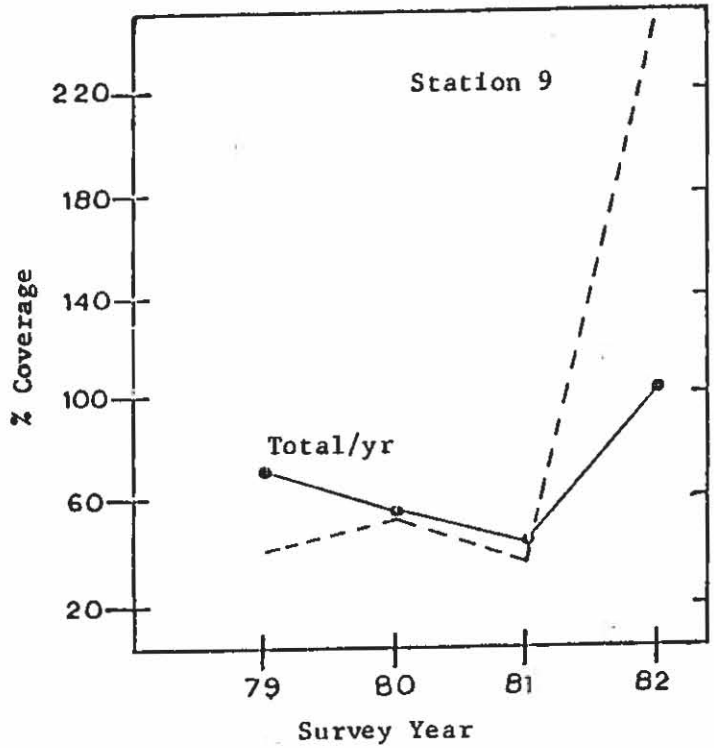

Figure ~~6~~ 7. *Halimeda opuntia*: total percent coverage for all stations in survey years 1978-1982 and Station 9.

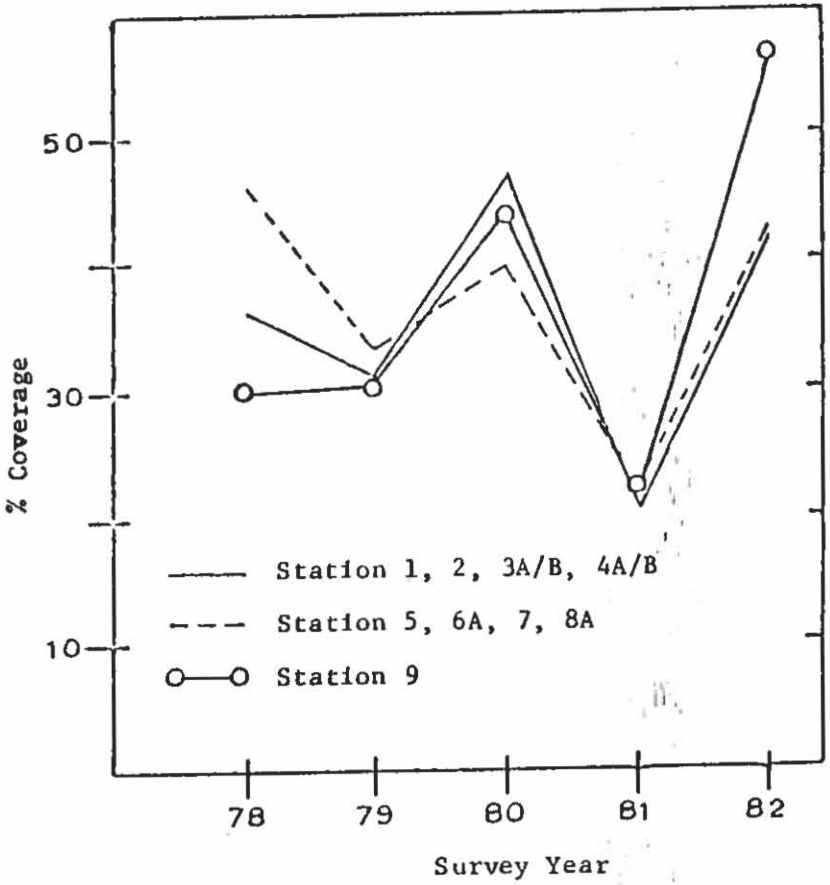

Figure ~~7~~ 8. Marine plant functional group percent coverage for survey years 1978-1982; encrusting, fleshy, calcarepus and fuzz (turf) algal types.

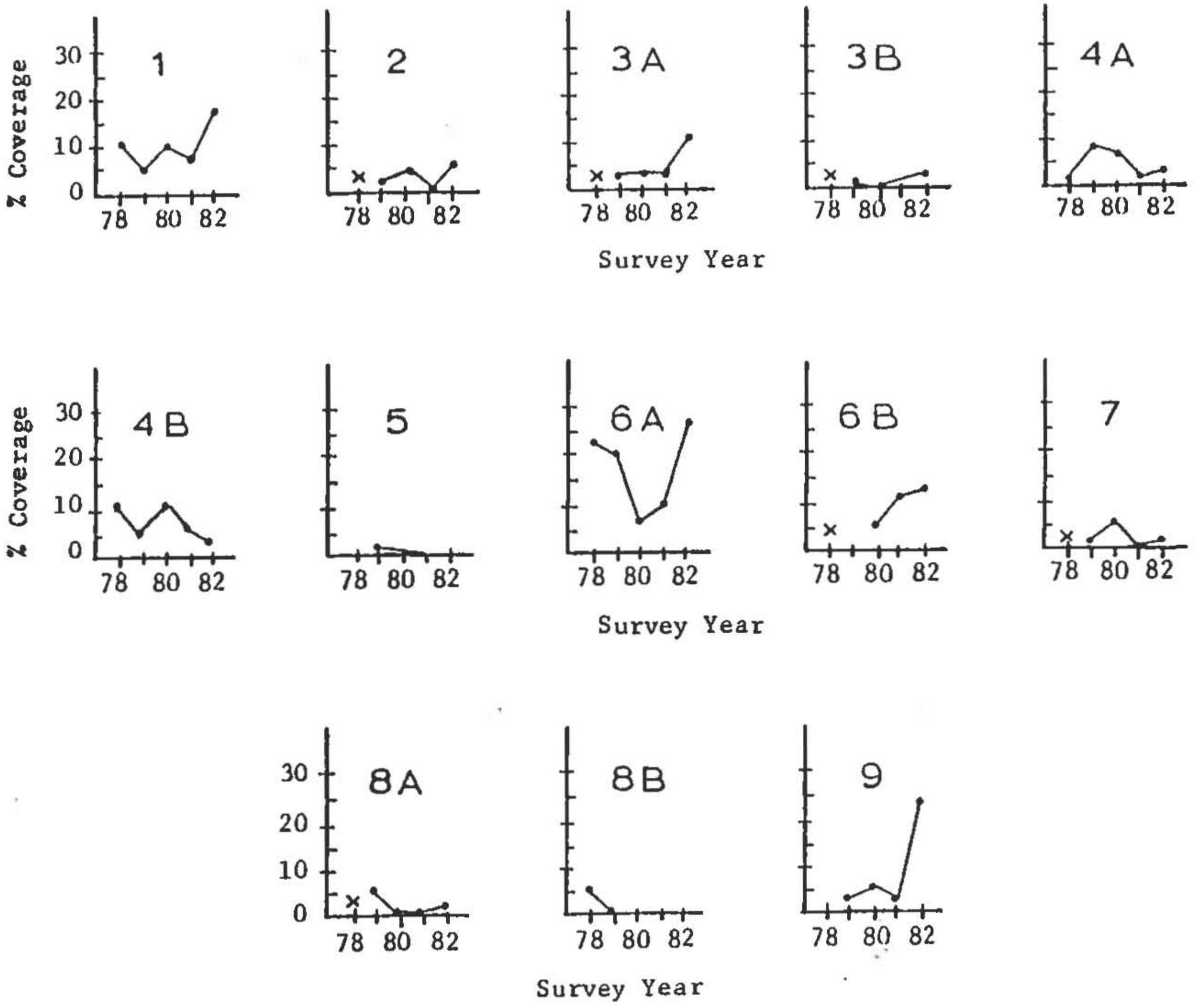

Figure ~~8~~9. Halimeda opuntia; total percent coverage at each station for the surveys 1978-1982. The "X" indicates that H. opuntia was observed at the station but was not quantified.

