A MARINE SURVEY OF THE NORTHERN TANAPAG REEF PLATFORM,

Saipan, Mariana Islands

Edited by

Richard H. Randall

Participating Authors

Richard H. Randall, Alan E. Davis, Ahser E. Edward, Paul D. Gates,

Thomas S. Potter and Susanne de C. Wilkins

Final Report

Submitted to

Office of Coastal Resources Management

Commonwealth of the Northern Mariana Islands

University of Guam, Marine Laboratory

Technical Report No. 87

February 1987

TABLE OF CONTENTS

	Page
Introduction and Project Narrative by Richard H. Randall	1
Currents and Substrate Characterization by Ahser Edward and Alan E. Davis	10
A Quantitative Assessment of Marine Plants by Susanne C. Wilkins	33
Corals by Richard H. Randall	47
Macroinvertebrates by Tom S. Potter	70
Fishes by Paul D. Gates	127
Anticipated Environmental Impact Upon the Marine Communities by Richard H. Randall	145

INTRODUCTION AND PROJECT NARRATIVE

By

Richard H. Randall

Introduction

Because of present and anticipated coastal development along the northern part of Tanapag reef platform the Coastal Resource Management (CRM) Office, Commonwealth of the Northern Mariana Islands, requested assistance from the University of Guam Marine Laboratory in obtaining a baseline marine assessment of the reef platform between Puntan Dogas and Puntan Magpi (Fig. 1). Data and recommendations obtained from this assessment will be used by CRM to make sound coastal management plans and regulatory decisions for this coastal region. Because of impending development adjacent to Unai Papau CRM requested that this part of the reef platform be assessed as quickly as possible as Phase I and that the remaining platform regions be assessed at a later time as Phase II.

A proposal to conduct a marine assessment adjacent to Unai Papau (Phase I) was submitted to CRM in October, 1984, and an agreement between the CRM and the University of Guam Marine Laboratory to conduct such an assessment was entered into on November 8, 1984 (CNMI Government Contract No. CO - 3887). Fieldwork for Phase I was conducted January 8-11, 1985, and a final report (Randall et al., 1985) was submitted to CRM in May, 1985. A proposal to assess the remaining parts of the northern Tanapag reef platform (Phase II) was submitted in July, 1985, and an agreement between the CRM and the University of Guam Marine Laboratory to conduct such an assessment was entered into on Aug. 8, 1985 (CNMI Government Contract No. CO-10692). Fieldwork for Phase II was conducted March 24-30, 1986. This report incorporates fieldwork data acquired during both phases of the study.

Project Description

This study consists of a limited marine survey of the Tanapag reef platform that lies between Puntan Dogas and Puntan Magpi. The study area is shown in Figure 1. Within this study area a quantitative assessment of major marine organisms was conducted and the general surface current patterns and substrate characteristics determined. Data obtained from these studies were used to determine anticipated impacts upon the marine environment resulting from proposed coastal development and to make recommendations to minimize or mitigate such impacts upon the area.

The study area was quantitatively assessed along eight transects (A-H), C, D, and E during Phase I and A, B, F, G, and H during Phase II. The eight transects were run perpendicular from the shoreline across the reef platform as shown in Figures 2-5. During fieldwork for Phase I time limitations allowed only two transects (C and E) to be run across the entire reef platform. A third shorter transect (D) was run from the shoreline midway between the two longer ones to provide a more comprehensive assessment of the inner part of the reef platform where anticipated impacts from development were expected to be greatest. The distribution and community structure of macroalgae, seagrasses, corals, fishes, macroinvertebrates other than corals, general surface current patterns, and substrate characteristics were analyzed along the eight transects.

Scope of Work

A. Community Structure

1. Corals:

Coral (scleractinian, hydrozoan, coenothecalian, stoloniferan, and alcyonacean species) communities were analyzed along the transects by using the point-centered (also called the point-quarter) technique as described by Randall et al. (1984), and by making a general reconnaissance of the overall study area. From these data distribution and community structure (colony size distribution, density, frequency, and coverage) of the corals were determined.

2. Algae and Seagrasses:

Benthic algal and seagrass communities were analyzed along the transects by using the point-quadrat method described by Best (1982), and by making a general reconnaissance of the overall study area. From these data the distribution and community structure of the benthic algae and seagrasses (coverage and frequency of occurrence) were determined.

3. Macroinvertebrates:

Macroinvertebrates (other than corals) consisting principally of molluscs, echinoderms, and crustaceans were analyzed at intervals along the transects by using the line-quadrat method described by Randall et al. (1984), and by making a general reconnaissance of the overall study area. From these data the distribution and density of benthic macroinvertebrates were determined.

B. Currents and Substrate Characterization

1. Currents:

Current speed and direction were determined by using the dye-injection technique described by Strong et al. (1982) at intervals along the transects. These data were used to characterize and map the general current patterns within the study area.

2. Substrate Characterization:

Characterization of the substrate was determined along the transects by using the point-quadrat method described by Best (1982), and by making a general reconnaissance of the overall study area. These data were used to determine the distribution of unconsolidated surface deposits (limesand, gravel, rubble, and boulders) and consolidated reef rock.

C. Environmental Impact and Recommendations

1. From data of parts A and B above the anticipated impact upon the marine environment was determined in relation to proposed development adjacent to the coastal areas. Recommendations were also made to minimize or mitagate such impacts.

Personnel

A. University of Guam Marine Laboratory Faculty

1. Richard H. Randall - Principal Investigator
Work Specialty - Corals and assistance with currents and substrate analysis during Phase I and II.

B. University of Guam Marine Laboratory Graduate Student Assistants

1. Susanne C. Wilkins
Work Specialty - Algae and seagrasses plus substrate characterization during Phase I and II.

2. Paul D. Gates
Work Specialty - Currents and substrate analysis during Phase I and fishes during Phase II.

3. James B. Neill
Work Specialty - Macroninvertebrates (other than corals) during Phase I.

4. Thomas S. Potter
Work Specialty - Macroninvertebrates (other than corals) during Phase II.

5. Alan E. Davis and Ahser Edward
Work Specialty - Currents and substrate analysis during Phase II.

Literature Cited

Best, B. R. 1982. A quantitative assessment of the marine algae and other common biotic and abiotic benthic constituents of the Luminao-Cabras-Piti Reefs. pp. 19-21. In Randall, R. H., and L. G. Eldredge [eds.], Assessment of the shoalwater environment in the vicinity of the proposed OTEC development at Cabras Island, Guam. Univ. of Guam, Mar. Lab. Tech. Rept. No. 79. 208 p.

Randall, R. H., H. G. Siegrist, Jr., and J. B. Neill. 1984. A marine survey and an environmental evaluation of three coastal regions of Tinian for proposed amphibious assault training exercises. Univ. of Guam, Mar. Lab. Misc. Rept. No. 47. 26 p.

Randall, R. H., P. D. Gates, J. B. Neill, and S. C. Wilkins. 1985. A marine survey of the Tanapag reef platform adjacent to Unai Papau. Univ. of Guam, Mar. Lab. Misc. Rept. No. 48. 55 p.

Strong, R. D., R. H. Randall, T. L. Smalley, B. Bumoon, and O. Bowoo. 1982. Environmental assessment for proposed dredging operations in Yap Lagoon. Univ. of Guam, Mar. Lab. Tech. Rept. No. 78. 88 p.

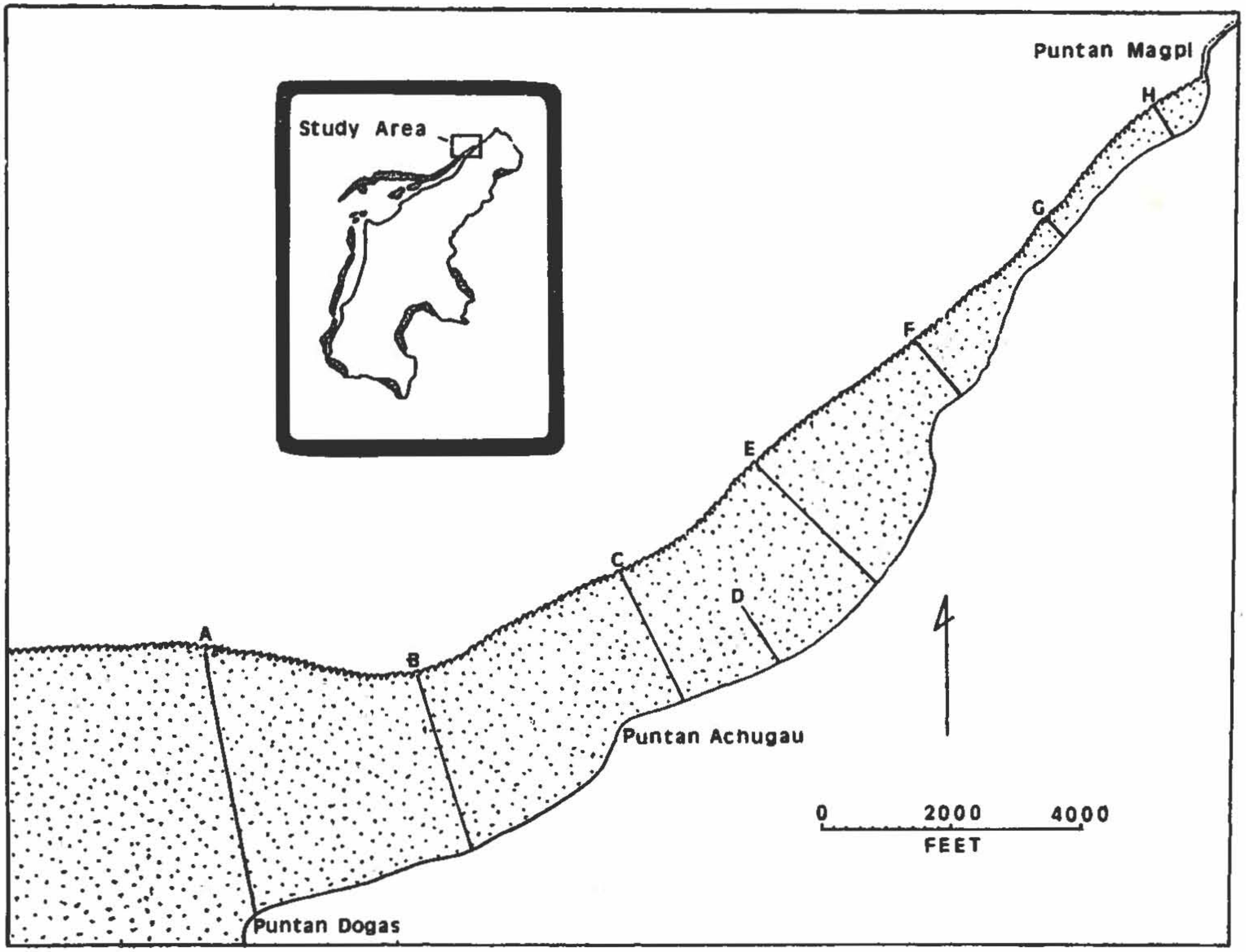

Figure 1. Map showing the location of the overall study area on Saipan (inset) and the locations of transects A-H.

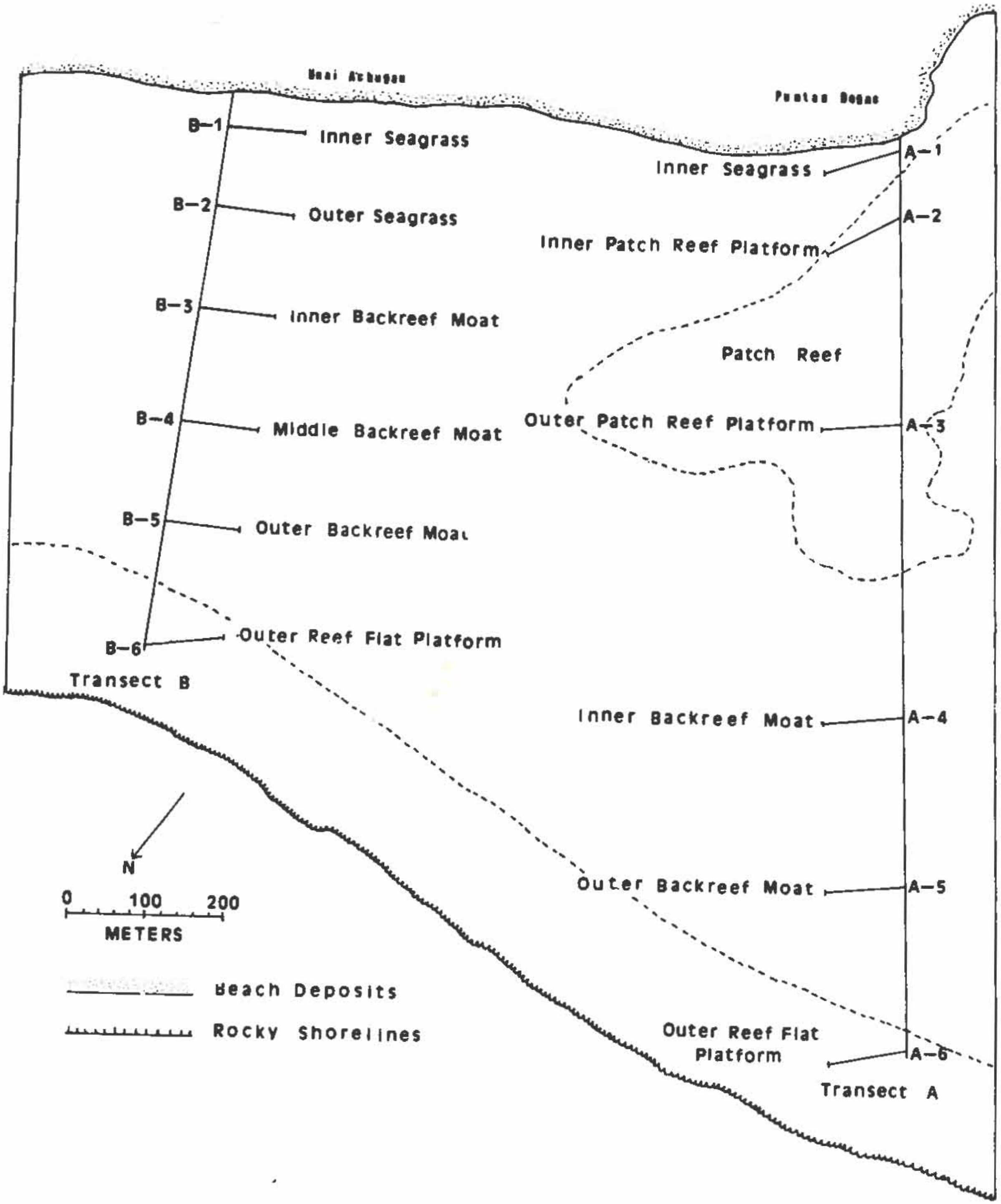

Figure 2. Map showing physiographic zonation patterns and the locations of transects A and B and their associated subtransects A-1 through A-6 and B-1 through B-6.

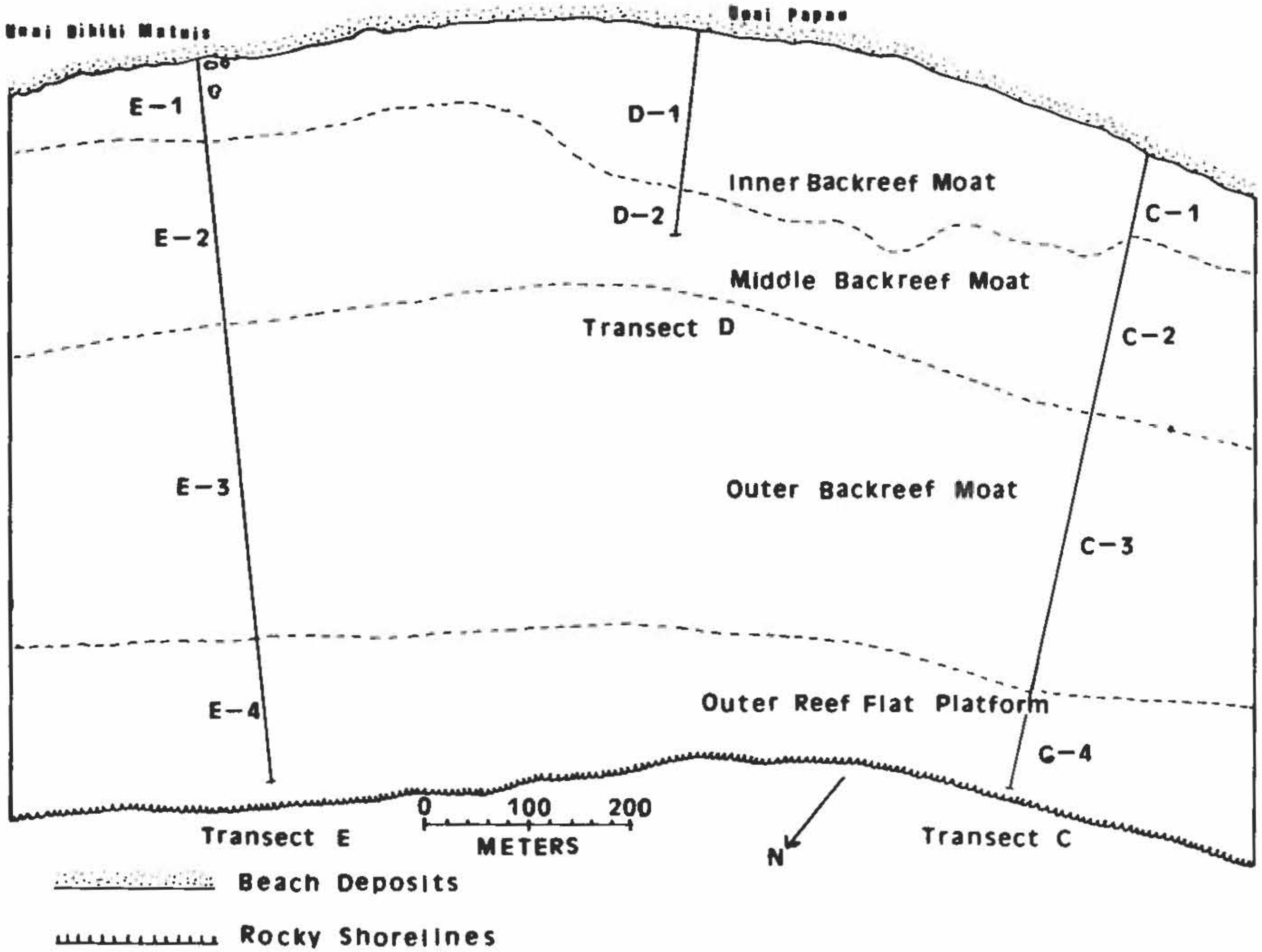

Figure 3. Map showing physiographic zonation patterns and the location of transects C, D, and E.

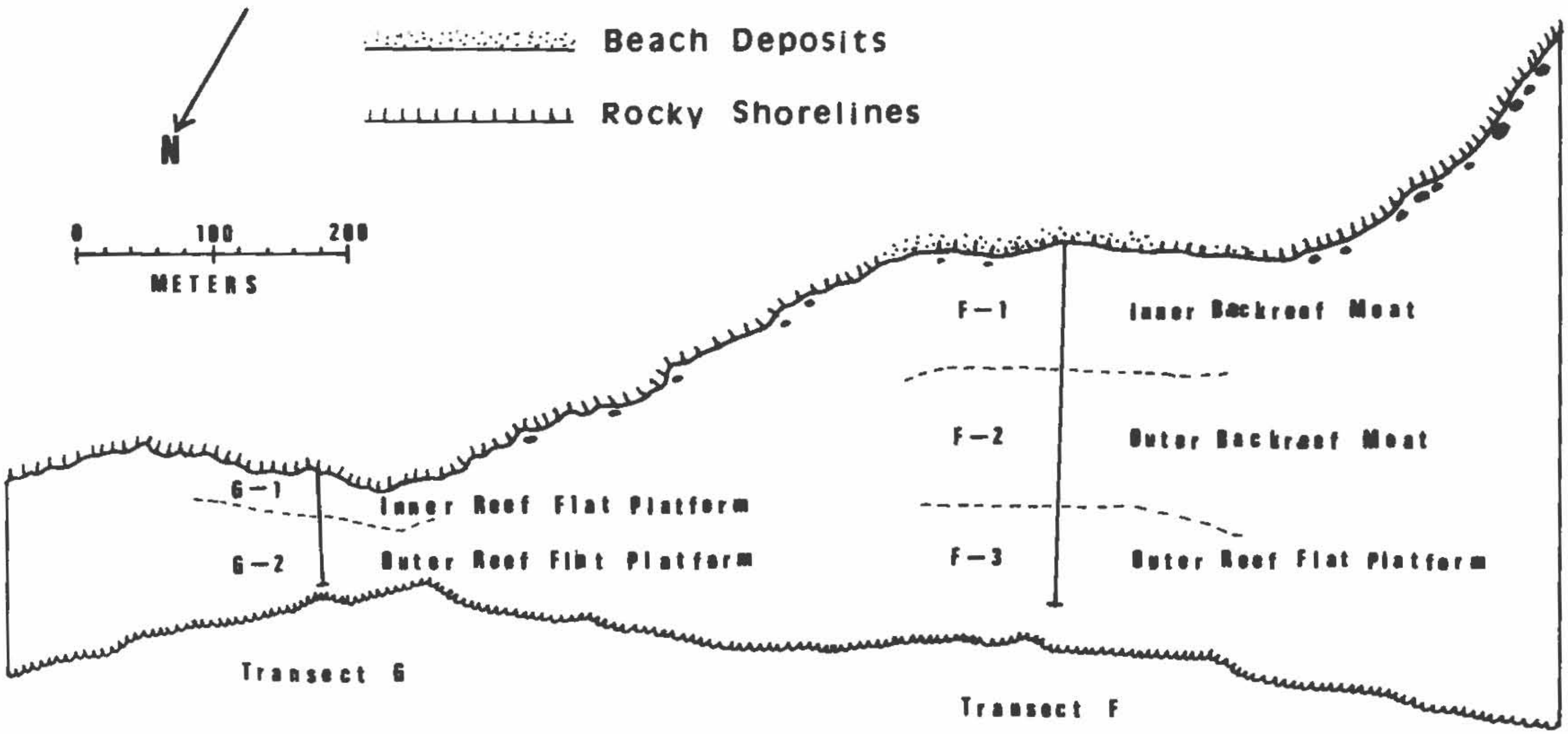

Figure 4. Map showing physiographic zonation patterns and the location of transects F and G.

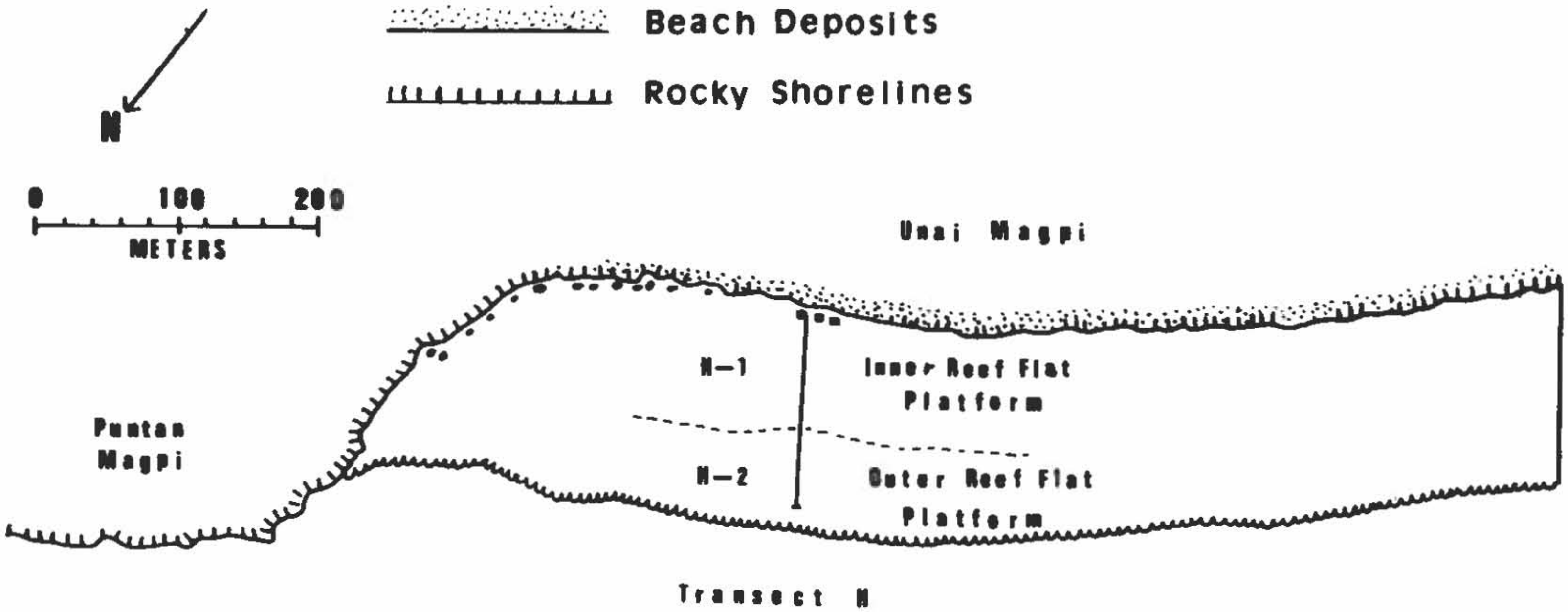

Figure 5. Map showing physiographic zonation patterns and the location of transect H.

CURRENTS AND SUBSTRATE CHARACTERIZATION

by

Ahser Edward and Alan E. Davis

Introduction

Current and substrate characterization data were generated for the northern part of Tanapag Lagoon on January 8-10 (Phase I), 1985 and March 24-30 (Phase II), 1986. Transects C, D, and E (Phase I) and A, B, F-H (Phase II) were studied by methods described individually in the current and substrate parts of this section.

Both currents and substrate characterization were determined at 20-meter intervals on transects C, D, and E and at 10-meter intervals on transects F,G, and H. At transects A and B excessive water depth and strong currents required that six subtransects, designated A1-A6 at transect A and B1-B6 at transect B, be laid out parallel to the shore and prevailing current as shown on Figure 1. Substrates and currents were studied at the up-current end of each of these subtransects, except at subtransect A3 (stations 7,8,9) where the data was collected at the down-current end. Three sampling stations were established for subtransects A1-A3 on transect A and B1-B6 on transect B; one 20 meters shoreward of the subtransect, a second one at the subtransect, and a third one 20 meters seaward of the subtransect. At each of these three sampling stations one or more replicates were made for current observations and substrate characterization. Where strong currents were encountered (at transect A stations located on subtransects A4-A6) a person was tethered on a 50-meter line from an anchored inflatable boat for current observations. The substrate study was done either from the boat anchor line or the 50-meter tether. At these subtransects all observations were made at one sampling station. Ordinal numbers were assigned to sampling stations, beginning at the shoreward station. Subtransect designations are included for reference in the tables, and on current maps (Figs. 1-4 and Tables 1-2). Current and substrate data from transects C, D, and E of Phase I (Randall et al., 1985) were incorporated into this section.

Currents

Current Analysis Methods

Fluorescein dye was injected into the water at each station on the transect line. During Phase I dye drift readings at transects C-E were made at 20-meter intervals, whereas during Phase II additional personnel allowed 10-meter intervals to be used at transects F-H. As previously mentioned transects A and B were treated differently. The time was recorded immediately prior to injecting dye at each station in order to evaluate the rate of current measured in respect to prevailing tidal conditions. Dye injections were made just below the surface of the water in order to reduce the influence of wind-generated surface-water movement. In most cases dye patches were observed until a dominant directional component was established. At each injection station the distance the dye patch traveled, elapsed time for travel, and directional heading of dye patch movement were recorded.

Water Movement Analysis and Discussion

From the study of transects C, D, and E (Randall et al., 1985), data revealed a prevailing longshore drift throughout the reef moat zone which moves generally from an east-northeast to west-southwest direction. Furthermore, under the tidal conditions that existed during the study, it appeared that the directionality of the established longshore current is free from influences that might often be induced by tidal fluctuations. Similar phenomena were observed during the second study phase of transects A, B, and F-H.

Further north at transects F-H, the direction of the current seemed to be more variable due to prevailing sea conditions such as surf, swells, and the depth of water in the areas of the transects. Shallow depth combined with periodicity of translatory wave action resulted in confused current patterns. At transect H, 14 readings were made. All readings showed no organized current pattern because of the strong movements of oscillating translatory waves. At transect G the presence of a shallow rock pavement caused sudden reflection of waves and created unusual current patterns as seen in Table 1 and Figure 3. The stations of this transect showed a lagoonward flow and similar velocities, as recorded earlier from transects C-E except for the two stations nearest the reef margin which showed a seaward current flow. At transect F, 27 current readings were taken and all showed disorganized current patterns. Readings made near the reef margin showed a seaward current flow.

The current directionality and speed measured at transect C, station 30, represents the horizontal movement of water caused by a wave breaking at the reef margin which momentarily overwhelmed the usual water flow pattern of the longshore current. The opposite situation was observed at transect C, station 31, when a wave trough reached the reef margin and the water piled up from a previous wave break began flowing seaward. For the above reason, transects stations nearest the reef margin sometimes have currents that flow in a seaward direction (Table 1, Figures 1-4).

At stations A6 and B6, data revealed a dominant flow of water from the reef margin toward the moat. In the central moat of transect B (B2-B5), the velocity of current appeared to be the highest with a direction that parallels the moat axis.

As the lagoon is approached on transect A the current pattern becomes less variable and the direction becomes more uniform as is revealed by stations A4-A5, possibly with increasing current velocity due to a constriction of the moat by a patch reef at station A3 (Fig. 1).

The narrow northern end of the island of Saipan points obliquely into the north equatorial drift current setting up local currents which run in a north-northeast to south-southeast direction on both sides of the island (Cloud, 1959). The east-northeast to west-southwest longshore drift revealed throughout the study site results from the local geographic orientation of the shoreline. The majority of the water piled up in the reef moat area most likely flows via longshore drift into Tanapag Lagoon and eventually returns to the Philippine Sea as described during Phase I of the study (Randall et al., 1985).

Substrate Characterization

Substrate Characterization Methods

The substrate at each station was characterized using a quadrat rigged with intersecting grids. The quadrat used for transects A-H consisted of a square frame of copper pipe, 25 centimeters on a side, with four parallel rows of nylon cord tied across each dimension, so that 16 equidistant intersecting points were contained within the quadrat. To characterize the substrate the quadrat was tossed randomly within a 5-meter radius of a station. Bottom material that occurred beneath each intersecting point was assigned to one of nine classes, A-I, as outlined in Table 2. For some quadrat samples fewer than 16 points were recorded, due to errors in the field.

In Table 2 data is given for substrate composition sampled by the random toss quadrat method for eight transects on the northern arm of Tanapag Lagoon. Depths for some stations are indicated in parentheses in the distance from shore column.

Substrate Analysis

Cloud (1959) noted that Tanapag Lagoon has a morphological appearance of a barrier reef in the middle part, grading into a fringing reef to the north (where this study was done) and to the south. The lagoon there effectively becomes a moat. Our observations were done in this region, blanketing the extent from a deeper moat at transect A to the shallow reef flat platform at transects G and H. Cloud also mentions that exposure of bare reef rock platforms increases at the northern and southern arms of the lagoon. The data of the present study supports this interpretation.

The longest transect, also nearest to the lagoon proper, is transect A. The character of transect A is more complex than the others, partly by virtue of the presence of a large patch reef at the shoreward end. Sorting of clastics is poorest on the outer reef platform, represented by subtransect A6. Sorting increases toward the innermost subtransect zones, where seagrass traps the smallest size fractions (the muds). A zone of living and dead coral is found in the middle part of the moat at subtransect A3. Reef rock was exposed in this zone, as well as on the outer reef platform at subtransect A6.

In the inner zone of transect B the chief means of navigation were through the prominent moat channels in a region dominated by shallow seagrass beds. On the central platform the water was two to three meters deep with scattered assorted clastics, coral, and fleshly and calcareous algae. Neogoniolithon dominated subtransect B4. On subtransect B5 arborescent Acropora patches formed conspicuous thickets on a rubbly sand plain in water about 2 meters in depth.

On transect F, large hummocks of sand were observed piled up behind thickets of Acropora in the central moat region. Table-like areas comprised of compacted unconsolidated rubble, bordered by steep microatoll-like terraces, were imposed on a somewhat deeper underlying topography about 60 meters from shore. During Phase I of this study it was noted that a fine sediment fraction dominated the inner 40 meters of transects C, D, and E. Similar substrate conditions exist for transect F. From 40 meters out to near the platform margin a heterogeneous clastic assemblage was found that grades into larger rubble, boulders, and pavement. This transition is not as abrupt as that on the inner flat from sand to heterogeneous clastics. The gravel component seems to be more prominent in the region from 60 to 150 meters seaward of the beach. Larger moveable fractions are less restricted, but also experience a peak in distribution over the inner-middle platform. At the platform margin clastics are conspicously unsorted. The presence of live coral at 50 meters was conspicuous. Patchy distribution of coral elsewhere is perhaps expected in an unconsolidated assemblage such as this one, subject as it is to overturning by storm wave surge.

