A MARINE SURVEY OF THE OBYAN-NAFTAN REEF AREA, Saipan, Mariana Islands

by

Richard H. Randall, Shelly D. Rogers, Elburn E. Irish, Susanne C. Wilkins, Barry D. Smith and Steven S. Amesbury

Final Report

Submitted to

Office of Coastal Resources Management

Commonwealth of the Northern Mariana Islands

UNIVERSITY OF GUAM MARINE LABORATORY

Technical Report No. 90

May 1988

TABLE OF CONTENTS

	Page
Introduction and Project Narrative *by* Richard H. Randall	1
Currents and Substrate Characterization *by* Shelly D. Rogers and Elburn E. Irish	6
A Quantitative Assessment of Marine Plants *by* Susanne C. Wilkins	16
Corals and Description of the Study Area *by* Richard H. Randall	22
Conspicuous Epibenthic Macroinvertebrates *by* Barry D. Smith	38
Fishes *by* Steven S. Amesbury	48
Acknowledgements	56

INTRODUCTION AND PROJECT NARRATIVE

by

Richard H. Randall

Introduction

Because of anticipated development along the southern coastal region of Saipan, the Coastal Resources Management (CRM) Office, Commonwealth of the Northern Marianas, requested assistance from the University of Guam Marine Laboratory in obtaining a baseline marine assessment of the shallow reef platform and upper reef front slope between Puntan Obyan and Puntan Naftan. Data obtained from this assessment will be used by CRM to make sound coastal management plans and regulatory decisions for the Obyan-Naftan coastal region.

A proposal to conduct a marine assessment along the Obyan-Naftan coastal region was submitted to CRM on April 30, 1987, and an agreement between the CRM and the University of Guam Marine Laboratory to conduct such an assessment was signed on August 6, 1987 (CNMI Contract No. CO - 18489). Field work for the assessment was conducted December 10-16, 1987.

Project Description

This study consists of a limited marine assessment of the shallow reef-flat platform and adjacent upper reef front slope habitats located along the southern Saipan coast between Puntan Obyan and Puntan Naftan. The overall study area is shown in Figures 1 and 2. Within this study area a quantitative assessment of major marine organisms was conducted, and the general surface current patterns and substrate characteristics were determined.

The study area was quantitatively assessed along five transects (A-E) as shown in Figures 1 and 2. Transects A-E were run perpendicular from the shoreline across the reef flat platform to the reef margin. Seaward of Transects A-D, assessments were conducted on the reef front slope along 50-meter transects established by following the 6- to 8-meter submarine contour. The distribution and community structure of macroalgae, seagrasses, reef-building corals, fishes, macroinvertebrates other than corals, general surface current patterns, and substrate characteristics were analyzed along the five transects as shown in Figures 1 and 2.

Scope of Work

A. Community Structure

1. Corals:

Coral (scleractinian, hydrozoan, coenothecalian, stoloniferan, and alcyonacean species) communities were assessed along the transects by using the point-centered (also called the point-quarter)

technique as described by Randall et al. (1987), and by making a general reconnaissance outside the general transect areas. From these data the distribution and community structure (colony size distribution, density, frequency, and coverage) of the corals were determined.

2. Algae and Seagrasses:

Benthic macroscopic algal and seagrass communities were assessed along the transects by using the point-quadrat method described by Randall et al. (1987), and by making a general reconnaissance outside the general transect areas. From these data the distribution and community structure (coverage and frequency of occurrence) of the benthic algae and seagrasses were determined.

3. Macroinvertebrates:

Macroinvertebrates (other than corals) consisting principally of molluscs, echinoderms, and crustaceans were assessed along the transects by using the line-quadrat method described by Randall et al. (1987), and by making a general reconnaissance outside the general transect areas. From these data the distribution and density of benthic macroinvertebrates were determined.

4. Fishes:

Fish communities were assessed within ecological zones along the transects by using the method described by Randall et al. (1987), and by making a general reconnaissance outside the general transect areas. From these data, population densities of the various fish species and species richness of the fish communities within each ecological zone were determined.

B. Currents and Substrate Characterization

1. Currents:

Current speed and direction were determined by using the dye-injection technique described by Randall et al. (1987). These data were used to characterize and map the general current patterns at intervals along the transects.