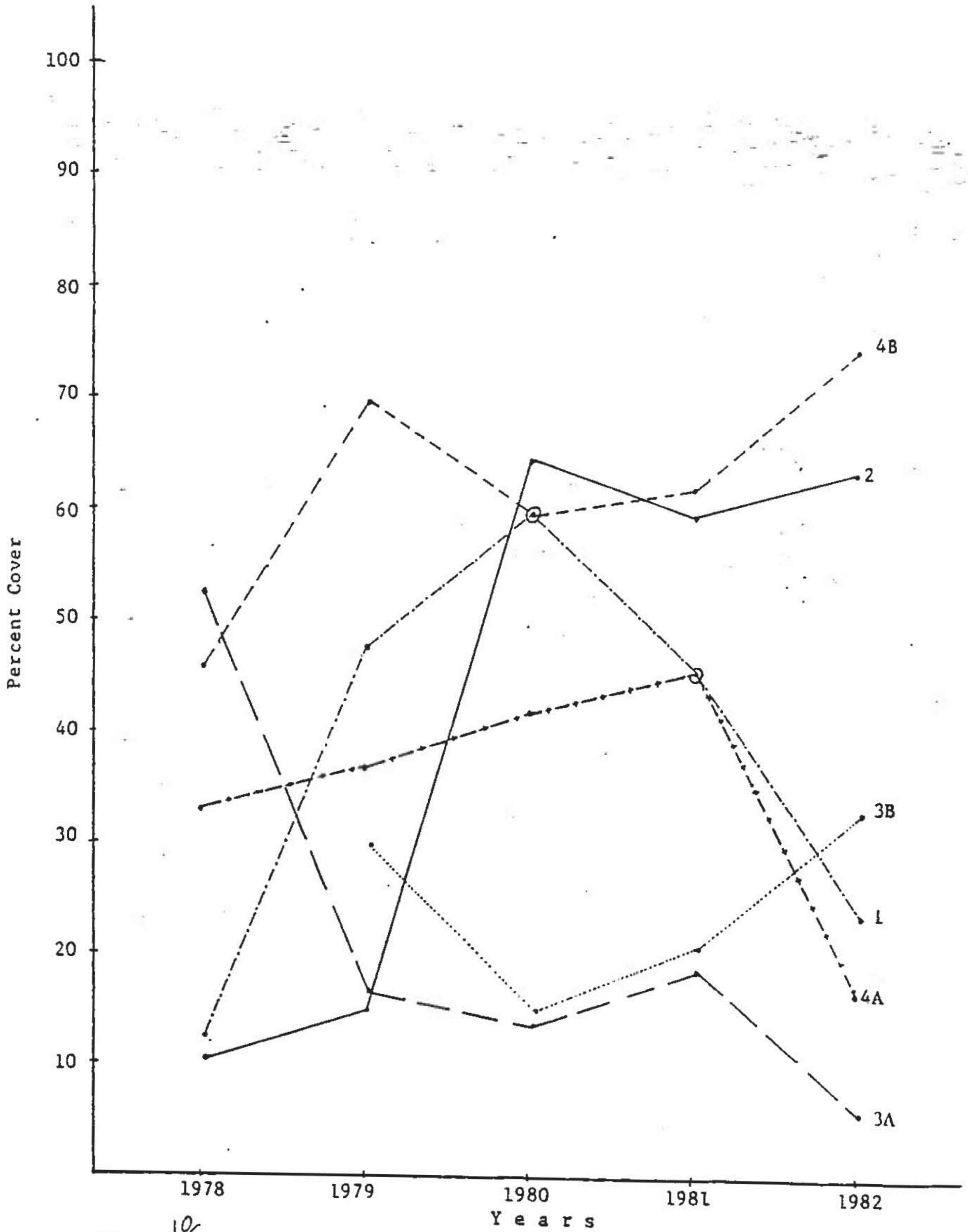

Figure ~~9~~ 10. Percent coral cover from 1978 to 1982, Stations 1 through 4, near the dredging sites.

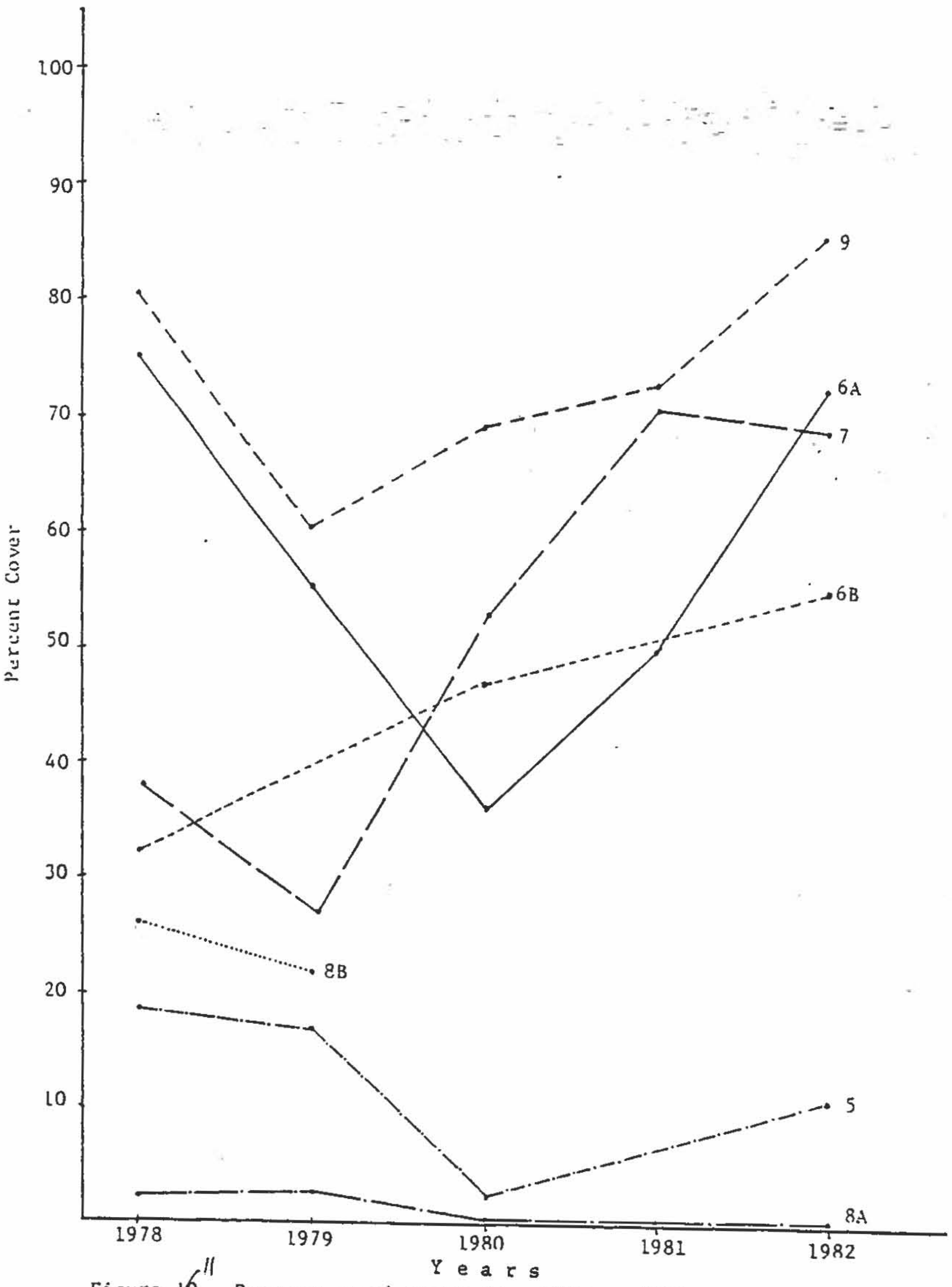

Figure ~~10~~ 11. Percent coral cover from 1978 to 1982, Stations 5 through 9, adjacent to the runway.

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Table 1. Current flow directions and relative speeds at water quality stations, July 19 to 25, 1982.

STATION		Current Flow Direction (degrees) DATE 7-19	7-20	7-21	7-22	7-23
1	FLOW	305	090	075	010	130
	rs*	M	F	M	M	F
2	FLOW	330	105	030	330	090
	rs	F	F	F	F	F
3	FLOW	360	030	005	130	360
	rs	F	S	M	S	F
4	FLOW	294	090	110	300	090
	rs	F	S	F	M	F
5	FLOW	280	030	010	070	060
	rs	M	F	M	S	M
6	FLOW	270	100	060	240	070
	rs	F	F	F	F	F
7	FLOW	225	135	040	060	045
	rs	M	M	F	S	M
8	FLOW	260	060	025	005	010
	rs	S	M	F	F	F
9	FLOW	245	270	030	360	360
	rs	F	F	F	S	M
10	FLOW	305	310	025	300	260
	rs	M	S	M	S	F

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* rs - Relative speed:
S - slow
M - moderate
F - fast

Table 2. Water current movements and wind directions at biological stations for July 26 to 30, 1982.

DATE	WQ Station	TIME	WATER CURRENT Direction°	Speed*	WIND Direction°	Speed (kts)	TIDE (ft) Time	Height
26 July	1	0945	065	M	230	12	0523	2.4
		1015	025	M	230	12	1236	1.1
		1145	360	S	250	10	1841	1.6
	2	1200	025	F	260	10	2148	1.4
		1230	060	F	260	10		
		1330	040	M	260	10		
	3	1350	045	M	280	10		
		1445	010	M	270	10		
		1500	340	M	270	10		
27 July	1	1130	060	F	260	10	0515	2.2
	4	1150	070	F	260	10	1217	1.1
		1600	060	F	220	10	1933	1.7
		1630	050	F	230	10	2203	1.5
	3	1200	060	F	220	10		
		1320	070	F	260	10		
28 July	4	0915	040	M	210	8	0439	2.0
		0930	350	M	210	8	1154	1.0
		0935	360	M	210	8		
		1045	030	M	220	10		
	9	1130	030	S	230	10		
		1140	055	S	230	10		
		1230	060	S	230	10		
		1245	070	S	230	10		
	7	1320	350	F	210	16		
		1420	340	F	210	18		
		1430	360	F	210	18		
29 July	6	0910	290	M	210	10	0319	2.0
		1130	300	F	210	8	1132	0.9
	7	1210	360	M	210	6		
		1300	040	F	220	6		
	8	1310	020	M	220	6		
	5	1500	045	M	220	7		
30 July	6	0820	210	S	360	2	0154	2.1
		0830	290	S	360	2	1114	0.9
		1000	200	S	330	4		
	5	0900	360	S	360	3		
		0945	350	S	360	3		
	8	1030	270	S	330	4		
	6-7	1420	090	M	310	3		

* Speed: F - fast; M - moderate; S - slow.

Table 3. Summary of weather data from NOAA weather station, Moen Island, and lagoon tidal changes.

DATE	TIME INTERVAL	WIND DIRECTION (degrees)	SPEED (kts)	FASTEST WIND-24hr (dir)	kts	AIR TEMPERATURE (°F)	BAROMETRIC PRESSURE (in. Hg)	TOTAL SUNSHINE (min)	RAINFALL 24-hr (in)	TIDAL TIME (ft)	CHANGE TIME (ft)	TIDE DURING SAMPLING
7-18	0800-1300	337	6	(N)	12	84.7	29.725	183	0.01	0201(2.8)	1029(0.5)	Fall*
7-19	0800-1300	100	6	(SW)	20	84.0	29.735	139	0.12	0233(3.0)	1053(0.4)	Fall
7-20	0800-1300	250	3	(W)	17	76.9	29.785	4	2.52	0306(3.1)	1122(0.3)	Fall
7-21	0800-1300	200	17	(SW)	36	77.9	29.805	0	2.40	0338(3.2)	1148(0.4)	Fall
7-22	1100-1600	210	19	(SW)	34	84.7	29.715	303	0.16	0410(3.2)	1214(0.5)	Neap
7-23	0800-1300	215	14	(SW)	36	82.3	29.785	87	1.47	0438(3.1)	1232(0.6)	Fall
7-24	24-hr	---	16.1	(SW)	32	81	---	384	0.20	0501(2.9)	1244(0.8)	--
7-25	24-hr	---	15.7	(SW)	23	85	---	511	0	0519(2.7)	1244(1.0)	--
7-26	24-hr	---	13.2	(SW)	19	85	---	392	0	0523(2.4)	1236(1.1)	--
7-27	24-hr	---	16.4	(SW)	25	83	---	46	0	0515(2.2)	1217(1.1)	--
7-28	24-hr	---	12.6	(SW)	23	82	---	510	0.25	0439(2.0)	1154(1.0)	--
7-29	24-hr	---	5.4	(SW)	17	84	---	536	0	0319(2.0)	1132(0.9)	--
7-30	24-hr	---	4.8	(NE)	17	80	---	83	.71	0154(2.1)	1101(0.8)	--

* Reef flats and patchreef (station 9) exposed during sampling.