Cloud (1959) refers to the northern reaches of the lagoon as a fringing reef. This is best represented by transects G, only 80 meters in length, and H. At transect G, this fringing platform experiences a sharp transition at about 30 meters from shore from the sand of the inner zone to a zone comprised of rock pavement with little or no moveable clastic component. Fleshly algae, and further seaward calcareous algae are present. The smooth platform of the inner reef flat grades into a region of greater relief on the outer 50 meters, where reef rock pavement is exposed.

Transect H consisted of reef rock pavement with a thin veneer of members of various sedimentary classes. On the inner part of the transect an algal mat was commonly encountered one or two centimeters thick in which was trapped a more or less dense burden of sand or small gravel (to 3 or 4 mm). Articulated coralline algae, probably Amphiroa sp., formed a morphologically similar mat on the outer platform. Shallow moat development is noted by Cloud (1959) for even the fringing reef system of the northern lagoon. The outer reef platform is in equilibrium with sealevel, as noted by its shallowness at low tide, and the luxurient coral growth just inside the platform margin where the shallow moat begins.

The Phase I report of this study noted the consistent dominance, along transects C, D, and E, of fine fractions of sediment along the beach. This trend is found in every transect studied, including A, B, and F, G, and H. The mechanism of sorting is increased suspension of fine fractions of the reef detrital production, with mud being washed out by wave and current action, either being trapped by seagrasses, moved into deeper regions, or carried into the Philippine Sea.

Sargassum polycystum was not dominant during the Phase II study, as it was during Phase I. There were complications in the simple pattern of gradation toward larger classes of sediments toward the reef margin, some of which might have been due to the more complex physiography of transects A and B, where zonation is more extensive. On transect A toward the reef margin the sediments are unsorted, while on transect B a trend toward increasing size indeed seems to be dominant at the outer margin. It thus appears that the zone of highest wave assault may be characterized by either or both of these characters.

Seagrasses increase in the inner moat zone southward from transect C. Within this seagrass zone the finest sediments, the silt and clay fractions, are trapped.

An additional substrate feature noted on the reef platform at transects G and H in particular was a more or less shallow coating of other sediment classes overlaying a solid reef rock pavement, which can be of considerable relief, or smooth and pavement-like. Such a reef rock pavement was not so obvious at other transects to the south. It is obvious as well, but not evident from an examination of the data, that on the inner reef platform at transects G and H an algal mat serves to trap sand. Sometimes this sand occurs as only a thin dusting, while at other times giving indications of being a sand mat in which algae can be discriminated. On transect H, as mentioned above, the algal mat was seen to grade into an articulated calcareous algal mat (possibly an Amphiroa sp.) of identical structure.

At transects C, D, and E sand is more abundant in the inner zone, with abundant seagrasses. A finer mud fraction also is extant but not reflected in our classification scheme. This fraction, not apparent at the extreme northern arm of the lagoon, is abundantly present from transect C south.

Potential Effects of Land Clearing and Dredging

As noted in Phase I of this study, dredging activities would suspend fine sediment in the water column. It is no doubt true that this material would be carried with the predominant longshore set, much of it being transported out of the lagoon with the water mass. Sorting of particles will occur, resulting from differential sedimentation of various fractions. Believed to be of special importance in the fate of this material is the presence of abundant seagrasses near transects A through E of this study. Trapping of fine sedimentary classes by seagrasses has been suggested. The effects of deposition of large amounts of fines is not known. Some of the burden will be deposited on the floor of the moats. Formations such as the *Acropora* patches on Transect F with developed hummocks of sand may accumulate some of this sediment. It seems doubtful that sediment input would continue at such levels as to affect the growth of corals.

In case of land clearing, terrigenous sediments might experience a similar fate, with the added effect of supplementation of mineral nutrients in the ecosystem. Long term alteration of the chemical makeup may be obviated by constant flux of ocean water through the system.

It is suggested that the seagrass beds be monitored for potential effects due to the mentioned processes of sediment trapping.

Literature Cited

Cloud, P. E., Jr. 1959. Submarine topography and shoal-water ecology, Part 4. of geology of Saipan, Mariana Islands. U.S. Geol. Survey Prof. Paper 280K, pp. 361-445.

Randall, R. H., P. D. Gates, J. B. Neill, and S. C. Wilkins. 1985. A marine survey of the Tanapag reef platform adjacent to Unai Papau. Univ. of Guam, Mar. Lab. Misc. Rept. No. 48. 55 p.

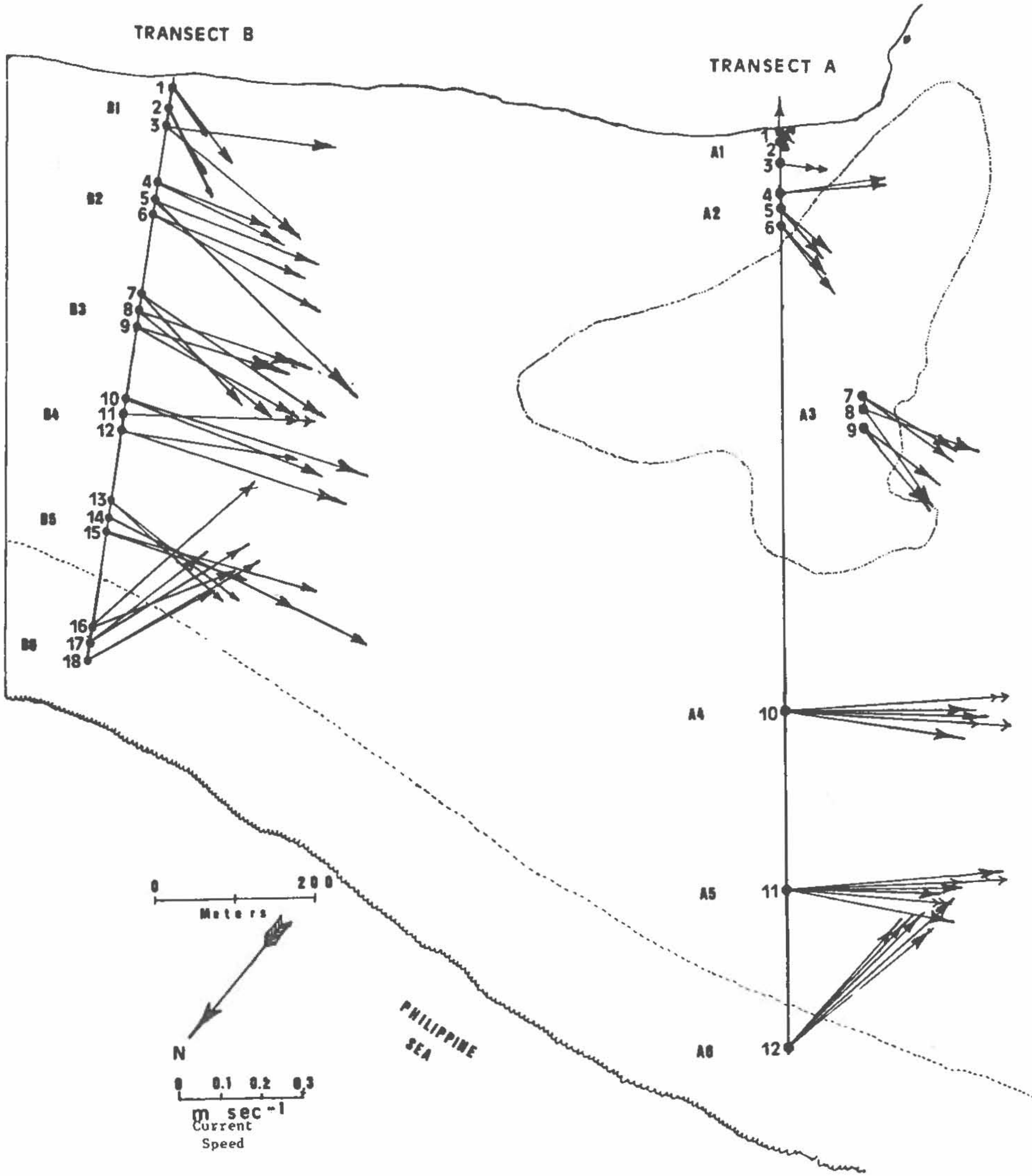

Figure 1. Map showing the locations of current and substrate stations along transects A and B. Arrows indicate current velocity vectors.

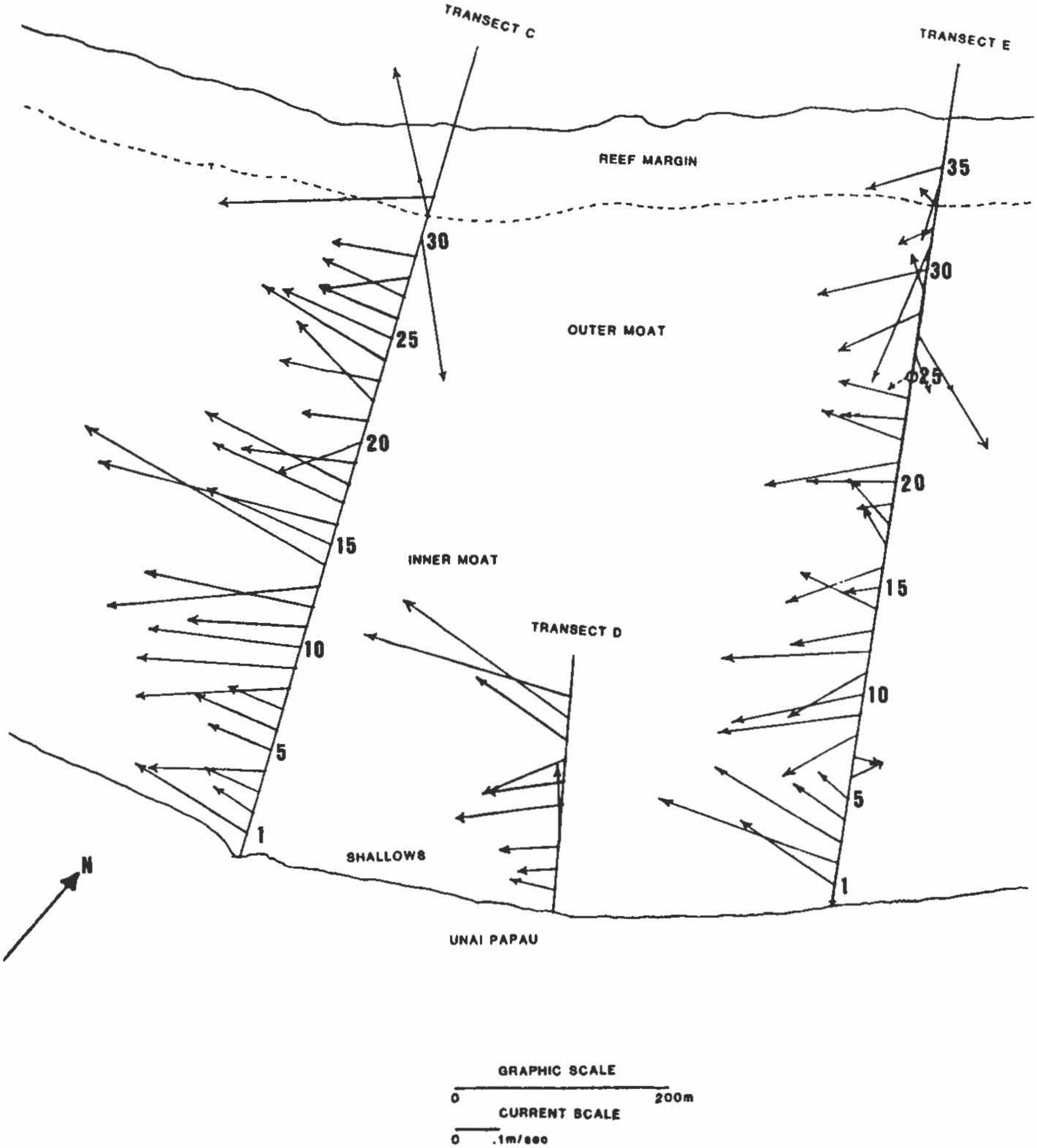

Figure 2. Map showing the locations of current and substrate stations along transects C, D, and E. Arrows indicate current velocity vectors.

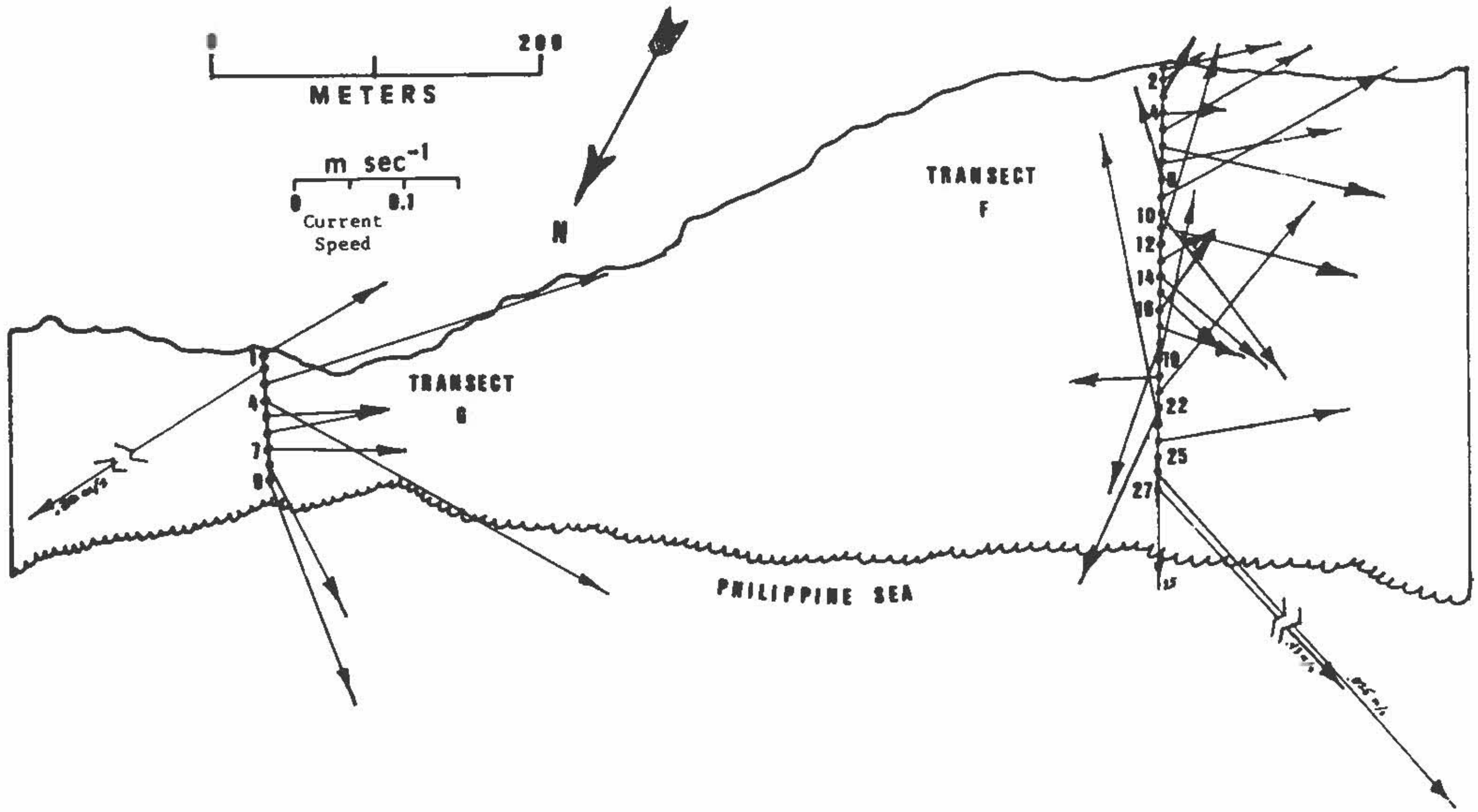

Figure 3. Map showing the locations of current and substrate stations along transects F and G. Arrows indicate current velocity vectors.

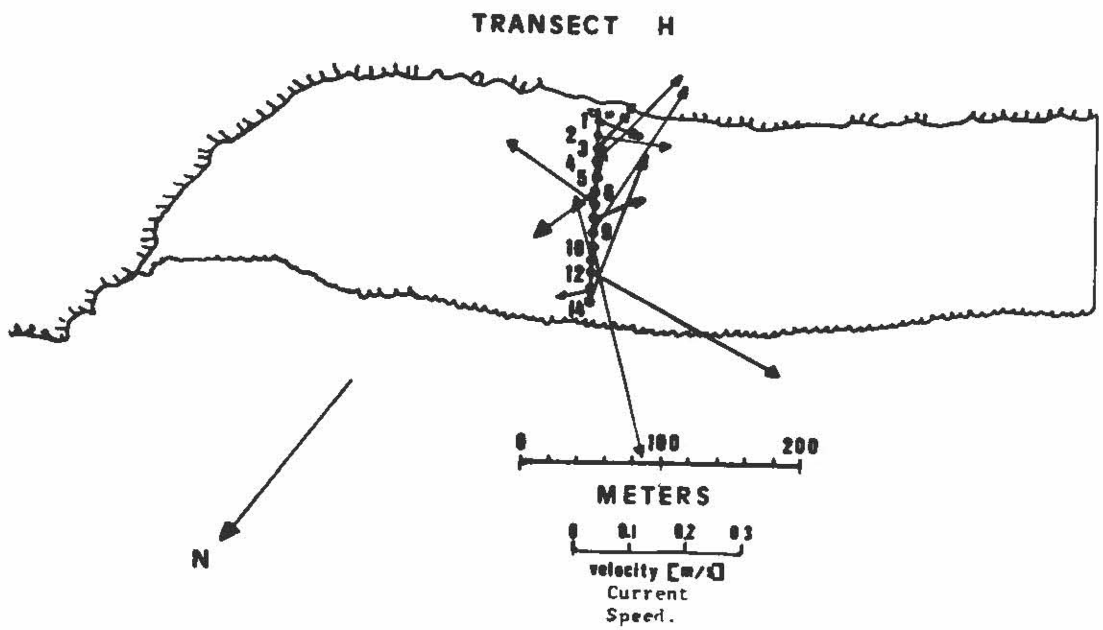

Figure 4. Map showing the locations of current and substrate stations along transect H. Arrows indicate current velocity vectors.

Table 1. Tanapag Lagoon current study data for transects A-H. See Fig. 1 for transect location.

Transect A: March 28, 1986; High Tide at 8:45 = .64 M
Low Tide at 15:13 = .00 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
1 (A1)	4	16:25	.040	274	E. Flood
1 (A1)	4	16:27	.086	143	E. Flood
2 (A1)	14	16:33	.026	273	E. Flood
2 (A1)	14	16:35	.042	185	E. Flood
3 (A1)	44	16:42	.114	238	E. Flood
3 (A1)	44	16:43	.082	238	E. Flood
4 (A2)	80	17:28	.254	227	E. Flood
4 (A2)	80	17:29	.257	223	E. Flood
5 (A2)	100	17:12	.161	272	E. Flood
5 (A2)	100	17:14	.156	280	E. Flood
6 (A2)	120	17:01	.160	278	E. Flood
6 (A2)	120	17:02	.212	283	E. Flood
7 (A3)	344	13:06	.263	262	M. Ebb
7 (A3)	344	13:09	.276	267	M. Ebb
8 (A3)	364	13:23	.300	252	M. Ebb
8 (A3)	364	13:25	.291	287	M. Ebb
9 (A3)	384	13:34	.230	268	M. Ebb
9 (A3)	384	13:35	.260	282	M. Ebb
10 (A4)	742	12:14	.517	227	M. Ebb
10 (A4)	742	12:15	.547	227	M. Ebb
10 (A4)	742	12:16	.489	232	M. Ebb
10 (A4)	742	12:17	.460	230	M. Ebb
10 (A4)	742	12:18	.470	234	M. Ebb
10 (A4)	742	12:19	.448	239	M. Ebb
10 (A4)	742	12:21	.544	234	M. Ebb
11 (A5)	961	11:27	.525	226	E. Ebb
11 (A5)	961	11:31	.433	230	E. Ebb
11 (A5)	961	11:32	.373	232	E. Ebb
11 (A5)	961	11:33	.413	236	E. Ebb
11 (A5)	961	11:34	.418	228	E. Ebb
11 (A5)	961	11:35	.391	236	E. Ebb
11 (A5)	961	11:36	.418	242	E. Ebb
11 (A5)	961	11:37	.535	228	E. Ebb
12 (A6)	1157	9:46	.631	196	H. Tide
12 (A6)	1157	9:47	.550	190	H. Tide
12 (A6)	1157	9:49	.423	183	H. Tide
12 (A6)	1157	9:50	.438	185	H. Tide
12 (A6)	1157	9:51	.465	187	H. Tide
12 (A6)	1157	9:52	.465	192	H. Tide

Table 1. Cont.

Transect B: March 26, 1986; Low Tide at 13:50 = .16 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
1 (B1)	23	12:18	.239	284	L. Ebb
1 (B1)	23	12:20	.137	286	L. Ebb
2 (B1)	43	12:27	.181	283	L. Ebb
2 (B1)	43	12:32	.240	286	L. Ebb
3 (B1)	63	12:40	.411	248	L. Ebb
3 (B1)	63	12:45	.412	281	L. Ebb
4 (B2)	135	13:16	.265	258	L. Ebb
4 (B2)	135	13:22	.335	362	L. Ebb
5 (B2)	155	13:27	.695	274	L. Ebb
5 (B2)	155	13:31	.427	250	L. Ebb
6 (B2)	175	13:37	.452	254	L. Ebb
6 (B2)	175	13:44	.475	262	L. Ebb
7 (B3)	278	14:41	.352	279	L. Tide
7 (B3)	278	14:53	.542	265	L. Tide
8 (B3)	298	14:55	.446	250	L. Tide
8 (B3)	298	14:56	.416	270	L. Tide
9 (B3)	318	14:57	.457	260	L. Tide
9 (B3)	318	14:59	.379	248	L. Tide
10 (B4)	410	13:57	.519	252	L. Ebb
10 (B4)	410	13:59	.629	248	L. Ebb
11 (B4)	430	13:51	.467	233	L. Ebb
11 (B4)	430	13:52	.420	233	L. Ebb
12 (B4)	450	13:41	.576	249	L. Ebb
12 (B4)	450	13:42	.432	240	L. Ebb

March 27, 1986; High Tide at 8:19 = .64 m.
Low Tide at 14:29 = .08 m.

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
13 (B5)	541	10:51	.400	269	E. Ebb
13 (B5)	541	10:52	.370	273	E. Ebb
14 (B5)	561	11:04	.490	257	E. Ebb
14 (B5)	561	11:06	.688	257	E. Ebb
15 (B5)	581	11:16	.365	250	M. Ebb
15 (B5)	581	11:24	.538	247	M. Ebb
16 (B6)	706	10:10	.375	210	E. Ebb
16 (B6)	706	9:59	.531	190	E. Ebb
17 (B6)	726	9:44	.459	200	E. Ebb
18 (B6)	746	9:38	.489	201	E. Ebb
18 (B6)	746	9:31	.353	202	E. Ebb

Table 1. Cont.

Transect C: January 9, 1985; High Tide at 10:23 = .62 M
Low Tide at 15:30 = .38 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
1	20	9:20	.155	260	L. Flood
2	40	9:24	.056	261	L. Flood
3	60	9:31	.070	251	L. Flood
4	80	9:40	.138	230	L. Flood
5	100	9:45	.080	251	L. Flood
6	120	9:52	.108	252	L. Flood
7	140	9:58	.071	250	L. Flood
8	160	10:07	.181	225	L. Flood
9	180	10:18	.185	232	High
10	200	10:28	.180	235	High
11	220	10:40	.138	232	E. Ebb.
12	240	10:47	.195	240	E. Ebb.
13	260	11:00	.226	223	E. Ebb.
14	280	11:08	.324	258	E. Ebb.
15	300	11:18	.157	252	E. Ebb.
16	320	11:26	.238	243	E. Ebb.
17	340	11:40	.167	253	E. Ebb.
18	360	11:51	.182	255	E. Ebb.
19	380	11:57	.136	235	E. Ebb.
20	400	12:08	.105	208	E. Ebb.
21	420	12:18	.077	235	M. Ebb.
22	440	12:26	.129	275	M. Ebb.
23	460	12:37	.118	240	M. Ebb.
24	480	12:43	.171	259	M. Ebb.
25	500	12:56	.142	252	M. Ebb.
26	520	13:03	.100	251	M. Ebb.
27	540	13:13	.105	253	M. Ebb.
28	560	13:25	.106	220	M. Ebb.
29	580	13:32	098	238	M. Ebb.
30	600	13:45	.168	130	L. Ebb.
31	620	14:00	.181	305	L. Ebb.
32	640	14:07	.244	277	L. Ebb.

Transect D: January 8, 1985; Low Tide at 14:49 = .41 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
1	20	14:01	.056	241	L. Ebb.
2	40	14:15	.043	224	L. Ebb.
3	60	14:33	.067	225	L. Ebb.
4	80	14:40	.072	317	L. Ebb.
5	100	14:47	.123	221	Low
6	120	14:59	.088	219	E. Flood
7	140	15:05	.105	206	E. Flood
8	160	15:16	.132	263	E. Flood
9	180	15:31	.235	264	E. Flood
10	200	15:44	.253	245	E. Flood

Table 1. Cont.

Transect E: January 10, 1985; High Tide at 11:01 = .62 M
Low Tide at 16:23 = .36 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
1	20	10:01	.135	262	L. Flood
2	40	10:04	.227	248	L. Flood
3	60	10:10	.173	259	L. Flood
4	80	10:14	.078	263	L. Flood
5	100	10:26	.048	270	L. Flood
6	120	10:36	.041	024	L. Flood
7	140	10:40	.026	062	L. Flood
8	160	10:49	.097	200	L. Flood
9	180	10:57	.162	221	L. Flood
10	200	11:07	.157	216	High
11	220	11:14	.108	199	E. Ebb.
12	240	11:23	.175	225	E. Ebb.
13	260	11:28	.102	218	E. Ebb.
14	280	11:35	.102	254	E. Ebb.
15	300	11:39	.041	219	E. Ebb.
16	320	12:02	.118	208	E. Ebb.
17	340	12:06	.053	288	E. Ebb.
18	360	12:23	.068	279	E. Ebb.
19	380	12:27	.042	220	E. Ebb.
20	400	12:31	.107	228	E. Ebb.
21	420	12:44	.160	218	E. Ebb.
22	440	12:47	.100	248	M. Ebb.
23	460	13:13	.077	232	M. Ebb.
24	480	13:17	.085	242	M. Ebb.
25	500	13:21	.031	198	M. Ebb.
26	520	13:40	.047	118	M. Ebb.
27	540	13:45	.154	108	M. Ebb.
28	560	14:07	.105	203	M. Ebb.
29	580	14:10	.047	300	M. Ebb.
30	600	14:15	.127	215	M. Ebb.
31	620	14:35	.173	163	L. Ebb.
32	640	14:38	.046	203	L. Ebb.
33	660	15:03	.030	275	L. Ebb.
34	680	15:07	.071	156	L. Ebb.
35	700	15:11	.099	212	L. Ebb.

Transect F: March 25, 1986; High Tide at 18:59 = .56 M
Low Tide at 13:13 = .24 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
1	4	13:01	.105	229	L. Ebb
2	10	13:06	.043	208	L. Ebb
3	20	13:12	.057	180	L. Ebb

Table 1. Cont.

Transect F: March 25, 1986; High Tide at 18:59 = .56 M
Low Tide at 13:13 = .24 M

Station no.	Dist. Form Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
4	30	13:17	.057	237	L. Tide
5	40	13:21	.155	212	L. Tide
6	50	13:27	.206	253	L. Tide
7	60	13:35	.169	230	L. Tide
8	70	13:41	.088	134	L. Tide
9	80	13:51	.243	212	L. Tide
10	90	13:55	.188	293	L. Tide
11	100	14:01	.184	255	L. Tide
12	110	14:06	.190	167	L. Tide
13	120	14:11	.056	211	L. Tide
14	130	14:18	.127	280	E. Flood
15	140	14:23	.078	283	E. Flood
16	150	14:32	.090	185	E. Flood
17	160	14:39	.082	260	E. Flood
18	170	14:43	.145	349	E. Flood
19	180	14:51	.155	162	E. Flood
20	190	14:58	.086	058	E. Flood
21	200	15:08	.226	190	E. Flood
22	210	15:24	.175	355	E. Flood
23	220	15:26	.263	139	E. Flood
24	230	15:29	.178	232	E. Flood
25	240	15:31	.119	330	E. Flood
26	250	15:34	.825	287	E. Flood
27	260	15:36	.432	287	E. Flood

Transect G: March 25, 1986; High Tide at 7:31 = .56 M
Low Tide at 13:13 = .24 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
1	4	9:44	.133	211	M. Ebb
2	10	9:51	.380	028	M. Ebb
3	20	9:55	.330	223	M. Ebb
4	30	9:59	.363	270	M. Ebb
5	40	10:05	.110	238	M. Ebb
6	50	10:06	.112	230	M. Ebb
7	60	10:17	.125	241	M. Ebb
8	70	10:25	.156	303	M. Ebb
9	80	10:32	.220	309	M. Ebb

Table 1. Cont.

Transect H: March 24, 1986; Low Tide at 12:36 = .32 M

Station no.	Dist. From Shore (M)	Time of day	Current Speed (M/SEC)	Bearing (DEG)	Stage of Tide
	(Sta. Exposed)				
1					
2	10	12:43	.130	240	L. Tide
3	20	13:06	.103	180	E. Flood
4	30	13:21	.213	185	E. Flood
5	40	13:30	.053	154	E. Flood
6	50	13:42	.136	015	E. Flood
7	60	13:50	.190	087	E. Flood
8	70	13:58	.089	206	E. Flood
9	80	14:00	.309	175	E. Flood
10	90	14:05	.384	308	E. Flood
11	100	14:11	.110	126	E. Flood
12	110	14:20	.380	260	E. Flood
13	120	14:32	.051	040	E. Flood
14	130	14:38	.275	162	E. Flood

Table 2. Substrate characterization of transects A-H in Tanapag Lagoon. Point counts of nine different substrate characteristics (A-I) are given for each quadrat station. Percent coverage for each type of substrate characteristic (A-I) is also given for the entire transect (percent coverage = total points of a substrate characteristic that occurs on a transect divided by the total number of transect points x 100). Definitions of substrate characteristic symbols A-I are given below.

A - Sand: grain size less than 2 mm
B - Gravel: grain size less than 4 cm
C - Cobbles, rubble, or boulders: grain size larger than gravel
D - Pavement: in situ reef rock
E - Living coral:
F - Coralline algae: any calcareous algae
G - Sea grass or fleshly algae
H - Loose <u>Halimeda</u> segments
I - In situ dead coral

Transect A: March 28, 1986.

Station no.	Distance from Shore in meters	A	B	C	D	E	F	G	H	I
				(Point Counts)						
1 (A1)	4							16		
1 (A1)	4						1*	15		
2 (A1)	14	4	2					9***		
2 (A1)	14	16								
2 (A1)	14							16****		
2 (A1)	14	4	2					10		
3 (A1)	44	1						19+		
3 (A1)	44							16+		
3 (A1)	44	4	1					11		
4 (A2)	80	4	7	4						
4 (A2)	80		7	8	1					
5 (A2)	100	1	5	9		1				
5 (A2)	100	2	6	6		1		1		
6 (A2)	120	1	10	3	2					
6 (A2)	120	4	6	4	1					1
7 (A3)	344	1	2		7	5		1		
7 (A3)	344	1			5	3	1	6		
8 (A3)	364			4	7	4				1
8 (A3)	364		3		6	5	1			1
9 (A3)	384	2			8	4		2		
9 (À3)	384	1			7	4	2	2		
9 (A3)	384	1	4	2	2	1	1	1		
10 (A4)	742	6	5	2				3		
10 (A4)	742	9	4	1				2		
10 (A4)	742	1	6	2				6		
11 (A5)	961	3	6	1			1	5		
11 (A5)	961	8	3	2				3		
11 (A5)	961	14	2							

Tran. A. Cont.

Station no.	Distance from Shore in meters	A	B	C	D	E	F	G	H	I
				(Point Counts)						
11 (A5)	961	10	2					4		
12 (A6)	1157 **				16					
12 (A6)	1157	4	2	5	5					
12 (A6)	1157			6	10					
12 (A6)	1157	4	5	3	4					
	Total Points	106	90	62	81	28	7	144	0	3
	Percent Coverage	20.3	17.3	11.9	15.5	5.4	1.3	27.6	0	0.6

* _Halimeda_
** Unsorted clastics.
**** _Enhalus_
*** _Halophila_
\+ _Halodule_

Transect B: March 26 and 27, 1986

Station no.	Distance from Shore in Meters	A	B	C	D	E	F	G	H	I
				(Point Counts)						
0 *	Shoreline	13	1					2		
1 (B1)	23	6						9		
2 (B1)	43							16		
2 (B1)	43	8					1***	7		
3 (B1)	63	14	2							
3 (B1)	63	9	1				2	4		
4 (B2)	135	4						12***		
4 (B2)	135	2						14***		
5 (52)	155	3	1				3	9***		
5 (B2)	155							16		
6 (B2) ****	175	8	5	3						
6 (B2)	175	7	6	1	2					
8 (B3) *	298	13		2		1				
8 (B3)	298	11		1			1	2		
8 (B3)	298	12		2				2		
8 (B3)	298	9		2				4		
10 (B4)	410	4				4	2	2		
10 (B4)	410	4	1	3			3+	5		
11 (B4)	430	1					15+			
11 (B4)	430	9		5			2+			
12 (B4)	450	8	2	1			5+			
12 (B4)	450	6	3	5			2+			
12 (B4)	450	2	5	6			2+	1		

Trans. B. Cont.