2. Substrate Characterization:

Characterization of the substrate was determined by using the point-quadrat method described by Randall et al. (1987), and by making a general reconnaissance outside the general transect areas. These data were used to determine the distribution of unconsolidated surface deposits (limesand, gravel, rubble, and boulders) and consolidated reef rock at intervals along the transects.

Personnel

A. University of Guam Marine Laboratory Faculty
   1. Richard H. Randall - Principal Investigator
      Work Speciality - Coral assessment
   2. Steven S. Amesbury - Associate Investigator
      Work Speciality - Fish assessment

   3. Barry D. Smith - Associate Investigator
      Work Speciality - Macroinvertebrates other than corals

B. University of Guam Marine Laboratory Technical Staff

   1. Elburn E. Irish - Associate Investigator
      Work Speciality - Currents and substrate characterization

   2. Susanne C. Wilkins - Associate Investigator
      Work Speciality - Macroalgae and seagrasses

C. University of Guam Marine Laboratory Graduate Assistant

   1. Shelly D. Rogers - Associate Investigator
      Work Speciality - Currents and substrate characterization

Literature Cited

Randall, R. H., A. E. Davis, A. E. Edward, P. D. Gates, T. S. Potter, and S. C. Wilkins. 1987. A marine survey of the northern Tanapag reef platform, Saipan, Mariana Islands. Univ. Guam Mar. Lab., Tech. Rept. 87. 147 p.