Table 4. Turbidity measurements at water quality stations for Part C monitoring.

				Turbidity (NTU)			
				DATE			
STATION		7-19	7-20	7-21	7-22	7-23	MEAN ± s.d.
1	TOP*	0.90	1.2	1.0	0.95	1.2	1.0 ± .14
	SUB*	0.59	0.85	0.75	1.0	1.2	0.88 ± .23
2	TOP	0.85	1.8	0.94	1.1	1.4	1.2 ± .39
	SUB	0.70	1.2	1.1	0.86	1.4	1.0 ± .28
3	TOP	0.70	0.78	0.94	1.1	1.4	0.98 ± .28
	SUB	1.3	0.70	0.72	1.5	1.8	1.2 ± .48
4	TOP	1.2	1.1	0.98	1.0	1.6	1.2 ± .25
	SUB	0.80	0.80	0.74	1.0	1.5	0.97 ± .31
5	TOP	1.2	1.2	1.1	1.4	5.5	2.1 ± 1.9
	SUB	0.98	1.1	0.78	1.01	4.5	1.7 ± 1.6
6	TOP	2.8	0.90	0.95	1.6	7.3	2.7 ± 2.7
	SUB	1.1	1.4	1.1	1.2	6.2	2.2 ± 2.2
7	TOP	1.2	1.0	1.1	1.6	3.2	1.6 ± .91
	SUB	0.70	1.5	0.94	1.9	1.5	1.3 ± .48
8	TOP	1.2	1.5	0.86	1.9	4.9	2.1 ± 1.6
	SUB	1.7	0.54	1.3	1.2	3.0	1.6 ± .91
9	TOP	0.45	0.45	0.50	0.60	0.81	0.56 ± .15
	SUB	0.68	0.45	0.58	0.67	0.78	0.63 ± .12
10	TOP	0.65	0.43	0.46	0.55	0.62	0.54 ± .10
	SUB	0.36	0.50	2.2	0.70	0.70	0.89 ± .75

* TOP: surface sample at -1 m below surface.
SUB: bottom sample at +1 m above substratum.

Table 5. Sedimentation 'rain' at stations for preconstruction, construction and postconstruction monitoring programs.

	PRE - CONSTRUCTION			BULK	CONSTRUCTION I			CONSTRUCTION II		POST-CONSTRUCTION	
STATIONS	mℓ/m^2/day	g/m^2/day	% Organic	Sediments % Organics	mℓ/m^2/day	g/m^2/day	% Organic Content	mℓ/m^2/day	% Organic Content	mℓ/m^2/day	g/m^2/day
1	51.4	11.6	12	3.2	75.1	19.7	10.4	86.2	---		
2	75.2	16.1	12	2.8	96.9	20.3	10.7	21.1	---		
3	73.8	18.8	12.6	3.4	45.6	12.4	8.5	66.5	---		
4	53.8	10.1	13	2.5	92.1	20.8	13.1	25.1	---		
5	143.2	42.3	8.2	3.3	39.8	9.2	14.5	73.6	---		
6	74.4	16.3	11.9	2.4	82.4	24.9	10.0	1221.3	17	255.6*	100.6*
7	75.9	14.4	14.3	2.6	59.6	15.6	9.7	233.5	---		
8	68.1	14.4	9.7	3.3	----	----	----	517.3	---		
9	42.8	17.9	13	3.6	14.1	3.9	10.2	18.3	8	23.6*	12.5*

* mean value for 20 sedimentation traps.

Table 6. Marine plant species observed at monitoring stations in 1982 (numbers = % coverage along transects, X = species observed at station).

	Station																							
Species	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'
CYANOPHYTA																								
Hormothamnion sp.	X	X																						
Microcoleus lyngbyaceus	X	X	X	X	X	X	X	X	X	X	.09				X	X	X	X						
Schizothrix calcicola	X	X	X	X	X	X	1.4		X	X	X	X			X	X	X	X					X	X
S. mexicana	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.04				X	X
Unidentified bluegreen										4.5	X	X					1.1							
CHLOROPHYTA																								
Avrainvillea sp.			X	X	X	X																		
Boergesenia forbesii																			.04					
Caulerpa filicoides					X	X							0.8	0.8			1.1			0.5	7.4	9.1		
C. racemosa					X	X																	0.6	0.4
C. serrulata																	X	X						
C. verticillata																	0.6					2.3	X	X
Chlorodesmis fastigiata																							X	X
Cladophoropsis sp.				1.3	X	X	X	X			X	X			1.9			1.1					1.7	0.6
Halimeda cylindrica					0.9	0.9	X.	X		0.4					X	X	X	X		1.8		0.3		
H. discoidea	2.5					0.9		2.1		2.1					X	X	2.8	2.5	X	X				
H. gigas	3.3	4.0	8.1	3.1	3.6	2.7		0.7	2.0	3.1	1.8								X	X		1.4	0.4	1.5
H. incrassata																			X	X			X	X
H. macroloba	6.9	1.7	1.9								0.5	0.9	10.9	0.8	3.1	3.1	1.1	0.6					2.7	2.7
H. microphysa									X	X			9.4	2.3			1.1		X	X			X	X
H. micronesica		1.7		1.3			X	X		1.4					1.3	6.9	1.1	0.6					14.2	
H. opuntia	20.6	16.5	7.5	5.6	5.6	18.8	3.5	1.4	6.9		2.7	5.4			45.6	28.8	23.3	5.7	0.4	0.5	3.3	2.3	25.6	23.3
H. taenicola	X	X				0.9			X	X					X	X			X	X	X	X		
Rhipilia orientalis					X	X					X	X	3.9	7.8						0.5				
Tydemania expeditionis											0.5			0.8						3.6				
Udotea argentea			X	X	X	X			X	X							X	X	X	X		0.3		
Valonia ventricosan							X	X											X	X				
PHAEOPHYTA																								
Dictyota bartayressi													X	X							5.4	6.8		

Table 6 Continued.

	Station																							
Species	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'
D. friabilis	1.7	1.7	0.6					0.7	0.7	3.8	5.8	0.5							0.4				0.4	0.8
D. patens							X	X																
Lobophora variegata	2.5				1.8	3.6	14.3	29.2			4.0	6.7	1.6	0.8	4.4					2.5		2.0	3.1	3.5
Padina jonesii																				0.4				
P. tenuis																					4.5	4.0		
Rosenvingea intricata									X	X													X	X
RHODOPHYTA																								
Actinotrichia fragilis					X	X					X	X							X	X			8.5	5.2
Amphiroa foliacea					X	X			X	X													X	X
A. fragilisima	X	X																						0.2
Asparagopsis taxiformis															X	X	X	X						
Centroceras sp.																							X	X
Ceramium sp.																							X	X
Galaxaura fascicularis																							X	X
Galaxaura intricata					X	X						1.3					X	X	0.4			1.2	X	X
Jania capillaceae	X	X	X	X			X	X	X	X	X	X			X	X	X	X	0.4				X	X
Laurencia papilosa																						2.6		
Lithophylum kotschyanum																							X	X
Lithoporella pacifica														5.5			X	X				0.6		
Peysonellia rubra	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X			0.4	1.7
Polysiphonia howei					X	X	X	X	X	X					X	X						0.3		
Porolithon sp.					x	x			2.6	0.7		5.4	0.8	1.6	4.9	3.1		1.3	3.3				X	X
Red filamentous turf	0.4	0.4	3.8	18.1	16.1	37.5	29.2	20.8	56.2	37.5	13.0	22.3	14.8	28.9	3.8	6.2	8.5	17.1	31.7	10.3	21.4	29.3	8.3	2.3
Total species/transect	7	6	5	5	6	7	5	7	5	8	8	7	7	8	7	5	7	7	10	6	5	12	11	11
Total species/station	15	15	15	15	20	20	17	17	16	16	17	17	10	10	17	17	17	17	19	19	13	13	15	15
Total coverage	37.9	25.8	21.9	30.6	28.4	65.2	48.6	56.3	70.4	53.1	29.0	42.4	42.2	49.2	64.4	48.1	40.9	34.9	40.4	17.0	44.0	57.9	66.3	47.3
Mean coverage/station	31.9		26.3		46.9		52.4		61.8		35.7		45.7		56.3		37.9		28.7		51.0		56.8	

Table 7. Species richness and percent coverage of marine plants recorded on the stations monitored during the years 1978-1982. Replicate transects are averaged.

Station	Number of species/transect				Number of species/station					Percent Coverage				
	1979	1980	1981	1982*	1978	1979	1980	1981	1982**	1978	1979	1980	1981	1982
1	15.5	16	9	6.5	15	19	24	29	15	50	34.6	63.1	27.4	31.9
2	12	16	6.5	5	9	15	25	20	15	24	29.2	31.3	10.4	26.3
3A	11.5	15.5	6.5	6.5	21	17	23	23	20	45	18.2	54.5	30.1	46.9
3B	10	10.5	5	6	6	17	23	29	20	38	32.4	48.8	34.4	52.4
4A	10	19	8	6.5	6	10	30	25	16	45	46.1	46.8	15.1	61.8
4B	11.5	24	10	7.5	12	14	22	19	17	20	31.0	38.1	24.9	35.7
5	12.5	13	--	7.5	15	14	18	--	10	51	39.6	44.1	--	45.7
6A	12	17	9	6	10	14	24	24	17	41	31.8	68.2	33.6	56.3
6B	--	17.5	9	7	20	--	23	17	17	51	--	54.3	42.2	37.9
7	11	16	4	8	14	13	22	24	19	41	23.8	27.4	7.4	28.7
8A	11	8	6	5.5	17	12	10	19	13	71	49.9	7.5	16.0	51.0
8B	13	--	--	--	17	19	--	--	--	25	23.0	--	--	--
9	19.5	17.5	10	11	17	23	25	24	15	30	31.2	44.2	21.4	56.8
10	19.0	15.5	--	--	--	21	23	--	--	--	31.9	44.4	--	--
Mean	13.0	15.8	7.5	6.9	13.8	16.0	22.5	23.0	16.2	40.9	32.5	44.1	23.9	44.3

Cumulative no. species observed at all stations: 1978 - 47, 1979 - 39, 1980 - 53, 1981 - 55, 1982 - 49

Cumulative no. species observed at stations 1-8: 1978 - 35, 1979 - 34, 1980 - 52, 1981 - 52, 1982 - 45

* This figure is not available for 1978.