Station no.	Distance from Shore in meters	A	B	C	D	E	F	G	H	I
				(Point Counts)						
13 (B5)	541	4	1	9			2			
14 (B5)	561	3	3	2		7				
14 (B5)	561			16++						
15 (B5)	581			16++						
15 (B5)	581					15+++		1		
15 (B5)	581	15				1				
15 (B5)	581	4	6	6						
16 (B6)	706		8	4	4					
17 (B6)	726		4	8	1	3				
18 (B6)	746		3	3	8	2				
	Total Points	179	52	95	15	33	40	106	0	0
	Percent Coverage	34.4	10.0	18.3	2.9	6.3	7.7	20.4	0	0

* B3 was sampled only at one station, and no current reading was possible at a shoreline station. Therefore, the numbering of the current stations differs from that of the sediment stations.

** _Halimeda_
*** _Halodule_
**** Rubbly sand plain
+ _Neogoniolithon_
++ _Acropora_ rubble
+++ _Acropora_ / _Polysiphonia_ complex

Transect C: January 9, 1985.

Station no.	Distance from Shore in meters	A	B	C	D	E	F	G	H	I
				(Point Counts)						
1	20	16								
2	40	16								
3	60	10							6	
4	80	16								
5	100	4						8	4	
6	120	16								
7	140	15						1		
8	160	11						5		
9	180	9						7		
10	200	16								
11	220	14						2		
12	240	12						4		
13	260	9						5	2	
14	280	9	4	3						
15	300	11	5							
16	320	4	6	6						

Trans. C. Cont.

Station no.	Distance from Shore in meters	A	B	C	D	E	F	G	H	I
				(Point Counts)						
17	340	1	3	12						
18	360	1	4			3	8			
19	380	5	3	8						
20	400	1	3	8		4				
21	420	2		2		10	2			
22	440	2	4	2		8				
23	460		6	6		4				
24	480	1	2	4		9				
25	500			14		2				
26	520		9	5			2			
27	540		8	7						1
28	560	1		4		8				3
29	580					3				13
30	600		3	12						1
31	620		1	11		1	3			
32	640			16						
	Total Points	202	62	120	0	52	15	32	12	18
	Percent Coverage	39.4	12.1	23.4	0	10.1	2.9	6.2	2.3	3.5

Transect D. January 8, 1985.

Station No.	Distance from Shore in Meters	A	B	C	D	E	F	G	H	I
1	20	16								
2	40	16								
3	60	16								
4	80			1				15		
5	100	14	2							
6	120	15						1		
7	140	14	2							
8	160	11	5							
9	180	7	9							
10	200	11	5							
	Total Points	120	23	1	0	0	0	16	0	0
	Percent Coverage	75.0	14.4	0.6	0	0	0	10.0	0	0

Transect E: Jan. 10, 1985

Station No.	Distance from Shore in Meters	A	B	C	D	E	F	G	H	I
1	20	16								
2	40	15					1			
3	60	13	3							
4	80	10	6							
5	100	8	3	1				4		
6	120	13						1		1
7	140	16								
8	160	16								
9	180	15					1			
10	200	5	1	2				8		
11	220	8						8		
12	240	11		3				2		
13	260	12		2			2			
14	280	16								
15	300	5	9					2		
16	320			15		1				
17	340				12	4				
18	360	3		10		1	1			
19	380	1	2	13						
20	400	5	6	5						
21	420	15					1			
22	440			10		1				5
23	460					14				2
24	480	4	2	5			5			
25	500	5	3	5			3			
26	520	6		5		5				
27	540		2	3						11
28	560					3	5			8
29	580	6	2	7		1				
30	600					1	3			12
31	620			1						15
32	640		2				2			12
33	660		2	14						
34	680			4		1	1			11
35	700		3	3	5	2				1
	Total Points	224	46	108	17	34	25	25	0	78
	Percent Coverage	40.2	8.3	19.4	3.1	6.1	4.5	4.5	0	14.0

Transect F: March 25, 1986. Depth indicated in parentheses at stations 1-3.

Station No.	Distance from Shore in Meters	A	B	C	D	E	F	G	H	I
1	4 (<0.3 m)	16								
2	10 (<1m)	6	5		4		1			
3	20 (1m)	15		1						
4	30 ***	12					3	1		
5	40 ***	16								
6	50	1		4		11				
7	60	3	5	6		1	1			
8	70 +	1	4	7		1	2			
9	80		2	8	2	2	2			
10	90	8		1	2	3		2		
11	100		5	4			6	1		
12	110	1	6	5	2	1		1		
13	120	1	5	4		2	2	1		1
14	130	1	5	5	1	1	3			
15	140	2	3	6	1	1	3			
16	150	3		3		10				
17	160	4		1	1	5	3			1
18	170	4		2	8		2			
19	180	7	1	1	5		2			
20	190	10		2	1		3			
21	200	1		11		3	1			
22	210	1		2	13					
23	220	1	2		7	2	1			3
24	230				9	3	3	1		
25	240	3	2	3	5		2	1		
26	250			3	6	1	3			3
27 *	260				9	1				6
	Total Points	117	45	79	76	48	43	8	0	14
	Percent Coverage	27.2	10.5	18.4	17.7	11.2	10.0	1.9	0	3.3

* Relief to 30cm.
** Table elevated 0.3m above surrounding substrate
*** Sand a veneer of <1-3 cm over pavement
\+ unconsolidated rubble with trapped sand, some showing, with reef rock under 10 cm.
Note: Inner zone: Tables of <0.6m abruptly superposed on sand in 1 m of depth.

Transect G: March 25, 1986. Depth indicated in parentheses at stations 5, 6, and 9.

Station No.	Distance from Shore in Meters	A	B	C	D	E	F	G	H	1
1	4	10						6		
2	10	7		1				8		
3	20					14			2	

Trans. G. Cont.

Station No.	Distance from Shore in Meters	A	B	C	D	E	F	G	H	I
4	30		1		9			6		
5	40 (C.6M)				6			5		
6	50 (0.6M)		1		8		3	4		
7	60				3		9	4		
8	70				6		4	6		
9	80 (0.5M)	3			3		2	8		
	Total Points	20	2	1	35	14	18	47	2	0
	Percent Coverage	14.4	1.4	0.7	25.2	10.1	12.9	33.8	1.4	0

Notes:
1,2,3,4 smooth platform grading into more relief further seaward.

Transect H: March 24, 1986. Depth indicated in parentheses at stations 1-5 and 7.

Station No.	Distance from Shore in Meters	A	B	C	D	E	F	G	H	I
1	0 (0.3M)	1						3		
2	10 (0.6M)	4				2		9		1
3	20 (0.5M)	3	5		2		1	4		
4 *	30 (0.6-0.9M)	2	1		2		3	8		
5	40 (0.6M)	8			1		3	4		
6	50	1			1	3	4	7		
7	60 (0.5M)	2	3		1		3	4		
8	70	8			2	2				
9	80				9	6				
10	90	2			4	10				
11	100				4	11	1			
12	110				7	5	3	1		
13	120	1			3	11		1		
14	130			16						
	Total Points	44	9	16	36	50	18	41	0	1
	Percent Coverage	20.5	4.2	7.4	16.7	23.3	8.4	19.1	0	0.5

* On eage of microatoll type ledge

A QUANTITATIVE ASSESSMENT OF MARINE PLANTS

by

Susanne C. Wilkins

Introduction

A baseline marine assessment of an area of the northern Tanapag reef platform was conducted on Jan. 8-11, 1985 (Phase I), and on Mar. 24-30, 1986 (Phase II). The objective of this portion of the study was to assess the shallow benthic flora of this area. Data from both Phase I and Phase II studies are incorporated into this report.

Methods

Marine plants and substrate were quantified by using the point-quadrat method described by Best (1982) along eight transects (A-H) as shown in Figures 1-5, pp. 5-9. Transects A-H, with the exception of transect D, ran from shoreline to near the seaward edge of the outer reef platform. Transect D was shorter and extended only partway across the reef platform between transects C and E. Transects A and B were each divided into six 100-meter substransects as shown in Figure 2, p. 6. These subtransects were run parallel to the reef axis, principally within the various physiographic zones that were discriminated, and numbered consecutively from 1 through 6 from the shoreline.

The point-quadrat method provides data from which a rapid general assessment of percent cover and frequency of occurrence of any marine plant species is possible. Thus, distribution patterns and evenness or patchiness of benthic plant species can easily be recognized. The benthic plant assemblages were analyzed by tossing a gridded quadrat at 10-meter intervals along the length of each transect or subtransect. The quadrat consisted of a square frame of copper pipe, 25 centimeters on a side, with four parallel rows of nylon cord tied across each dimension, so that 16 intersecting points were contained within. Each plant species was recorded at every point it occurred. If algal turf was encountered under the points, samples were taken to the laboratory and species present in each sample were identified. If no marine plant was found under the points, then whatever was present, e.g. sand, dead coral, coral rubble, or live coral was recorded.

Percent cover for each transect was calculated by taking the total points at which a species occurred, divided by the total points per transect. In addition, frequency of occurrence was calculated by taking the number of quadrat tosses in which a benthic constituent occurred, divided by the number of tosses per transect. Both cover and frequency values were converted to percent by multiplying by 100. Additional algal species along the transect were also recorded.

The first 100 meters of transects C, D, and E, initially sampled during Phase I, were resurveyed during Phase II of this study.

Results and Discussion

Results of the survey are presented in Tables 1-4. A total of 64 species of marine plants were quantified within the study area. The highest percent cover (70.1%) was recorded on subtransect B-2, an area of thick seagrass beds. Other transects with abundant algal cover included substransect A-1 and transect G.

Prevailing longshore currents occurring throughout the northern moat area usually flowed in a west-southwesterly direction (Cloud, 1959, and this study). Such current patterns strongly influence the distribution and orientation of bottom sediments, resulting in sand being the most dominant textural substrate component of nearshore areas. These nearshore areas are frequently dominated by seagrass beds. Fine sediments appear to be trapped in these zones, resulting in a gradual buildup of the surface. Halodule beds, for instance, frequently have a mound like configuration.

The areas closest to the reef edge are affected by strong undirectional currents as a result of wave transport from the platform margin into the backreef moat areas. Such currents were particurlarly strong at subtransects A-6 and B-6.

Habitat variations as indicated on the transect location maps (Figs. 2-5, pp. 6-9) can basically be arranged into 4 different zones: 1) sandy bottom area with or without seaweed, 2) shallow areas of gravel and rubble with coraline algae and scattered live corals, 3) patches of living corals among areas of boulders and sand, and 4) outer reef flat pavement areas.

Marine plants can be categorized and described with respect to the zones they were recorded in. The sandy substrate nearshore is restricted to those species which are able to tolerate salinity fluctuations and which possess modified attachment organs, for example, creeping rhizomes as those of Halodule and Halophila, or sand binding hold-fasts as those of Halimeda macroloba (Randall, 1978). Although Sargassum polycystum, with thalli over a meter long was recorded within the nearshore areas of transect E during the Phase I survey, percent cover was quite low. During the resurvey of this same transect during Phase II, only Sargassum hold-fasts were recorded indicating seasonal changes in the abundnce of this alga.

A definite increase in the number of species and diversity was noted in areas near the reef platform margin. Algae such as Gelidiopsis intricata, Boodlea composita, Microcoleus lyngbyaceus, Dictyosphaeria versluysii, and two Sphacelaria species represent the prominent lagoon turf forming species along transects C-H. Most corraline algae, especially Lithophyllum and Neogoniolithon, seemed to grow well both in areas of very strong current as well as in calmer areas.

Potential Effects of Coastal Development

Environmental impacts arising from development along the shoreline of Tanapag reef platform will primarily be of two types: those of a temporary nature during construction and those of a continuous nature arising from permanent structures, additional discharges, and run off.

Increased sedimentation during excavation and the generation of sediment plumes could affect marine communities downstream. Increased freshwater seepage caused by excavations on land and increased runoff may result in nutrient rich effluent and possible eutrofication of nearby waters. Additional impacts may include some changes in the direction of the currents causing changes in sediment deposition and thus changes in the composition of the marine plant community.

Literature Cited

Best, B. R. 1982. A quantitative assessment of the marine algae and other common biotic and abiotic benthic constituents of the Luminao-Cabras-Piti Reefs. pp. 19-21. In R. H. Randall, and L. G. Eldredge (eds.). Assessment of the shoalwater environment in the vicinity of the proposed OTEC development at Cabras Island, Guam. Univ. of Guam, Mar. Lab. Tech. Rept. No. 79. 208 p.

Cloud, P. E., Jr. 1959. Submarine topography and shoal-water ecology, Part 4, of geology of Saipan, Mariana Islands. U.S. Geol. Survey Prof. Paper 280 K, pp. 361-445.

Randall, R. H. (ed.). 1978. Guam's reefs and Beaches Part II. Transect studies. Univ. of Guam Mar. Lab. Tech. Rept. No. 48. 90 p.

Table 1. Frequency and percent cover of the benthic flora of six 100 m-subtransects along transect A at Tanapag Reef running parallel to shore. Plain numbers indicate percent coverage, numbers in parentethesis indicate frequency of occurrence converted to percent (see Methods in text). Algal species occurring epiphytic on other algae or occurring in the vicinity of the transect are marked with an X.

	TRANSECT A					
	1	2	3	4	5	6
Cyanophyta (blue-green)						
Hormothamnion enteromorphoides Bornet & Thuret		0.6(9)			1.2(18)	
Microcoleus lyngbyaceus (Kutz.) Crouan			1.2(18)		1.7(18)	
Schizothrix calcicola (Ag.) Gomont		1.2(18)	1.2(9)		1.7(27)	
Schizothrix mexicana Gomont	1.2(9)		X			0.6(9)
Chlorophyta (green)						
Caulerpa antoensis Yamada		1.7(18)		X		X
Dictyosphaeria cavernosa (Forsk.) Boerg.			0.6(9)	X		
Dictyosphaeria versluysii W. v. Bosse		1.2(18)	1.7(18)			
Halimeda macroloba Decaisne		X				
Halimeda opuntia (L.) Lamx.	1.7(18)	2.3(18)	4.0(27)	1.7(18)	2.8(27)	
Halimeda simulans				1.2(9)		
Valonia fastigiata Har.						1.2(9)
Udotea argentea Zanard.	X		X			
Phaeophyta (brown)						
Dictyota bartayresii Lamx.					X	X
Dictyota cervicornis Kutz.	1.2(18)	1.2(9)				
Dictyota friabilis Setch.					1.7(27)	
Feldmannia indica (Sonder) Womersley & Bailey				1.7(18)		
Lobophora variegata (Lamx.) Womersley		1.2(18)	0.6(9)			
Padina tenius Bory	2.3(18)	1.2(9)	1.7(27)			
Ralfsia pangoensis Setch.			X			X
Sargassum polycystum C. Ag. (hold fasts)	1.7(18)					
Sphacelaria tribuloides Menegh.			X	2.3(27)		2.8(36)
Turbinaria ornata (Turner) J. Ag.					X	

Table 1 continued.........

Rhodophyta (red)						
Acanthophora spicifera (Vahl) Boerg.				23.4(73)		
Amphiroa fragilissima Lamx.			4.0(36)		X	
Centroceras minutum Yanada					X	1.2(9)
Ceramium gracillimum Griff. & Gard.	1.2(18)					X
Ceramium mazatlenese Dawson			X			
Gelidiopsis intricata (Ag.) Vickers	1.7(18)					
Gelidium pusillum (Stackh.) LeJolis	0.6(9)			X		
Gelidiella acerosa (Forsk.) Feldmann & Hamel		0.6(9)	1.2(9)			
Griffithsia tenius C. Ag.	0.6(9)					X
Herposiphonia tenella (C. Ag.) Naegeli		0.6(9)			X	
Hydrolithon reinboldii (W. v. Bosse & Foslie) Foslie	2.3(27)	2.3(27	2.8(36)			4.0(45)
Jania capillacea Harvey		1.2(9)	1.7(18)			0.6(9)
Laurencia sp.					14.2(73)	
Leveillea jungermannioides (Her. & Mart.) Harv.				X	X	
Lithophyllum moluccense Foslie						1.7(18)
Neogoniolithon frutescens (Foslie) Setch. & Mason				0.6(9)	5.7(27)	
Polysiphonia scopulorum Harv.	1.2(18)	1.2(18)			X	
Spyridia filamentosa (Wulfen) Harv.	10.2(54)					
Anthophyta (seagrasses)						
Enhalus acoroides (L. F.) Royle	10.4(18)			2.3(27)		
Holodule uninervis (Forsk.) Ascherson	21.8(54)					
Halophila minor (Zoll.) den Hartog	1.2(9)					
Dead coral		5.7(27)	10.8(54)	5.1(27)		4.5(27)
Coral rock		9.1(36)	24.4(100)			13.3(45)
Live coral		6.2(27)	16.5(64)	1.2(18)		19.4(36)
Rubble		10.8(27)	2.8(18)		4.0(18)	2.8(18)
Sand	42.0(82)	50.6(82)	24.4(54)	60.2(100)	66.5(100)	42.7(64)
Sea cucumber	0.6(9)	0.6(9)				

Table 1 continued..........

Sea Urchin					1.2(9)	5.7(9)
Number of plant genera/transect	14	13	10	7	7	7
Number of plant species/transect	15	13	11	7	7	7
Overall percent plant coverage	59.3	16.5	20.7	33.2	29.0	12.1
Total number of plant genera	36					
Total number of plant species	43					

Table 2. Frequency and percent cover of the benthic flora of six 100 subtransects along transect B at Tanapag Reef running parallel to shore. Plain numbers indicate percent coverage, numbers in parentethesis indicate frequency of occurrence converted to percent (see Methods in text). Algal species occurring epiphytic on other algae or occurring in the vicinity of the transect are marked with an X.

	TRANSECT B					
	1	2	3	4	5	6
Cyanophyta (blue-green)						
Hormothamnion enteromorphoides Bornet & Thuret					0.6(9)	
Microcoleus lyngbyaceus (Kutz.) Crouan	1.2(9)				2.3(18)	
Schizothrix calcicola (Ag.) Gomont	1.2(9)		10.9(45)	1.2(9)	1.2(9)	1.2(9)
Schizothrix mexicana Gomont	0.6(9)	1.2(18)	1.2(18)			
						0.6(9)
Chlorophyta (green)						
Caulerpa racemosa (Forsk.) J. Ag.		1.2(9)				
Dictyosphaeria cavernosa (Forsk.) Boerg.						1.2(18)
Dictyosphaeria versluysii W. v. Bosse		1.2(9)				2.3(36)
Enteromorpha clathrata (Roth) J. Ag.	1.7(18)		X			
Halimeda macroloba Decaisne	1.2(18)	1.2(18)				
Halimeda opuntia (L.) Lamx.	2.3(18)		1.2(18)	1.2(18)	X	1.7(18)
Neomeris annulata Dickie		1.2(18)				
Valonia fastigiata Har.			X			X
Valonia ventricosa J. Ag.			X		X	
Phaeophyta (brown)						
Dictyota bartayresii Lamx.	2.3(27)		1.2(9)	1.2(9)		1.2(9)
Dictyota cervicornis Kutz.			X			X
Dictyota friabilis Setch.			1.7(18)	2.8(18)		
Feldmannia indica (Sonder) Womersley & Bailey			1.2(18)			
Lobophora variegata (Lamx.) Womersley				X		1.7(27)
Padina tenius Bory				1.7(27)		
Ralfsia pangoensis Setch.			X		1.2(18)	
Sphacelaria furcigera Kutz.				X		
Sphacelaria tribuloides Menegh.		1.2(18)	2.3(27)		X	
Sphacelaria sp.		X				X
Turbinaria ornata (Turner) J. Ag.			1.2(18)		1.7(18)	

Table 2 continued.........

Rhodophyta (red)						
Acanthophora spicifera (Vahl) Boerg.			X	12.3(64)		
Amphiroa fragilissima Lamx.			X		X	0.6(9)
Centroceras minutum Yamada		0.6(9)				
Ceramium mazatlenese Dawson		1.2(18)		X		
Galaxaura fasciculata Kjellm.		1.7(27)	2.3(23)		1.2(18)	
Gelidiopsis intricata (Ag.) Vickers		1.7(18)	1.7(18)		0.6(9))	
Gelidium pusillum (Stackh.) LeJolis					1.2(18)	
Gelidiella acerosa (Forsk.) Feldmann & Hamel						
Griffithsia tenius C. Ag.		X				X
Hydrolithon reinboldii (W. v. Bosse & Foslie) Foslie			4.0(27)	1.7(18)		X
Hypnea esperi Bory				1.2(18)		
Hypnea pannosa J. Ag.		0.6(9)			X	
Jania capillacea Harvey	1.2(18)	1.7(9)	01.2(18)		1.7(18)	2.3(27)
Jania tenella Kuetz.						1.2(18)
Leveillea jungermannioides (Her. & Mart.) Harv.	1.2(18)		1.2(18)	1.7(27)	0.6(9)	1.7(18)
Liagaora sp.	1.2(18)					
Lithophyllum moluccense Foslie			0.6(9)		1.7(18)	
Neogoniolithon frutescens (Foslie) Setch. & Mason	X	1.2(9)	2.3(27)	16.7(82)	1.7(18)	
Polysiphonia scopulorum Harv.	0.6(9)					
Porolithon onkodes (Heydrich) Foslie				0.6(9)		
Sporolithon schmidtii (Foslie) Gordon, Masaki & Akioka				X		1.2(18)
Spyridia filamentosa (Wulfen) Harv.	8.5(36)	2.8(18)	0.6(9)			
Tolypiocladia glomerulata (Ag.) Schmitz	1.2(9)		X		0.6(9)	1.2(18)
Unidentified turf						2.3(27)
Anthophyta (seagrasses)						
Holodule uninervis (Forsk.) Ascherson	14.8(36)	53.4(73)				
Halophila minor (Zoll.) den Hartog	9.1(36)					
Dead coral				2.8(18)	9.7(36)	5.1(27)
Coral rock		2.3(27)				25.6(54)
Live coral				10.4(27)	41.3(64)	6.8(27)
Pavement	1.2(18)					

Table 2 continued.........

Rubble				13.9(36)	12.5(27)	13.6(36)
Sand	48.8(91)	25.6(64)	64.4(100)	30.4(100)	18.8(45)	24.4(64)
Sea cucumber	1.2(18)	2.3(18)		0.6(9)		1.2(18)
Sponge	1.2(9)				1.2(18)	0.6(9)
Snail		0.6(9)	1.2(18)			
Number of plant genera/transect	13	15	15	11	12	11
Number of plant species/transect	15	15	16	11	13	14
Overall percent plant coverage	48.3	70.1	34.8	42.3	16.3	20.4
Total number of plant genera	40					
Total number of plant species	50					

Table 3. Frequency and percent cover of the benthic flora of six transects (C,D,E,F,G,H) along Tanapag Reef. Plain numbers indicate percent coverage, numbers in parentethesis indicate frequency of occurrence converted to percent (see Methods in text). Algal species occurring epiphytic on other algae or occurring in the vicinity of the transect are marked with an X.

	TRANSECTS					
	C	D	E	F	G	H
Cyanophyta (blue-green)						
Colothrix crustacea (Shousboe & Thuret)	0.4(3)					
Hormothamnion enteromorphoides Bornet & Thuret	0.5(3)		0.1(1)		X	
Microcoleus lyngbyaceus (Kutz.) Crouan	0.1(2)		0.2(3)	2.4(20)	X	0.2(4)
Schizothrix calcicola (Ag.) Gomont	0.6(6)	X	0.3(3)	2.4(31)	7.0(50)	0.5(8)
Schizothrix mexicana Gomont	X		X	1.4(15)	0.8(12)	
Chlorophyta (green)						
Boergesenia forbesii Harv.) Feldmann						0.2(4)
Boodlea composita (Harv.) Brand	1.0(9)		0.5(4)			
Caulerpa ambigua Okam.	0.1(2)					
Caulerpa antoensis Yamada				X	X	1.0(8)
Caulerpa cupressoides (West) C. Ag.	0.1(2)					
Caulerpa racemosa (Forsk.) J. Ag.			0.2(1)		4.7(38)	
Caulerpa sertularioides (Gmel.) Howe	0.2(2)					
Caulerpa serrulata (Forsk.) J. Ag.				1.4(8)	2.3(12)	0.5(4)
Caulerpa taxifolia (Vahl) C. Ag.	0.7(4)					
Chaetamorpha crassa (C.Ag.)	X					0.2(4)
Chlorodesmis fastigiata (C. Ag.)			X	0.5(8)		
Codium geppii O. C. Schmidt						1.2(12)
Dictyosphaeria cavernosa (Forsk.) Boerg.	0.3(4)		0.1(1)			1.0(8)
Dictyosphaeria versluysii W. v. Bosse	0.8(9)		0.4(4)	1.9(15)	3.1(25)	0.5(8)
Enteromorpha clathrata (Roth) J. Ag.			X			
Halimeda discoidea Decaisne	0.2(2)					
Halimeda macroloba Decaisne	0.2(3)					
Halimeda opuntia (L.) Lamx.	0.4(4)	0.8(4)		2.9(31)	X	1.4(15)
Microdictyon okamurai Setch.	0.1(2)		0.2(3)			
Valonia fastigiata Har.	0.1(2)			X		
Valonia ventricosa J. Ag.	0.1(2)		X		X	0.5(8)

Table 3 continued ....

<u>Udotea argentea</u> Zanard.	0.2(2)		X			
Phaeophyta (brown)						
<u>Dictyota bartayresii</u> Lamx.	0.8(6)	0.3(4)	0.2(1)		X	X
<u>Dictyota cervicornis</u> Kutz.	0.2(2)					0.2(4)
<u>Dictyota friabilis</u> Setch.					0.8(12)	0.7(8)
<u>Lobophora variegata</u> (Lamx.) Womersley	0.6(8)		0.4(4)	1.0(15)		0.5(4)
<u>Padina minor</u> Yamada			0.1(1)			
<u>Padina tenius</u> Bory	0.2(3)	0.3(4)	0.1(1)			
<u>Ralfsia pangoensis</u> Setch.				0.5(8)	1.6(25)	
<u>Sargassum polycystum</u> C. Ag.	0.3(2)		0.9(3)			
<u>Sphacelaria furcigera</u> Kutz.	X					0.5(4)
<u>Sphacelaria tribuloides</u> Menegh.	0.6(8)		0.7(7)	X	1.6(25)	1.2(12)
<u>Sphacelaria</u> sp.						
<u>Turbinaria ornata</u> (Turner) J. Ag.	0.3(3)		1.4(4)	1.9(15)	0.8(12)	1.0(8)
Rhodophyta (red)						
<u>Acanthophora spicifera</u> (Vahl) Boerg.	0.7(6)		0.1(1)			
<u>Amphiroa fragilissima</u> Lamx.	0.2(3)		0.1(1)	1.4(15)	X	1.4(15)
<u>Centroceras minutum</u> Yamada		X			2.3(25)	0.2(4)
<u>Ceramium gracillimum</u> Griff. & Gard.			0.2(3)	1.0(15)		X
<u>Ceramium mazatlenese</u> Dawson	0.2(3)		0.1(1)			
<u>Gelidiopsis intricata</u> (Ag.) Vickers	0.2(3)		0.2(3)	0.5(8)	2.3(12)	0.5(8)
<u>Gelidium divericatum</u> Martens			X	X		0.2(4)
<u>Gelidium pusillum</u> (Stackh.) LeJolis					2.3(12)	0.5(4)
<u>Griffithsia tenius</u> C. Ag.	0.1(2)					X
<u>Herposiphonia tenella</u> (C. Ag.) Naegeli			X	1.4(15)	X	
<u>Hydrolithon reinboldii</u> (W. v. Bosse & Foslie) Foslie			0.3(3)	4.3(15)	3.1(25)	1.4(15)
<u>Hypnea esperi</u> Bory	0.4(4)		0.2(3)			0.2(4)
<u>Hypnea pannosa</u> J. Ag.	0.2(3)				X	
<u>Jania capillacea</u> Harvey	0.7980		0.5(6)	1.9(15)	9.4(25)	1.2(12)
<u>Jania tenella</u> Kuetz.					7.0(38)	0.7(8)
<u>Leveillea jungermannioides</u> (Her. & Mart.) Harv.	0.1(2)			X	X	0.7(8)
<u>Lithophyllum moluccense</u> Foslie	1.1(8)			0.9(6)	X	1.7(15)

Table 3 continued.........

Lithoporella pacifica (Heydr.) Foslie					0.9(12)	
Neogoniolithon frutescens (Foslie) Setch. & Mason	0.2(3)		0.3(3)	1.0(8)	1.9(12)	1.7(19)
Polysiphonia scopulorum Harv.	0.4(8)		0.2(3)	1.0(15)		0.2(4)
Pterocladia parva Dawson						11.7(38)
Sporolithon schmidtii (Foslie) Gordon, Masaki & Akioka	0.3(3)	0.2(3)			0.8(12)	
Spyridia filamentosa (Wulfen) Harv.	0.1(1)					
Tolypiocladia glomerulata (Ag.) Schmitz			X		0.8(12)	
Unidentified turf	0.2(3)			1.9(15)		
Anthophyta (seagrasses)						
Holodule uninervis (Forsk.) Ascherson	12.2(24)	27.5(54)				
Halophila minor (Zoll.) den Hartog	3.3(18)	2.3(9)				
Dead coral	3.1(12)		8.6(21)	5.8(31)		10.6(23)
Coral rock	9.1(18)		8.4(22)	5.8(31)	5.5(38)	7.7(15)
Live coral	7.6(18)		7.8(29)	25.5(70)	3.1(25)	12.3(46)
Pavement	1.0(3)		3.7(6)	6.7(54)	1.8(12)	1.0(8)
Rubble	2.5(9)	0.6(14)	6.6(11)	4.3(8)	3.1(38)	8.9(23)
Sand	47.0(82)	68.8(95)	54.8(78)	20.6(54)	17.2(88)	37.3(69)
Sea cucumber			0.1(1)		0.8(12)	
Sea urchin					2.3(25)	0.2(4)
Sponge					0.8(12)	
Starfish						0.2(4)
Number of plant genera/transect	32	5	25	18	17	24
Number of plant species/transect	41	5	28	19	20	30
Overall percent plant coverage	29.7	31.2	8.9	31.6	65.2	21.9
Total number of plant genera	46					
Total number of plant species	64					
Length of transects (m)	650	210	700	260	80	130

Table 4. Frequency and percent cover of the benthic flora of the first 100 m of transects C, D, and E (resurveyed) at Papau Reef. Plain numbers indicate percent coverage, numbers in parentethesis indicate frequency of occurrence converted to percent (see Methods in text). Algal species occurring epiphytic on other algae or occurring in the vicinity of the transect are marked with an X.

	TRANSECTS C	D	E
Chlorophyta (green)			
Chaetamorpha crassa (C. Ag.)			0.6(9)
Enteromorpha clathrata (Roth) J. Ag.	0.6(9)		
Halimeda opuntia (L.) Lamx.		1.2(18)	
Phaeophyta (brown)			
Dictyota bartayresii Lamx.		13.6(45)	
Lobophora variegata (Lamx.) Womersley			1.2(18)
Rhodophyta (red)			
Ceramium mazatlenese Dawson	X		
Hypnea pannosa J. Ag.		0.6(9)	2.3(9)
Polysiphonia scopulorum Harv.	X		
Spyridia filamentosa (Wulfen) Ha.			1.2(9)
Anthophyta (seagrasses)			
Halophila minor (Zoll.) den Hartog	23.9(73)		
Coral rock			1.7(9)
Rubble	2.3(9)		
Sand	65.9(100)	61.9(100)	93.2(100)
Sea urchin		1.2(18)	
Snail	1.2(9)		
Bivalve		4.0(18)	
Number of plant genera/transect	2	4	3

Table 4 continued...........

Number of plant species/transect	2	4	3
Overall percent plant coverage	29.9	16.0	4.7
Total number of plant genera	8		
Total number of plant species	8		

CORALS

BY

Richard H. Randall

Introduction

Reef building scleractinian, octocorallian, and hydrozoan corals are seesile invertebrates with potentially long life spans and distribution patterns that depend upon the particular setting found from one habitat to another. Their stony calcium carbonate skeletons are major contributors to both in situ framework and detrital reef deposits in the shoal-water environments of Tanapag Reef. Characteristic coral communities develop in response to variable environmental conditions found from one habitat to another, ranging from conditions completely unfavorable for corals to optimum conditions where corals are the dominant organisms in the community. Corals are sensitive to many environmental variables, particularly suspended materials in the water column, sediment accumulation on the substrate upon which they grow, water currents, sea water dilution from surface drainage and groundwater discharge, temperature fluctuations, emersion on shallow platforms during low tides, and various forms of pollution from toxic substances and thermal, storm drain, and sewage discharges. Because of their sensitivity to such factors, corals can be useful as indicator organisms which reflect the quality of the environment. Assessment of the present coral communities on the Tanapag Reef will establish baseline data from which changes in the quality of the reef environment can be determined or predicted. This data will be useful in establishing sound planning practices and management of these reef areas in relation to present and future development.