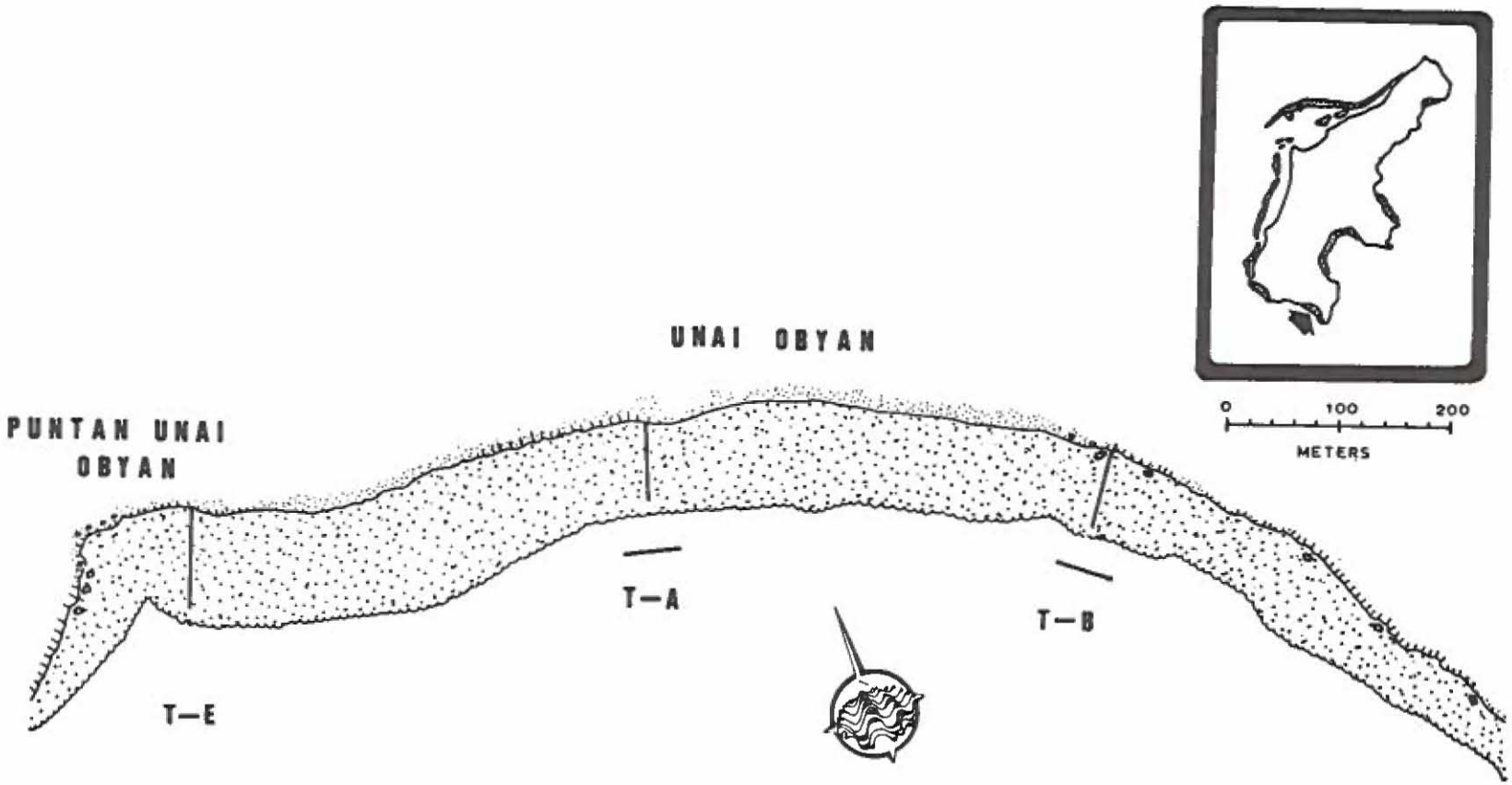

Figure 1. Map of the southern coastal region of Saipan showing the location of Transects A,B, and E. Shallow fringing reef platform areas and beach deposits are indicated by stippling seaward and landward of the shoreline respectively. Coastal exposures of limestone and beachrock are indicated by short lines drawn normal to the shoreline. Fig. modified from Eldredge and Randall, 1980.