** Data for transects 3A and 3B were lumped for comparative purposes with previous studies (see Amesbury, et al. 1981).

Table 8. The most abundant marine plants species observed at each station in the 1978-1982 survey. The numerical entries are percent cover.

Site	1978		1979		1980		1981		1982	
1	*Halimeda opuntia*	12%	Coralline	8.3	Coralline	18.9	*H. opuntia*	9.4	*Halimeda opuntia*	18.5
			H. opuntia	5.6	*H. opuntia*	10.9	*H. discoidea*	4.1	*H. macroloba*	4.3
			Lobophora	3.8	*Lobophora*	6.9	*Polysiphonia* turf	3.3	*H. gigas*	3.7
2	*Dictyota patens*	12	Coralline	6.9	Coralline	6.2	Coralline	4.1	Red filamentous turf	3.3
			H. gigas	6.4	*Lobophora*	6.8	*Polysiphonia* turf	2.6	*H. opuntia*	6.6
			H. opuntia	4.0	*H. opuntia*	5.2	*Caulerpa verticillata*	1.3	*H. gigas*	5.6
3A	*D. patens*	20	Coralline	4.9	*Dictyota* sp.	20.1	*Polysiphonia turf*	12.5	Red filamentous turf	11.0
			H. opuntia	4.1	Coralline	12.0	*Dictyota friabilis*	7.3	*H. opuntia*	12.2
			Lobophora	8.0	*Lobophora*	3.6	*H. gigas*	3.1		
3B	*D patens*	14	*L. variegata*	18.4	*Lobophora* sp.	18.7	Coralline	15.7	Red filamentous turf	25.0
			Coralline	5.2	*Dictyota* sp.	18.4	*D. friabilis*	10.4	*Lobophora variegata*	21.7
			Polysiphonia/		Coralline	9.4	*Polysiphonia* turf	6.0	*H. macroloba*	1.4
			Gelidiopsis turf	5.2						
4A	*H. opuntia*	11	*H. opuntia*	19.6	Coralline	14.2	Coralline	6.7	Red filamentous turf	47.7
			Coralline	9.9	*Dictyota* sp.	9.2	*H. opuntia*	3.4	*H. opuntia*	3.5
			Polysiphonia/		*H. opuntia*	7.9			*H. gigas*	2.6
			Gelidiopsis turf	4.6	*Lobophora*	6.0				
4B	*D. patens*		Coralline	9.6	*H. opuntia*	11.5	*Polysiphonia* turf	8.3	Red filamentous turf	17.6
			Lobophora variegata	5.9	Coralline	11.3	*H. opuntia*	6.7	*Lobophora variegata*	5.4
			H. opuntia	5.8	*Dictyota*	5.4	*D. friabilis*	4.6	*H. opuntia*	5.4
					Lobophora	4.2				
5	*Microcoleus*		*Polysiphonia*/		*Polysiphonia* turf	11.2			Red filamentous turf	21.9
	lyngbyaceus	15	*Gelidiopsis* turf	15.3	Coralline	12.8			*H. macroloba*	5.9
			Coralline	14.8	*Lobophora*	5.4			*H. microphysa*	5.9
					Caulerpa filicoides	5.4				

Table 8 Continued.

6A	*H. opuntia*	22%	*H. opuntia*	20.8	Coralline	21.7	*H. opuntia*	10.2	*H. opuntia*	37.2
					Polysiphonia turf	12.8	*Asparagopsis taxiformis*	9.1	*H. micronesica*	4.0
					Lobophora	12.5	Coralline	7.5	*Porolithon* sp.	3.8
					H. opuntia	7.0				
6B	*H. cylindracea*	17			*Polysiphonia* turf	16.7	*Halimeda opuntia*	13.8	*H. opuntia*	14.5
					Coralline	13.0	Coralline	15.0	Red filamentous truf	12.8
					H. opuntia	5.0	*Dictyota friabilis*	2.8	*H. discoidea*	5.7
					Dictyota sp.	5.0				
7	*D. patens*	16	*Polysiphonia/ Gelidiopsis* turf	12.7	Coralline	14.4	Coralline	3.3	Red filamentous turf	21.0
			Coralline	7.2	*Polysiphonia* turf	5.0	*Polysiphonia* turf	2.7	*Lobophora variegata*	1.8
									Tydemannia expedetionis	1.8
8A	*Padina jonesii*	40	*Polysiphonia/ Gelidiopsis* turf	12.7	Coralline	6.5	*Padina jonesii*	10.8	Red filamentous turf	25.4
			Coralline	1.24			*Halimeda gigas*	1.2	*Caulerpa filicoides*	8.3
			H. opuntia	10.3			*Galaxaura fasciluta*	1.1	*Dictyota bartayresii*	6.9
			P. jonesii	7.2						
8B	*H. cylindracea*	7	*Polysiphonia/ Gelidiopsis* turf	11.4	-------------		-------------		*H. opuntia*	24.5
			Coralline	5.4					*H. macroloba*	5.2
									Lobophora variegata	3.3
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	-------------		-------------	
			Coralline	10.1	*Polysiphonia* turf	8.1				
			L. variegata	6.2	*Lobophora*	5.4				
					Dictyota	4.2				

Table 9. Halimeda opuntia: percent coverage, 1978-1982 (replicate transects are averaged).

	YEAR					
Station	1978	1979	1980	1981	1982	
1	12	5.6	11.0	9.4	18.6	44.6
2	X	4.1	5.2	.7	6.6	16.6
3A	X	4.1	4.0	4.3	12.2	24.6
3B	X	0.4	0.3	0.8	2.5	4.0
4A	X	9.8	1.9	3.4	4.0	25.1
4B	11.0	5.8	11.5	6.6	4.1	28.0
5	X	1.3	2.8	14.1	11.71	29.9
6A	22	20.6	7.0	10.1	27.2	64.9
6B	X	10.3	5.1	13.8	14.5	43.7
7	X	1.4	0.2	.4	1.53	3.3
8A	X	5.3	0.7	0.4	2.8	9.2
9	X	4.1	5.5	3.6	34.5	37.7

Table 10. Percent coverage of marine plant functional groups at monitoring stations, 1979-1982.

CALCARIOUS		SURVEY			ENCRUSTING		SURVEY		
Station	1979	1980	1981	1982	Station	1979	1980	1981	1982
1	14.4	22.8	18.1	35.8	1	13.2	25.8	4.0	4.7
2	11.8	6.3	1.6	30.7	2	10.8	13.0	4.2	0
3A	36.0	7.3	6.9	17.7	3A	7.3	20.2	3.6	2.7
3B	1.4	0.9	0.8	4.3	3B	22.6	28.1	16.9	21.7
4A	21.9	9.3	4.2	8.0	4A	12.2	6.0	5.0	1.7
4B	9.6	13.4	8.8	6.1	4B	25.0	4.3	1.9	4.8
6A	25.6	11.3	12.1	44.9	6A	3.5	34.3	8.0	3.0
7	2.8	0.4	0.2	1.6	7	8.5	16.9	3.9	22.3
8A	10.7	1.6	1.8	11.4	8A	14.0	6.2	0	1.0
9	6.9	16.8	7.1	39.4	9	8.5	15.5	1.8	4.4
TOTAL	141.0	90.0	61.6	199.9	TOTAL	126.6	170.1	49.3	66.3

TURF		SURVEY			FLESHY		SURVEY		
Station	1979	1980	1981	1982	Station	1979	1980	1981	1982
1	4.2	6.0	3.9	0.4	1	9.1	5.4	1.8	1.7
2	3.4	7.1	2.0	11.6	2	4.6	6.1	2.8	0.3
3A	.4	7.0	12.5	26.8	3A	1.6	22.1	7.8	0
3B	3.5	0	5.6	25.0	3B	2.2	19.1	10.7	0.4
4A	5.9	5.1	0.2	47.7	4A	1.4	10.6	3.4	2.6
4B	3.4	2.1	8.4	18.4	4B	1.4	5.7	5.6	3.5
6A	7.1	14.0	0.6	7.0	6A	0.6	0.8	9.4	0
7	5.9	5.0	1.8	13.3	7	0	0.3	0.2	2.6
8A	6.4	0	1.0	21.2	8A	0.1	0.4	2.2	7.6
9	5.0	3.4	7.8	6.5	9	0.9	0.8	0	0.6
TOTAL	39.2	49.7	44.7	217.9	TOTAL	23.7	74.0	43.9	20.7

Table 11. Living coral density, percent cover (dominance), and frequency of occurrence (1982). Importance value is the sum of the relative values of the above parameters. Corals arranged in order of their importance value. N = sample number, Y = mean coral diameter, S = standard deviation of coral diameter and W = range of coral diameter.

A.	Point Quarter Transects	n	$\overline{Y}$	s	w	Frequency	Relative Frequency	Density	Relative Density	Percent Cover	Relative Percent Cover	Importance Factor
1	Acropora formosa	22	37	8	23-49	.70	35	1.32	55	13.90	76.71	166.71
	Porites (S.) iwayamaensis	7	27	14	9-45	.30	15	.42	17.50	3.0	16.56	49.06
	Pocillopora damicornis	3	11	8	2-16	.30	15	.18	7.50	.24	1.32	23.72
	Acropora elseyi	3	19	10	8-27	.20	10	.18	7.50	.59	3.25	20.75
	Acropora quelchi	1				.10	5	.06	2.50	.13	.72	8.22
	Porites lutea	1				.10	5	.06	2.50	.11	.61	8.11
	Acropora variabilis	1				.10	5	.06	2.50	.10	.55	8.05
	Fungia repanda	1				.10	5	.06	2.50	.04	.22	7.72
	Acropora cerealis	1				.10	5	.06	2.50	.01	.05	7.55

Overall Density 2.40
Percent Cover 18.12%

1'	Acropora formosa	22	39	16	17-66	.60	37.5	1.32	55.0	18.80	59.25	151.75
	Porites (S.) iwayamaensis	10	21	18	4-65	.30	18.75	.60	25.0	3.61	11.38	55.13
	Acropora divaricata	2	67	11	60-75	.10	6.25	.12	5.0	4.39	13.83	25.08
	Acropora austera	1				.10	6.25	.06	2.50	2.90	9.14	17.89
	Porites lutea	1				.10	6.25	.06	2.50	1.17	3.69	11.94
	Acropora granulosa	1				.10	6.25	.06	2.50	.42	1.32	10.07
	Acropora cerealis	1				.10	6.25	.06	2.50	.22	.69	9.44
	Acropora elseyi	1				.10	6.25	.06	2.50	.21	.66	9.41
	Seriatopora hystrix	1				.10	6.25	.06	2.50	.01	.03	8.78

Over Density 2.40
Percent Cover 31.73%

Table 11 Continued.