The principal objectives of this part of the study were to determine the distribution and community structure of corals within the study area.

METHODS

Coral communities were analyzed along transects by using the plotless point-centered or point-quarter technique of Cottom et al. (1953). Eight transects were established within the study area by placing a plastic surveyors tape along the bottom at the locations shown in Figures 1-5, pp. 5-9. Sampling was conducted along the entire lengths of transects C through H, which were oriented perpendicular to the shoreline. Because of the long lengths of transects A and B sampling at each was conducted along six 100-meter subtransects that were oriented parallel to the shoreline. Locations of these subtransects were selected to represent zones of physiographic variation encountered across the reef platform. Random sampling points were then established by throwing a geology hammer from the surface at ten-meter intervals along the length of each transect. Throws along transects C-H were made by standing at, or swimming over, each ten-meter transect interval facing toward the west (Puntan Dogas side of the transect) and tossing the hammer over ones shoulder into a five-meter-wide corridor along the east side of the transect line. At subtransect locations along transects A and B sampling was conducted in a similar manner except that each throw was made by facing the ocean and tossing the hammer over ones shoulder toward the shore. Where the thrown hammer came to rest a sample point was established at the intersection of the hammer handle and head. Four quadrants were then formed around the point by establishing one axis along the hammer handle and another at right angles to it along the hammer head. The coral nearest the sample point in each quadrant was located and its specific name, size (diameter or maximum length and width), and the distance from the center of the corallum to the sample point were recorded. From these point-quarter data the following calculations were used to estimate community structural parameters:

1. Total density of all species = $\dfrac{\text{unit area}}{(\text{mean point-to colony distance})^2}$

2. Relative density = $\dfrac{\text{individuals of a species}}{\text{total individuals of all species}} \times 100$

3. Density = $\dfrac{\text{relative density of a species}}{100} \times$ total density of all species

4. Total percent coverage = total density of all species X average coverage value for all species

5. Percent coverage = density of a species X average coverage value for the species

6. Relative percent coverage = $\dfrac{\text{Percent coverage for a species}}{\text{total coverage for all species}} \times 100$

7. Frequency = $\dfrac{\text{number of points at which a species occurs}}{\text{total number of points}}$

8. Relative frequency = $\dfrac{\text{frequency value for a species}}{\text{total of frequency values for all species}} \times 100$

9. Importance value = relative density + relative percent coverage + relative frequency

Colony size distribution data ($\bar{Y}$ = arithmatic mean, s = standard deviation, and w = size range) were also calculated from the point-quarter data.

Quantitative data of the coral species encountered from the point-quarter analysis are presented in Table 1. The coral species encountered during the point-quarter analysis indicate the predominate and common species along the transects. The presence of uncommon and rare species, not encountered during the point-quarter analysis, were determined for each transect by making ten-minute snorkel observations along each side of the transect line for each 100 meters of transect length. An overall list of species is compiled for each transect zone by combining those encountered during the point-quarter analysis (Table 1) with those from snorkel observations in Table 2.

Results and Discussion

Physiographic Description of the Study Site

Although the study area represents a part of the overall Tanapag barrier reef system, a distinct navigable lagoon between the shoreline and outer reef platform is either poorly developed or absent. Adjacent to transects A and B the deeper lagoon areas located west of Puntan Dogas shoals into a shallower backreef moat which at most locations is less than 2.5 meters deep during low tides. This shoaling trend, as well as a reduction in overall reef width, continues to the northeast where adjacent to transects C through F the low-tide backreef moat depth ranges from 1.5 to less than 0.5 meters. At the extreme northeastern end of the study area the reef becomes a narrow fringing reef platform which during low tides is mostly exposed at transect G and only covered by a few decimeters of water along the inner part adjacent to transect H.

Overall bottom topography within the moat is somewhat undulatory with a relief that generally ranges from a few decimeters in shallower parts to a meter or more in deeper regions along transects A and B. Principal topographic relief features include a large patch reef on the inner part of transect A, hydrodynamically accumulated mounds and low ridges of bioclastic sediments, thickets of branching corals, and local mounds, knobs, and pinnacles composed of individual or aggregate clumps of living and dead coral colonies. During low tides many of these topographic relief features extend upward to or near the surface which makes small boat navigation difficult to impossible. Isolated seagrass patches trap and hold sediments which imparts a low hummocky relief of a decimeter or more along the inner parts of the moat between transects A-E.

Overall physiography of the outer reef platform within the study area is more homogeneous than that of the adjacent backreef moat. Relief is somewhat subdued with a reef surface that appears truncated because of upward reef accretion to approxmately the mean tow tide level. Principal relief features include an occasional intertidal or supratidal block that has been transported onto the platform surface by storm waves. Scattered rubble-floored holes and pockets generally less than 5 decimeters deep were also occasionally observed. Where the outer reef plaform slopes downward into the backreef moat topographic relief conspicously increases because of abundant isolated and aggregate clumps of corals forming knobs and pinnacles. Where the moat is deepest along transects A and B such coral prominences may have a relief of up to two meters.

The substrate in the backreef moat mostly consists of a truncated reef rock platform patchily or thinly veneered with coarse bioclastic sand, gravel, and rubble. The sediment veneer is thickest in the deeper parts of the moat at transects A and B and becomes more patchily distributed as the water depth decreases from transects C to F. Sediments also accumulate along the inner backreef moat where seagrass patches tend to stabilize and accumulate silt and sand-sized particles. In the outer part of the backreef moat sediment texture becomes coarser and more patchily distributed among outcrops of reef rock and clumps and thickets of corals. Although strong currents keeps much of the outer reef platform surface swept free of sediments, some local patches were found on the floors of scattered holes and depressions.

Coral Distribution and Community Structure

Coral size distribution, frequency, density, and percentage of substrate coverage by zones for each transect are given in Table 1. Distribution of all coral species by zones for each transect are given in Table 2.

A cummulative total of 93 coral species representing 13 families and 30 genera were recorded from the entire study area (Table 2). Of these 93 species only 2, Pocillopora damicornis and Acropora aspera, were common to all 8 transects, and of the remaining 91 species 4 were common to 7 transects, 5 were common to 6 transects, 9 were common to 5 transects, 12 were common to 4 transects, 16 were common to 3 and 2 transects, and 29 were found only at single transect locations. Species richness along individual transects that extend across the entire reef platform ranged from 60 species at transect B to 12 species at transect G (transect D with only 3 species extends only across the inner part of the backreef moat where corals are rare).

One of the most noticeable aspects of corals on the Tanapag reef platform is their unequal distribution along the transects from the shoreline to the outer reef platform. Some platform areas are without corals at all, while other areas support communities ranging from a few widely scattered colonies and species to regions dominated by a relatively rich diversity of species. Because of this variation in coral distribution it was necessary to divide the reef platform into a number of zones in order to make a realistic quantitative assessment of the coral community.

Corals were widely scattered, rare, or absent from most of the seagrass and inner backreef moat zones. The presence of abundant unstable sediments and sediment-trapping seagrass patches, along with the possibility of elevated water temperatures during low spring tides when water circulation on the platform is minimal, probably accounts for the near absence of corals in those zones. Many of the corals that were found in these inner platform zones consisted of broken fragments of branching species that had apparently been transported there by storm waves. Many of these coral fragments were also observed to be in a poor state of health, as evidenced by dead areas and loss of pigment. Coral density, percentage of substrate coverage, colony size, and species richness increase dramatically from the inner backreef moat zones to the outer backreef moat and outer reef flat platform zones (Tables 1 and 2). Factors responsible for increased values of these community structural parameters include more area of stable substrates for colony recruitment (larger-sized pieces of boulder rubble and bare reef rock), absence of seagrass beds, presence of arborescent species which can successfully colonize unstable sandy substrates by fragmentation, and better water circulation, particularly during low spring tides. Exceptions to the above patterns of coral distribution were found at transect A where a patch reef occupies a large portion of the inner backreef moat and at transect H where a narrow reef flat platform replaces the backreef moat. At both of these locations the reef platform is dominated by large areas of reef rock instead of sandy sediments and seagrass beds and is occupied by a community of 5 to 21 reef coral species which cover 12 to 23 percent of the substrate.

Anticipated Impact from Coastal Development

Because of the near absence of corals in the seagrass and inner and middle backreef moat zones and the pattern of longshore currents in the region, anticipated impacts from dredging and construction activities along the coastal region of Tanapag Lagoon are not expected to seriously affect the coral communities living on the outer parts of the reef platform. Although such impacts are expected to be minimal, a sediment-charged dredge plume could affect coral communities located on the patch reef at transect A and on the inner reef flat platform at transect H.

Literature Cited

Cottam, G., J. T. Curtis, and B. W. Hale. 1953. Some sampling characteristics of a population of randomly dispersed individuals. Ecology 34:731-757.

Table 1. Coral size distribution, frequency and relative frequency, density and relative density, percent coverage and relative coverage, and importance values for coral species at Transects A through H. Species are listed in order of their importance values.

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	 Y	 s	 w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect A-1 Inner Seagrass Zone (40 meters from shore)	no coral encountered										
Transect A-2 Inner Patch Reef Platform zone (110 meters from shore)											
Heliopora coerulea	18	17.8	13.0	4.0-45.2	0.80	38.10	1.87	45.00	7.02	76.64	159.74
Pocillopora damicornis	17	6.9	5.5	1.0-20.8	0.90	42.86	1.76	42.50	1.06	11.57	96.93
Montipora lobulata	5	15.8	4.4	12.5-23.3	0.40	19.05	0.52	12.50	1.08	11.79	43.34
Totals:	40	12.9	10.8	1.0-45.2			4.15		9.16		
Transect A-3 Outer Patch Reef Platform Zone (380 meters from shore)											
Heliopora coerulea	22	11.5	11.2	3.0-44.8	0.90	45.00	6.42	55.00	12.71	54.71	154.71
Pavona divaricata	6	18.9	14.2	6.5-42.4	0.20	10.00	1.75	15.00	7.21	31.04	56.04
Pocillopora damicornis	7	8.1	6.1	3.0-20.8	0.50	25.00	2.04	17.50	1.57	6.76	49.26
Montipora lobulata	2	17.9	7.5	12.6-23.2	0.20	10.00	0.58	5.00	1.60	6.89	21.89
Sylocoeniella armata	2	1.9	0.7	1.4-2.4	0.10	5.00	0.58	5.00	0.02	0.09	10.09
Goniastrea retiformis	1	7.3	-	-	0.10	5.00	0.29	2.50	0.12	0.52	8.02
Totals:	40	11.7	10.9	1.4-44.8			11.66		23.23		

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	 Y	 s	 w)	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect A-4 Inner Backreef Moat Zone (750 meters from shore)											
Psammocora stellata	20	3.4	1.3	1.4-6.3	0.60	85.71	0.04	95.24	0.004	80.00	260.95
Acropora aspera	1	5.9	-	-	0.10	14.29	0.002	4.76	0.001	20.00	39.05
Totals:	21	3.5	1.3	1.4-6.3			0.042		0.005		
Transect A-5 Outer Backreef Moat Zone (970 meters from shore)											
Acropora aspera	3	16.1	5.4	9.9-20.0	0.20	50.00	0.0004	60.00	0.0009	81.82	191.82
Millepora tuberosa	2	8.5	0.0	8.5- 8.5	0.20	50.00	0.0003	40.00	0.0002	18.18	108.18
Totals:	5	13.1	5.7	8.5-20.0			0.0007		0.0011		
Transect A-6 Outer Reef Flat Platform Zone (1180 meters from shore)											
Acropora tenuis	2	49.1	15.1	38.4-59.8	0.20	5.41	0.16	5.00	3.13	26.18	36.59
Goniastrea edwardsi	6	9.6	4.3	5.3-17.5	0.50	13.51	0.47	15.00	0.40	3.35	31.86
Montipora verrilli	3	17.9	17.4	6.0-37.9	0.20	5.41	0.24	7.50	0.97	8.11	21.02
Pocillopora elegans	2	30.8	1.8	29.5-32.0	0.20	5.41	0.16	5.00	1.17	9.79	20.20
Porites lutea	3	19.6	10.6	7.5-27.4	0.20	5.41	0.24	7.50	0.87	7.29	20.20
Acropora palifera	1	52.6	-	-	0.10	2.70	0.08	2.50	1.72	14.41	19.61
Heliopora coerulea	1	50.1	-	-	0.10	2.70	0.08	2.50	1.55	12.98	18.18
Cyphastrea serailia	2	16.0	1.3	15.0-16.9	0.20	5.41	0.16	5.00	0.32	2.68	13.09
Acropora nasuta	2	12.0	11.3	4.0-20.0	0.20	5.41	0.16	5.00	0.26	2.17	12.58
Stylophora mordax	2	12.5	7.1	7.5-17.5	0.20	5.41	0.16	5.00	0.23	1.92	12.33

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Porites australiensis	2	12.5	4.3	9.4-15.5	0.20	5.41	0.16	5.00	0.20	1.67	12.08
Cyphastrea chalcidicum	2	4.9	0.6	4.5- 5.3	0.20	5.41	0.16	5.00	0.03	0.25	10.66
Favia pallida	2	5.2	1.0	4.5- 5.9	0.20	5.41	0.16	5.00	0.03	0.25	10.66
Platygyra pini	2	5.2	0.7	4.7- 5.7	0.20	5.41	0.16	5.00	0.03	0.25	10.66
Acropora studeri	1	30.0	-	-	0.10	2.70	0.08	2.50	0.56	4.68	9.88
Pocillopora verrucosa	1	19.0	-	-	0.10	2.70	0.08	2.50	0.22	1.84	7.04
Leptastrea transversa	1	13.7	-	-	0.10	2.70	0.08	2.50	0.12	1.01	6.21
Pavona duerdeni	1	11.2	-	-	0.10	2.70	0.08	2.50	0.08	0.67	5.87
Coscinaraea sp. 1	1	5.3	-	-	0.10	2.70	0.08	2.50	0.02	0.17	5.37
Leptastrea purpurea	1	5.3	-	-	0.10	2.70	0.08	2.50	0.02	0.17	5.37
Favia favus	1	5.7	-	-	0.10	2.70	0.08	2.50	0.02	0.17	5.37
Totals:	40	16.5	14.4	3.5-59.8			3.19		11.957		
Transect B-1 Inner Seagrass Zone (50 meters from shore)	no corals encountered										
Transect B-2 Outer Seagrass Zone (145 meters from shroe)											
Pocillopora damicornis	33	6.2	5.3	1.0-20.3	1.00	90.91	0.20	97.06	0.11	52.38	240.35
Portes lutea	1	45.9	-	-	0.10	9.09	0.01	2.94	0.10	47.62	59.65
Totals:	34	7.4	8.6	1.0-45.9			0.21		0.21		
Transect B-3 Inner Backreef Moat Zone (280 meters from shore)											
Pocillopora damicornis	21	4.1	4.6	1.0-21.5	0.80	50.00	0.12	63.64	0.03	22.90	136.54
Acropora aspera	7	12.8	13.5	2.0-36.4	0.40	25.00	0.04	21.21	0.10	76.36	122.55
Psammocora stellata	5	1.5	0.5	1.0- 2.4	0.40	25.00	0.03	15.15	0.001	0.76	40.91
Totals:	33	5.5	7.9	1.0-36.4			0.19		0.131		

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m²)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect B-4 Middle Backreef Moat Zone (430 meters from shore)											
Acropora aspera	12	25.2	19.0	6.9-64.7	0.60	30.00	0.54	30.00	4.12	91.96	151.96
Psammocora stellata	17	3.8	1.5	2.0- 6.9	0.80	40.00	0.77	42.50	0.10	2.23	84.73
Pocillopora damicornis	10	6.1	6.0	1.4-17.5	0.50	25.00	0.45	25.00	0.25	5.58	55.58
Cyphastrea serailia	1	5.5	-	-	0.10	5.00	0.05	2.50	0.01	0.22	7.72
Totals:	40	10.9	14.2	1.4-64.7			1.81		4.48		
Transect B-5 Outer Backreef Moat Zone (560 meters from shore)											
Acropora aspera	20	28.6	16.3	4.9-54.0	0.80	42.11	2.70	50.00	22.69	93.14	185.25
Pocillopora damicornis	14	8.5	3.4	2.0-16.0	0.60	31.58	1.89	35.00	1.24	5.09	71.67
Millepora tuberosa	3	8.6	1.8	6.6- 9.9	0.20	10.53	0.41	7.50	0.24	0.99	19.02
Astreopora myriophthalma	1	11.5	-	-	0.10	5.26	0.14	2.50	0.14	0.57	8.33
Stylocoeniella armata	1	4.9	-	-	0.10	5.26	0.14	2.50	0.03	0.12	7.88
Porites (S.) sp. 1	1	4.6	-	-	0.10	5.26	0.14	2.50	0.02	0.08	7.84
Totals:	40	18.5	15.5	2.0-54.0			5.42		24.36		
Transect B-6 Outer Reef Flat Platform Zone (720 meters from shore)											
Montipora verrilli	4	19.9	9.2	14.4-33.5	0.40	11.43	0.44	10.00	1.58	13.54	34.97
Montipora tuberculosa	2	31.0	27.8	11.3-50.6	0.20	5.71	0.22	5.00	2.32	19.88	30.59
Porites lutea	3	23.6	9.3	13.0-30.3	0.30	8.57	0.33	7.50	1.59	13.62	29.69
Platygyra pini	4	9.2	2.7	5.5-11.8	0.30	8.57	0.44	10.00	0.31	2.66	21.23
Goniatrea edwardsi	4	8.7	1.9	7.0-11.4	0.30	8.57	0.44	10.00	0.27	2.31	20.88
Pocillopora verrucosa	4	8.1	2.1	5.0- 9.4	0.30	8.57	0.44	10.00	0.24	2.06	20.63

Table 1. (continued)

Transect No. Reef Zone Species	Size Distribution (Colony Diameters in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Pocillopora damicornis	4	11.1	8.3	3.9-20.0	0.20	5.71	0.44	10.00	0.40	3.43	19.14
Montipora ehrenbergii	2	20.7	4.2	17.7-23.6	0.20	5.71	0.22	5.00	0.75	6.43	17.14
Porites australiensis	1	37.3	-	-	0.10	2.86	0.11	2.50	1.20	10.28	15.64
Millepora platyphylla	1	36.3	-	-	0.10	2.86	0.11	2.50	1.13	9.68	15.04
Montipora hoffmeisteri	1	28.2	-	-	0.10	2.86	0.11	2.50	0.69	5.91	11.27
Acropora studeri	1	28.0	-	-	0.10	2.86	0.11	2.50	0.68	5.83	11.19
Cyphastrea serailia	1	12.0	-	-	0.10	2.86	0.11	2.50	0.12	1.03	6.39
Goniastrea retiformis	1	10.8	-	-	0.10	2.86	0.11	2.50	0.10	0.86	6.22
Favia matthai	1	8.0	-	-	0.10	2.86	0.11	2.50	0.06	0.51	5.87
Leptastrea purpurea	1	8.5	-	-	0.10	2.86	0.11	2.50	0.06	0.51	5.87
Stylophora mordax	1	8.5	-	-	0.10	2.86	0.11	2.50	0.06	0.51	5.87
Psammocora contigua	1	7.5	-	-	0.10	2.86	0.11	2.50	0.05	0.43	5.79
Favia pallida	1	5.0	-	-	0.10	2.86	0.11	2.50	0.02	0.17	5.53
Stylocoeniella armata	1	2.8	-	-	0.10	2.86	0.11	2.50	0.01	0.09	5.49
Totals:	40	14.7	11.1	2.8-50.6			4.40		11.67		
Transect C-1 Inner Backreef Moat Zone (0-80 meters)	no corals encountered										
Transect C-2 Middle Backreef Moat Zone (80-250 meters)											
Pocillopora damicornis	21	5.61	2.52	1.0-10.5	.588	62.49	.007	77.78	.002	15.38	155.65
Acropora aspera	5	24.28	10.88	17.4-42.8	.294	31.24	.002	18.52	.009	69.24	119.00
Acropora formosa	1	28.70	-	-	.589	6.27	.0003	3.70	.002	15.38	25.35
Totals:	27	9.93	9.55	1.0-42.8			.0093		.013		

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameter in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect C-3 Outer Backreef Moat Zone (250-530 meters)											
Pocillopora damicornis	50	7.66	5.89	1.0-21.8	.821	35.95	1.29	44.64	.94	21.97	102.56
Psammocora contigua	29	16.89	9.08	3.0-35.0	.607	26.58	.75	25.89	2.14	50.00	102.47
Montipora lobulata	17	12.33	8.30	3.0-35.9	.321	14.05	.44	15.18	.75	17.52	46.75
Psammocora stellata	5	3.50	1.45	2.4- 6.0	.143	6.26	.13	4.46	.01	.23	10.95
Acropora formosa	3	10.73	6.24	5.2-17.5	.107	4.68	.08	2.68	.09	2.10	9.46
Porites lutea	2	18.00	16.97	6.0-30.0	.071	3.11	.05	1.79	.19	4.44	9.34
Acropora aspera	3	9.73	5.60	5.2-16.0	.107	4.68	.08	2.68	.07	1.64	9.00
Acropora nasuta	2	8.55	3.75	5.9-11.2	.071	3.11	.05	1.79	.03	.70	5.60
Platygyra pini	1	17.40	-	-	.036	1.58	.03	.89	.06	1.40	3.87
Totals:	112	11.00	8.27	1.0-35.9			2.90		4.28		
Transect C-4 Outer Reef Flat Platform Zone (530-630 meters)											
Acropora nasuta	16	13.23	9.90	3.2-32.9	.750	23.71	2.41	33.33	5.06	36.69	93.73
Pocillopora damicornis	9	6.18	6.25	2.0-21.0	.667	21.07	1.36	18.76	.77	5.58	45.41
Acropora palifera	4	20.85	18.07	2.0-45.5	.333	10.52	.60	8.33	3.21	23.28	42.13
Montipora lobulata	6	14.62	7.25	6.3-25.9	.333	10.52	.90	12.50	1.83	13.27	36.29
Stylophora mordax	4	11.83	10.26	3.9-21.0	.333	10.52	.60	8.33	1.04	7.54	26.39
Goniastrea retiformis	3	8.37	6.96	4.2-16.4	.250	7.90	.45	6.25	.37	2.68	16.83
Acropora aspera	1	30.7	-	-	.083	2.62	.15	2.08	1.12	8.12	12.82
Pavona venosa	2	9.15	2.62	7.3-11.0	.167	5.28	.30	4.18	.21	1.52	10.98
Acropora squarrosa	1	9.0	-	-	.083	2.62	.15	2.08	.10	.73	5.43
Porites lichen	1	7.1	-	-	.083	2.62	.15	2.08	.06	.44	5.14
Porites (S.) convexa	1	4.0	-	-	.083	2.62	.15	2.08	.02	.15	4.85
Totals:	48	12.21	10.22	2.0-45.5			7.22		13.79		

Table 1. (continued)

Transect No. Reef Zone Species	Size Distribution (Colony Diameters in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect D-1 Inner Backreef Moat Zone (0-150 meters)	no corals encountered										
Transect D-2 Middle Backreef Moat Zone (150-200 meters)											
Acropora formosa	7	23.11	22.70	2.4-56.5	.600	42.86	.019	46.67	.001	.65	189.95
Acropora aspera	1	14.0	-	-	.200	14.28	.003	6.67	.004	2.60	16.20
Pocillopora damicornis	7	21.57	1.43	1.4- 5.6	.600	42.86	.019	46.67	.001	.65	93.85
Totals:	15	12.91	18.09	1.4-56.5			.041		.006		
Transect E-1 Inner Backreef Moat Zone (0-80 meters)	no corals encountered										
Transect E-2 Middle Backreef Moat Zone (80-250 meters)											
Pocillopora damicornis	23	5.51	4.72	1.0-16.3	.706	46.14	.029	48.94	.014	13.46	108.54
Acropora aspera	11	12.55	7.62	2.4-23.4	.412	26.92	.014	34.40	.023	22.12	72.44
Acropora formosa	10	12.95	8.09	3.9-27.5	.294	19.22	.012	21.27	.022	21.15	61.64
Montipora lobulata	2	33.75	11.10	25.9-41.6	.059	3.86	.003	4.26	.024	23.08	31.20
Heliopora coerulea	1	46.00	-	-	.059	3.86	.001	2.13	.021	20.19	26.18
Totals:	47	11,07	10.21	1.0-46.0			.059		.104		

Table 1. (continued)

Transect No. / Reef Zone / Coral Species	Size Distribution (Colony Diameters in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect E-3 Outer Backreef Moat Zone (250-560 meters)											
Acropora aspera	58	16.13	13.00	2.4-64.4	.871	37.02	.97	46.76	3.29	62.12	145.90
Acropora palifera	19	15.57	9.26	4.5-38.5	.419	17.81	.32	15.31	.86	16.23	49.35
Pocillopora damicornis	15	8.24	6.10	2.0-23.4	.323	13.73	.25	12.10	.21	3.97	29.80
Acropora formosa	10	8.58	6.12	3.0-21.0	.129	5.48	.17	8.06	.14	2.64	16.18
Montipora lobulata	5	14.84	11.26	4.5-28.6	.129	5.48	.08	4.03	.21	3.97	13.48
Goniastrea edwardsi	6	11.07	7.16	3.0-18.0	.129	5.48	.10	4.84	.13	2.46	12.78
Montipora ehrenbergii	3	20.30	13.29	5.0-28.5	.097	4.12	.05	2.42	.21	3.97	10.51
Montipora monasteriata	1	23.5	-	-	.032	1.36	.02	.81	.07	1.32	3.49
Acropora irregularis	1	19.7	-	-	.032	1.36	.02	.81	.05	.94	3.11
Stylophora mordax	1	18.0	-	-	.032	1.36	.02	.81	.04	.76	2.93
Millepora tuberosa	1	15.0	-	-	.032	1.36	.02	.81	.03	.57	2.74
Montipora tuberculosa	1	15.0	-	-	.032	1.36	.02	.81	.03	.57	2.74
Acropora nasuta	1	11.0	-	-	.032	1.36	.02	.81	.02	.38	2.55
Goniastrea retiformis	1	5.5	-	-	.032	1.36	.02	.81	.004	.08	2.25
Stylocoeniella armata	1	1.0	-	-	.032	1.36	.02	.81	.001	.02	2.19
Totals:	124	14.25	11.8	1.0-64.4			2.10		5.29		
Transect E-4 Outer Feet Flat Platform Zone (560-700 meters)											
Acropora palifera	15	24.54	15.09	4.0-44.0	.571	25.00	1.70	26.78	10.80	44.83	96.61
Acropora aspera	19	19.11	13.21	5.0-52.8	.500	21.89	2.15	33.92	8.91	36.99	92.80
Stylophora mordax	8	8.61	6.39	2.0-23.0	.286	12.52	.90	14.29	.77	3.20	30.01
Pocillopora damicornis	4	6.07	1.48	4.0- 7.5	.286	12.52	.45	7.14	.13	.54	20.20
Goniastrea retiformis	2	21.60	8.34	15.7-27.5	.143	6.26	.22	3.57	.89	3.69	13.52
Goniastrea edwardsi	2	17.10	8.34	11.2-23.0	.143	6.26	.22	3.57	.58	2.41	12.24
Acropora nasuta	1	27.00	-	-	.071	3.11	.11	1.79	.65	2.70	7.60

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Pocillopora verrucosa	1	25.90	–	–	.071	3.11	.11	1.79	.60	2.49	7.39
Porities lutea	2	13.00	0.00	13.0-13.0	.071	3.11	.22	3.57	.03	.12	6.80
Acropora irregularis	1	21.20	–	–	.071	3.11	.11	1.79	.40	1.66	6.56
Astreopora myriophthalma	1	19.4	–	–	.071	3.11	.11	1.79	.33	1.37	6.27
Totals:	56	17.92	12.98	2.0-52.8			6.30		24.09		
Transect F-1 Inner Backreef Moat Zone (0-90 meters)											
Acropora aspera	26	10.2	9.2	2.4-46.2	1.00	56.49	1.10	72.22	1.59	70.98	199.69
Acropora palifera	1	35.7	–	–	0.11	6.21	0.04	2.78	0.42	18.75	27.74
Psammocora stellata	4	3.5	0.4	3.0- 4.0	0.22	12.42	0.17	11.11	0.02	0.89	24.42
Pocillopora damicornis	3	6.2	7.3	1.0-14.5	0.22	12.42	0.13	8.33	0.07	3.13	23.88
Montipora lobulata	1	17.4	–	–	0.11	6.21	0.04	2.78	0.10	4.46	13.45
Psammocora contigua	1	10.4	–	–	0.11	6.21	0.04	2.78	0.04	1.79	10.78
Totals:	36	10.00	9.5	1.0-46.2			1.52		2.24		
Transect F-2 Outer Backreef Moat Zone (90-190 meters)											
Acropora aspera	23	19.0	13.5	4.6-53.7	1.00	47.62	4.78	57.50	20.16	80.74	185.86
Pocillopora damicornis	8	4.3	2.5	1.0- 8.5	0.40	19.05	1.66	20.00	0.30	1.20	40.25
Goniastrea retiformis	1	45.6	–	–	0.10	4.76	0.21	2.50	3.40	13.62	20.88
Psammocora stellata	4	3.2	1.2	1.4- 4.0	0.20	9.52	0.83	10.00	0.08	0.32	19.84
Porites australiensis	2	9.7	5.9	5.5-13.9	0.20	9.52	0.42	5.00	0.36	1.44	15.96
Pavona varians	1	19.5	–	–	0.10	4.76	0.21	2.50	0.62	2.48	9.74
Pavona venosa	1	5.5	–	–	0.10	4.76	0.21	2.50	0.05	0.20	7.46
Totals:	40	14.3	13.4	1.0-53.7			8.32		24.97		

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	 Y	 s	 w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect F-3 Outer Reef Flat Platform Zone (190-260 meters)											
Acropora digitifera	5	15.0	3.0	9.0-16.7	0.57	18.14	1.08	17.86	1.73	27.13	63.37
Porites lutea	8	6.8	4.2	2.0-14.5	0.57	18.14	1.73	28.57	0.84	13.29	60.00
Pocillopora damicornis	4	5.6	7.2	2.0-16.3	0.43	13.68	0.87	14.29	0.47	7.44	35.41
Acropora aspera	2	17.2	9.0	10.8-23.5	0.29	9.23	0.43	7.14	1.13	17.88	34.25
Montipora planiuscula	1	21.2	-	-	0.14	4.45	0.22	3.57	0.76	12.03	20.05
Goniastrea retiformis	2	8.1	0.6	7.7- 8.5	0.29	9.23	0.43	17.14	0.22	3.48	19.85
Galaxea fascicularis	1	16.0	-	-	0.14	4.45	0.22	3.57	0.43	6.80	14.82
Pavona varians	1	14.1	-	-	0.14	4.45	0.22	3.57	0.34	5.38	13.40
Pavona sp. 3	1	5.9	-	-	0.14	4.45	0.22	3.57	0.06	0.95	8.97
Acropora azurea	1	12.0	-	-	0.14	4.45	0.22	3.57	0.24	3.80	11.82
Acropora squarrosa	1	5.3	-	-	0.14	4.45	0.22	3.57	0.05	0.79	8.81
Porites australiensis	1	5.5	-	-	0.14	4.45	0.22	3.57	0.05	0.79	8.81
Totals:	28	9.9	6.0	2.0-23.5			6.08		6.32		
Transect G-1 Inner Reef Flat Platform (0-30 meters)											
Acropora digitifera	2	5.0	0.1	4.9- 5.0	0.67	40.36	0.006	33.33	0.001	25.00	98.69
Acropora cerealis	2	4.5	0.0	4.5- 4.5	0.33	19.88	0.006	33.33	0.001	25.00	78.21
Acropora aspera	1	4.9	-	-	0.33	19.88	0.003	16.67	0.001	25.00	61.55
Porites lutea	1	5.0	-	-	0.33	19.88	0.003	16.67	0.001	25.00	61.55
Totals:	6	5.3	1.1	4.5-5.0			0.018		0.004		

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	Y	s	w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importanct Value
Transect G-2 Outer Reef Flat Platform (30-80 meters)											
Porites australiensis	4	15.3	8.1	5.2-25.0	0.40	14.29	0.14	20.00	0.30	51.37	85.66
Porites lutea	4	9.3	3.3	5.5-12.4	0.60	21.43	0.14	20.00	0.10	17.12	58.55
Acropora digitifera	6	4.2	1.4	2.4- 5.9	0.60	21.43	0.20	30.00	0.03	5.14	56.57
Porites annae	1	22.2	-	-	0.20	7.14	0.03	5.00	0.13	22.26	34.40
Acropora cerealis	2	3.0	0.8	2.4- 3.5	0.40	14.29	0.07	10.00	0.005	0.86	25.15
Pocillopora damicornis	1	5.5	-	-	0.20	7.14	0.03	5.00	0.008	1.37	13.51
Pocillopora verrucosa	1	5.0	-	-	0.20	7.14	0.03	5.00	0.006	1.03	13.17
Porites (S.) rus	1	4.5	-	-	0.20	7.14	0.03	5.00	0.005	0.86	13.00
Totals:	20	8.3	6.6	2.4-25.0			0.67		0.584		
Transect H-1 Inner Reef Flat Platform (0-80 meters)											
Acropora aspera	10	13.1	13.5	3.5-49.5	0.63	28.00	3.20	31.25	8.41	67.07	126.32
Pocillopora damicornis	12	4.6	2.3	2.4-10.0	0.75	33.33	3.84	37.50	0.78	6.22	77.05
Porites lutea	4	5.1	4.8	1.4-12.0	0.25	11.11	1.28	12.50	0.43	3.43	30.04
Goniastrea retiformis	1	29.0	-	-	0.13	5.78	0.32	3.13	2.11	16.83	25.74
Acropora digitifera	2	6.3	1.1	5.5- 7.0	0.13	5.78	0.64	6.25	0.20	1.59	13.62
Hydnophora microconos	1	15.0	-	-	0.13	5.78	0.32	3.13	0.57	4.55	13.46
Porites australiensis	1	2.4	-	-	0.13	5.78	0.32	3.13	0.02	0.16	9.07
Acropora nasuta	1	3.0	-	-	0.13	5.78	0.32	3.13	0.02	0.16	9.07
Totals:	32	8.4	9.4	1.4-49.5			10.24		12.54		

Table 1. (continued)

Transect No. Reef Zone Coral Species	Size Distribution (Colony Diameters in cm) n	 Y	 s	 w	Frequency	Relative Frequency	Density (Per m^2)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Transect H-2 Outer Reef Flat Platform (80-130 meters)											
Acropora digitifera	6	9.5	4.9	4.5-15.5	0.80	30.77	10.44	30.00	9.01	15.48	76.25
Acropora cerealis	6	6.4	1.4	5.0- 8.9	0.60	23.08	10.44	30.00	3.48	5.98	59.06
Acropora aspera	2	29.0	5.7	24.9-33.0	0.20	7.69	3.48	10.00	23.41	40.22	57.91
Acropora squarrosa	3	12.5	10.8	5.5-24.9	0.40	15.38	5.22	15.00	9.57	16.44	46.82
Goniastrea retiformis	1	24.0	-	-	0.20	7.69	1.74	5.00	7.87	13.52	26.21
Pocillopora damicornis	1	18.3	-	-	0.20	7.69	1.74	5.00	4.59	7.89	20.58
Porites lutea	1	4.5	-	-	0.20	7.69	1.74	5.00	0.27	0.46	13.15
Totals:	20	11.87	8.7	4.5-33.0			34.80		58.20		

Table 2. List of coral species recorded from transects A through H. List also includes species observed within a 5-meter wide band along each side of the transects.