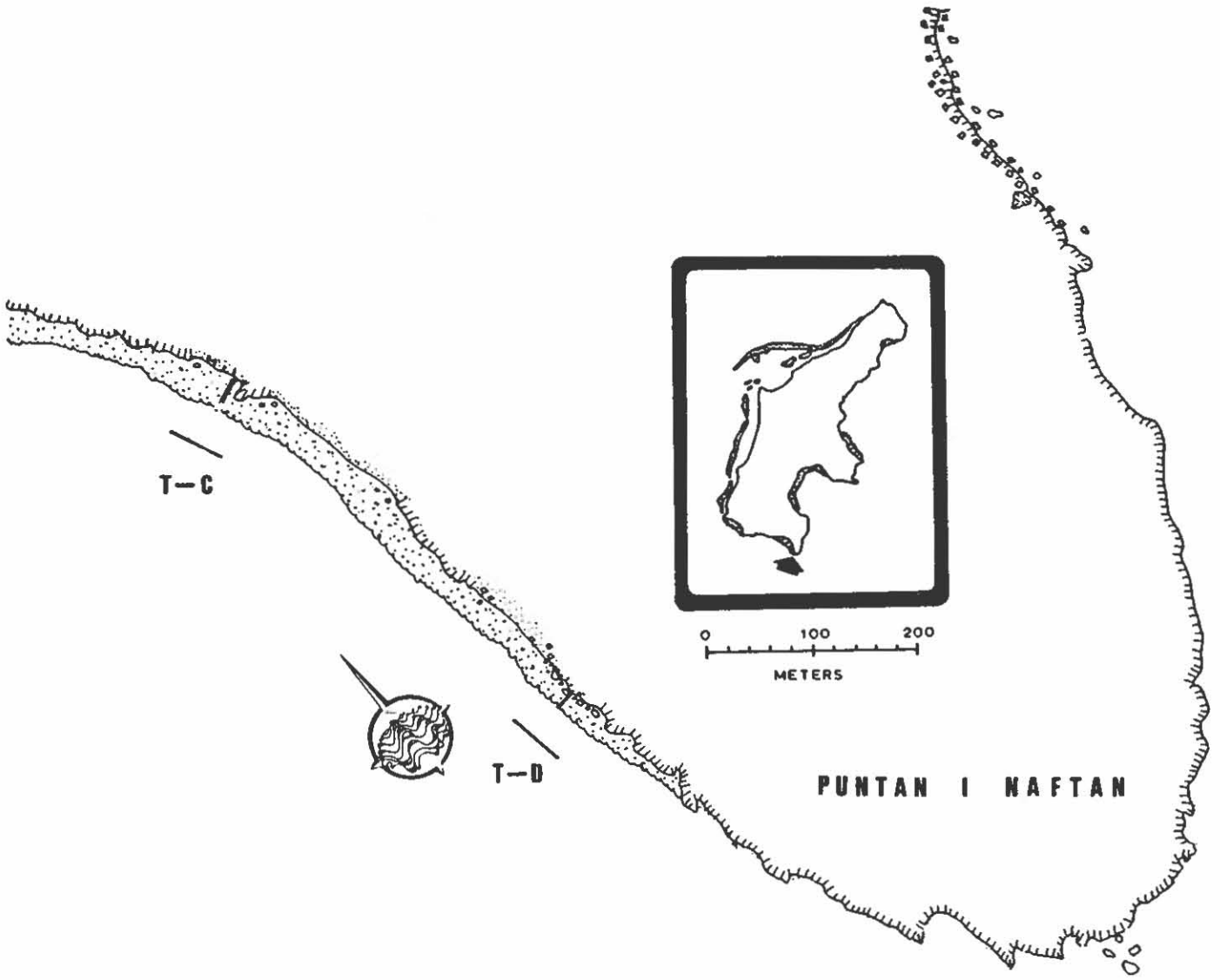

Figure 2. Map of the southern coastal region of Saipan showling the location of Transects C and D. Shallow fringing reef platform areas and beach deposits are indicated by stippling seaward and landward of the shoreline respectively. Coastal exposures of limestone and beachrock are indicated by short lines drawn normal to the shoreline. Fig. modified from Eldredge and Randall, 1980.

CURRENTS AND SUBSTRATE CHARACTERIZATION

by

Shelly D. Rogers and Elburn Irish

Introduction

Current and substrate characterization data were generated for the reef platform and reef slope of Unai Obyan Bay, Saipan, on December 11-16, 1987. Data were taken at 20-meter intervals at along Transects A, B, and E and at 15-meter intervals along Transects C and D. The reef slope stations were located along the 8-meter contour. No data were recorded for the reef slope of Transect E. Figures 1 and 2 show the locations of all the stations.

Currents

Current Analysis Methods

Flourescein dye was injected into the water at each station on the transect line. The time was recorded at the time of dye injection 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

Current speed and bearing, water depth, distance from shore, and tide stage data are given in Table 1 for each transect station. Current velocity vectors for each transect station are plotted on Figures 1 and 2.

All of Transect A, Stations 1 and 2 at Transect B, and Stations 2 and 3 at Transect C have easterly current directions. In comparison, all of Transect D, Stations 3 and 4 at Transect B, and Station 1 at Transect C have westerly current directions due to a channel in the reef flat leading seaward between Transects B and C.

On Transects A, C, and E the current direction ran inshore in a south southwest to north northeast pattern. Much of this was due to surf and swell action and direction. The speed of the current increased in conjunction with the distance from shore at all transect sites on the reef flat. Three

readings at Transect B had no noticeable current direction, being closest to the seaward reef channel.

Currents at offshore transects on reef front slopes at Transects B, C, and D ran in an east southeast to west northwest direction with currents at Transects C and D moving at a faster speed than that of Transect B. The current at Transect A ran offshore in a northwest to southeast direction, but at a speed similar to that of Transect B.

Substrate Characterization

Substrate Characterization Methods

The substrate at each station was characterized by using a quadrat, rigged with eight intersecting cords which formed 16 equidistant points. The quadrat was tossed randomly within a 3-meter radius of each station. The substrate under each of the 16 points was assigned to one of eight classes (A-H) described in Table 2. A point was assigned as sand or gravel, only if the sand or gravel was greater then one centimeter in thickness.

The quadrat was thrown three times on each reef platform station, nine times on the reef slope of Transect A, and five times on the reef slopes of Transects B-D. The reef platform was divided into an inner reef platform and an outer reef platform. The inner reef platform was a deeper moat zone, while the outer reef platform was shallow to intertidal. Thus, there were three distinct reef zones: inner reef platform, outer reef platform, and reef slope. The points of each substrate class were summed together by reef zone. Percent cover for each zone was calculated by dividing the points of each substrate class by the total points recorded in the zone and multiplying by 100%.

Substrate Analysis

Table 2 shows the results of the substrate study. The inner reef platform consisted mostly of pavement and some cobble with a thin layer (usually less than 2 centimeters) of sand on top. Transects D and E had thicker layers of sand. Forams were abundant in the sand, except on Transect E. Few corals or fleshy algae were recorded in the zone. No coralline algae was recorded for any of the transects along the inner reef platform; however, a small amount was observed. Transect E was the only transect with a zone of large conspicuous coral heads. This zone was approximately five meters wide and was located at the seaward edge of the inner platform, 30 meters from shore.