A.	Point Quarter Transects	n	$\overline{Y}$	s	w	Frequency	Relative Frequency	Density	Relative Density	Percent Cover	Relative Percent Cover	Importance Factor
3A	*Acropora formosa*	13	42	12	17-65	.60	27.27	.14	32.50	2.06	39.61	99.38
	Porites lutea	13	28	19	7-66	.70	31.81	.14	32.50	1.24	23.85	88.16
	Porites (S.) iwayamaensis	5	44	22	20-65	.20	9.09	.05	12.50	.99	19.04	88.16
	Acropora hyacinthus	3	42	35	16-79	.20	9.09	.03	7.50	.64	12.31	28.90
	Pocillopora damicornis	2	11	13	2-21	.20	9.09	.02	5.0	.04	.76	14.85
	Acropora elseyi	2	23	7	23-24	.10	4.54	.02	5.0	.10	1.92	11.46
	Psammocora digitata	1				.10	4.54	.01	2.50	.10	1.92	8.96
	Seriatopora hystrix	1				.10	4.54	.01	2.50	.03	.58	7.62
		Overall Density			.42							
		Percent Cover			5.42%							
3A'	*Porites lutea*	7	45	31	3-86	.40	19.04	.11	17.50	2.49	41.09	77.63
	Acropora formosa	14	21	4	16-27	.60	28.57	.22	35.0	.78	12.87	76.44
	Porites (S.) iwayamaensis	6	34	16	22-65	.30	14.28	.10	15.0	1.02	16.83	46.11
	Acropora sp. 3	2	56	30	35-77	.10	4.76	.03	5.0	.90	14.85	24.61
	Acropora hyacinthus	3	31	4	28-35	.20	9.52	.05	7.50	.38	6.27	23.29
	Seriatopora hystrix	3	20	14	5-33	.20	9.52	.05	7.50	.19	3.13	20.15
	Acropora divaricata	2	29	8	24-35	.10	4.76	.03	5.0	.23	3.79	13.55
	Pocillopora damicornis	1		11		.01	4.76	.02	2.50	.003	4.95	12.21
	Acropora elseyi	2				.10	4.76	.03	5.0	.07	1.15	10.91
		Overall Density			.64							
		Percent Cover			6.06%							
3B	*Porites lutea*	11	75	72	13-270	.70	28.0	.16	27.50	13.52	45.53	101.03
	Porites (S.) iwayamaensis	9	106	76	74-309	.50	20.0	.13	22.50	17.48	54.99	97.49
	Acropora formosa	7	17	3	13-21	.40	16.0	.10	17.50	.26	.82	34.32
	Acropora hyacinthus	5	17	2	15-19	.30	12.0	.07	12.50	.17	.53	25.03
	Seriatopora hystrix	3	19	7	15-27	.20	8.0	.04	7.50	.14	.44	15.94

Table 11 Continued.

A.	Point Quarter Transects	n	$\bar{Y}$	s	w	Frequency	Relative Frequency	Density	Relative Density	Percent Cover	Relative Percent Cover	Importance Factor
	Pocillopora damicornis	2	8	4	5-11	.20	8.0	.03	5.0	.02	.06	13.06
	Acropora austera	2	21	21	18-24	.1	4.0	.03	5	.11	.35	9.35
	Acropora elseyi	1				.1	4.0	.01	2.50	.09	.28	6.78
		Overall Density .57										
		Percent Cover 31.79%										
3B'	*Porites (S.) iwayamaensis*	6	113	154	28-424	.30	12.50	.09	15.0	23.06	65.09	92.59
	Porites lutea	13	72	45	6-133	.60	25.0	.19	32.50	11.27	31.81	89.31
	Acropora formosa	8	16	5	7-24	.50	20.83	.12	20.0	.27	.76	41.59
	Acropora hyacinthus	4	13	6	4-18	.30	12.50	.06	10.0	.10	.28	22.78
	Pocillopora damicornis	3	4	2	2-5	.30	12.50	.04	7.50	.007	.02	20.02
	Acropora divaricata	3	20	19	3-41	.20	8.33	.06	10.0	.3	.85	19.18
	Acropora elseyi	2	41	7	41-42	.10	4.17	.03	5.0	.41	1.16	10.33
	Pachyseris rugosa	1				.10	4.16	.01	2.50	.01	.03	6.69
		Overall Density .60										
		Percent Cover 35.43%										
4A	*Porites (S.) iwayamaensis*	3	115	142	19-278	.20	7.14	.10	7.50	22.07	81.37	96.01
	Porites andrewsi	10	11	8	4-17	.50	17.85	.03	25.0	.05	.18	43.03
	Acropora formosa	6	17	16	5-45	.40	14.28	.21	15.0	.88	3.24	35.52
	Seriatopora hystrix	4	15	5	8-20	.40	14.28	.14	10.0	.28	1.03	25.31
	Acropora divaricata	4	18	6	12-25	.20	7.14	.14	10.0	.39	1.44	18.58
	Acropora hyacinthus	2	43	1	42-44	.20	7.14	.07	5.0	1.01	3.72	15.86
	Pachyseris rugosa	2	24	26	6-43	.10	3.57	.07	5.0	.51	1.88	10.45
	Psammocora contigua	1				.10	3.57	.03	2.50	.11	3.69	9.67
	Acropora tenuis	1				.10	3.57	.03	2.50	.98	3.61	9.68
	Pocillopora damicornis	2	14	12	6-23	.10	3.57	.07	5.0	.15	.55	9.12
	Acropora sp. 2	1				.10	3.57	.03	2.50	.57	2.10	8.17

Table 11 Continued.

A.	Point Quarter Transects	n	$\bar{Y}$	s	w	Frequency	Relative Frequency	Density	Relative Density	Percent Cover	Relative Percent Cover	Importance Factor
	Symphyllia valenciennesii	1				.10	3.57	.03	2.50	.05	.18	6.25
	Acropora sp. 3	1				.10	3.57	.03	2.50	.04	.15	6.22
	Porites lutea	1				.10	3.57	.03	2.50	.02	.07	6.14
	Fungia repanda	1				.10	3.57	.03	2.50	.01	.04	6.11
		Overall Density			1.04							
		Percent Cover			27.12%							
4A'	*Acropora formosa*	9	22	6	15-32	.40	12.90	.38	22.50	1.57	22.82	58.22
	Porites andrewsi	7	14	11	1-32	.50	16.13	.30	17.50	.73	10.61	44.24
	Acropora hyacinthus	2	43	3	41-46	.20	6.45	.08	5.0	1.29	18.75	30.20
	Seriatopora hystrix	3	25	7	17-31	.30	9.68	.13	7.50	.65	9.45	26.63
	Pocillopora damicornis	4	10	4	5-14	.20	6.45	.17	10.0	.17	2.47	18.92
	Fungia repanda	3	10	4	6-14	.30	9.68	.13	7.50	.11	1.60	18.78
	Acropora complanata	1				.10	3.22	.04	2.50	.77	11.19	16.91
	Porites lutea	1				.10	3.22	.04	2.50	.49	7.12	12.84
	Psammocora contigua	1				.10	3.22	.04	2.50	.37	5.38	11.10
	Montipora hoffmeisteri	1				.10	3.22	.04	2.50	.17	2.47	8.19
	Porites (S.) iwayamaensis	1				.10	3.22	.04	2.50	.13	1.89	7.61
	Acropora elseyi	1				.10	3.22	.04	2.50	.11	1.60	7.32
	Astreopora myriophthalma	1				.10	3.22	.04	2.50	.10	1.45	7.17
	Psammocora digitata	1				.10	3.22	.04	2.50	.08	1.16	6.88
	Acropora divaricata	1				.10	3.22	.04	2.50	.07	1.02	6.74
	Montipora lobulata	1				.10	3.22	.04	2.50	.04	.58	6.30
	Goniastrea sp.	1				.10	3.22	.04	2.50	.03	.44	6.16
	Pavona varians	1				.10	3.22	.04	2.50	.003	.04	5.76
		Overall Density			1.67							
		Percent Cover			6.88%							

Table 11 Continued.

A.	Point Quarter Transects	n	$\overline{Y}$	s	w	Frequency	Relative Frequency	Density	Relative Density	Percent Cover	Relative Percent Cover	Importance Factor
6B	Acropora formosa	9	34	15	11-62	.90	28.57	.11	45.0	.84	54.19	127.87
	Acropora divaricata	2	47	28	27-67	.40	14.28	.02	10.0	.50	32.25	56.53
	Pocillopora damicornis	4	8	4	4-13	.60	21.92	.05	20.0	.03	1.93	43.35
	Fungia repanda	3	14	11	5-27	.60	21.42	.04	15.0	.08	5.16	41.58
	Acropora granulosa	1				.20	7.14	.01	5.0	.10	6.45	18.59
	Acropora sp. 3	1				.20	7.14	.01	5.0	.0006	.04	12.18
		Overall Density			.24							
		Percent Cover			1.55%							
6B'	Acropora formosa	4	29	20	6-47	.60	20.0	.08	20.0	.70	72.16	112.16
	Fungia fungites	4	12	7	2-18	.60	20.0	.08	20.0	.11	11.34	51.34
	Pocillopora damicornis	5	6	4	2-13	.60	20.0	.09	25.0	.04	4.12	49.12
	Acropora divaricata	2	16	11	8-24	.20	6.66	.04	10.0	.09	9.28	25.94
	Fungia repanda	2	2	2	1-4	.40	13.33	.04	10.0	.003	.31	23.64
	Acropora hyacinthus	1				.20	6.66	.02	5.0	.02	2.06	13.72
	Acropora granulosa	1				.20	6.66	.02	5.0	.002	.21	11.87
	Acropora sp. 3	1				.20	6.66	.02	5.0	.001	.10	11.76
		Overall Density			.39							
		Percent Cover			.97%							

Table 11 Continued.