Transects	A						B						C				D		E				F			G		H	
Taxon Transect No.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	1	2	1	2	3	4	1	2	3	1	2	1	2
Class - ANTHOZOA																													
Order - SCLERACTINIA																													
Suborder - ASTROCOENIINA																													
Family - ASTROCOENIIDAE																													
Stylocoeniella armada (Ehrenberg)		X	X								X	X									X		X	X					X
Family - THAMNASTERIIDAE																													
Psammocora cotingua (Esper)				X								X			X							X	X	X				X	
Psammocora digitata Milne Edwards and Haime						X				X		X												X					
Psammocora obtusangula (Lamarck)												X											X						
Psammocora stellata (Verrill)				X	X	X			X	X		X			X					X			X	X					
Psammocora sp. 1												X																	
Family - POCILLOPORIDAE																													
Stylophora mordax (Dana)			X			X						X			X	X					X	X							
Seriatopora hystrix Dana																					X								
Pocillopora damicornis (Linneaus)		X	X			X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Pocillopora danae Verrill																													X
Pocillopora elegans Dana						X						X																	
Pocillopora ligulata Dana																													X
Pocillopora setchelli Hoffmeister						X						X				X						X			X		X		X
Pocillopora verrucosa (Ellis and Solander)				X		X				X	X	X				X						X					X		X

Table 2. Cont.

Transects	A						B						C				D		E				F			G		H	
Taxon Transect No.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	1	2	1	2	3	4	1	2	3	1	2	1	2
Family - ACROPORIDAE																													
Acropora aspera (Dana)			X	X	X				X	X	X			X	X	X		X		X	X	X	X	X	X	X		X	X
Acropora azurea Veron and Wallace																									X				
Acropora cerealis (Dana)																					X					X	X	X	X
Acropora digitifera (Dana)												X			X	X					X	X		X	X	X	X	X	X
Acropora formosa (Dana)																		X											
Acropora humilus (Dana)						X						X			X							X							
Acropora irregularis (Brook)																					X	X							
Acropora nasuta (Dana)						X				X	X	X			X	X					X	X						X	
Acropora ocellata (Klunzinger)						X						X																	
Acropora palifera (Lamarck)			X			X				X	X				X	X					X	X	X						
Acropora smithi (Brook)												X																	
Acropora squarrosa (Ehrenberg)																X					X				X				X
Acropora studeri (Brook)						X						X										X							
Acropora surculosa (Dana)										X		X									X								
Acropora tenuis (Dana)						X						X									X								
Acropora sp. 2																						X							
Astreopora myriophthalma (Lamarck)						X					X	X			X	X													
Montipora ehrenbergii Verrill											X	X				X					X	X			X				
Montipora hoffmeisteri Wells						X				X	X	X										X							
Montipora lobulata Bernard		X	X	X				X	X	X	X	X			X	X			X	X	X		X	X	X				X
Montipora monasteriata (Forskal)																					X	X							
Montipora planiuscula (Dana)										X	X	X													X				
Montipora tuberculosa (Lamarck)												X				X					X	X							

Table 2. Cont.

Transects	A						B						C				D		E				F			G		H	
Taxon Transect No.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	1	2	1	2	3	4	1	2	3	1	2	1	2
Montipora verrilli Vaughan				X	X	X						X									X				X				
Montipora verrucosa (Lamarck)											X																		
Montipora sp. 2												X																	
Suborder - FUNGIINA																													
Family - AGARICIIDAE																													
Pavona divaricata (Lamarck)			X													X													
Pavona duerdeni Vaughan						X						X																	X
Pavona varians Verrill		X									X										X			X	X			X	
Pavona venosa (Ehrenberg)																X								X					
Pavona sp. 1																					X			X					
Pavona sp. 2																					X								
Pavona sp. 3										X		X												X	X			X	
Family - SIDERASTREIDAE																													
Coscinarea sp. 1						X																							
Family - FUNGIIDAE																													
Fungia (*Fungia*) *fungites* (Linnaeus)																						X							
Fungia (*Pleuractis*) *scutaria* (Lamarck)			X																			X							
Family - PORITIDAE																													
Goniopora lobata Milne Edwards and Haime										X																			

Table 2. Cont.

Transects	A						B						C				D		E				F			G		H	
Taxon / Transects No.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	1	2	1	2	3	4	1	2	3	1	2	1	2
Porites (Porites) annae Crossland											X																X	X	
Porites (Porites) australiensis Vaughan				X	X	X						X		X	X	X					X			X	X		X	X	
Porites (Porites) lichen Dana						X															X								
Porites (Porites) lutea Milne Edwards and Haime			X	X		X	X	X	X		X	X		X	X				X		X	X			X	X	X	X	X
Porites (Porites) murrayensis Vaughan						X				X	X	X																X	
Porites (Porites) solida (Forskal)															X						X							X	
Porites (Synaraea) convexa Verrill																X													
Porites (Synaraea) rus (Forskal)						X																					X		
Porites (Synaraea) sp. 1			X								X																		
Suborder - FAVIINA																													
Family - FAVIIDAE																													
Favia favus (Forskal)						X						X				X					X								
Favia matthai Vaughan						X						X										X		X					
Favia pallida (Dana)			X			X						X										X		X					
Favia stelligera (Dana)						X						X				X					X								
Favites abdita (Ellis and Solander)																											X		
Favites russelli (Wells)												X									X			X					
Oulophyllia crispa (Lamarck)																						X							
Goniastrea edwardsi Chevalier						X				X	X	X									X	X	X					X	
Goniastrea pectinata (Ehrenberg)																					X								
Goniastrea retiformis (Lamarck)			X							X	X	X			X	X					X	X	X	X	X		X	X	X

Table 2. Cont.

Transects	A						B						C				D		E				F			G		H	
Taxon / Transects No.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	1	2	1	2	3	4	1	2	3	1	2	1	2
Platgyra deadalea (Ellis and Solander)												X																	
Platygyra pini Chevalier			X			X				X		X			X						X		X					X	
Leptoria phrygia (Ellis and Solander)						X				X		X			X													X	
Hydnophora microconos (Lamarck)												X				X						X						X	
Montastrea curta (Dana)																						X							
Leptastrea bottae (Milne Edwards and Haime)															X									X					
Leptastrea purpurea (Dana)						X				X		X									X			X	X				
Leptastrea transversa Klunzinger						X																							
Cyphastrea chalcidicum (Forskal)						X						X																X	
Cyphastrea micriophthalma (Lamarck)																								X					
Cyphastrea serailia (Forskal)				X	X	X				X		X				X													
Echinopora lamellosa (Esper)																						X							
Family - OCULINIDAE																													
Galaxea fascicularis (Linnaeus)		X				X						X				X								X	X				
Family - MUSSIDAE																													
Lobophyllia corymbosa (Forskal)																									X				

Table 2. Cont.

Taxon / Transects	A						B						C				D		E				F			G		H	
Transects No.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	1	2	1	2	3	4	1	2	3	1	2	1	2
<u>Lobophyllia costata</u> (Dana)																							X					X	
<u>Lobophyllia hemprichii</u> (Ehrenberg)																					X								
Order – COENOTHECALIA																													
Family – HELIOPORIDAE																													
<u>Heliopora coerulea</u> (Pallas)		X	X			X		X		X	X	X			X					X	X		X						
Class – HYDROZOA																													
Order – MILLEPORINA																													
Family – MILLEPORIDAE																													
<u>Millepora dichotoma</u>			X			X					X																		
<u>Millepora platyphylla</u> Hemprich and Ehrenberg						X						X										X							
<u>Millepora tuberosa</u> Boschma			X		X	X			X		X	X									X								
Order – STYLASTERINA																													
Family – STYLASTERIDAE																													
<u>Distichopora violacea</u> (Pallas)						X						X																	
Total Species per Transect Zone	0	5	18	9	6	39	2	4	6	21	22	53	0	4	19	22	1	3	3	5	39	31	14	20	17	4	11	21	15
Total Genera per Transect Zone	0	5	15	6	6	19	2	4	6	13	10	21	0	3	12	11	1	2	3	5	19	15	10	13	8	2	5	12	8
Total Species per Transect	49						60						32				3		57				34			12		29	
Total Genera per Transect	21						22						17				2		25				16			5		14	
Total Species for the Study Area 93																													
Total Genera for the Study Area 30																													

Macroinvertebrates

by

Tom S. Potter

Methods

Macroinvertebrate fauna was assessed along each transect (A 1-6, B 1-6, C, D, E, F, G, and H) within the study site (Figs. 1-5, pp. 5-9). For the purpose of quantification, a meter stick was placed perpendicularly to each transect line and a visual census was made of the epibenthic macroinvertebrates occurring in this area along successive 10-m sections of each transect. This yielded successive 1 X 10 meter ($10m^2$) quadrats for the length of each transect.

When organisms were encountered outside the given sampling area along a transect, a note of occurrence was made. Voucher specimens (for the purposes of identification) were collected for major taxonomic groups on all transects. These were deposited in the University of Guam Marine Laboratory zoological collection.

Macroinvertebrates were grouped into the zones in which they were encountered. The beginning and end of each zone are expressed in the number of meters they occur from the beginning of the transect (Tables 1-2, and 5-6). Within each zone densities for each species of organism encountered were expressed as the number of individuals per $10m^2$ quadrat occupied by the organism (Tables 3-4, and 7-8).

The data on Tables 1-4 for transects C, D, and E were obtained during the Phase I study (Randall et al., 1985). The data on Tables 5-8 are follow up data for the first 100 m of each of the transects C, D, and E, 14 months after the Phase I study.

Results

Because of the vast diversity of the invertebrates that inhabit coral reef ecosystems, the results of this survey were divided into three sections: echinoderms, mollusks, and remaining invertebrates.

Echinoderms

The abundances of echinoderms are listed in Table 3. Within this group, the holothurians (sea cucumbers) were the most common group encountered. They were also found to have the widest range of distribution, being found from the shoreline to the platform margin (Table 1). *Holothuria atra* was by far the most common macroinvertebrate encountered in this survey. *Holothuria atra* along with *H. leucospilota* inhabited areas of sand as well as that of rubble. One species, *H. marmorata*, was found only in sandy substrate, whereas *Actinopyga echinites*, *A. mauritiana*, *Bohadaschia argus*, and *Stichopus chloronotus* were present in habitats of coralline rubble and live coral.

Holothuria cinerascens, H. hilla, and H. impatiens were found buried under rubble or burrowed under live coral. The wide range of habitats occupied by the various species of holothurians may account for their dominant numbers and high densities.

The echinoids (sea urchins) were the second most abundant group of echinoderms encountered (Tables 1 and 3). They occupied a narrower distributional range than the holothurians and were restricted to areas of stable substrate (coralline rubble, seagrass, live coral). With the exception of one case, the densities of sea urchins were highest near the reef margin. Echinothrix diadema and Diadema savignyi were usually found together and were most dense near the reef margin. For this report the sea urchins Diadema savignyi and D. setosum have been combined under the name D. savignyi. Along transects A6 and B6, they were the most dominant invertebrate observed. Toward the middle of the lagoon along transects A5 and B3, which crossed different patch reefs, the urchin Echinometra mathaei was present in high numbers and was the most conspicuous invertebrate observed. Two specimens of the species Heterocentrotus mammillatus were collected near the reef margin on transects A6 and E.

The asteroids (starfish or sea stars) were the third most common echinoderm group encountered. Like the sea urchins, the sea stars were found in areas of stable substrate. Five species were observed (Tables 1 and 3). More thorough sampling, including nocturnal sampling, would probably yield greater numbers or individuals and species of sea stars in the study site.

Ophiuroids (brittle stars) were found on transects A3, A6, C, E, F, and G.

Mollusks

Gastropods were the most common class of mollusks encountered on all transects (Tables 2 and 4). The gastropods were fairly evenly distributed throughout the transects. As a whole, the gastropods were encountered in lower densities than those of the echinoderms, although there were some noteworthly exceptions to this trend.

Near the shore, cerithiids and buccinids were encountered in local areas within the sand-seagrass complex at densities too great to allow for an accurate quantification of their true numbers. Such high density assemblages have been labled "TNTC", meaning "too numerous to count." Such notation was also used in limited cases for the holothurians and echinoderms. A simple quantification of a subset of these high density populations yielded a density range of 50-200 individuals per m^2, depending on the organism. This figure is an estimate, but it serves as a guideline for relative and actual abundances.

The top shell, Trochus niloticus, was present in coralline rubble and live coral habitats near the reef margin.

Bivalves tended to inhabit areas of sand in the middle of the lagoon and areas of sand associated with seagrass near the shore. The striking exception to this was the presence of tridacnid clams in areas devoid of sand because of their need to anchor on hard substrates.

Six members of the subclass Opisthobranchia (sea slugs) were encountered within the sampling areas. On transects A4, F, and G the shelled opisthobranch Otopleura mitralis was encountered in the sandy areas. On each of the transects A3, B3, B6, C, and E single specimens of four different nudibranchs were observed - one on each transect.

Other Invertebrates

Ascidians were found to be too numerous to count in localized regions in the seagrass beds and under rocks in various parts of the study area.

Sand-dwelling hemichordate worms, Ptychodera flava, were encountered near the shore on transects E and F where sand was present over a hard platform of limestone pavement. These worms occurred in numbers often too numerous to count.

Several members from the class Crustacea were found inhabiting different transects. Numerous holes and actual specimens of the burrowing red reef lobster, Enoplometopus occidentalis, were encountered in the sandy areas of transects A2, A3, A4, B2, B3, B4, B5, F, and H. In addition, several mounds of the burrowing shrimp, Callianassa sp., were observed in the muddy sand on transects A1 and A2. Single specimens of various unidentified species of stomatopods (mantis shrimp) were encountered on transects A3, B4, F and H. A single pair of Stenopus hispidus (banded coral shrimp) was encountered within the large strands of Sargassum seaweed on transect E. Dardanus sp. (hermit crabs) were encountered on transects C, E, and B5. Small hermit crabs occupying shells from the gastropod Cerithium zonatus and Cerithium alveoulus were found on transects A1 and B1 in numbers too numerous to count. Specimens of the xanthid crab, Actea tomentosa, were observed in rubble on transects A2, A3, B2, B6, F, and G. A specimen of the xanthid crab, Zosymus aeneus, was encountered in rubble on transect H.

Non-coral cnidarians were represented by five patches of the sea anenome, Entachmaea quadricolor, in areas of live coral or coralline rubble. On transect C there were two patches, and on transects B5, E, and F, single patches were observed.

Three species of polychaetes (marine worms) were observed. Under a rock on transect A5 the bristle worm, Eurythoe complanata, was found. The sedentary feather duster worm, Sabellastarte sanctijosephi, was encountered on transects B5 and B6. The smaller sedentary Christmas tree worm, Spirobranchus giganteus, was observed on transect A5.

Several colonies of sponges (Porifera) were observed throughout the study area. One colony of Terpios sp. was noted near the margin on transect C. A red encrusting sponge was observed on transect B4. A similar looking sponge but black in color was found on transect H. On transects F, G, and H, extensive colonies of a green encrusting sponge covered the limestone pavement and rubble. Colonies of an erect orange sponge were observed on transects A2 and F. Several colonies of a similar looking erect brown sponge were present throughout much of transect B5.

Results of the Follow-up Survey on the First 100 m of Transects C, D, and E

The results from the first 100 m of transects C, D, and E (Tables 5-8) appeared to show that these areas have not changed much over the last 14 months with respect to the amount and diversity of visible macroinvertebrate fauna. Holothuria atra was the most common invertebrate and was present on all three transects. Holothuria atra and H. leucospilota were the only echinoderms encountered. Among the mollusks observed, Cerithium zonatus was the most abundant and was sometimes present in numbers too high to count. Other gastropod mollusks present in recognizable numbers were Rhinoclavis aspera, R. fasciatus, and Cantharus undosus. The most notable bivalve mollusks were Fragum fragum and Ctena bella.

Other notable invertebrates were encountered on all three transects. Ascidians were found on transect D in localized areas on the seagrass in numbers often too high to count. The sand-dwelling hemichordate, Ptychodera flava, was observed on transect E. Mounds from a burrowing callianassid shrimp were encountered on transects C and D. Holes and specimens of the burrowing red reef lobster, Enoplometopus occidentalis, were observed on transects D and E. The burrowing crab Calappa hepatica was seen on transect C. On transect E several specimens of the dome-shaped sponge Cinchyra australiensis were recorded.

Discussion

As previously mentioned, coral-reef ecosystems are among the most diverse, highly complex, and dynamic environments on earth. In order to accurately and completely describe the fauna of such a system, a variety of sampling techniques must be employed. The data presented here represent that portion of the macroinvertebrate community which diurnally resides on or very close to the substrate surface and which does not rapidly avoid human observers. Given these limitations, this report provides sufficient data to make basic predictions concerning the macroinvertebrate community sampled in the given study areas. It is important to note that nocturnal sampling, more extensive sampling, and sampling below the substrate surface would add to the results presented herein.

Anticipated Environmental Impact Upon The Marine Communities

As is normally the case, a loss of or drastic change in the available habitats would pose the most serious threat to the macroinvertebrate fauna in this area. Such alterations could include changes in the amount of available substrate, changes in water quality, changes in current velocities and flow patterns, and near shore eutrophication. Any and all of these could be incurred through careless construction and land use practices by man. With proper planning, however, the invertebrate resources described by this survey could continue to thrive along with increased human utilization of this area.

Acknowledgements

Mr. Barry Smith and Dr. Lucius Eldredge of the University of Guam Marine Laboratory graciously assisted in the identificaiton of serveral specimens named in this report.

Literature Cited

Randall, R. H., P. D. Gates, J. B. Neill, and S. C. Wilkins. 1985. A marine survey of the Tanapag reef platform adjacent to Unai Papau. Univ. of Guam, Mar. Lab. Misc. Rept. No. 48. 55 p.

TABLE 1. Distributional zonation of occurrence for echinoderms. Zones are determined by the distance in meters from the starting end of the transect. A dash (-) represents that the organism was not found on that transect. An N represents the occurrence of the organism on the transect line, but outside the sampling area.

SPECIES	TRANSECT A_1	A_2	A_3	A_4	A_5	A_6
Ophiuroidea (Brittle stars)						
Ophicoma sp.	-	-	90-100	-	-	0-10
Asteroidea (Sea stars)						
Culcita novaeguineae (Muller & Troschel)	-	70-80	-	-	-	-
Fromia milliporella (Lamarck)	-	0-10	-	-	-	-
Linkia laevigata (Linnaeus)	80-90	0-100	30-90	-	10-20	0-100
L. multifora (Lamarck)	-	-	-	-	-	10-20
Acanthaster planci (Linnaeus)	-	-	-	-	-	70-80
Crinoidea						
Comanthus schlegeli (Carpenter)	-	-	-	-	-	20-40
Echinoidea (Sea urchins)						
Diadema savignyi Michelin	-	-	-	N	0-10	0-100
Echinothrix diadema (Linnaeus)	-	-	-	N	0-10	0-100
Toxopneustes pileolus (Lamarck)	-	-	-	-	-	-
Tripneustes gratilla (Linnaeus)	90-100	-	80-90	-	-	-
Echinostephanus aciculatus A. Agassiz	-	-	-	-	-	30-40
Echinometra mathaei (de Blainvelle)	-	0-90	70-100	N	-	20-90
Heterocentrotus mammillatus (Linnaeus)	-	-	-	-	-	70-80
Holothuriodea (Sea cucumbers)						
Stichopus chloronotus Brandt	-	90-100	-	-	-	0-100
S. horrens Selenka	-	-	-	-	-	-
Actinopyga echinites (Jaeger)	-	20-50	-	-	-	-
A. mauritiana (Quoy & Gaimard)	-	-	-	-	-	-
Bohadschia argus Jaeger	-	-	-	-	-	90-100
B. marmorata Jaeger	-	60-100	-	-	-	-
Labidodemas semperianum (Selenka)	-	-	-	-	-	-
Holothuria atra Jaeger	0-100	0-100	0-100	20-50	0-100	0-100
H. axiologa H. L. Clark	-	-	-	-	-	80-90
H. cinerascens (Brandt)	-	-	-	-	-	-

TABLE 1. (continued)

SPECIES	TRANSECT					
	A_1	A_2	A_3	A_4	A_5	A_6
H: *hilla* Lesson	0-70	10-100	80-90	0-100	10-100	0-100
H. *impatiens* (Forskal)	-	-	-	-	-	-
H. *leucospilota* (Brandt)	-	-	80-90	-	-	-
H. *nobilis* (Selenka)	-	-	-	-	-	-
Synapta maculata (Chamisso & Eysenhardt)	-	-	-	-	-	-

TABLE 1. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
Ophiuroidea (Brittle stars)						
Ophicoma sp.	-	-	-	-	-	-
Asteroidea (Sea stars)						
Culcita novaeguineae (Muller & Troschel)	-	-	-	0-10	30-40	-
Fromia milliporella (Lamarck)	-	-	-	-	-	-
Linkia laevigata (Linnaeus)	-	-	-	0-30	10-20	10-80
L. multifora (Lamarck)	-	-	-	-	10-20	-
Acanthaster planci (Linnaeus)	-	-	-	-	-	-
Crinoidea						
Comanthus schlegeli (Carpenter)	-	-	-	-	-	-
Echinoidea (Sea urchins)						
Diadema savignyi Michelin	-	-	-	0-10	90-100	0-100
Echinothrix diadema (Linnaeus)	-	-	-	-	90-100	0-100
Toxopneustes pileolus (Lamarck)	-	-	-	60-70	-	50-100
Tripneustes gratilla (Linnaeus)	N	80-90	-	20-80	60-70	-
Echinostephanus aciculatus A. Agassiz	-	-	-	-	-	50-60
Echinometra mathaei (de Blainvelle)	-	-	0-10	40-100	0-100	10-90
Heterocentrotus mammillatus (Linnaeus)	-	-	-	-	-	-
Holothuriodea (Sea cucumbers)						
Stichopus chloronotus Brandt	-	-	-	-	-	N
S. horrens Selenka	-	-	-	-	-	0-30
Actinopyga echinites (Jaeger)	-	-	-	-	-	-
A. mauritiana (Quoy & Gaimard)	-	-	-	-	-	-
Bohadschia argus Jaeger	-	-	-	-	30-90	10-40
B. marmorata Jaeger	-	-	-	0-50	-	-
Labidodemas semperianum (Selenka)	-	-	-	-	-	-
Holothuria atra Jaeger	0-100	0-100	30-70	0-100	0-90	0-100
H. axiologa H. L. Clark	-	-	-	-	-	-
H. cinerascens (Brandt)	-	-	-	-	-	-
H. hilla Lesson	0-10	-	0-100	0-100	0-100	30-100
H. impatiens (Forskal)	-	-	-	-	-	-

TABLE 1. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
H. leucospilota (Brandt)	N	N	-	0-10	60-70	-
H. nobilis (Selenka)	-	-	-	-	-	0-10
Synapta maculata (Chamisso & Eysenhardt)	-	-	-	40-50	90-100	-

TABLE 1. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
Ophiuroidea (Brittle stars)						
Ophicoma sp.	620-630	-	650-660	60-210	50-60	-
Asteroidea (Sea stars)						
Culcita novaeguineae (Muller & Troschel)	-	-	500-700	-	-	-
Fromia milliporella (Lamarck)	-	-	-	-	-	-
Linkia laevigata (Linnaeus)	300-620	-	250-700	100-160	-	-
L. multifora (Lamarck)	-	-	-	-	-	-
Acanthaster planci (Linnaeus)	N	-	560-670	-	-	-
Crinoidea						
Comanthus schlegeli (Carpenter)	-	-	-	-	-	-
Echinoidea (Sea urchins)						
Diadema savignyi Michelin	490-700	-	600-610	200-220	60-70	0-130
Echinothrix diadema (Linnaeus)	590-650	-	560-670	190-210	70-80	20-130
Toxopneustes pileolus (Lamarck)	-	-	650-660	-	-	-
Tripneustes gratilla (Linnaeus)	-	-	-	-	-	-
Echinostephanus aciculatus A. Agassiz	-	-	690-700	-	-	-
Echinometra mathaei (de Blainvelle)	320-650	-	150-690	130-210	60-70	-
Heterocentrotus mammillatus (Linnaeus)	-	-	-	-	-	-
Holothuriodea (Sea cucumbers)						
Stichopus chloronotus Brandt	350-620	-	670-690	120-220	-	30-90
S. horrens Selenka	-	-	300-520	-	-	-
Actinopyga echinites (Jaeger)	-	-	640-650	N	-	-
A. mauritiana (Quoy & Gaimard)	-	-	N	200-220	60-80	110-130
Bohadschia argus Jaeger	400-550	-	-	N	-	N
B. marmorata Jaeger	-	-	-	10-30	-	-
Labidodemas semperianum (Selenka)	-	-	N	-	-	-
Holothuria atra Jaeger	0-640	0-210	0-700	0-220	0-80	0-90
H. axiologa H. L. Clark	-	-	640-650	-	-	-
H. cinerascens (Brandt)	-	-	-	200-220	60-70	-
H. edulis Lesson	140-250	-	-	-	-	-
H. hilla Lesson	80-120	0-210	0-240	-	50-60	-

TABLE 1. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
H. impatiens (Forskal)	590-600	-	-	170-180	-	-
H. leucospilota (Brandt)	140-630	-	220-650	10-210	10-70	0-80
H. nobilis (Selenka)	-	-	-	-	-	50-60
Synapta maculata (Chamisso & Eysenhardt)	200-400	-	520-700	-	-	-

TABLE 2. Distributional zonation of occurrence for mollusks. Zones are determined by the distance in meters from the starting end of the transect. A dash (-) represents that this organism was not encountered on the transect. An N represents the occurrence of the organism on the transect line but outside the sampling area.