The outer reef platform also consisted of mostly pavement and some cobble with a thin layer of sand. The amount of cobble varied greatly. Transect A had no cobble recorded while Transect E had 66% cobble. The cobble was formed of calcium carbonate chunks cemented together so that it was difficult to separate and lift as separate pieces. The sand layer was thinner and much less apparent than in the inner reef platform. Forams were still abundant in

the sand. A few live corals and fleshy algae were recorded (less than four percent cover each). Coralline algae were common (twelve percent), especially Halimeda and Amphiroa.

The reef slope was predominantly pavement (85%). The cobble in this area was loose, unlike the outer reef platform. The amount of cobble on the reef slope seemed to increase toward the reef front. Data, however, were only recorded along the 8-meter contour. Transects A, B, and C contained between three and four percent live coral. Some calcareous algae, between three and four percent, were recorded in Transects A and B. Very little of any of the other substrate classes were noted.

Table 1. Unai Obyan Bay current study data for Transects A-E. See Figs. 1 and 2 for transect locations.

Transect A: December 11, 1987
High Tide at 12:46 = 0.7 m — Time: Start 14:15
Low Tide at 18:24 = 0.5 m — Finish 14:45

Sta. no.	Dist. From Shore (m)	Current Speed (m/sec)	Depth (m)	Bearing (deg)	Tide Stage
1	13	0.13	0.88	090	EBB
1	13	0.15	0.88	080	EBB
1	13	0.21	0.88	080	EBB
2	33	0.16	0.93	050	EBB
2	33	0.22	0.93	082	EBB
2	33	0.18	0.93	023	EBB
3	53	0.50	0.42	033	EBB
3	53	0.30	0.42	040	EBB
3	53	0.30	0.42	036	RBB
4	73	0.63	0.42	018	EBB
4	73	0.40	0.42	019	EBB
4	73	0.37	0.42	050	EBB
	December 14, 1987				
	Low Tide at 07:11 = 0.2 m			Time: Start	10:30
	High Tide at 14:25 = 0.7 m			Finish	11:00
5	150	0.09	8	221	FLOOD
5	150	0.13	8	150	FLOOD
5	150	0.11	8	138	FLOOD

Transect B: December 11, 1987
High Tide at 12:46 = 0.7 m — Time: Start 15:45
Low Tide at 18:24 = 0.5 m — Finish 16:15

Sta. no.	Dist. From Shore (m)	Current Speed (m/sec)	Depth (m)	Bearing (deg)	Tide Stage
1	20	0.14	0.69	106	EBB
1	20	0.00	0.69	N/A	EBB
1	20	0.00	0.69	N/A	EBB
2	40	0.10	0.64	110	EBB
2	40	0.14	0.64	142	EBB
2	40	0.21	0.64	202	EBB

Table 1. Continued.

Sta. no.	Dist. From Shore (m)	Current Speed (m/sec)	Depth (m)	Bearing (deg)	Tide Stage
3	60	0.13	0.54	235	EBB
3	60	0.15	0.54	346	EBB
3	60	0.00	0.54	N/A	EBB
4	80	0.25	0.51	313	EBB
4	80	0.63	0.51	345	EBB
4	80	0.33	0.51	325	EBB

Transect B: December 14, 1987
Low Tide at 07:11 = 0.2 m
High Tide at 14:25 = 0.7 m
Time: Start 1:45
Finish 12:05

5	150	0.06	8	275	FLOOD
5	150	0.09	8	272	FLOOD
5	150	0.12	8	265	FLOOD

Transect C: December 12, 1987
High Tide at 13:21 = 0.7 m
Low Tide at 19:30 = 0.4 m
Time: Start 12:15
Finish 12:35

Sta. no.	Dist. From Shore (m)	Current Speed (m/sec)	Depth (m)	Bearing (deg)	Tide Stage
1	15	0.14	0.72	340	FLOOD
1	15	0.11	0.72	135	FLOOD
1	15	0.13	0.72	347	FLOOD
2	30	0.17	0.65	350	FLOOD
2	30	0.17	0.65	090	FLOOD
2	30	0.20	0.65	076	FLOOD
3	45	0.46	0.51	067	FLOOD
3	45	0.21	0.51	090	FLOOD
3	45	0.17	0.51	061	FLOOD

Transect C: December 14, 1987
Low Tide at 07:11 = 0.2 m
High Tide at 14:25 = 0.7 m
Time: Start 13:15
Finish 13:30

4	115	0.24	8	316	FLOOD
4	115	0.28	8	319	FLOOD
4	115	0.30	8	303	FLOOD

Table 1. Continued.