		Relative Percent Cover	Percent Cover
7	*Pavona clavus*	44.60	56.56
	Porites (S.) iwayamaensis	22.33	28.32
	Porites lutea	7.13	9.04
	Pavona varians	2.80	3.55
	Acropora divaricata	1.33	1.69
	Fungia repanda	.67	.85
	Percent Cover 78.86%		
	Total Length 15 m		
7'	*Pavona clavus*	40.67	68.80
	Diploastrea heliopora	5.40	9.13
	Porites lutea	4.67	7.90
	Porites (S.) iwayamaensis	3.00	5.07
	Acropora formosa	3.00	5.07
	Pavona varians	2.27	3.84
	Pocillopora damicornis	.40	.67
	Percent Cover 59.11%		
	Total Length 15 m		

		Percent Cover	Relative Percent Cover
9a.	*Acropora formosa*	70.80	79.97
	Porites (S.) iwayamaensis	12.60	14.23
	Alveopora japonica	3.00	3.39
	Porites lutea	1.20	1.35
	Acropora humilis	.40	.45
	Acropora squarrosa	.33	.37
	Pavona repens	.20	.23
	Percent Cover 88.53%		
	Total Length 30 m		
9b.	*Acropora formosa*	66.77	79.49
	Porites (S.) iwayamaensis	13.33	15.87
	Acropora elseyi	1.67	1.99
	Acropora divaricata	1.63	1.94
	Acropora diversa	.60	.71
	Percent Cover 84.00%		
	Total Length 30 m		

Table 11 Continued.

A.	Point Quarter Transects	n	$\bar{Y}$	s	w	Frequency	Relative Frequency	Density	Relative Density	Percent Cover	Relative Percent Cover	Importance Factor
8A	*Porites lutea*	12	18	10	4-31	.71	25.09	.09	42.86	.26	56.52	124.47
	Favia favus	3	14	13	2-28	.43	15.19	.02	10.71	.05	10.87	36.77
	Porites andrewsi	3	10	3	6-13	.43	15.91	.02	10.71	.02	4.35	30.97
	Alveopora japonica	2	17	13	8-26	.28	9.89	.01	7.14	.04	8.69	25.72
	Platygyra lamellina	2	12	6	817	.28	9.89	.01	7.14	.02	4.35	21.38
	Goniastrea sp.	2	15	2	14-17	.14	4.95	.01	7.14	.03	6.52	18.61
	Polyphyllia talpina	1				.14	4.95	.007	3.57	.02	4.35	12.87
	Fungia repanda	1				.14	4.95	.07	3.57	.01	2.17	10.69
	Favites flexuosa	1				.14	4.95	.007	3.57	.01	2.17	10.69
	Leptastrea purpurea	1				.14	4.95	.007	3.57	.001	.22	8.74

Overall Density	.18
Percent Cover	.46

B.	Line Intercept Transects	Percent Cover	Relative Percent Cover
2	*Porites lutea*	30.60	51.17
	Porites (S.) iwayamaensis	23.50	39.30
	Acropora reticulata	3.40	5.69
	Acropora formosa	1.80	3.01
	Pocillopora damicornis	.50	.84

Percent Cover	59.8%
Total Length	10 m

		Percent Cover	Relative Percent Cover
2'	*Porites lutea*	52.60	76.56
	Porites (S.) iwayamaensis	10.00	14.56
	Acropora formosa	6.1	8.88

Percent Cover	68.7%
Total Length	10 m

Table 11 Continued.

B. Line Intercept Transects		Percent Cover	Relative Percent Cover
4B	*Porites lutea*	68.36	94.75
	Acropora formosa	3.79	5.25
	Percent Cover 72.15%		
	Total Length 14 m		
4B'	*Porites lutea*	76.14	96.65
	Lobophyllia hemprichii	1.64	2.08
	Acropora hyacinthus	1.00	1.27
	Percent Cover 78.78%		
	Total Length 14 m		
5	*Porites lutea*	13.22	9.155
	Acropora arbuscula	1.22	8.45
	Percent Cover 14.44%		
	Total Length 9 m		
5'	*Porites lutea*	6.11	78.53
	Acropora arbuscula	1.67	21.46
	Percent Cover 7.78%		
	Total Length 9 m		
6A	*Acropora formosa*	72.18	90.85
	Porites lutea	5.73	7.21
	Pocillopora damicornis	1.00	1.26
	Montipora acanthella	.54	.68
	Percent Cover 79.45%		
	Total Length		
6A'	*Acropora formosa*	60.73	90.40
	Montipora acanthella	5.45	8.11
	Acropora hyacinthus	.82	1.22
	Porites lutea	.18	.27
	Percent Cover 67.18%		
	Total Length 11 m		
6B	*Porites lutea*	54.67	100.00
	Percent Cover 54.67%		
	Total Length 6 m		
6B'	*Porites lutea*	53.50	100.00
	Percent Cover 53.50%		
	Total Length 6 m		

Table 12. A list containing all coral species found at each site in 1982. Where species names have changed, the current name is listed first, followed by the name used in the 1981 survey (i.e., Acropora reticulata (Brook) = A. cythrata). Starred species (*) indicate the species was found only in 1982.

	1	2	3A	3B	4A	4B	5	6A	6B	7	8A	9
CLASS ANTHOZOA												
Stylocoeniella armata (Ehrenberg)					X					X		
Psammocora contigua (Esper)					X					X		
P. digitata Milne Edwards & Haime			X		X					X		X
P. nierstraszi van der Horst									X			
P. profundacella* Gardiner										X		
Stylophora mordax (Dana)		X										
Seriatopora hystrix (Dana)	X	X	X	X	X	X			X			X
Pocillopora damicornis (Linnaeus)	X		X	X	X		X	X	X	X		X
P. danae* (Verrill)												X
P. elegans (Dana)												X
P. ligulata* Dana						X		X				
P. verrucosa (Ellis & Solander)						X			X			
Acropora acuminata Verrill												X
A. arbuscula* (Dana)							X					
A. austera*	X	X		X	X							
A. cerealis* (Dana)	X											
A. clathrata (Brook)								X				
A. complanata* (Brook)					X							
A. divaricata (Dana)	X	X	X	X	X	X	X		X	X		X
A. diversa (Brook)		X										X
A. elseyi (Brook)	X		X	X	X		X	X				X
A. granulosa Milne Edwards & Haime	X			X			X		X			
A. formosa (Dana)	X	X	X	X	X	X	X	X	X			X
A. humilis (Dana)		X										X
A. hyacinthus (Dana)			X	X	X	X	X		X	X		X
A. polymorpha (Brook)	X											
A. quelchi (Brook)	X											
A. rambleri* (Basset-Smith)										X		
A. reticulata (Brook = A. cythrata)	X	X										

Table 12 Continued.

	1	2	3A	3B	4A	4B	5	6A	6B	7	8	9
Acropora squarrosa (Ehrenberg)									X			
A. tenuis (Dana)		X			X				X			X
A. valida (Dana)	X											
A. variabilis (Klunzinger)	X							X				
A. vaughani* Wells						X						
A. sp. 1			X									
A. sp. 2					X							
A. sp. 3		X	X		X				X			
Astreopora gracilis Bernard					X							
A. myriophthalma (Lamarck)			X		X					X	X	
Montipora acanthella Bernard								X				
M. berryi Hoffmiester						X			X			X
M. elschneri Vaughan				X								
M. hoffmeisteri Wells					X							
M. lobulata Bernard			X		X				X			
M. tuberculosa (Lamarck)			X			X	X	X	X	X		X
M. verrilli Vaughan										X		
M. verrucosa (Lamarck)										X		
Pavona clavus (Dana) = P. maldivensis										X		
P. varians Verrill	X	X		X	X					X		X
P. sp. 1					X		X					X
Pachyseris rugosa (Lamarck)			X	X	X	X				X		X
Fungia echinata (Pallas)										X		
F. fungites (Linnaeus)	X	X	X						X			X
F. repanda Dana	X	X	X		X	X		X	X	X	X	X
Herpetoglossa simplex (Dana)										X		
Polyphyllia talpina (Lamarck)											X	
Goniopora columna* Dana						X						X
G. lobata Milne Edwards & Haime	X											
Porites andrewsi Vaughan	X		X	X	X	X				X	X	X
P. lobata Dana												
P. lutea Milne Edwards & Haime	X	X	X	X	X	X	X	X	X	X	X	X
P. (S.) iwayamaensis Eguchi	X	X	X	X	X	X	X			X		X
Alveopora japonica* Eguichi					X		X	X	X	X	X	X

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Table 6 Continued.

	1	2	3A	3B	4A	4B	5	6A	6B	7	8A	9
Favia favus (Forskal)		X	X						X		X	
F. matthai Vaughan		X			X					X		
F. pallida (Dana)			X		X	X						
F. stelligera (Dana)										X		X
Favites abdita Ellis & Solander												
F. flexuosa (Dana)											X	
F. russelli (Wells)												
Goniastrea edwardsi Chevalier						X						
G. pectinata (Ehrenberg)	X			X	X	X						
G. sp. 1	X	X	X	X	X					X	X	X
Platygyra lamellina (Ehrenberg)		X		X		X		X	X	X	X	
Leptoria phrygia Ellis & Solander					X					X		
*Hydnophora rigida** (Dana)	X		X									
Montastrea curta (Dana)	X	X		X								
Diploastrea heliopora (Lamarck)						X				X		
Leptastrea purpurea (Dana)	X					X				X	X	
Cyphastrea serailia (Forskal)						X					X	
Galaxea fascicularis (Linnaeus)												
Acrhelia horrescens (Dana)												X
Lobophyllia corymbosa (Forskal)			X				X					
L. costata (Dana)	X		X	X		X		X		X		
L. hemprichii (Ehernberg)		X	X			X						
Symphyllia valenciennesii Milne Edwards & Haime			X		X				X			
Echinophyllia aspera (Ellis & Solander)		X		X								X
Pectinia lactuca (Dana)										X	X	
Euphyllia glabrescens Chamisso & Eysenshardt)										X	X	
Plerogyra sinuosa (Dana)												
Physogyra lichtensteni Milne Edwards & Haime	X			X		X				X		
CLASS HYDROZOA												
*Millepora tuberosa** (Boschma)										X		
M. exaesa Forskal			X		X			X	X	X		X
M. dichotoma Forskal		X										

Table 12 Continued.

	1	2	3A	3B	4A	4B	5	6A	6B	7	8	9
Disticophora violacea (Pallas)		X			X	X		X				
Stylaster elegans Verrill						X						
TOTAL GENERA (40)	13	14	15	13	16	19	6	8A	13	22	13	17
TOTAL SPECIES (96)	27	24	27	22	33	28	10	13	22	37	14	33

Table 13. Mean percent coral cover (Y) and range (W) at the monitoring stations from 1978-1982.