SPECIES	TRANSECT					
	A_1	A_2	A_3	A_4	A_5	A_6
Gastropoda						
Acmaeidae						
Patelloida chamorrorum Lindberg & Vermeij	-	-	-	-	-	-
Trochidae						
Trochus niloticus (Linnaeus)	-	-	30-40	-	-	0-50
T. intextus Kiener	-	-	-	-	-	-
T. conus Gmelin	-	-	-	-	-	-
Tectus pyramis (Born)	-	-	-	-	-	50-70
Turbinidae						
Turbo argystomus Linnaeus	-	-	-	-	-	70-80
T. setosus Gmelin	-	-	-	-	-	-
Astrea rhodostoma Lamarck	-	-	-	-	-	-
Phasianellidae						
Phasianella solida (Born)	-	-	-	-	-	-
Neritidae						
Nerita plicata Linnaeus	-	-	-	-	-	-
Vermetidae						
Dendropoma maxima Sowerby	-	0-60	-	-	-	0-90
Cerithiidae						
Cerithium alveolus (Harmon & Jaquinot)	-	-	-	-	-	-
C. columna Sowerby	-	-	-	-	-	10-20
C. nodulosum Bruguiere	-	-	-	-	-	90-100
C. zonatum (Wood)	30-70	-	-	-	-	-
Rhinoclavis aspera (Linnaeus)	-	-	60-70	30-90	-	-
R. fasciata (Bruguiere)	-	-	-	70-100	-	-

TABLE 2. (continued)

SPECIES	TRANSECT					
	A_1	A_2	A_3	A_4	A_5	A_6
Strombidae						
Lambis chiragra Linnaeus	-	-	-	-	-	-
L. lambis Linnaeus	-	0-10	-	90-100	-	-
L. truncata (Kiener)	-	-	-	-	N	-
Strombus gibberulus (Roeding)	-	-	-	60-90	-	-
S. lentiginosus Linnaeus	-	-	-	-	-	-
S. luhuanus Linnaeus	-	-	-	70-80	-	-
Cypraeidae						
Cypraea annulus Linnaeus	-	-	30-40	-	-	-
C. helvola Linnaeus	-	-	-	-	-	10-20
C. lynx Linnaeus	-	-	-	-	-	-
C. moneta Linnaeus	-	-	N	-	-	90-100
C. tigris Linnaeus	-	-	50-60	-	-	-
Naticidae						
Natica sp.	-	-	-	-	-	-
Cassidae						
Cassis cornuta (Linnaeus)	-	-	-	-	N	-
Cymatiidae						
Cymatium muricinum (Roeding)	-	-	-	-	-	10-20
C. nicobaricum (Roeding)	-	-	-	-	-	-
Distorsio anus (Linnaeus)	-	-	-	-	-	-
Bursidae						
Bursa bufonia (Gmelin)	-	-	-	-	-	-
Muricidae						
Drupa morum Roeding	-	-	-	-	-	-
D. ricinus (Linnaeus)	-	-	-	-	-	-
Morula uva (Roeding)	-	-	-	-	-	-
Chicoreus brunneus (Link)	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT A_1	A_2	A_3	A_4	A_5	A_6
Buccinidae						
Cantharus fumosus (Dillwyn)	-	-	-	-	-	-
C. undosus (Linnaeus)	-	-	-	-	-	-
Fasciolariidae						
Latirus maculatus (Reeve)	-	-	-	30-40	-	-
L. polygonus (Reeve)	-	-	-	-	-	-
Peristernia nassatula (Lamark)	-	-	-	-	-	-
Olividae						
Oliva annulata Gmelin	-	-	-	-	-	-
Vasidae						
Vasum turbinellus (Linnaeus)	-	50-60	-	-	-	30-50
Harpidae						
Harpa amouretta (Roeding)	-	-	-	-	-	-
Mitriidae						
Mitra imperialis (Roeding)	-	-	-	-	-	-
M. litterata Lamarck	-	-	-	-	-	-
Costellariidae						
Vexillum exasperatum Gmelin	-	-	-	50-80	-	-
V. amabilis (Reeve)	-	-	-	60-80	-	-
V. coronatum (Helbling)	-	-	-	40-50	-	-
Conidae						
Conus chaldeus Roeding	-	-	-	-	-	-
C. coronutus Gmelin	-	-	-	-	-	-
C. distans Hwass	50-60	-	-	-	-	-
C. ebraeus Linnaeus	-	-	-	-	-	-
C. eburneus Hwass	-	-	-	-	-	-
C. flavidus Lamark	-	-	-	-	-	-
C. litteratus Linnaeus	-	-	-	-	70-80	-

TABLE 2. (continued)

SPECIES	TRANSECT					
	A_1	A_2	A_3	A_4	A_5	A_6
C. lividus Hwass	-	-	-	-	-	-
C. miles Linnaeus	-	-	-	-	-	-
C. pulicarius Hwass	-	-	-	50-60	-	10-20
C. quercinus Solander	-	-	-	-	-	-
C. rattus Hwass	-	-	-	-	-	20-30
C. sanguinolentus Quoy & Gaimard	-	-	-	-	-	-
C. sponsalis Hwass	70-80	-	-	30-40	-	-
C. virgo Linnaeus	-	-	-	-	-	-
C. vitulinus Hwass						
Terebridae						
Terebra maculata (Linnaeus)	-	-	-	-	90-100	-
T. sublata (Linnaeus)	-	-	-	-	N	-
Bivalvia						
Mytilidae						
Nodiolus sp.	-	-	-	-	-	-
Pinnidae						
Pinna muricata (Linnaeus)	-	-	-	-	-	-
Isognominidae						
Isognomon perna (Linnaeus)	-	-	-	-	-	-
Lucinidae						
Ctena bella (Conrad)	-	40-80	-	-	-	-
Codakia punctata (Linnaeus)	-	-	-	-	-	-
Cartidae						
Cardita variegata Bruguiere	-	-	-	-	-	-
Cardiidae						
Fragum fragum (Linneaus)	-	-	-	10-20	10-30	-

TABLE 2. (continued)

SPECIES	TRANSECT					
	A_1	A_2	A_3	A_4	A_5	A_6
Tridacnidae						
Tridacna maxima (Roeding)	-	50-60	-	-	-	50-80
Tellinidae						
Quidnapagus palatum Iredale	-	-	-	-	-	-
Scutarcopagia scobinata (Linnaeus)	-	-	-	-	-	-
Tellina robusta (Hanley)	-	-	80-90	50-70	80-100	-
Tellina sp.	-	-	-	-	-	-
Veneridae						
Grafrarium pectinatum (Linnaeus)	-	-	-	-	-	-
G. tumidum (Roeding)	-	-	-	-	-	-
Glycodonta marica (Linneaus)	-	-	-	70-100	-	-
Lioconcha hieroglyphica (Conrad)	-	-	-	-	-	-
Periglypta reticulata (Linnaeus)	-	-	-	-	-	-
Pitar sp.	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
Gastropoda						
Acmaeidae						
Patelloida chamorrorum Lindberg & Vermeij	-	-	-	-	-	-
Trochidae						
Trochus niloticus (Linnaeus)	-	-	-	0-80	20-60	40-100
T. intextus Kiener	-	-	-	-	-	-
T. conus Gmelin	-	-	-	-	-	20-30
Tectus pyramis (Born)	-	-	-	40-50	-	60-70
Turbinidae						
Turbo argystomus Linnaeus	-	-	-	-	-	-
T. setosus Gmelin	-	-	-	-	-	-
Astrea rhodostoma Lamarck	-	-	-	-	-	-
Phasianellidae						
Phasianella solida (Born)	-	-	-	-	-	-
Neritidae						
Nerita plicata Linnaeus	-	-	-	-	-	-
Vermetidae						
Dendropoma maxima Sowerby	-	-	N	0-70	0-100	60-80
Cerithiidae						
Cerithium alveolus (Harmon & Jaquinot)	-	-	-	-	-	-
C. columna Sowerby	-	-	-	-	-	-
C. nodulosum Bruguiere	-	10-90	50-60	30-40	-	-
C. zonatum (Wood)	10-20	-	-	-	-	-
Rhinoclavis aspera (Linnaeus)	-	-	-	0-10	0-10	-
R. fasciata (Bruguiere)	-	-	90-100	N	0-10	-
Strombidae						
Lambis chiragra Linnaeus	-	-	-	-	-	-
L. lambis Linnaeus	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
L. truncata (Kiener)	-	-	-	-	-	90-100
Strombus gibberulus (Roeding)	-	-	-	-	-	-
S. lentiginosus Linnaeus	-	-	-	-	-	-
S. luhuanus Linnaeus	-	-	-	20-30	-	-
Cypraeidae						
Cypraea annulus Linnaeus	-	-	-	-	-	-
C. helvola Linnaeus	-	-	-	-	-	-
C. lynx Linnaeus	-	-	-	-	-	-
C. moneta Linnaeus	-	-	-	30-80	-	90-100
C. tigris Linnaeus	-	-	-	-	N	-
Naticidae						
Natica sp.	-	-	-	-	-	-
Cassidae						
Cassis cornuta (Linnaeus)	-	-	-	-	-	-
Cymatiidae						
Cymatium muricinum (Roeding)	-	-	-	-	-	-
C. nicobaricum (Roeding)	-	-	-	-	-	-
Distorsio anus (Linnaeus)	-	-	-	-	-	-
Bursidae						
Bursa bufonia (Gmelin)	-	-	-	-	-	-
Muricidae						
Drupa morum Roeding	-	-	-	-	-	-
D. ricinus (Linnaeus)	-	-	-	-	-	-
Morula uva (Roeding)	-	-	-	-	-	-
Chicoreus brunneus (Link)	-	-	-	-	-	-
Buccinidae						
Cantharus fumosus (Dillwyn)	-	-	-	-	-	-
C. undosus (Linnaeus)	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
Fasciolariidae						
Latirus maculatus (Reeve)	-	-	-	-	-	-
L. polygonus (Reeve)	-	-	-	-	-	-
Peristernia nassatula (Lamark)	-	-	-	-	-	-
Olividae						
Oliva annulata Gmelin	-	-	-	-	-	-
Vasidae						
Vasum turbinellus (Linnaeus)	-	-	-	-	90-100	0-90
Harpidae						
Harpa amouretta (Roeding)	-	-	-	-	-	-
Mitriidae						
Mitra imperialis (Roeding)	-	-	-	-	-	-
M. litterata Lamarck	-	-	-	-	-	-
Costellariidae						
Vexillum exasperatum Gmelin	-	-	-	-	-	-
V. amabilis (Reeve)	-	-	-	-	-	-
V. coronatum (Helbling)	-	-	-	-	-	-
Conidae						
Conus chaldeus Roeding	-	-	-	-	-	-
C. coronutus Gmelin	-	-	-	-	-	-
C. distans Hwass	-	-	-	-	-	-
C. ebraeus Linnaeus	-	-	-	-	-	-
C. eburneus Hwass	-	-	-	-	-	-
C. flavidus Lamark	-	-	-	N	-	-
C. litteratus Linnaeus	-	-	-	-	-	-
C. lividus Hwass	-	-	50-60	-	-	-
C. miles Linnaeus	-	-	-	-	-	-
C. pulicarius Hwass	N	-	60-70	-	-	-
C. quercinus Solander	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
C. rattus Hwass	-	-	-	-	-	-
C. sanguinolentus Quoy & Gaimard	-	-	-	-	-	-
C. sponsalis Hwass	-	-	-	-	-	-
C. virgo Linnaeus	-	-	-	-	-	-
C. vitulinus Hwass	-	-	-	-	-	-
Terebridae						
Terebra maculata (Linnaeus)	-	-	-	-	-	-
T. sublata (Linnaeus)	-	-	-	-	-	-
Bivalvia						
Mytilidae						
Modiolus sp.	-	-	-	-	-	-
Pinnidae						
Pinna muricata (Linnaeus)	60-70	-	-	-	-	-
Isognominidae						
Isognomon perna (Linnaeus)	-	-	-	10-20	-	-
Lucinidae						
Ctena bella (Conrad)	40-90	10-50	-	-	-	-
Codakia punctata (Linnaeus)	-	-	-	-	-	-
Cartidae						
Cardita variegata Bruguiere	-	-	-	-	-	-
Cardiidae						
Fragum fragum (Linneaus)	0-100	0-40	70-80	-	-	-
Tridacnidae						
Tridacna maxima (Roeding)	-	-	-	-	0-10	-

TABLE 2. (continued)

SPECIES	TRANSECT B_1	B_2	B_3	B_4	B_5	B_6
Tellinidae						
Quidnapagus palatum Iredale	40-50	-	-	-	-	-
Scutarcopagia scobinata (Linnaeus)	-	-	-	-	-	-
Tellina robusta (Hanley)	-	-	10-20	-	-	-
Tellina sp.	-	-	-	-	-	-
Veneridae						
Grafrarium pectinatum (Linnaeus)	40-50	-	-	-	-	-
G. tumidum (Roeding)	-	-	-	-	-	-
Glycodonta marica (Linneaus)	-	-	-	-	-	-
Lioconcha hieroglyphica (Conrad)	-	40-50	-	-	-	-
Periglypta reticulata (Linnaeus)	80-90	-	-	-	-	-
Pitar sp.	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
Gastropoda						
Acmaeidae						
Patelloida chamorrorum Lindberg & Vermeij	-	-	-	0-10	0-10	-
Trochidae						
Trochus niloticus (Linnaeus)	340-580	-	340-700	120-190	-	120-130
T. intextus Kiener	-	-	-	-	-	-
T. conus Gmelin	-	-	-	-	-	-
Tectus pyramis (Born)	630-640	-	-	90-100	-	-
Turbinidae						
Turbo argystomus Linnaeus	-	-	-	-	-	110-120
T. setosus Gmelin	-	-	-	210-220	-	100-120
Astrea rhodostoma Lamarck	-	-	530-540	-	-	-
Phasianellidae						
Phasianella solida (Born)	-	-	-	-	-	-
Neritidae						
Nerita plicata Linnaeus	-	-	-	-	0-10	-
Vermetidae						
Dendropoma maxima Sowerby	330-630	-	250-610	90-120	-	-
Cerithiidae						
Cerithium alveolus (Harmon & Jaquinot)	-	-	-	-	-	-
C. columna Sowerby	-	-	-	-	-	-
C. nodulosum Bruguiere	30-400	10-210	-	40-60	-	-
C. zonatum (Wood)	30-400	10-210	30-280	50-60	-	-
Rhinoclavis aspera (Linnaeus)	-	-	-	0-70	0-10	-
R. fasciata (Bruguiere)	-	60-90	0	0-190	40-50	-
Strombidae						
Lambis chiragra Linnaeus	-	-	-	-	-	-
L. lambis Linnaeus	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
L. truncata (Kiener)	-	-	-	-	-	-
Strombus gibberulus (Roeding)	-	-	-	0-60	0-10	-
S. lentiginosus Linnaeus	-	-	N	-	-	-
S. luhuanus Linnaeus	-	-	140-500	0-50	0-20	-
Cypraeidae						
Cypraea annulus Linnaeus	-	-	N	-	10-60	20-30
C. helvola Linnaeus	-	-	N	-	-	-
C. lynx Linnaeus	-	-	-	-	-	-
C. moneta Linnaeus	300-650	-	300-700	110-150	20-70	-
C. tigris Linnaeus	-	-	-	-	-	-
Naticidae						
Natica sp.	-	-	-	-	-	-
Cassidae						
Cassis cornuta (Linnaeus)	-	-	-	-	-	-
Tonnidae						
Tonna perdix (Linnaeus)	-	-	N	-	-	-
Cymatiidae						
Cymatium muricinum (Roeding)	-	-	-	-	-	-
C. nicobaricum (Roeding)	500-510	-	-	-	-	-
Distorsio anus (Linnaeus)	-	-	-	-	-	20-30
Bursidae						
Bursa bufonia (Gmelin)	-	-	-	20-30	-	-
Muricidae						
Drupa morum Roeding	-	-	-	120-130	-	-
D. ricinus (Linnaeus)	-	-	-	-	50-60	-
Morula uva (Roeding)	490-560	-	-	-	60-80	-
Chicoreus brunneus (Link)	610-620	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
Buccinidae						
Cantharus fumosus (Dillwyn)	30-400	10-210	30-280	-	-	-
C. undosus (Linnaeus)	-	-	-	-	-	-
Fasciolariidae						
Latirus maculatus (Reeve)	-	-	-	-	-	-
L. polygonus (Reeve)	-	-	-	-	-	-
Peristernia nassatula (Lamark)	-	-	-	-	60-70	-
Olividae						
Oliva annulata Gmelin	-	-	440-450	-	-	-
Vasidae						
Vasum turbinellus (Linnaeus)	500-510	-	540-550	180-190	50-70	10-20
Harpidae						
Harpa amouretta (Roeding)	-	-	-	-	-	30-40
Mitriidae						
Mitra imperialis (Roeding)	300-310	-	-	-	-	-
M. litterata Lamarck	-	-	-	-	0-10	-
Costellariidae						
Vexillum exasperatum Gmelin	-	-	-	-	-	-
V. amabilis (Reeve)	-	-	-	20-30	0-10	-
V. coronatum (Helbling)	-	-	-	-	-	-
Conidae						
Conus chaldeus Roeding	N	-	-	-	50-60	-
C. coronutus Gmelin	-	-	-	N	-	-
C. distans Hwass	-	-	-	-	-	-
C. ebraeus Linnaeus	420-430	-	40-540	-	0-60	-
C. eburneus Hwass	-	-	40-50	-	-	-
C. flavidus Lamark	-	-	-	160-170	60-70	-
C. litteratus Linnaeus	-	-	-	-	-	-

TABLE 2. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
C. lividus Hwass	-	-	-	0-10	60-70	120-130
C. miles Linnaeus	N	-	-	-	-	-
C. pulicarius Hwass	-	-	-	0-10	-	-
C. quercinus Solander	N	-	-	-	-	-
C. rattus Hwass	300-510	-	690-700	70-80	-	-
C. sanguinolentus Quoy & Gaimard	-	-	-	-	-	-
C. sponsalis Hwass	-	-	-	-	0-20	-
C. vellixum Gmelin	-	-	N	-	-	-
C. *virgo* Linnaeus	-	-	-	-	-	-
C. vitulinus Hwass	N	-	-	-	-	-
Terebridae						
Terebra maculata (Linnaeus)	-	-	-	-	-	-
T. sublata (Linnaeus)	-	-	-	-	-	-
Bivalvia						
Mytilidae						
Modiolus sp.	-	-	40-80	-	-	50-60
Pinnidae						
Pinna muricata (Linnaeus)	-	-	-	-	-	-
Isognominidae						
Isognomon perna (Linnaeus)	-	-	-	160-170	-	-
Lucinidae						
Ctena bella (Conrad)	50-80	-	-	-	-	-
Codakia punctata (Linnaeus)	-	-	-	-	-	-
Cartidae						
Cardita variegata Bruguiere	-	-	-	160-170	-	-
Cardiidae						
Fragum fragum (Linneaus)	480-490	-	30-270	0-50	-	-

TABLE 2. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
Tridacnidae						
Tridacna maxima (Roeding)	380-570	-	590-600	150-190	-	30-50
Tellinidae						
Quidnapagus palatum Iredale	-	-	-	-	-	-
Scutarcopagia scobinata (Linnaeus)	80-90	-	-	-	-	-
Tellina robusta (Hanley)	-	-	-	-	-	-
Tellina sp.	-	-	-	-	-	-
Veneridae						
Grafrarium pectinatum (Linnaeus)	-	-	-	-	-	-
G. tumidum (Roeding)	80-90	-	-	-	-	-
Glycodonta marica (Linneaus)	-	-	-	-	-	-
Lioconcha hieroglyphica (Conrad)	-	-	-	-	-	-
Periglypta reticulata (Linnaeus)	-	-	-	-	-	-
Pitar sp.	-	-	-	-	-	-

TABLE 3. Abundances for echinoderms. Densities are given as individuals per 10 m^2, followed by the number of quadrats in which this organism was found. A dash (-) represents that this organism was not found on that transect. An N represents the occurrence of the organism on the transect line, but outside the sampling area.

SPECIES	TRANSECT A_1	A_2	A_3	A_4	A_5	A_6
Ophiuroidea (Brittle stars)						
Ophicoma sp.	-	-	1.0(1)	-	-	1.0(1)
Asteroidea (Sea stars)						
Culcita novaeguineae (Muller & Troschel)	-	1.0(1)	-	-	-	-
Fromia milliporella (Lamarck)	-	1.0(1)	-	-	-	-
Linkia laevigata (Linnaeus)	1.0(1)	2.0(7)	1.3(4)	-	1.0(1)	1.9(10)
L. multifora (Lamarck)	-	-	-	-	-	1.0(1)
Acanthaster planci (Linnaeus)	-	-	-	-	-	1.0(1)
Crinoidea						
Comanthus schlegeli (Carpenter)	-	-	-	-	-	1.0(2)
Echinoidea (Sea urchins)						
Diadema savignyi Michelin	-	-	-	N	2.0(1)	TNTC(10)
Echinothrix diadema (Linnaeus)	-	-	-	N	10(1)	5.4(10)
Toxopneustes pileolus (Lamarck)	-	-	-	-	-	-
Tripneustes gratilla (Linnaeus)	1.0(1)	-	1.0(1)	-	-	-
Echinostephanus aciculatus A. Agassiz	-	-	-	-	-	1.0(1)
Echinometra mathaei (de Blainvelle)	-	2.4(5)	24(3)	N	-	1.0(5)
Heterocentrotus mammillatus (Linnaeus)	-	-	-	-	-	1.0(1)
Holothuriodea (Sea cucumbers)						
Stichopus chloronotus Brandt	-	1.0(1)	-	-	-	1.0(1)
S. horrens Selenka	-	-	-	-	-	-
Actinopyga echinites (Jaeger)	-	1.0(2)	-	-	-	-
A. mauritiana (Quoy & Gaimard)	-	-	-	-	-	-
Bohadschia argus Jaeger	-	-	-	-	-	1.0(1)
B. marmorata Jaeger	-	1.0(2)	-	-	-	-
Labidodemas semperianum (Selenka)	-	-	-	-	-	-
Holothuria atra Jaeger	34(10)	8.7(10)	3.8(9)	1.0(1)	1.4(10)	1.4(5)
H. axiologa H. L. Clark	-	-	-	-	-	1.0(1)
H. cinerascens (Brandt)	-	-	-	-	-	-

TABLE 3. (continued)

SPECIES	TRANSECT A_1	A_2	A_3	A_4	A_5	A_6
H. hilla Lesson	1.8(4)	7.6(9)	3.0(1)	4.3(10)	7.1(9)	7.3(7)
H. impatiens (Forskal)	-	-	-	-	-	-
H. leucospilota (Brandt)	-	-	1.0(1)	-	-	-
H. nobilis (Selenka)	-	-	-	-	-	-
Synapta maculata (Chamisso & Eysenhardt)	-	-	-	-	-	-

TABLE 3. (continued)

SPECIES	TRANSECT B_1	B_2	B_3	B_4	B_5	B_6
Ophiuroidea (Brittle stars)						
Ophicoma sp.	-	-	-	-	-	-
Asteroidea (Sea stars)						
Culcita novaeguineae (Muller & Troschel)	-	-	-	1.0(1)	1.0(1)	-
Fromia milliporella (Lamarck)	-	-	-	-	-	-
Linkia laevigata (Linnaeus)	-	-	-	1.0(3)	1.0(1)	3.3(7)
L. multifora (Lamarck)	-	-	-	-	1.0(1)	-
Acanthaster planci (Linnaeus)	-	-	-	-	-	-
Crinoidea						
Comanthus schlegeli (Carpenter)	-	-	-	-	-	-
Echinoidea (Sea urchins)						
Diadema savignyi Michelin	-	-	-	2.0(1)	1.0(1)	18(10)
Echinothrix diadema (Linnaeus)	-	-	-	-	1.0(1)	3.8(10)
Toxopneustes pileolus (Lamarck)	-	-	-	1.0(1)	-	1.5(2)
Tripneustes gratilla (Linnaeus)	N	1.0(1)	-	1.5(2)	1.0(1)	-
Echinostephanus aciculatus A. Agassiz	-	-	-	-	-	1.0(1)
Echinometra mathaei (de Blainvelle)	-	-	1.0(1)	1.3(4)	41(10)	1.3(4)
Heterocentrotus mammillatus (Linnaeus)	-	-	-	-	-	-
Holothuriodea (Sea cucumbers)						
Stichopus chloronotus Brandt	-	-	-	-	-	N
S. horrens Selenka	-	-	-	-	-	4.0(2)
Actinopyga echinites (Jaeger)	-	-	-	-	-	-
A. mauritiana (Quoy & Gaimard)	-	-	-	-	-	-
Bohadschia argus Jaeger	-	-	-	-	1.0(2)	1.0(1)
B. marmorata Jaeger	-	-	-	1.0(2)	-	-
Labidodemas semperianum (Selenka)	-	-	-	-	-	-
Holothuria atra Jaeger	41(10)	35(10)	1.0(3)	1.2(6)	1.0(5)	1.5(1)
H. axiologa H. L. Clark	-	-	-	-	-	-
H. cinerascens (Brandt)	-	-	-	-	-	-
H. hilla Lesson	1.0(1)	-	6.9(10)	5.7(10)	3.2(5)	5.0(7)
H. impatiens (Forskal)	-	-	-	-	-	-

TABLE 3. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
H. leucospilota (Brandt)	N	N	-	1.0(1)	1.0(1)	-
H. nobilis (Selenka)	-	-	-	-	-	1.0(1)
Synapta maculata (Chamisso & Eysenhardt)	-	-	-	1.0(1)	1.0(1)	-

TABLE 3. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
Ophiuroidea (Brittle stars)						
Ophicoma sp.	1.0(1)	-	1.0(1)	1.5(2)	1.0(1)	-
Asteroidea (Sea stars)						
Culcita novaeguineae (Muller & Troschel)	-	-	1.0(1)	-	-	-
Fromia milliporella (Lamarck)	-	-	-	-	-	-
Linkia laevigata (Linnaeus)	1.7(10)	-	1.4(13)	1.0(3)	-	-
L. multifora (Lamarck)	-	-	-	-	-	-
Acanthaster planci (Linnaeus)	N	-	1.0(2)	-	-	-
Crinoidea						
Comanthus schlegeli (Carpenter)	-	-	-	-	-	-
Echinoidea (Sea urchins)						
Diadema savignyi Michelin	1.0(3)	-	3.0(5)	1.5(2)	1.0(1)	1.2(9)
Echinothrix diadema (Linnaeus)	3.4(5)	-	4.6(9)	1.0(2)	1.0(1)	1.0(7)
Toxopneustes pileolus (Lamarck)	-	-	1.0(1)	-	-	-
Tripneustes gratilla (Linnaeus)	-	-	-	-	-	-
Echinostephanus aciculatus A. Agassiz	-	-	1.0(1)	-	-	-
Echinometra mathaei (de Blainvelle)	1.6(7)	-	10.9(37)	2.2(6)	1.0(1)	-
Heterocentrotus mammillatus (Linnaeus)	-	-	N	-	-	-
Holothuriodea (Sea cucumbers)						
Stichopus chloronotus Brandt	-	-	1.5(2)	1.0(4)	-	1.7(3)
S. horrens Selenka	-	-	1.0(4)	-	-	-
Actinopyga echinites (Jaeger)	-	-	1.0(1)	N	-	-
A. mauritiana (Quoy & Gaimard)	-	-	N	1.0(2)	3.0(2)	5.5(2)
Bohadschia argus Jaeger	1.0(2)	-	1.0(2)	N	-	N
B. marmorata Jaeger	-	-	-	1.0(2)	-	-
Labidodemas semperianum (Selenka)	-	-	N	-	-	-
Holothuria atra Jaeger	18.0(58)	39.5(21)	14.7(66)	4.2(18)	14.4(8)	3.7(9)
H. axiologa H. L. Clark	-	-	1.0(1)	-	-	-
H. cinerascens (Brandt)	-	-	-	1.0(2)	3.0(1)	-
H. edulis Lesson	1.6(5)	-	-	-	-	-
H. hilla Lesson	3.0(6)	6.5(11)	1.5(4)	-	3.0(1)	-

TABLE 3. (continued)

SPECIES	TRANSECT					
	C	D	E	F	G	H
H. impatiens (Forskal)	1.0(1)	-	-	1.0(2)	-	-
H. leucospilota (Brandt)	3.0(16)	-	2.0(16)	6.2(18)	3.3(4)	3.3(6)
H. nobilis (Selenka)	-	-	-	-	-	1.0(1)
Synapta maculata (Chamisso & Eysenhardt)	1.3(3)	-	1.0(3)	-	-	-

TABLE 4. Abundances of mollusks. Densities are given as individuals per 10 m^2, followed by the number of quadrats in which this organism was found. A dash (-) represents that this organism was not found on that transect. An N represents the occurrence of the organism on the transect line, but outside the sampling area.

SPECIES	TRANSECT					
	A_1	A_2	A_3	A_4	A_5	A_6
Gastropoda						
Acmaeidae						
Patelloida chamorrorum Lindberg & Vermeij	-	-	-	-	-	-
Trochidae						
Trochus niloticus (Linnaeus)	-	-	1.0(1)	-	-	1.0(3)
T. intextus Kiener	-	-	-	-	-	-
T. conus Gmelin	-	-	-	-	-	-
Tectus pyramis (Born)	-	-	-	-	-	1.0(2)
Turbinidae						
Turbo argystomus Linnaeus	-	-	-	-	-	1.0(1)
T. setosus Gmelin	-	-	-	-	-	-
Astrea rhodostoma Lamarck	-	-	-	-	-	-
Phasianellidae						
Phasianella solida (Born)	-	-	-	-	-	-
Neritidae						
Nerita plicata Linnaeus	-	-	-	-	-	-
Vermetidae						
Dendropoma maxima Sowerby	-	8.0(4)	-	-	-	5.2(8)
Cerithiidae						
Cerithium alveolus (Harmon & Jaquinot)	TNTC(4)	-	-	-	-	-
C. columna Sowerby	-	-	-	-	-	2.0(1)
C. nodulosum Bruguiere	-	-	-	-	-	1.0(1)
C. zonatum (Wood)	TNTC(2)	-	-	-	-	-
Rhinoclavis aspera (Linnaeus)	-	-	1.0(1)	1.0(4)	-	-
R. fasciata (Bruguiere)	-	-	-	1.0(2)	-	-

TABLE 4. (continued)

SPECIES	TRANSECT A_1	A_2	A_3	A_4	A_5	A_6
Strombidae						
<u>Lambis chiragra</u> Linnaeus	-	-	-	-	-	-
<u>L. lambis</u> Linnaeus	-	1.0(1)	-	1.0(1)	N	-
<u>L. truncata</u> (Kiener)	-	-	-	-	-	-
<u>Strombus gibberulus</u> (Roeding)	-	-	-	1.3(3)	-	-
<u>S. lentiginosus</u> Linnaeus	-	-	-	-	-	-
<u>S. luhuanus</u> Linnaeus	-	-	-	1.0(1)	-	-
Cypraeidae						
<u>Cypraea annulus</u> Linnaeus	-	-	1.0(1)	-	-	-
<u>C. helvola</u> Linnaeus	-	-	-	-	-	2.0(1)
<u>C. lynx</u> Linnaeus	-	-	-	-	-	-
<u>C. moneta</u> Linnaeus	-	-	N	-	-	1.0(1)
<u>C. tigris</u> Linnaeus	-	-	1.0(1)	-	-	-
Naticidae						
<u>Natica</u> sp.	-	-	-	-	-	-
Cassidae						
<u>Cassis cornuta</u> (Linnaeus)	-	-	-	-	N	-
Cymatiidae						
<u>Cymatium muricinum</u> (Roeding)	-	-	-	-	-	1.0(1)
<u>C. nicobaricum</u> (Roeding)	-	-	-	-	-	-
<u>Distorsio anus</u> (Linnaeus)	-	-	-	-	-	-
Bursidae						
<u>Bursa bufonia</u> (Gmelin)	-	-	-	-	-	-
Muricidae						
<u>Drupa morum</u> Roeding	-	-	-	-	-	-
<u>D. ricinus</u> (Linnaeus)	-	-	-	-	-	-
<u>Morula uva</u> (Roeding)	-	-	-	-	-	-
<u>Chicoreus brunneus</u> (Link)	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT					
	A_1	A_2	A_3	A_4	A_5	A_6
Buccinidae						
Cantharus fumosus (Dillwyn)	-	-	-	-	-	-
C. undosus (Linnaeus)	-	-	-	-	-	-
Fasciolariidae						
Latirus maculatus (Reeve)	-	-	-	1.0(1)	-	-
L. polygonus (Reeve)	-	-	-	-	-	-
Peristernia nassatula (Lamark)	-	-	-	-	-	-
Olividae						
Oliva annulata Gmelin	-	-	-	-	-	-
Vasidae						
Vasum turbinellus (Linnaeus)	-	1.0(1)	-	-	-	1.5(2)
Harpidae						
Harpa amouretta (Roeding)	-	-	-	-	-	-
Mitriidae						
Mitra imperialis (Roeding)	-	-	-	-	-	-
M. litterata Lamarck	-	-	-	-	-	-
Costellariidae						
Vexillum exasperatum Gmelin	-	-	-	1.0(3)	-	-
V. amabilis (Reeve)	-	-	-	1.0(2)	-	-
V. coronatum (Helbling)	-	-	-	1.0(1)	-	-
Conidae						
Conus chaldeus Roeding	-	-	-	-	-	-
C. coronutus Gmelin	-	-	-	-	-	-
C. distans Hwass	1.0(1)	-	-	-	-	-
C. ebraeus Linnaeus	-	-	-	-	-	-
C. eburneus Hwass	-	-	-	-	-	-
C. flavidus Lamark	-	-	-	-	-	-
C. litteratus Linnaeus	-	-	-	-	1.0(1)	-

TABLE 4. (continued)

SPECIES	TRANSECT A_1	A_2	A_3	A_4	A_5	A_6
C. lividus Hwass	-	-	-	-	-	-
C. miles Linnaeus	-	-	-	-	-	-
C. pulicarius Hwass	1.0(1)	-	-	1.0(10	-	-
C. quercinus Solander	-	-	-	-	-	-
C. rattus Hwass	-	-	-	-	-	-
C. sanguinolentus Quoy & Gaimard	-	-	-	-	-	1.0(1)
C. sponsalis Hwass	-	-	-	-	-	-
C. virgo Linnaeus	1.0(1)	-	-	1.0(1)	-	-
C. vitulinus Hwass	-	-	-	-	-	-
Terebridae						
Terebra maculata (Linnaeus)	-	-	-	-	1.0(1)	-
T. sublata (Linnaeus)	-	-	-	-	N	-
Bivalvia						
Mytilidae						
Modiolus sp.	-	-	-	-	-	-
Pinnidae						
Pinna muricata (Linnaeus)	-	-	-	-	-	-
Isognominidae						
Isognomon perna (Linnaeus)	-	-	-	-	-	-
Lucinidae						
Ctena bella (Conrad)	-	2.7(4)	-	-	-	-
Codakia punctata (Linnaeus)	-	-	-	-	-	-
Cartidae						
Cardita variegata Bruguiere	-	-	-	-	-	-
Cardiidae						
Fragum fragum (Linneaus)	-	-	-	1.0(1)	2.0(1)	-

TABLE 4. (continued)