Station	1978		1979		1980		1981		1982	
	Y	W	Y	W	Y	W	Y	W	Y	W
1	13.00	-	48.02	46.82-49.22	61.44	49.05-73.83	46.43	43.93-48.93	24.92	18.12-31.73
2	10.15	-	15.89	12.78-18.99	65.02	60.00-70.04	60.42	57.78-63.05	64.25	59.80-68.70
3a	53.13	-	17.40	13.64-21.15	14.13	12.27-15.99	19.75	15.25-24.25	5.63	5.20- 6.06
3b	-	-	29.99	29.29-30.68	14.93	9.51-20.35	21.67	19.83-23.50	33.61	31.79-35.43
4a	33.11	-	37.58	-	43.50	27.93-49.07	46.23	39.55-52.91	17.00	6.88-27.12
4b	46.60	-	70.41	65.75-75.06	60.59	56.47-64.70	62.63	61.24-64.02	75.46	72.15-78.78
5	18.06	-	17.15	8.73-25.56	1.54	.39- 2.69	-	-	11.11	7.78-14.44
6a	75.40	63.07-97.73	55.85	33.30-78.40	36.67	30.16-45.07	50.71	36.40-65.02	73.31	67.18-79.45
6b	32.36	1.82-62.90	-	-	47.77	62.72-32.81	-	-	55.34	55.05-55.64
7	38.62	-	27.93	25.25-30.60	53.75	49.35-58.14	71.02	66.51-75.54	68.98	59.11-78.86
8a	2.71	-	2.75	2.74- 2.76	.125	.10- .15	.58	.05- 1.11	.57	.46- .68
8b	26.45	-	22.87	18.12-27.62	-	-	-	-	-	-
9	80.40	-	60.10	59.81-60.39	69.40	63.50-75.29	73.39	62.83-83.96	86.26	84.00-88.53
10	-	-	19.30	18.58-20.02	25.73	21.00-30.45	-	-	-	-

Table 14. Macroinvertebrate mean densities quantified at biological monitoring stations. The units are number of individuals per square meter. Macroinvertebrates found at the stations but not quantified are indicated with the letter P (present).

	BIOLOGICAL MONITORING STATIONS											
	1	2	3a	3b	4a	4b	5	6a	6b	7	8	9
PROTOZOA												
Foraminiferdia	P	P	P	P	P	P	P	P	P			P
PORIFERA	.90	1.42	3.27	2.99		2.10	2.26	.48	2.89	1.26	P	1.53
CNIDARIA												
hydroidea spp.	.71	P	1.78		P	P	.59	P	P	P	P	.28
Actiniaria			P						.05		.06	
Alcyonacae	2.03	.32	1.05	.29	.92	.65	2.62		.22	.93	.39	.04
Antipatharia	.15	.05		P	.02	.28	.15		.11	P	.11	P
Gorgonacae	.07			P	P	1.23	P		5.86		.03	P
ANNELIDA												
Polychaeta		.49	.45		.02	.18	.04		.47	2.11		.09
MOLLUSCA												
Gastropoda												
Pseudovertagus aluco												.03
Cerithium echinatum					.02							.04
C. nodulosum												.11
Chicoreus brunneus		.06	.03	.09		P	P			.02		.01
C. ramosus				.05								
Conus marmoreus					.02			P	P			
C. miles												.02
Coralliophila violacea	.01	.06		.17	.82	.30			.06	.38		.27
Cymatium gemmatum												.02
Cyprea erosa				.06								

Table 14 Continued.

	BIOLOGICAL MONITORING STATIONS											
	1	2	3a	3b	4a	4b	5	6a	6b	7	8	9
C. tigris	.02											
Drupella rugosa					.02							.01
Lambis scorpius					.02			P				
Padaloconchus sp.	.23	6.05	.47	.57	.33	2.79	.04		.30	.89		.21
Pyrene deshayesii	P	.16	.18	.14	.27	P	P	.34	P	.09	.10	.34
Rhinoclavis aspera					.03	P						
Strombus luhuanus	P	.03			.05	P	P	P	P			
Tectus pyramis	.09	.06	.21	.17		.13		.06	.14			.28
Tectus triserialis						.02						P
Trochus maculatus						P						.02
T. niloticus	.04		.04									
Nudibranchia spp.			.03						P			P
Bivalvia												
Arca/Barbatia spp.	.05	7.41	1.88	1.23	.25	9.01	.56	.11	4.11	1.08	.03	.20
Atrina vexillum				.03							P	
Chama sp.	.02					.18						
Lopha cristagalli	P	.29	P	P		.37				P		
Malleus malleus		.03										
Ostrea sp.						.28		.02	.08	.07		
Pedum spondyloideum		.32	.09	.17		.15		.05	.02			
Pteria cypellus	P	P				.33						
Pinctada margaritifera						P				.06		
Pinna sp.						.06			.08			
(*Pycnodonte*) *Hyotissa hyotis*	.20	.49	.07	.07	.08	.28	.15	.06	.17	.04	.03	.03
Tridacna crocea		.06										
ARTHROPODA												
Diogenidae	.10	.16	P	P	.05	.22	.33	.10	.02	.07	.01	.16

Table 14 Continued.

	BIOLOGICAL MONITORING STATIONS											
	1	2	3a	3b	4a	4b	5	6a	6b	7	8	9
ECHINODERMATA												
Asteroidea												
<u>Acanthaster planci</u>												.05
Crinoidea												
<u>Comanthus bennettii</u>	.02	.07		.07	P	.04						
<u>C. multifidus</u>	P				P	.09						
Echinoidea												
<u>Brissus latecarinatus</u>	P	.03	P					P	P	P		
<u>Diadema setosum</u>	P	P				.07						
<u>Echinothrix diadema</u>		P			.07	.09						
<u>Echinothrix</u> sp.		.07		.30								
Holothuroidea												
<u>Bohadschia graeffeii</u>	.05	P		P					.08	P		.03
<u>Holothuria atra</u>	.01	P	P	P	P	P	P		P			P
<u>H. edulis</u>	.02	P	P	P		.02	P		P			P
<u>H. noblis</u>		P	.03	P	P		P		P			P
<u>Stichopus chlornotus</u>	P	P	.06	P	.03	P						P
<u>S. variegatus</u>	P	P	.07		P	.02	.04		P	P		P
CHORDATA												
Ascidacea												
<u>Didemnum moseleyi</u>	P	P		.07	P	.29	.07	.44	P	.85	.96	P
<u>D. ternatanum</u>	P	11.68		.38	6.88	.60	5.85	16.38	16.05	6.06	P	1.09
<u>Phallusia julinea</u>	.34	.55	.53	.48	.32	.18	.33	.08	.22	1.23	1.12	.15
Ascidacean spp.	.22	.26	.15	.33	P	P						

Table 15. Checklist of macroinvertebrates found at monitoring stations which were not quantified on transects.

Foraminiferida:

Gypsina vesicularis
Marginopora vertebralis
Homotrema rubrum
Miniacia miniacea

Scyphozoa:

Cassiopeia sp.

Gastropoda:

Casmaria erinaceus
Cassis cornuta
Conus ebraeus
Conus eburneus
Conus leopardus
Conus litteratus
Conus magus
Cypraea annulus
Cypraea arabica
Cypraea carneola
Cypraea isabella
Cypraea moneta
Harpa harpa
Lambis lambis
Nebularia cucumerina
Olivia miniacea
Pterynotus trigueter
Strombus gibberulus
Strombus urceus
Terebra affinis
Terebra crenulata
Terebra dimidiata
Terebra guttata
Turbo petholatus
Vasum ceramicum
Vasum turbinellus
Vexillum granosum
Vexillum plicarium
Vexillum rugosum

Bivalvia:

Lima sp.
Lopha folium
Tridacna squamosa

Arthopoda:

Panulirus ornatus

Asteroidea:

Culcita novaeguineae
Linckia multifora

Holothuroidea:

Actinopyga echinites
Bohadschia argus
Holothuria axiloga

Table 16. Mean densities (no./m^2) of macroinvertebrate indicator groups at monitoring stations from 1978 to 1982.

MACROINVERTEBRATE Indicator Groups	YEAR	1	2	3a	3b	4a	4b	5*	6a	6b**	7	8a	9
ALCYONACEANS	1978	2.20	0.10	0.25	0.05	0.11	0.39	5.00	0	0	0.70	0.54	0.01
	1979	2.58	0.05	0.91	0.08	0.69	0.64	5.63	0	-	1.13	0.98	0.01
	1980	0.70	0.06	0.53	0.28	0.18	0.45	1.81	0	0.23	0.39	0.14	0.05
	1981	2.94	0.03	1.59	1.52	1.15	0.16	-	0	0.43	0.75	0.45	0.02
	1982	2.03	0.32	1.05	0.29	0.92	0.65	2.62	0	0.22	0.93	0.39	0.04
Arca/*Barbatia* spp.	1978	0.05	7.33	1.08	0.45	0.11	5.29	1.19	0	5.45	0.30	0	0.03
	1979	0.03	10.97	1.50	0.97	0.07	5.76	1.07	0	-	0.07	0	0
	1980	0.10	23.2	2.33	1.76	0.41	4.37	0.38	0.06	2.02	0.26	0.10	0.06
	1981	0.03	10.83	1.82	1.35	0.05	4.81	-	0.21	0.02	0.24	0.15	0
	1982	0.05	7.41	1.88	1.23	0.25	9.01	0.56	0.11	4.11	1.08	0.03	0.20
Hyotissa hyotis	1978	0	0.06	0.08	0.05	0.03	0.32	0.19	0.24	0.08	0.03	0.01	0
	1979	0.02	0.41	0.24	0.05	0.04	0.38	0.85	0	-	0.11	0.12	0.03
	1980	0.02	0.35	0.10	0.12	0.04	0.16	0.45	0.04	0.50	0.03	0.32	0
	1981	0	0.25	0.07	0.08	0.12	0.15	-	0	0.23	0.10	0.13	0.04
	1982	0.20	0.49	0.07	0.07	.08	0.28	0.15	0.06	0.17	0.04	0.03	0.03
Phallusia julinea	1978	0.28	0	0	0	0.14	0.18	0.19	0.04	0.12	1.63	0.36	0.17
	1979	0.18	0	0.60	0.38	0.11	0.45	0.18	0	-	1.33	0.87	0.71
	1980	0.15	0.05	0.47	0.14	0.88	0.36	0.12	0.04	0.30	1.7	0.86	0.26
	1981	0.24	0.06	0.33	0.16	0.08	0.22	-	0.02	0.46	0.64	0.52	0.20
	1982	0.34	0.55	0.53	0.48	0.32	0.18	0.33	0.08	0.22	1.23	1.12	0.15

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* Station not used in statistical analysis.

** Station was transected at two locations, only 1978 and 1982 data sets are comparable.

Table 17. Total number of species or macroinvertebrate groups quantified on transects for 1978 to 1982. The 1978, 1980 and 1982 surveys include subdivisions of the alcynacean group.

Biological Station	Number of Analyzed Transects*	Total Number of Species or Macroinvertebrate Groups Quantified for Transects				
		1982	1981	1980	1979	1978
1	4	20	14	32	11	12
2	3	23	7	18	10	8
3a	4	18	11	18	5	8
3b	4	19	13	22	6	5
4a	3	19	12	30	11	11
4b	3	27	17	26	10	17
5	3	13	--	16	7	9
6a	3	11	3	10	2	8
6b	3	18	10	24	--	11
7	3	15	11	29	7	12
8a	3	10	6	12	13	13
9	3	23	6	23	10	10

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* For 1982 survey.

Table 18. Census counts of fish species at the monitoring stations, 1982. X indicates the presence of species at the monitoring stations which were not enumerated on the transect censuses.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'
ACANTHURIDAE																								
Acanthurus nigrofuscus					X					X	4	3		1						X				
A. xanthopterus																	X	X	X		4			
Ctenochaetus striatus	9	6	1	2	4	2	3	5	6	4	15	12	4	2	5	4	7	5	4	3			7	1
Naso lituratus											X	X												
N. vlamingi																	1							
[illegible]		1							2		X								X					
[illegible]		X						X																
juvenile acanthurids						2					X		1								X		2	
APOGONIDAE																								
Apogon leptacanthus									500	150			80	40										
A. novemfasciatus			1																					
Archamia fucata									212	4			200	370						X				
Cheilodipterus macrodon													X	X										
C. quinquelineata	60	X	X			X	3	1	2				X	1			X	X	2	4	4	14	1	X
unidentified apoginids									300	X											1	1	X	
BALISTIDAE																								
Pseudobalistes flavomarginatus	X																							
Sufflamen chrysoptera												X											X	
BLENNIIDAE																								
Ecsenius bicolor													1	X			1			X				
Meiacanthus atrodorsalis	14	X	X	X	X	X	X	X	1		X	1			X	X	1	1	X	X			3	X
Plagiotremus rhinorynchus																			1	1				
P. tapeinosoma																			1					

Table 18 Continued.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'
CARANGIDAE																								
Caranx sp.									1	X														
CHAETODONTIDAE																								
Chaetodon auriga							2	X											X				X	
C. citrinellus			1	1																				
C. ephippium											X													
C. kleini	2	X				1		X		1		1	1		X		1	2	1	1				
C. trifasciatus		X					1			1					X	X	1			1			2	X
C. ulietensis											X	1												
Heniochus acuminatus																				X				
H. varius																			X	1				
Megaprotodon trifascialis		X																						X
CIRRHITIDAE																								
Cirrhitichthys falco													1											
ECHENEIDAE																								
Echeneis naucrates											2	X												
GOBIIDAE																								
Amblygobius albimaculatus																					X	3		
Ptereleotris evides											X													
unidentified gobies					1		X						X		X									X
HOLOCENTRIDAE																								
Adioryx spinifer									1	X														

Table 18 Continued.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'
Flammeo sammara																1								
Myripristis sp.			X						1	X		X			1									X
LABRIDAE																								
Cheilinus diagrammus	2	1							X	1	X						X						X	1
C. fasciatus	1		X	3			X		X	X	X	1						1	1				X	
Cheilio inermis		1																						
Cirrhilabrus cyanopleura																	5	1						
Coris variegatus	1		X	1	X	X	X	1	X	X	X		4	X	2	X	X	1					X	
Epibulus insidiator																				X			1	
Gomphosus varius										X														
Halichoeres hoeveni	14	5	4	7	9	11	12	8	7	3	6	13	8	5	2	10	1	3	3	3		X	11	11
H. hortulanus		X																						
Hemigymnus melapterus	X									1														
Labrichthys unilineata	3	5				1				3	1	X			1	2			2				2	14
Labroides dimidiatus	1	2	2	2	2	3	X		1	3	2	1	1	X	1	X	1	X	2	3			2	2
Macropharyngodon meleagris					1																			
Stethojulis bandanensis													2	1		1	X	2	1		X			
Thalassoma lutescens									1	1		X												
unidentified labrid			1	2			X	1	1		1 -	2							X	X				
LETHRINIDAE																								
Gnathodentex aureolineatus									X	1		1												
Monotaxis grandoculis	X	X					X		X	X		X	1											
LUTJANIDAE																								
Caesio caerulaureus									402	20			X	150					50	500				
Caesio sp.									100	41		200	20	20		50			200					
Lutjanus fulvus							X	X																
L. monostigmus	X																							

Table 18 Continued.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'
MONACANTHIDAE																								
<u>Oxymonacanthus</u> <u>longirostris</u>				1							X													
MULLIDAE																								
<u>Mulloidichthys</u> <u>flavolineatus</u>															X	X								
<u>Parupeneus</u> <u>barberinus</u>													1	X			3	1			2	4		
<u>P.</u> <u>chryserydros</u>															X									
<u>P.</u> <u>pleurostigma</u>													1	X										
<u>P.</u> <u>trifasciatus</u>	1											X	1	2			3	2			2	2		
PEMPHERIDAE																								
<u>Pempheris</u> <u>oualensis</u>									X	X													X	
POMACANTHIDAE																								
<u>Centropyge</u> <u>vroliki</u>								1	X	4	X	X								X				
POMACENTRIDAE																								
<u>Amblyglyphidodon</u> <u>curacao</u>	150	106	2	9	9	9	9	21			14	42	1	2	14	9	37	38	60	22			37	14
<u>Amphiprion</u> <u>clarkii</u>																	4	4			1	1		
<u>Chromis</u> <u>atripectoralis</u>	50	20	30		5	13	7	5	9	14	92	56			18	3				30			12	13
<u>C.</u> <u>caerulea</u>						X																		
<u>C.</u> <u>margaritifer</u>			2	1					1	1	1								1	2				
<u>C.</u> <u>ternatensis</u>											4			1			2	1	1	X			1	5
<u>C.</u> <u>xanthura</u>	19	32	18	19	6	3	2	6	4	9	4	1			7	3	6	8	7	7			24	6
<u>Dascyllus</u> <u>aruanus</u>	X		X	2			10	8	2	2	7	14							3				X	
<u>D.</u> <u>reticulatus</u>											X													
<u>D.</u> <u>trimaculatus</u>																	3	3						
<u>Glyphidodontops</u> <u>traceyi</u>	X	1	5	3			6	5	2	7	3	1					X	X	3	5			2	4

Table 18 Continued.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9	9'
Plectroglyphidodon lacrymatus																			1					
Pomacentrus mollucensis	1	1	1		1	2					X	1							1	X		1	X	
P. pavo	46	5	95	63		1	2	4	222	170	50	92	145	120			44	70	124	205	77	78	14	25
P. vaiuli	X	X	1	X	1	1				X	5	3		X	1	1	2							
Stegastes nigricans																			2	1				
sp. A				2		1	1	1	1							1							2	
sp. B	4		X				1	1	X		4	4											2	
sp. C	1		5	5	6	1	1	2			23	6	X	X	3	1	9	8	8	X	3	2		1
sp. D		5																					8	7
sp. E																								
sp. F																								
SCARIDAE																								
Cetoscarus bicolor									X															
Scarus dimidiatus																							X	
S. ghobban	4	X							X												1	2		
S. schlegeli	X	2																					1	
unidentified scarids						2				X							1	3					X	X
juvenile scarids	6	X			X										X									
SCORPAENIDAE																								
Pterois volitans										1														
SERRANIDAE																								
Cephalopholis urodelus									X															
Epinephelus merra												1												
Plectropomus melanoleucus	X																							
unidentified serranids	1								1	1														X

Table 18 Continued.

	1	1'	2	2'	3A	3A'	3B	3B'	4A	4A'	4B	4B'	5	5'	6A	6A'	6B	6B'	7	7'	8A	8A'	9
SIGANIDAE																							
Siganus puellus																			7				
S. virgatus	2																						X
S. vulpinus																							X
SYNGNATHIDAE																							
Corythoichthys intestinalis	3	X					X	X															
TETRAODONTIDAE																							
Arothron stellatus																			X				
Canthigaster solandri			1	2						X				1									
C. valentini										X													
ZANCLIDAE																							
Zanclus cornutus	1	X					X	X		1	1									1			
No. Species on Transect	24	15	16	17	11	15	14	15	24	24	19	22	18	15	11	12	20	18	23	17	9	10	18
No. Species at Station	36	28	23	19	15	19	25	22	36	38	33	31	23	22	19	17	26	22	31	28	12	11	34
Transect Length (m)	30	30	10	10.5	8	7	10	10.5	15	15	20	20	9	9	11.5	11.5	12	12	15.5	14	23	23	30
No. Individuals on Transect	402	193	170	125	45	53	60	70	1780	444	239	457	494	717	55	86	133	154	476	780	95	108	133
No. Individuals per m²	6.7	3.2	8.5	6.0	2.8	3.8	3.0	3.3	59.3	14.8	6.0	11.4	27.4	39.8	2.4	3.7	5.5	6.4	15.4	27.9	2.1	2.3	2.2

Table 19. Mean fish abundance along transects at monitoring stations, 1978-1982.

Station	1978	1979	1980	1981	1982
1	4.00	4.42	2.58	0.93	4.96
2	3.95	4.19	8.26	3.42	7.20
3A	3.26	2.27	4.29	3.04	3.27
3B	4.70	2.77	4.17	3.80	3.17
4A	11.08	15.57	4.93	10.21	37.07
4B	3.37	7.55	5.84	4.05	8.70
5	14.83	7.67	41.84	--	33.64
6A	1.71	0.93	1.48	3.04	3.07
6B	6.00	--	3.90	2.02	5.98
7	4.50	2.80	7.13	3.69	21.29
8A	1.97	5.84	1.10	1.22	2.21
8B	3.50	0.83	0	0	0
9	3.73	3.66	2.93	3.33	2.00
10	--	4.88	2.00	--	--

Table 20. Mean number of fish species seen at the monitoring stations, 1978-1982.

Station	1978	1979	1980	1981	1982
1	34	37	33	22.5	32
2	10	14	16.5	16.5	21
3A	14	13.5	15.5	16	17
3B	19	21.5	22.5	21.5	23.5
4A	22	29.5	31	36.5	37
4B	17	32	32	37	32
5	16	14.5	20	--	22.5
6A	20.5	13.5	22	21	18
6B	30	--	25.5	22.5	24
7	33	27.5	39	33	29.5
8A	27	17.5	7	10.5	11.5
8B	22	12.5	0	0	0
9	48	38.5	39	42	28.5
10	--	30	15.5	--	--