SPECIES	TRANSECT A_1	A_2	A_3	A_4	A_5	A_6
Tridacnidae						
Tridacna maxima (Roeding)	-	1.0(1)	-	-	-	1.5(2)
Tellinidae						
Quidnapagus palatum Iredale	-	-	-	-	-	-
Scutarcopagia scobinata (Linnaeus)	-	-	-	-	-	-
Tellina robusta (Hanley)	-	-	2.0(1)	1.5(2)	1.5(2)	-
Tellina sp.	-	-	-	-	-	-
Veneridae						
Grafrarium pectinatum (Linnaeus)	-	-	-	-	-	-
G. tumidum (Roeding)	-	-	-	-	-	-
Glycodonta marica (Linneaus)	-	-	-	-	1.0(2)	-
Lioconcha hieroglyphica (Conrad)	-	-	-	-	-	-
Periglypta reticulata (Linnaeus)	-	-	-	-	-	-
Pitar sp.	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
Gastropoda						
Acmaeidae						
Patelloida chamorrorum Lindberg & Vermeij	-	-	-	-	-	-
Trochidae						
Trochus niloticus (Linnaeus)	-	-	-	1.0(3)	1.0(2)	1.0(3)
T. intextus Kiener	-	-	-	-	-	-
T. conus Gmelin	-	-	-	-	-	1.0(1)
Tectus pyramis (Born)	-	-	-	1.0(1)	-	1.0(1)
Turbinidae						
Turbo argystomus Linnaeus	-	-	-	-	-	-
T. setosus Gmelin	-	-	-	-	-	-
Astrea rhodostoma Lamarck	-	-	-	-	-	-
Phasianellidae						
Phasianella solida (Born)	-	-	-	-	-	-
Neritidae						
Nerita plicata Linnaeus	-	-	-	-	-	-
Vermetidae						
Dendropoma maxima Sowerby	-	-	N	4.3(4)	6.0(4)	11(2)
Cerithiidae						
Cerithium alveolus (Harmon & Jaquinot)	-	-	-	2.0(1)	-	-
C. columna Sowerby	-	-	-	-	-	-
C. nodulosum Bruguiere	-	1.0(2)	1.0(1)	1.0(1)	-	-
C. zonatum (Wood)	5.0(1)	-	-	-	-	-
Rhinoclavis aspera (Linnaeus)	-	-	2.0(1)	1.0(1)	1.0(1)	-
R. fasciata (Bruguiere)	-	-	-	N	2.0(1)	-
Strombidae						
Lambis chiragra Linnaeus	-	-	-	-	-	-
L. lambis Linnaeus	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
L. truncata (Kiener)	-	-	-	-	-	1.0(1)
Strombus gibberulus (Roeding)	-	-	-	-	-	-
S. lentiginosus Linnaeus	-	-	-	-	-	-
S. luhuanus Linnaeus	-	-	-	1.0(1)	-	-
Cypraeidae						
Cypraea annulus Linnaeus	-	-	-	-	-	-
C. helvola Linnaeus	-	-	-	-	-	-
C. lynx Linnaeus	-	-	-	-	-	-
C. moneta Linnaeus	-	-	-	1.5(2)	-	1.0(1)
C. tigris Linnaeus	-	-	-	-	N	-
Naticidae						
Natica sp.	-	-	-	-	-	-
Cassidae						
Cassis cornuta (Linnaeus)	-	-	-	-	-	-
Cymatiidae						
Cymatium muricinum (Roeding)	-	-	-	-	-	-
C. nicobaricum (Roeding)	-	-	-	-	-	-
Distorsio anus (Linnaeus)	-	-	-	-	-	-
Bursidae						
Bursa bufonia (Gmelin)	-	-	-	-	-	-
Muricidae						
Drupa morum Roeding	-	-	-	-	-	-
D. ricinus (Linnaeus)	-	-	-	-	-	-
Morula uva (Roeding)	-	-	-	-	-	-
Chicoreus brunneus (Link)						
Buccinidae						
Cantharus fumosus (Dillwyn)	-	-	-	-	-	-
C. undosus (Linnaeus)	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT B_1	B_2	B_3	B_4	B_5	B_6
Fasciolariidae						
Latirus maculatus (Reeve)	-	-	-	-	-	-
L. polygonus (Reeve)	-	-	-	-	-	-
Peristernia nassatula (Lamark)	-	-	-	-	-	1.0(1)
Olividae						
Oliva annulata Gmelin	-	-	-	-	-	-
Vasidae						
Vasum turbinellus (Linnaeus)	-	-	-	-	1.0(1)	1.3(3)
Harpidae						
Harpa amouretta (Roeding)	-	-	-	-	-	-
Mitriidae						
Mitra imperialis (Roeding)	-	-	-	-	-	-
M. litterata Lamarck	-	-	-	-	-	-
Costellariidae						
Vexillum exasperatum Gmelin	-	-	-	-	-	-
V. amabilis (Reeve)	-	-	-	-	-	-
V. coronatum (Helbling)	-	-	-	-	-	-
Conidae						
Conus chaldeus Roeding	-	-	-	-	-	-
C. coronutus Gmelin	-	-	-	-	-	-
C. distans Hwass	-	-	-	-	-	-
C. ebraeus Linnaeus	-	-	-	-	-	-
C. eburneus Hwass	-	-	-	-	-	-
C. flavidus Lamark	-	-	-	N	-	-
C. litteratus Linnaeus	-	-	-	-	-	-
C. lividus Hwass	-	-	1.0(1)	-	-	-
C. miles Linnaeus	-	-	-	-	-	-
C. pulicarius Hwass	N	-	1.0(1)	-	-	-
C. quercinus Solander	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT B_1	B_2	B_3	B_4	B_5	B_6
C. rattus Hwass	-	-	-	-	-	-
C. sanguinolentus Quoy & Gaimard	-	-	-	-	-	-
C. sponsalis Hwass	-	-	-	-	-	-
C. virgo Linnaeus	-	-	-	-	-	-
C. vitulinus Hwass	-	-	-	-	-	-
Terebridae						
Terebra maculata (Linnaeus)	-	-	-	-	-	-
T. sublata (Linnaeus)	-	-	-	-	-	-
Bivalvia						
Mytilidae						
Modiolus sp.	-	-	-	-	-	-
Pinnidae						
Pinna muricata (Linnaeus)	1.0(1)	-	-	-	-	-
Isognominidae						
Isognomon perna (Linnaeus)	-	-	-	1.0(1)	-	-
Lucinidae						
Ctena bella (Conrad)	3.0(3)	1.0(3)	-	-	-	-
Codakia punctata (Linnaeus)	-	-	-	-	-	-
Cartidae						
Cardita variegata Bruguiere	-	-	-	-	-	-
Cardiidae						
Fragum fragum (Linneaus)	1.2(3)	1.2(6)	1.0(1)	-	-	-
Tridacnidae						
Tridacna maxima (Roeding)	-	-	-	-	1.0(1)	-

TABLE 4. (continued)

SPECIES	TRANSECT					
	B_1	B_2	B_3	B_4	B_5	B_6
Tellinidae						
Quidnapagus palatum Iredale	1.0(1)	-	-	-	-	-
Scutarcopagia scobinata (Linnaeus)	-	-	-	-	-	-
Tellina robusta (Hanley)	-	-	1.0(1)	-	-	-
Tellina sp.	-	-	-	-	-	-
Veneridae						
Grafrarium pectinatum (Linnaeus)	2.0(1)	-	-	-	-	-
G. tumidum (Roeding)	-	-	-	-	-	-
Glycodonta marica (Linneaus)	-	-	-	-	-	-
Lioconcha hieroglyphica (Conrad)	-	1.0(1)	-	-	-	-
Periglypta reticulata (Linnaeus)	-	-	-	-	-	-
Pitar sp.	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT					
	C	D	E	F	G	H
Gastropoda						
Acmaeidae						
Patelloida chamorrorum Lindberg & Vermeij	-	-	-	27.0(1)	16.0(1)	-
Trochidae						
Trochus niloticus (Linnaeus)	1.8(8)	-	4.0(10)	1.0(2)	-	2.0(1)
T. intextus Kiener	-	-	-	-	-	-
T. conus Gmelin	-	-	-	-	-	-
Tectus pyramis (Born)	2.0(1)	-	-	1.0(1)	-	-
Turbinidae						
Turbo argystomus Linnaeus	-	-	-	-	-	1.0(1)
T. setosus Gmelin	-	-	-	1.0(1)	-	1.5(2)
Astrea rhodostoma Lamarck	-	-	1.0(1)	-	-	-
Phasianellidae						
Phasianella solida (Born)	-	-	-	-	-	-
Neritidae						
Nerita plicata Linnaeus	-	-	-	-	4.0(1)	-
Vermetidae						
Dendropoma maxima Sowerby	8.8(4)	-	3.5(4)	4.0(3)	-	-
Cerithiidae						
Cerithium alveolus (Harmon & Jaquinot)	-	-	-	-	-	-
C. columna Sowerby	-	-	-	-	-	-
C. nodulosum Bruguiere	TNTC(14)	1.9(7)	1.1(7)	1.5(2)	-	-
C. zonatum (Wood)	TNTC(14)	TNTC(17)	TNTC(19)	1.0(1)	-	-
Rhinoclavis aspera (Linnaeus)	-	-	-	1.7(3)	1.0(1)	-
R. fasciata (Bruguiere)	-	1.0(2)	-	1.0(4)	1.0(1)	-
Strombidae						
Lambis chiragra Linnaeus	-	-	-	-	-	-
L. lambis Linnaeus	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
L. truncata (Kiener)	-	-	-	-	-	-
Strombus gibberulus (Roeding)	-	-	-	3.8(4)	15.0(1)	-
S. lentiginosus Linnaeus	-	-	N	-	-	-
S. luhuanus Linnaeus	-	-	2.0(2)	2.0(3)	4.0(2)	-
Cypraeidae						
Cypraea annulus Linnaeus	-	-	N	-	2.0(3)	2.0(1)
C. helvola Linnaeus	-	-	N	-	-	-
C. lynx Linnaeus	-	-	-	N	-	-
C. moneta Linnaeus	2.7(14)	-	2.0(1)	1.0(3)	3.0(3)	-
C. tigris Linnaeus	-	-	-	-	-	-
Tonnidae						
Tonna perdix (Linnaeus)	-	-	N	-	-	-
Naticidae						
Natica sp.	-	-	-	-	-	-
Cassidae						
Cassis cornuta (Linnaeus)	-	-	-	-	-	-
Cymatiidae						
Cymatium muricinum (Roeding)	-	-	-	-	-	-
C. nicobaricum (Roeding)	1.0(3)	-	1.0(1)	-	-	-
Distorsio anus (Linnaeus)	-	-	-	-	-	1.0(1)
Bursidae						
Bursa bufonia (Gmelin)	-	-	-	-	1.0(1)	-
Muricidae						
Drupa morum Roeding	-	-	-	1.0(1)	-	-
D. ricinus (Linnaeus)	-	-	-	-	1.0(1)	-
Morula uva (Roeding)	1.5(2)	-	-	-	1.0(2)	-
Chicoreus brunneus (Link)	1.0(1)	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT C	D	E	F	G	H
Buccinidae						
Cantharus fumosus (Dillwyn)	TNTC(14)	TNTC(17)	TNTC(19)	-	-	-
C. undosus (Linnaeus)	-	-	-	-	-	-
Fasciolariidae						
Latirus maculatus (Reeve)	-	-	-	-	-	-
L. polygonus (Reeve)	-	-	-	-	-	-
Peristernia nassatula (Lamark)	-	-	-	-	2.0(1)	-
Olividae						
Oliva annulata Gmelin	-	-	1.0(1)	-	-	-
Vasidae						
Vasum turbinellus (Linnaeus)	1.0(1)	-	1.0(1)	1.0(1)	1.5(2)	1.0(1)
Harpidae						
Harpa amouretta (Roeding)	-	-	-	-	-	1.0(1)
Mitriidae						
Mitra imperialis (Roeding)	1.0(1)	-	-	-	-	-
M. litterata Lamarck	-	-	-	-	1.0(1)	-
Costellariidae						
Vexillum exasperatum Gmelin	-	-	-	-	-	-
V. amabilis (Reeve)	-	-	-	1.0(1)	1.0(1)	-
V. coronatum (Helbling)	-	-	-	-	-	-
Conidae						
Conus chaldeus Roeding	-	-	N	-	1.0(1)	-
C. coronutus Gmelin	-	-	-	N	-	-
C. distans Hwass	-	-	-	-	-	-
C. ebraeus Linnaeus	1.0(1)	N	-	-	1.3(3)	-
C. eburneus Hwass	-	-	-	-	-	-
C. flavidus Lamark	-	-	-	1.0(1)	1.0(1)	-
C. litteratus Linnaeus	-	-	-	-	-	-

TABLE 4. (continued)

SPECIES	TRANSECT					
	C	D	E	F	G	H
C. lividus Hwass	-	-	-	1.0(1)	1.0(1)	1.0(1)
C. miles Linnaeus	-	N	-	-	-	-
C. pulicarius Hwass	-	-	-	1.0(1)	-	-
C. quercinus Solander	-	N	-	-	-	-
C. rattus Hwass	1.0(1)	-	1.0(1)	-	1.0(1)	-
C. sanguinolentus Quoy & Gaimard	-	-	-	-	-	-
C. sponsalis Hwass	-	-	-	-	3.0(2)	-
C. virgo Linnaeus	-	-	-	-	-	-
C. vitulinus Hwass	-	N	-	-	-	-
Terebridae						
Terebra maculata (Linnaeus)	-	-	-	-	-	-
T. sublata (Linnaeus)	-	-	-	-	-	-
Bivalvia						
Mytilidae						
Modiolus sp.	-	-	1.0(2)	-	2.0(1)	-
Pinnidae						
Pinna muricata (Linnaeus)	-	-	-	-	-	-
Isognominidae						
Isognomon perna (Linnaeus)	-	-	-	1.0(1)	-	-
Lucinidae						
Ctena bella (Conrad)	2.0(2)	-	-	-	-	-
Codakia punctata (Linnaeus)	-	-	-	-	-	-
Cartidae						
Cardita variegata Bruguiere	-	-	-	2.0(1)	-	-
Cardiidae						
Fragum fragum (Linneaus)	1.0(1)	1.0(1)	1.7(3)	1.2(5)	-	-

TABLE 4. (continued)

SPECIES	TRANSECT					
	C	D	E	F	G	H
Tridacnidae						
Tridacna maxima (Roeding)	1.5(8)	-	1.0(1)	1.3(3)	-	1.0(2)
Tellinidae						
Quidnapagus palatum Iredale	-	-	-	-	-	-
Scutarcopagia scobinata (Linnaeus)	8.0(1)	-	-	-	-	-
Tellina robusta (Hanley)	-	-	-	-	-	-
Tellina sp.	-	-	-	-	-	-
Veneridae						
Grafrarium pectinatum (Linnaeus)	-	-	-	-	-	-
G. tumidum (Roeding)	9.0(1)	-	-	-	-	-
Glycodonta marica (Linneaus)	-	-	-	-	-	-
Lioconcha hieroglyphica (Conrad)	-	-	-	-	-	-
Periglypta reticulata (Linnaeus)	-	-	-	-	-	-
Pitar sp.	-	-	-	-	-	-

TABLE 5. Distributional zonation of occurrence for echinoderms on the first 100 m of transect C, D, and E, 14 months after data presented on Table 1 was obtained. Zones are determined by the distance in meters from the starting end of the transect. A dash (-) represents that this organism was not found on that transect. An N represents the occurrence of the organism on the transect, but outside the sampling area.

SPECIES	TRANSECT C	TRANSECT D	TRANSECT E
Ophiuroidea (Brittle stars)			
Ophicoma sp.	-	-	-
Asteroidea (Sea stars)			
Culcita novaeguineae (Muller & Troschel)	-	-	-
Fromia milliporella (Lamarck)	-	-	-
Linkia laevigata (Linnaeus)	-	-	-
L. multifora (Lamarck)	-	-	-
Acanthaster planci (Linnaeus)	-	-	-
Crinoidea			
Comanthus schlegeli (Carpenter)	-	-	-
Echinoidea (Sea urchins)			
Diadema savignyi Michelin	-	-	-
Echinothrix diadema (Linnaeus)	-	-	-
Toxopneustes pileolus (Lamarck)	-	-	-
Tripneustes gratilla (Linnaeus)	-	-	-
Echinostephanus aciculatus A. Agassiz	-	-	-
Echinometra mathaei (de Blainvelle)	-	-	-
Heterocentrotus mammillatus (Linnaeus)	-	-	-
Holothuriodea (Sea cucumbers)			
Stichopus chloronotus Brandt	-	-	-
S. horrens Selenka	-	-	-
Actinopyga echinites (Jaeger)	-	-	-
A. mauritiana (Quoy & Gaimard)	-	-	-
Bohadschia argus Jaeger	-	-	-
B. marmorata Jaeger	-	-	-
Labidodemas semperianum (Selenka)	-	-	-
Holothuria atra Jaeger	30-100	0-100	0-100
H. axiologa H. L. Clark	-	-	-
H. cinerascens (Brandt)	-	-	-
H. hilla Lesson	-	-	-
H. impatiens (Forskal)	-	-	-
H. leucospilota (Brandt)	-	30-60	-
H. nobilis (Selenka)	-	-	-
Synapta maculata (Chamisso & Eysenhardt)	-	-	-

TABLE 6. Distributional zonation of occurrence for mollusks on the first 100 m of transects C, D, and E, 14 months after the data in Table 2 was obtained. Zones are determined by the distance in meters from the starting end of the transect. A dash (-) represents that this organism was not found on that transect. An N represents the occurrence of the organism on the transect line, but outside the sampling area.

SPECIES	TRANSECT C	TRANSECT D	TRANSECT E
Gastropoda			
Acmaeidae			
Patelloida chamorrorum Lindberg & Vermeij	-	-	-
Trochidae			
Trochus niloticus (Linnaeus)	-	-	-
T. intextus Kiener	-	-	-
T. conus Gmelin	-	-	-
Tectus pyramis (Born)	-	-	-
Turbinidae			
Turbo argystomus Linnaeus	-	-	-
T. setosus Gmelin	-	-	-
Astrea rhodostoma Lamarck	-	-	-
Phasianellidae			
Phasianella solida (Born)	-	-	-
Neritidae			
Nerita plicata Linnaeus	-	-	-
Vermetidae			
Dendropoma maxima Sowerby	-	-	-
Cerithiidae			
Cerithium alveolus (Harmon & Jaquinot)	-	-	-
C. columna Sowerby	-	-	-
C. nodulosum Bruguiere	-	-	-
C. zonatum (Wood)	50-100	10-100	-
Rhinoclavis aspera (Linnaeus)	-	50-60	20-90
R. fasciata (Bruguiere)	-	30-80	20-90
Strombidae			
Lambis chiragra Linnaeus	-	-	-
L. lambis Linnaeus	-	-	-
L. truncata (Kiener)	-	-	-
Strombus gibberulus (Roeding)	-	-	-
S. lentiginosus Linnaeus	-	-	-
S. luhuanus Linnaeus	-	-	-
Cypraeidae			
Cypraea annulus Linnaeus	-	-	-
C. helvola Linnaeus	-	-	-

TABLE 6. (continued)

SPECIES	TRANSECT C	TRANSECT D	TRANSECT E
C. lynx Linnaeus	-	-	-
C. moneta Linnaeus	-	-	-
C. tigris Linnaeus	-	-	-
Naticidae			
Natica sp.	-	N	-
Tonnidae			
Tonna perdix (Linneaus)	-	-	-
Cassidae			
Cassis cornuta (Linnaeus)	-	-	-
Cymatiidae			
Cymatium muricinum (Roeding)	-	-	-
C. nicobaricum (Roeding)	-	-	-
Distorsio anus (Linnaeus)	-	-	-
Bursidae			
Bursa bufonia (Gmelin)	-	-	-
Muricidae			
Drupa morum Roeding	-	-	-
D. ricinus (Linnaeus)	-	-	-
Morula uva (Roeding)	-	-	-
Chicoreus brunneus (Link)	-	-	-
Buccinidae			
Cantharus fumosus (Dillwyn)	-	50-60	-
C. undosus (Linnaeus)	-	30-70	-
Fasciolariidae			
Latirus maculatus (Reeve)	-	-	-
L. polygonus (Reeve)	-	-	-
Peristernia nassatula (Lamark)	-	-	-
Olividae			
Oliva annulata Gmelin	-	-	-
Vasidae			
Vasum turbinellus (Linnaeus)	-	-	-
Harpidae			
Harpa amouretta (Roeding)	-	-	-
Mitriidae			
Mitra imperialis (Roeding)	-	-	-
M. litterata Lamarck	-	-	-

TABLE 6. (continued)

SPECIES	TRANSECT C	TRANSECT D	TRANSECT E
Costellariidae			
Vexillum exasperatum Gmelin	-	-	-
V. amabilis (Reeve)	-	-	-
V. coronatum (Helbling)	-	-	-
Conidae			
Conus chaldeus Roeding	-	-	-
C. coronutus Gmelin	-	-	-
C. distans Hwass	-	-	-
C. ebraeus Linnaeus	-	-	-
C. eburneus Hwass	-	-	-
C. flavidus Lamark	-	-	-
C. litteratus Linnaeus	-	-	-
C. lividus Hwass	-	-	-
C. miles Linnaeus	-	-	-
C. pulicarius Hwass	-	-	N
C. quercinus Solander	-	-	-
C. rattus Hwass	-	-	-
C. sanguinolentus Quoy & Gaimard	-	-	-
C. sponsalis Hwass	-	-	-
C. virgo Linnaeus	-	-	-
C. vitulinus Hwass	-	-	-
Terebridae			
Terebra maculata (Linnaeus)	-	-	-
T. sublata (Linnaeus)	-	-	-
Bivalvia			
Mytilidae			
Modiolus sp.	-	-	-
Pinnidae			
Pinna muricata (Linnaeus)	-	40-70	-
Isognominidae			
Isognomon perna (Linnaeus)	-	-	-
Lucinidae			
Ctena bella (Conrad)	40-70	20-60	-
Codakia punctata (Linnaeus)	N	N	-
Cartidae			
Cardita variegata Bruguiere	-	-	-
Cardiidae			
Fragum fragum (Linneaus)	-	-	10-20
Tridacnidae			
Tridacna maxima (Roeding)	-	-	-

TABLE 7. Abundances for echinoderms on the first 100 m of transects C, E, and E 14 months after the data presented in Table 3 was obtained. Densities are given as individuals per 10 m^2, followed by the number of quadrats in which this organism was found. A dash (-) represents that this organism was not found on that transect. An N represents the occurrence of the organism on the transect line, but outside the sampling area.

SPECIES	TRANSECT C	TRANSECT D	TRANSECT E
Ophiuroidea (Brittle stars)			
Ophicoma sp.	-	-	-
Asteroidea (Sea stars)			
Culcita novaeguineae (Muller & Troschel)	-	-	-
Fromia milliporella (Lamarck)	-	-	-
Linkia laevigata (Linnaeus)	-	-	-
L. multifora (Lamarck)	-	-	-
Acanthaster planci (Linnaeus)	-	-	-
Crinoidea			
Comanthus schlegeli (Carpenter)	-	-	-
Echinoidea (Sea urchins)			
Diadema savignyi Michelin	-	-	-
Echinothrix diadema (Linnaeus)	-	-	-
Toxopneustes pileolus (Lamarck)	-	-	-
Tripneustes gratilla (Linnaeus)	-	-	-
Echinostephanus aciculatus A. Agassiz	-	-	-
Echinometra mathaei (de Blainvelle)	-	-	-
Heterocentrotus mammillatus (Linnaeus)	-	-	-
Holothuriodea (Sea cucumbers)			
Stichopus chloronotus Brandt	-	-	-
S. horrens Selenka	-	-	-
Actinopyga echinites (Jaeger)	-	-	-
A. mauritiana (Quoy & Gaimard)	-	-	-
Bohadschia argus Jaeger	-	-	-
B. marmorata Jaeger	-	-	-
Labidodemas semperianum (Selenka)	-	-	-
Holothuria atra Jaeger	10.9(7)	30.6(10)	13.3(8)
H. axiologa H. L. Clark	-	-	-
H. cinerascens (Brandt)	-	-	-
H. hilla Lesson	-	-	-
H. impatiens (Forskal)	-	-	-
H. leucospilota (Brandt)	-	1.0(1)	-
H. nobilis (Selenka)	-	-	-
Synapta maculata (Chamisso & Eysenhardt)	-	-	-

TABLE 6. (continued)

SPECIES	TRANSECT C	D	E
Tellinidae			
Quidnapagus palatum Iredale	N	N	-
Scutarcopagia scobinata (Linnaeus)	N	N	-
Tellina robusta (Hanley)	-	-	-
Tellina sp.	N	-	-
Veneridae			
Grafrarium pectinatum (Linnaeus)	N	N	-
G. tumidum (Roeding)	-	-	-
Glycodonta marica (Linneaus)	-	-	-
Lioconcha hieroglyphica (Conrad)	-	-	-
Periglypta reticulata (Linnaeus)	-	-	-
Pitar sp.	N	-	-

TABLE 8. Abundances for mollusks on the first 100 m of transect C, D, and E 14 months after the data presented in Table 4 was obtained. Densities are given as individuals per 10 m^2, followed by the number of quadrats in which this organism was found. A dash (-) represents that this organism was not found on that transect. An N represents the occurrence of the organism on the transect line, but ouside the sampling area.

SPECIES	TRANSECT C	TRANSECT D	TRANSECT E
Gastropoda			
Acmaeidae			
Patelloida chamorrorum Lindberg & Vermeij	-	-	-
Trochidae			
Trochus niloticus (Linnaeus)	-	-	-
T. intextus Kiener	-	-	-
T. conus Gmelin	-	-	-
Tectus pyramis (Born)	-	-	-
Turbinidae			
Astrea rhodostoma Lamarck	-	-	-
Turbo argystomus Linnaeus	-	-	-
T. setosus Gmelin	-	-	-
Phasianellidae			
Phasianella solida (Born)	-	-	-
Neritidae			
Nerita plicata Linnaeus	-	-	-
Vermetidae			
Dendropoma maxima Sowerby	-	-	-
Cerithiidae			
Cerithium alveolus (Harmon & Jaquinot)	-	-	-
C. columna Sowerby	-	-	-
C. nodulosum Bruguiere	-	-	-
C. zonatus (Wood)	TNTC(4)	TNTC(7)	-
Rhinoclavis aspera (Linnaeus)	-	1.0(1)	1.0(6)
R. fasciata (Bruguiere)	-	1.0(3)	1.0(5)
Strombidae			
Lambis chiragra Linnaeus	-	-	-
L. lambis Linnaeus	-	-	-
L. truncata (Kiener)	-	-	-
Strombus gibberulus (Roeding)	-	-	-
S. lentiginosus Linnaeus	-	-	-
S. luhuanus Linnaeus	-	-	-
Cypraeidae			
Cypraea annulus Linnaeus	-	-	-
C. helvola Linnaeus	-	-	-

TABLE 8. (continued)

SPECIES	TRANSECT C	D	E
C. lynx Linnaeus	-	-	-
C. moneta Linnaeus	-	-	-
C. tigris Linnaeus	-	-	-
Naticidae			
Natica sp.	-	N	-
Cassidae			
Cassis cornuta (Linnaeus)	-	-	-
Tonnidae			
Tonna perdix (Linnaeus)	-	-	-
Cymatiidae			
Cymatium muricinum (Roeding)	-	-	-
C. nicobaricum (Roeding)	-	-	-
Distorsio anus (Linnaeus)	-	-	-
Bursidae			
Bursa bufonia (Gmelin)	-	-	-
Muricidae			
Drupa morum Roeding	-	-	-
D. ricinus (Linnaeus)	-	-	-
Morula uva (Roeding)	-	-	-
Chicoreus brunneus (Link)	-	-	-
Buccinidae			
Cantharus fumosus (Dillwyn)	-	2.0(1)	-
C. undosus (Linnaeus)	-	6.0(3)	-
Fasciolariidae			
Latirus maculatus (Reeve)	-	-	-
L. polygonus (Reeve)	-	-	-
Peristernia nassatula (Lamark)	-	-	-
Olividae			
Oliva annulata Gmelin	-	-	-
Vasidae			
Vasum turbinellus (Linnaeus)	-	-	-
Harpidae			
Harpa amouretta (Roeding)	-	-	-
Mitriidae			
Mitra imperialis (Roeding)	-	-	-
M. litterata Lamarck	-	-	-

TABLE 8. (continued)

SPECIES	TRANSECT C	D	E
Costellariidae			
Vexillum exasperatum Gmelin	-	-	-
V. amabilis (Reeve)	-	-	-
V. coronatum (Helbling)	-	-	-
Conidae			
Conus chaldeus Roeding	-	-	-
C. coronutus Gmelin	-	-	-
C. distans Hwass	-	-	-
C. ebraeus Linnaeus	-	-	-
C. eburneus Hwass	-	-	-
C. flavidus Lamark	-	-	-
C. litteratus Linnaeus	-	-	-
C. lividus Hwass	-	-	-
C. miles Linnaeus	-	-	-
C. pulicarius Hwass	-	-	N
C. quercinus Solander	-	-	-
C. rattus Hwass	-	-	-
C. sanguinolentus Quoy & Gaimard	-	-	-
C. sponsalis Hwass	-	-	-
C. virgo Linnaeus	-	-	-
C. vitulinus Hwass	-	-	-
Terebridae			
Terebra maculata (Linnaeus)	-	-	-
T. sublata (Linnaeus)	-	-	-
Bivalvia			
Mytilidae			
Modiolus sp.	-	-	-
Pinnidae			
Pinna muricata (Linnaeus)	-	1.0(2)	-
Isognominidae			
Isognomon perna (Linnaeus)	-	-	-
Lucinidae			
Ctena bella (Conrad)	1.0(2)	1.5(2)	-
Codakia punctata (Linnaeus)	N	N	-
Cartidae			
Cardita variegata Bruguiere	-	-	-
Cardiidae			
Fragum fragum (Linneaus)	-	-	1.0(1)
Tridacnidae			
Tridacna maxima (Roeding)	-	-	-

TABLE 8. (continued)

SPECIES	TRANSECT C	D	E
Tellinidae			
Quidnapagus palatum Iredale	N	N	-
Scutarcopagia scobinata (Linnaeus)	N	N	-
Tellina robusta (Hanley)	-	-	-
Tellina sp.	N	-	-
Veneridae			
Grafrarium pectinatum (Linnaeus)	N	N	-
G. tumidum (Roeding)	-	-	-
Glycodonta marica (Linneaus)	-	-	-
Lioconcha hieroglyphica (Conrad)	-	-	-
Periglypta reticulata (Linnaeus)	-	-	-
Pitar sp.	N	-	-

FISHES

by

Paul D. Gates

Methods

The fish surveys were conducted from March 24 to 30, 1986. Fish censuses were carried out in the folling manner. Along each of the primary transects (A through H) the reef was broadly classified into zones which roughly paralleled the shore. Zones were determined visually based on physiographic features which correlated with different habitat types. A 100-m transect tape was strectched within each zone. Then a surveyor, using snorkel or scuba, swam along the transect and counted the number of fish of each species within 1 m on either side of the transect. After transect counts were completed the surveyor swam throughout the zone and made an additional species list of fishes that were present in the zone but not encountered along the transect.

Results

The position of the census transects relative to the permanent sampling transects A - H are depicted in Figures 1-4. Table 1 indicates the primary features of each habitat zone and lists the census transects contained within each classification. Results of individual transects which list species and numbers of individuals represented are given in Tables 2 and 3. A list of the additional species of fishes sighted near census transects along permanent transects A - E appear in Table 4.

When census transects from the same habitat zones are considered collectively, general patterns are evident. The zones that are characterized by seagrasses or sandy bottoms are represented by the fewest species as well as the fewest individuals (Tables 1 - 4). The habitat zones nearest the reef platform margin, particularyly along the widest reef transects (A6, B6, and E2), consistently support the greatest diversity of fishes. The fish fauna most typical along the narrow, most northern reef platform transects (F and G) was comprised of small, substrate-attached species adapted to high surge environment.

Discussion

Several points must be addressed to fully utilize this type of survey of fishes. First of all, these results are best suited to developing general impressions of fish assemblages within distinct habitats. The patterns that are represented by these results are consistent with other observations in similar habitats (Amesbury et al., 1979). As habitat complexity increased species diversity became greater, although individuals of a single species were not necessarily more abundant.

Secondly, recruitment patterns of resident species are important. Therefore, the time of year that surveys are made needs to be considered if data is gathered with comparisons in mind. The abundances and distributions of the pomacentrids Chrysiptera leucompomus and C. glaucus illustrate this point. Not only were these fishes two of the most widely distributed species, they were also the most abundant representatives along several census transects. Adult fishes of these species are most commonly associated with reef flat areas like transects G and H. Throughout their distribution along survey transects many individuals of these species were small juveniles. It seems likely that their abundance was related to a recent recruitment event. If that is the case, it is unlikely that the number of individuals of these species will remain at the present levels in the future.

Additionally, these results probably under estimate the number of species in all habitat types. Visual censusing techniques work best for conspicuous species of fishes, particularly for species which are substrate-attached. Fishes with crepuscular or nocturnal habits, as well as species which generally have cryptic habits are the groups most likely to be under represented.

These aspects of fish surveys point out that in a strict sense fishes are poor barometers for monitoring environmental change. Too many widely fluctuating, and in many cases, not well understood factors influence their reproductive success, recruitment, and permanence at any locality. Fishes are likely to respond to environmental changes, but unless responses are marked and dramatic, it remains unlikely that any specific cause and effect relationship can be established for changes in fish community structure.

Furthermore, because of the strong prevailing currents, any effects of shoreline development on fish communities will have the greatest impact down-current, southwest of the survey area, and not where fish surveys were carried out.

There is one way that development, particularly nearshore dredging, could directly affect fish communities in the survey area. Seagrass, and seagrass/sand habitats occur nearest to the shoreline. Seagrass beds served as nurseries for juvenile fishes of many species. Once individuals reach a certain size they leave the seagrass beds and become members of fish communities located elsewhere on the reef. Dredging away the seagrass beds would destroy this source of important spawning grounds for fishes.

Literature Cited

Amesbury, S. S., D. R. Lassuy, R. F. Mayers, and V. Tyndzik. 1979. A survey of the fish resources of Saipan Lagoon. Univ. of Guam Mar. Lab. Tech. Rept. No. 59. 58 p.

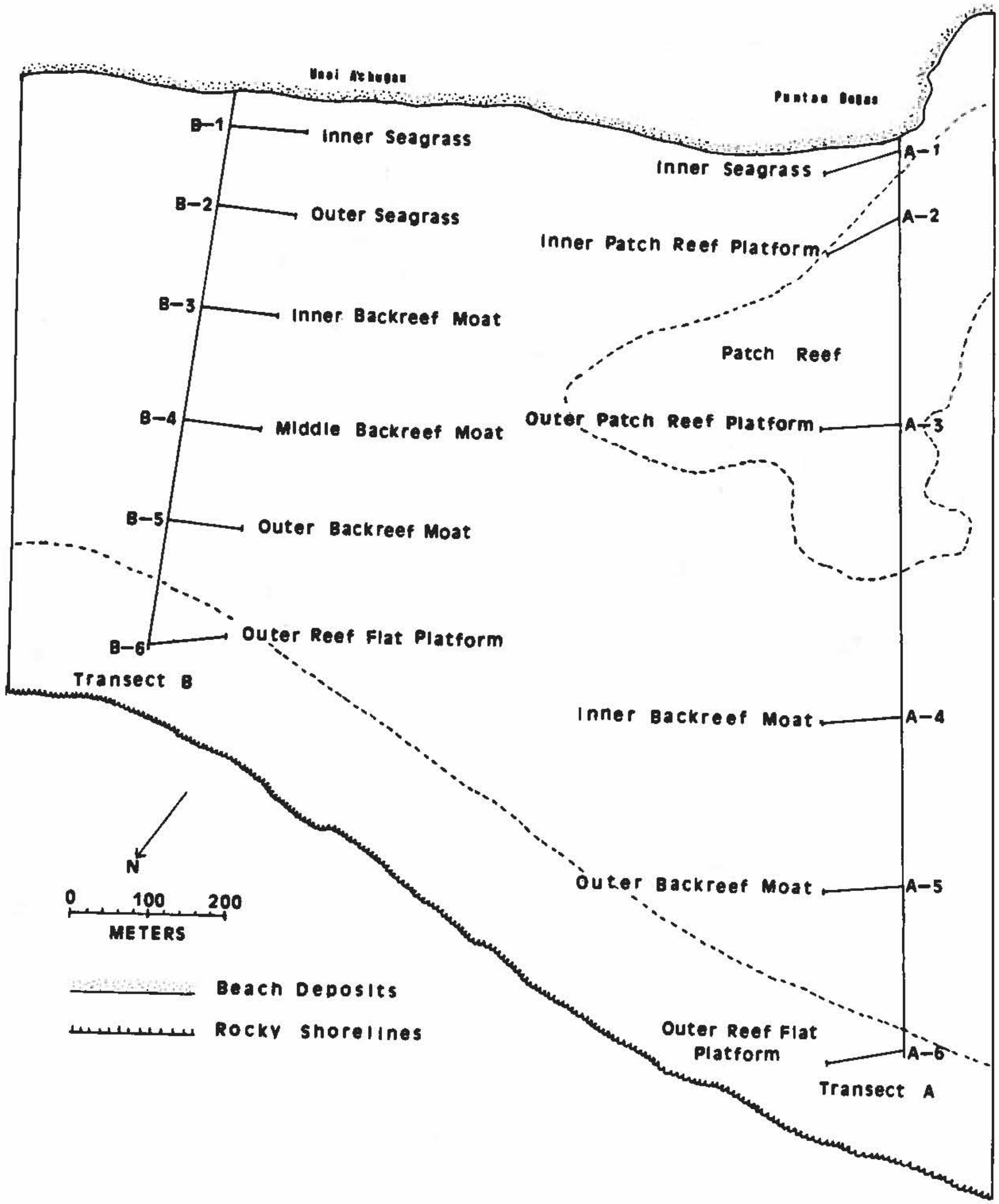

Figure 1. Location of fish-census transects along permanent transects A and B.

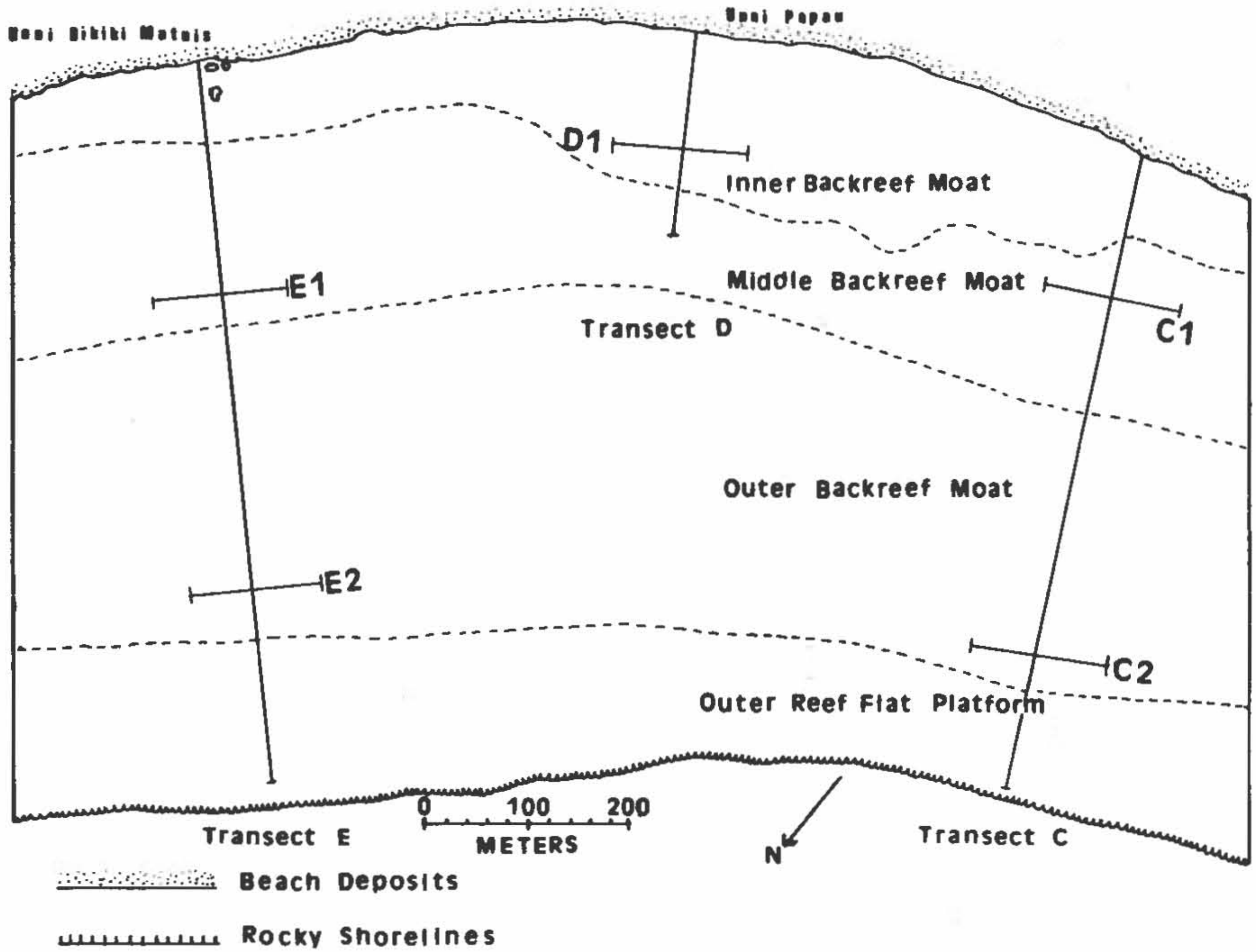

Figure 2. Location of fish-census transects along permanent transects C, D, and E.

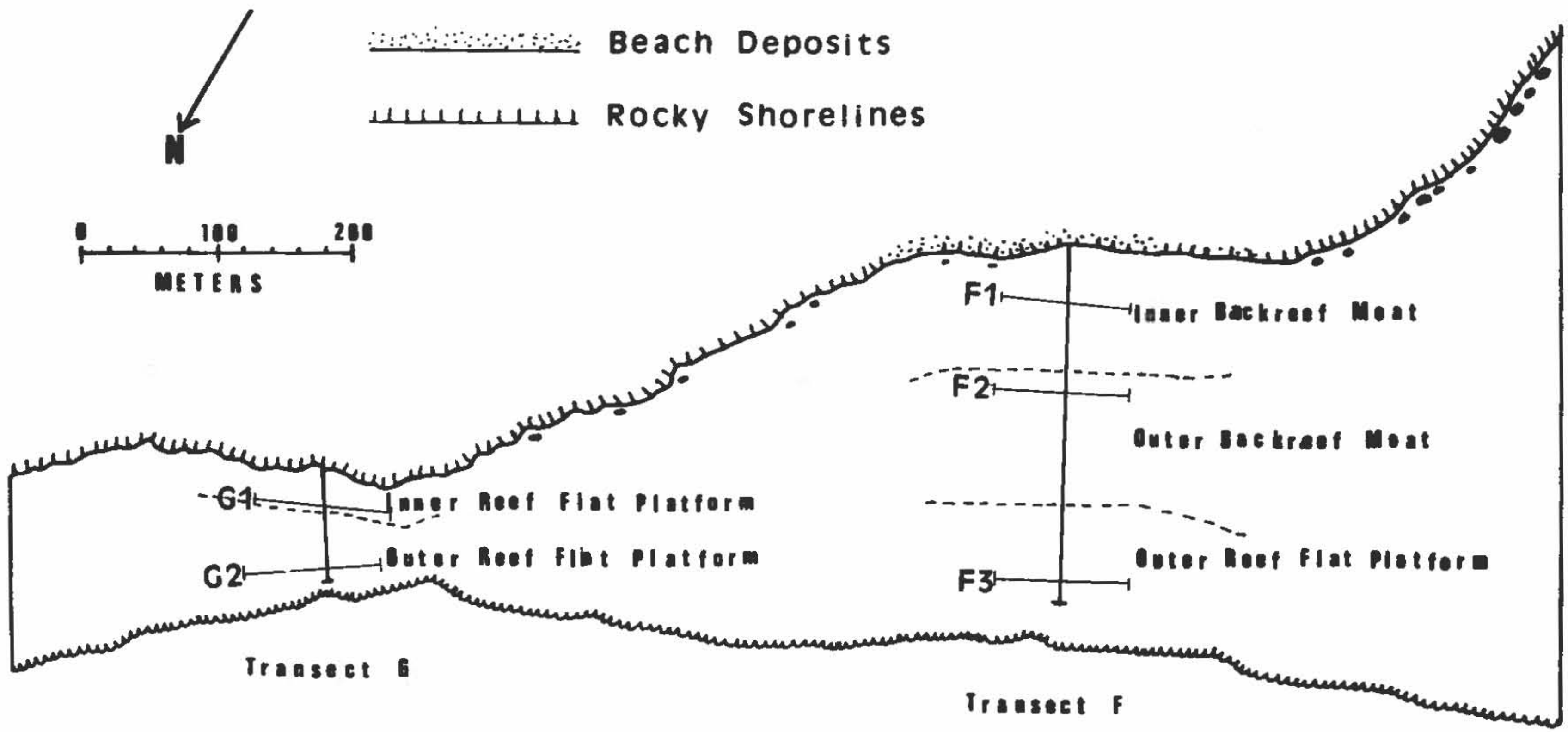

Figure 3. Location of fish-census transects along permanent transects F and

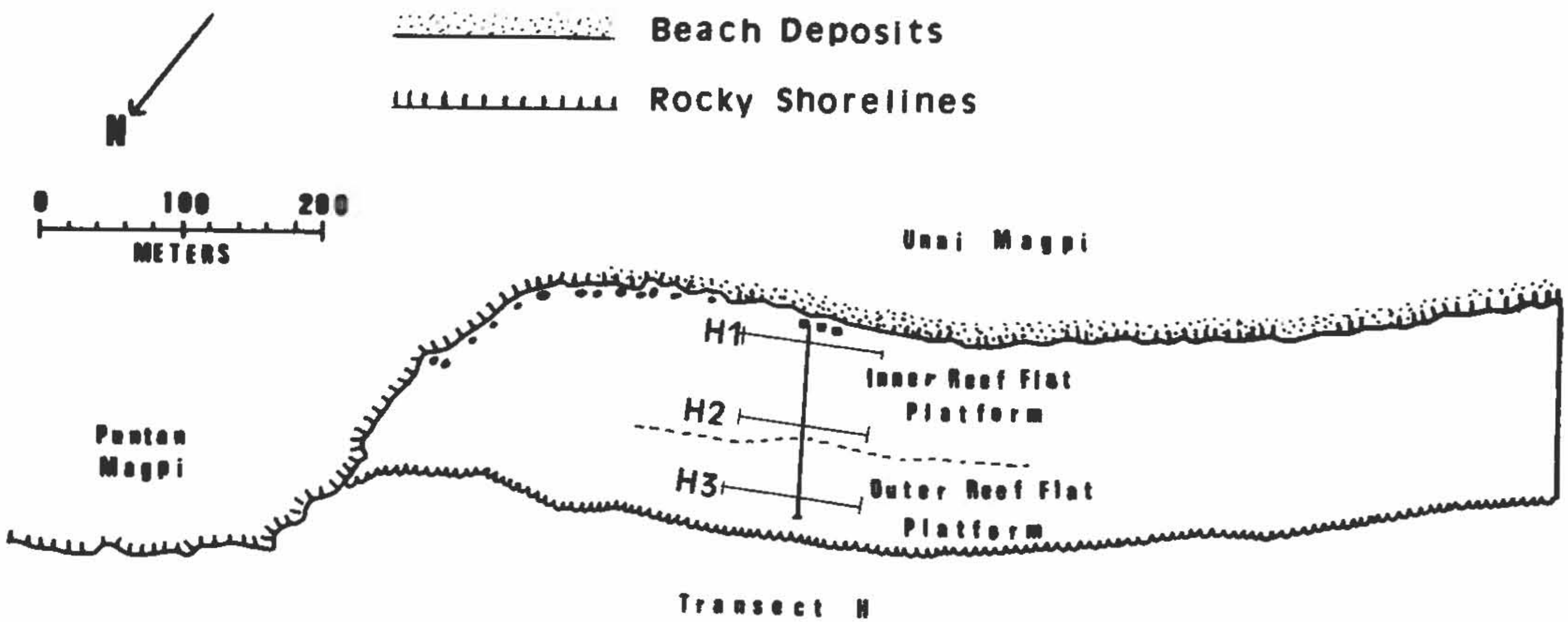

Figure 4. Location of fish-census transects along permanent transect H.

Table 1. Description of habitat-zone features followed by a list of the census transects within each zone.

ZONE CHARACTERISTICS	CENSUS TRANSECTS
Pavement with a thin veneer of sand	G1, H1
Scattered seagrass (<u>Holdule</u> <u>uninervis</u>) with sand/mud bottom	A1, B1
Seagrass beds (<u>Halodule</u> <u>uninervis</u>)	B2, C1, D1, E1
Coral, coralline rubble, dead coral in-situ, pockets of sand	A2, B4, C2, E2, F1, F2, H2
Low profile coral and dead coral in-situ	A3
Sandy bottom, scattered small corals, coralline algae, or fleshly algae	A4, A5, B3, B4
Predominately pavement, dead coral in-situ, some fleshly algae	F3, G2
<u>Acropora</u> beds	B5, H3
Pavement with large limestone boulders, live corals, and pockets of sand	A6, B6

Table 2. Number of individuals of fish species observed along transects A & B.

SPECIES	TRANSECTS A 1	2	3	4	5	6	B 1	2	3	4	5	6
MURAENIDAE												
Echidna nebulosa										1		
SYNODONTIDAE												
Saurida gracilis		1										
HOLOCENTRIDAE												
Neoniphon sammara						2				1	11	
Sargocentron caudimaculatus						1						
Sargocentron spinniferum						1						
AULOSTOMIDAE												
Aulostomas chinensis						1						
SYNGNATHIDAE												
Corythoichthys intestinalis		1					1					
APOGONIDAE												
Apogon novemfasciatus		2	3				1					
Chelodipterus quinquelineata											1	
LETHRINIDAE												
Lethrinus sp.	4							2				
MULLIDAE												
Mulloidichthys flavolineatus						1						
Parupeneus barberinus	2	1				2		2				
Perupeneus bifasciatus						1						
Parupeneus pleurostigmata											2	3
Parupeneus poryphyreus			1			2						
CIRRHITIDAE												
Paracirrhites arcatus						1						2
Paracirrhites foresteri					1	1						

Table 2. (Continued)

SPECIES	A 1	2	3	4	5	6	B 1	2	3	4	5	6
CHAETODONTIDAE												
Chaetodon auriga			1							3	2	
Chaetodon citrinell											1	
Chaetodon ephippium			1							1	1	
Chaetodon kleini						1						
Chaetodon lunula	1		1			3						
Chaetodon punctatofasciatus						2						
Chaetodon trifasciatus											7	
Heniochus chrysostomus											1	
Megaprotodon trifascialis											9	
POMACANTHIDAE												
Centropyge flavissimus						1					1	
POMACENTRIDAE												
Chromis atripectoralis						4					1	
Chromis caerulea										52	78	
Chrysiptera glaucus			13									23
Chrysiptera leucopomas		3	15	3		14	7	9	1	3		76
Dascyllus aruanus	3	38		4	6			1	70	66	130	3
Dascyllus reticulatus						5						
Dascyllus trimaculatus				10		5						
Plectroglyphydodon dickii						3					10	
Plectroglyphydodon lacrymatus						1						
Pomacentrus pavo				1								
Pomacentrus vaiuli		22	1	4		23				5	9	13
Stegastes albifasciatus			10			1						
Stegastes lividus		10	3						2	21	140	40
Stegastes nigricans		68	135							8	9	
LABRIDAE												
Chelinus undulatus		11	1			1				3		
Chelio inermis										1	1	
Coris gaimard												1
Epibulis insidiator											3	
Gomphosus varius		1								2	11	1

Table 2. (Continued)

SPECIES	A 1	2	3	4	5	6	B 1	2	3	4	5	6
Halichoeres sp.						2						
Halichoeres hortulanus						4						1
Halichoeres margaritaceus			1									15
Halichoeres trimaculatus	12											
Halichoeres sp.		1	23									30
Hemigymnus melapterus		1									2	
Labroides dimidiatus			1			1					1	2
Macrophyaryngodon meleagris						1						
Novoculichthys taeniourus								1				
Stethojulis bandanensis		2					1	1				5
Stethojulis strigiventor	3	6			1	6		14		5	1	5
Thalassoma trilobatum						4						1
Tholassoma hardwickii											3	
Tholassoma lutescens										1	17	9
Tholassoma quinquevittatum						3						1
Thalassoma trimaculatus		53	36		3	7	3	5	2	39	11	35
juvenile labrids	1	12	3	1	2	3	3	2	11	12		5
SCARIDAE												
Calotomus sp.	3	1										
Scarus sp.		4										
Scarus sordidus			1								32	
juvenile scarids	23									12		
MUGILOIDIDAE												
Parapercis clathrata												2
ACANTHURIDAE												
Acanthurus glaucopareius						2						
Acanthurus nigrofuscus			1			4						
Acanthurus triostegus						1						1
Ctenochaetus striatus			2			4					1	2
Naso literatus		8								1		2
Zebrasoma flavescens											7	
ZANCLIDAE												
Zanclus cornutus						1					1	

Table 2. (Continued)

SPECIES	A						B					
	1	2	3	4	5	6	1	2	3	4	5	6
SIGANIDAE												
Siganus spinus		1								2		
BLENNIIDAE												
Plagiotremus tapeinosoma										1	1	
Salarias fasciatus												11
GOBIIDAE												
unidentified goby	2	3		3			1		1	1		
BALISTIDAE												
Rhinecanthus aculeatus	1	1		1	1			3		2		
MONOCANTHIIDAE												
Oxymonocanthus longirostris											2	
TETRODONTIDAE												
Canthigaster solandri		4	3			1			2	4	3	1

Table 3. Number of individuals of fish species observed along the transects C-H.

	TRANSECTS												
	C		D	E		F			G		H		
SPECIES	1	2	1	1	2	1	2	3	1	2	1	2	3
MURAENIDAE													
Gymnothorax sp.												1	
HOLOCENTRIDAE													
Neoniphon sammara		4			1		2						
APOGNIDAE													
Apogon novemfasciatus		2		3									
NEMIPTERIDAE													
Scolopsis cancellatus						2							
MULLIDAE													
Mulloidichthys flavolineatus					1								
Parupeneus barberinus			1			1							
Parupeneus poryphyreus					2								
CIRRHITIDAE													
Paracirrhites foresteri													2
CHAETODONTIDAE													
Chaetodon auriga													1
Chaetodon citrinellus					1					1			4
Chaetodon kleini					1								
Chaetodon lunula					1							2	
Chaetodon quadrimaculatus										1			2
Chaetodon trifasciatus					3	2	2	5				5	3
Megaprotodon trifascialis													1

Table 3. (Continued)

SPECIES	C 1	C 2	D 1	E 1	E 2	F 1	F 2	F 3	G 1	G 2	H 1	H 2	H 3
POMACENTRIDAE													
Amblygliphydodon curacao										1			
Abudefduf septemfasciatus											6	1	1
Chromis atripectoralis													5
Chromis caerulea			20		50	10	1					10	
Chrysiptera glaucus							4	12	12	71		43	
Chrysiptera leucopomas	1	2	2	7	1		5	61	49	87	9	47	44
Dascyllus aruanus	10	157	20	20	75	94	69	31				42	
Plectrogliphydodon dickii												1	10
Plectrogliphydodon leucozonatus		36											
Pomacentrus imparipennis										3		1	
Pomacentrus pavo				1									
Pomacentrus vaiuli												6	1
Stegastes albifasciatus					2	2	1			20	4	21	95
Stegastes lividus	1	62		18	74	35	101	15					
Stegastes nigricans					2	35	59	89				5	1
LABRIDAE													
Chelinus undulatus		1				1							
Chelio inermis	2				1								
Coris gaimard					1								
Epibulis insidiator							1						
Gomphosus varius							2	3				3	8
Halichoeres sp.									3				
Halichoeres hortulanus							1	2		2			2
Halichoeres sp.									38	28			
Hemigymnus melapterus					1		1						
Labroides dimidiatus										2			1
Labrichthys unilineatus						1							
Macropharyngodon melaegris													1
Stethojulis bandanensis		2			1	2	2	2					
Stethojulis strigiventor	1	13		4	1	12	5	4		1		1	
Thalassoma hardwickii								4					5
Thalassoma guinquevittatum								3		23		9	34
Thalassoma sp.	4			23	13	40	58	54				11	
juvenile labrids		5			3	11	3	9		8		13	11

Table 3. (Continued)

SPECIES	C 1	C 2	D 1	E 1	E 2	F 1	F 2	F 3	G 1	G 2	H 1	H 2	H 3
SCARIDAE													
Calotomus sp.	2												
Scarus sp.										6			
Scarus sordidus		10			18								
juvenile scarids	7		55			6							
TRICHONOTIDAE													
unidentified trichonotid	1												
ACANTHURIDAE													
Acanthurus glaucopareius													2
Acanthurus lineatus										1			
Acanthurus triostegus								2	1			2	
Ctenochaetus striatus		1					1						
BLENNIIDAE													
Salarias fasciatus					1	1	4	4				4	
GOBIIDAE													
Amblygobius albimaculatus				1									
BALISTIDAE													
Rhinecanthus rectangulus									2			1	
Rhinecanthus aculeatus						1			1				
MONOCANTHIIDAE													
Oxymonocanthus longirostris		2			4			2					
TETRODONTIDAE													
Arothron nigropunctatus													2
Canthigaster solandri		5		1	1	2	3					1	

Table 4. List of additional species of fishes seen near transects A-E.

SPECIES	A 1	A 2	A 3	A 4	A 5	A 6	B 1	B 2	B 3	B 4	B 5	B 6	C 1	C 2	D 1	E 1	E 2
ORECTOLOBIDAE																	
Nebrius ferrugineum					x												
MYLOBATIDAE																	
Aetobatis narinari																x	
MURAENIDAE																	
Echidna nebulosa											x						
Gymnothorax sp.							x										
SYNODONTIDAE																	
Saurida gracilis				x	x												
HOLOCENTRIDAE																	
Sargocentron caudimaculatus						x											
Sargocentron spinniferum		x															
Flammeo sp.												x					
Neoniphon sammara							x						x				
Myripristis kuntee						x			x								
AULOSTOMIDAE																	
Aulostomas chinensis		x															
SCORPAENIDAE																	
Synanceia verrucosa										x							
APOGONIDAE																	
Apogon sp. 1													x				
Apogon sp. 2				X													
Chelodipterus quinquelineata									x	x							
SERRANIDAE																	
Cephalopholis argus												x					
Cephalopholis urodelus											x	x					
Epinephelus hexagonatus				x						x							

Table 4. (Continued)

	A						B						C		D	E	
SPECIES	1	2	3	4	5	6	1	2	3	4	5	6	1	2	1	1	2
LUTJANIDAE																	
Lutjanus kasmira						x											
LETHRINIDAE																	
Lethrinus harak																x	
MULLIDAE																	
Mulloidichthys flavolineatus																	x
Parupeneus barberinus		x		x			x			x	x	x	x	x			
Parupeneus pleurostigma						x		x		x		x			x		
Parupeneus poryphyreus											x						
CIRRHITIDAE																	
Paracirrhites arcatus											x						
CHAETODONTIDAE																	
Chaetodon auriga		x		x		x	x					x		x			x
Chaetodon citrinellus						x						x					x
Chaetodon ephippium		x				x		x			x			x	x		x
Chaetodon kleini				x								x					
Chaetodon lunula		x									x			x			
Chaetodon melanotus																	x
Chaetodon ornatissimus						x						x					
Chaetodon punctatofasciatus												x					
Chaetodon quadrimaculatus						x											
Chaetodon trifasciatus		x	x			x			x	x		x		x			x
Chaetodon ulietensis																	x
Chaetodon unimaculatus											x	x					
Forcipiger flavissimus						x											
Heniochus chrysostomus						x				x		x					
Megaprotodon trifascialis						x											x
POMACANTHIDAE																	
Pomacanthus imperator							x										

Table 4. (Continued)

SPECIES	A 1	A 2	A 3	A 4	A 5	A 6	B 1	B 2	B 3	B 4	B 5	B 6	C 1	C 2	D 1	E 1	E 2
POMACENTRIDAE																	
Abudefduf sexfasciatus						x											
Chromis caerulea		x							x								
Chrysiptera leucopomus					x												
Pomacentrus pavo		x					x		x	x					x		
Pomacentrus vaiuli									x								x
Stegastes lividus									x								
Stegastes nigricans				x													
LABRIDAE																	
Chelinus trilobatus						x						x					
Chelinus undulatus															x	x	x
Chelio inermis								x							x		
Coris agyula																	x
Gomphosus varius						x					x			x			
Halichoeres hortulanus											x						x
Hemigymnus fasciatus						x											
Hemigymnus melapterus			x			x						x		x			
Labroides dimidiatus		x		x						x							x
Labrichthys unilineatus											x						
Novoculichthys taeniourus		x		x	x					x		x					
Stethojulis bandanensis										x			x				
Stethojulis strigiventor				x			x		x								
Thalassoma hardwickii		x															x
Thalassoma lutescens										x							
Thalassoma sp.				x				x									
juvenile labrids					x												
SCARIDAE																	
Calotomus sp.															x		
Scarus ghobban		x															
Scarus oviceps		x								x				x			
Scarus sordidus									x								x
Scarus sp. 1						x											
Scarus sp. 2								x									

Table 4. (Continued)

	A						B						C		D	E	
SPECIES	1	2	3	4	5	6	1	2	3	4	5	6	1	2	1	1	2
ACANTHURIDAE																	
<u>Acanthurus glaucopareius</u>											x						
<u>Acanthurus mata</u>		x					x			x					x		x
<u>Acanthurus nigrofuscus</u>		x															
<u>Acanthurus olivaceous</u>					x	x						x					
<u>Acanthurus triostegus</u>			x							x							x
<u>Ctenochaetus striatus</u>										x							
<u>Naso literatus</u>						x		x	x		x			x			x
<u>Zebrasoma flavescens</u>		x				x				x		x					x
<u>Zebrasoma veliferum</u>		x					x										x
ZANCLIDAE																	
<u>Zanclus cornutus</u>		x												x			
SIGANIDAE																	
<u>Siganus spinus</u>						x					x	x					x
BLENNIIDAE																	
<u>Salarius fasciatus</u>											x						
GOBIIDAE																	
<u>Amblygobius albimaculatus</u>									x	x					x		
<u>Ctenogobiops</u> sp.								x	x								
unidentified goby															x	x	
BALISTIDAE																	
<u>Rhinecanthus aculeatus</u>		x					x							x	x	x	x
OSTRACIONTIDAE																	
<u>Ostracion cubicus</u>		x															
TETRODONTIDAE																	
<u>Canthigaster solandri</u>			x	x			x	x							x		
DIODONTIDAE																	
<u>Diodon hystrix</u>									x								

ANTICIPATED ENVIRONMENTAL IMPACT UPON THE MARINE COMMUNITIES AS A RESULT OF COASTAL DEVELOPMENT

by

Richard H. Randall

Environmental impact upon the marine community found along the coastal region of northern Tanapag reef platform, as a result of anticipated coastal development, has been briefly addressed in various section of this report. Here some of the major anticipated impacts are identified and addressed in relation to coastal development.

Fringing reef systems, such as the northern Tanapag reef platform, are subject to varying degrees of influence from adjacent terrestrial land areas. Much of this influence consists of a terrestrial contribution to the marine environment in the form of surface water and groundwater runoff along with an associated load of suspended and dissolved inorganic and organic substances. Such terrestrial influence varies in magnitude, both spacially and temporally, even under natural conditions. Community structure of reef organisms and geomorphic processes become somewhat adjusted to long-term patterns of naturally-occurring influences. In fact, much of the spacial variation observed in the community structure of marine organisms on the inner Tanapag reef platform can be related to differing degrees of terrestrial influence. Corals for instance, may be locally absent from this marine community because of reduced salinity where surface waters periodically debouch at the shoreline, but seagrasses may thrive there because of terrestrial sediment accumulation. Most environmental impact occurs when coastal development significantly alters the naturally occurring spacial and temporal patterns of terrestrial influence upon the adjacent marine environment.

Major anticipated environmental impacts resulting from coastal development include dredging to deepen nearshore reef platform areas, construction of docking and other shoreline facilities, beach and shoreline alteration by addition or removal of beach deposits, alteration of surface and ground water drainage patterns by removal of natural vegetation and soil disturbance, and introduction of pollutants into the marine environment via point, surface, and groundwater discharges.

Dredging of Shallow Nearshore Reef Platform Areas

The impact of dredging operations to deepen nearshore areas would destroy and alter present reef platform habitats and their associated marine communities. No marine habitat areas would actually be lost, but the dredged area would be significantly altered. Although some marine organisms could be expected to colonize dredged areas the new communities would most likely be different from the original ones. With time, though, the dredged depressions could be expected to fill in and then possibly succession could restore the original community structure.

A short-term impact from dredging nearshore areas would be the generation of a sediment-charged plume of water that could potentially affect nearby marine communities. Suspended material in such a plume would be mostly silt- and clay-size particles which could potentially stay in suspension for some time. Our current study indicates that such a plume would probably move along the shore in a southwesterly direction and eventually enter Tanapag Lagoon. Although marine organisms within the impacted area are somewhat adjusted to suspended material presently being fluxed through the inshore region, the dredging operations would greatly increase the amount of sediment carried by the longshore drift. To mitigate the effects of this sediment-charged plume silt curtains could be installed around potential dredging areas, which would not completely eliminate a plume, but it would certainly minimize and restrict it. Also dredging during periods when the speed of the longshore drift is minimal might reduce plume generation or tend to confine it to a smaller region.

Construction of Shoreline Facitities

Impacts from the construction of piers, docks, ramps, and breakwaters to facitate boat launching, loading and unloading of boat passengers, and shoreline stabilization depend on the type of construction, size, and site location of such a facility. In general this class of coastal construction impacts nearshore environments by physically altering, shading, or covering subtidal and intertidal marine communities and habitats. In addition, nearshore current and sedimentation patterns may be altered as well.

Shoreline Beach Alteration

Beach alteration generally consists of the removal or addition of unconsolidated shoreline deposits resulting in a regression or transgression of a present shoreline configuration. In some instances a beach may be enlarged by the addition of deposits along the landward edge without significantly altering present shoreline configurations. Commonly nearshore dredging operations involve beach progradation simply as a means to dispose of unconsolidated dredge spoil materials, especially if the deposits are principally of sand-sized texture. Larger textural spoil materials (boulder-sized) may also be used to stabilize certain portions of existing or altered shoreline areas. Removal of beach deposits to or below mean sea level (shoreline regression) creates new intertidal and subtidal marine habitats, whereas the addition of unconsolidated materials to widen a present beach in a seaward direction (shoreline transgression) results in a loss of marine habitat. Before altering a present beach shoreline configuration an investigation should be made to determine if such a change would most likely be stable. Present beach shoreline configurations are for the most part in some sort of dynamic equilibrium that is adjusted to all the factors of aggradation and degradation that influence such geomorphic systems. Beach alteration commonly involves changes in a natural shoreline which perturbes equilibrium conditions, resulting in a tendency for the system to be restored to its original configuration by natural aggrational or degrational processes.

Alteration of Adjacent Terrestrial Areas

Ground (soil and rock) disturbance as a result of land clearing, grading, construction, and farming activities; removal of vegetation cover; and changes in natural slope and drainage patterns within the watershed adjacent to the Tanapag reef system could have a considerable impact upon the marine environment, particularly on nearshore shallow platform areas. Such activities within this watershed area could result in more rapid runoff of surface waters into the marine environment during periods of heavy rainfall. This runoff would also most likely carry increased amounts of suspended particulates and dissolved materials to the coastal region as well. Impact to marine organisms by surface runoff has been previously reported on the reef platform in the vicinity of transects G and H. During this particular event land clearing caused increased amounts of freshwater to flow onto the platform during a period of heavy rainfall and was most likely the principal cause of the coral kill observed imediately afterwards. Shallow platform marine communities are particularly vulnerable to freshwater inundation during periods of low spring tides when water depth and circulation are minimal. Dilution during such times may lower normal salinity to lethal or sublethal levels for some organisms. Drainage basin alteration could also greatly increase the load of suspended materials in freshwater runoff that reaches coasal areas. Because of the normal longshore current patterns observed on the Tanapag reef platform, effects from increased terrestrial sedimentation would be mostly restricted to nearshore areas. Although some of this sediment load would be carried southwestward into deeper parts of Tanapag Lagoon, part would settle out as well. Seagrass patches located on inner platform areas between transects A-E would tend to act as a baffle and allow some sediments to settle out and become trapped.