Transect D: December 12, 1987
High Tide at 13:21 = 0.7 m — Time: Start 11:12
Low Tide at 19:30 = 0.4 m — Finish 11:32

Sta. no.	Dist. From Shore (m)	Current Speed (m/sec)	Depth (m)	Bearing (deg)	Tide Stage
1	7	0.19	0.54	340	FLOOD
1	7	0.13	0.54	335	FLOOD
1	7	0.19	0.54	341	FLOOD
2	22	0.23	0.94	254	FLOOD
2	22	0.19	0.94	282	FLOOD
2	22	0.18	0.94	255	FLOOD
3	37	0.31	0.98	258	FLOOD
3	37	0.28	0.98	265	FLOOD
3	37	0.46	0.98	265	FLOOD

Transect D: December 14, 1987
Low Tide at 07:11 = 0.2 m — Time: Start 14:20
High Tide at 14:25 = 0.7 m — Finish 14:35

4	110	0.17	8	330	HIGH
4	110	0.18	8	304	HIGH
4	110	0.25	8	330	HIGH

Transect E: December 13, 1987
High Tide at 13:53 = 0.7 m — Time: Start 10:30
Low Tide at 06:24 = 0.1 m — Finish 10:50

Sta. no.	Dist. From Shore (m)	Current Speed (m/sec)	Depth (m)	Bearing (deg)	Tide Stage
1	20	0.15	1.07	295	FLOOD
1	20	0.15	1.07	297	FLOOD
1	20	0.15	1.07	291	FLOOD
2	40	0.17	0.54	293	FLOOD
2	40	0.18	0.54	310	FLOOD
2	40	0.12	0.54	333	FLOOD
3	60	0.27	0.48	342	FLOOD
3	60	0.18	0.48	335	FLOOD
3	60	0.28	0.48	330	FLOOD
4	80	0.20	0.48	354	FLOOD
4	80	0.23	0.48	306	FLOOD
4	80	0.18	0.48	325	FLOOD

Table 2. Substrate characterization of Transects A–E in Unai Obyan Bay. Point counts of eight different substrate characteristics (A–H) are given for each quadrat station. Percent cover for each class of substrate is also given for each area along the transect. The reef zones are abbreviated I, O, and S for inner reef platform, outer reef platform, and reef slope. Definitions of substrate classes are given below.

A – Sand: grain size less than 2 mm
B – Gravel: grain size between 2 mm and 4 cm
C – Cobble/rubble: grain size greater than 4 cm
D – Pavement: *In situ* reef rock
E – Living coral
F – Coralline algae: any calcareous algae
G – Fleshy algae
H – *In situ* dead coral

Station no.	Distance from Shore in meters	Reef Type*	A	B	C	D	E	F	G	H
Transect A:										
A-1	13	I			9	7				
A-1	13	I			2	14				
A-1	13	I			16					
A-2	33	I	13	3						
A-2	33	I	15				1			
A-2	33	I	14	2						
A-3	53	O	6	2		6		2		
A-3	53	O	13			3				
A-3	53	O	5			8		3		
A-4	73	O	3			4		8	1	
A-4	73	O	5			11				
A-4	73	O				11		2		3
A-5	--	S				16				
A-5	--	S				16				
A-5	--	S				15	1			
A-5	--	S				16				
A-5	--	S	1	1	1	13				
A-5	--	S			4	7	2	3		
A-5	--	S				15			1	
A-5	--	S			4	11	1			
A-5	--	S		3		11	2			
Total Points: Inner Reef Platform			42	5	27	21	1			
Total Points: Outer Reef Platform			32	2		43		15	1	3
Total Points: Reef Slope (25ft)			1	4	9	120	6	3	1	
% Substrate: Inner Reef Platform			44	5	28	22	1			
% Substrate: Outer Reef Platform			33	2		45		16	1	3
% Substrate: Reef Slope (25ft)			1	3	6	83	4	2	1	

Table 2. Continued.

Station no.	Distance from Shore in meters	Reef Type*	A	B	C	D	E	F	G	H
Transect B:										
B-1	20	I			1	15				
B-1	20	I			1	15				
B-1	20	I				16				
B-2	40	O			8		2	4	2	
B-2	40	O				16				
B-2	40	O								16
B-3	60	O	3		6	7				
B-3	60	O			8	3	1	1	2	1
B-3	60	O	8		1				7	
B-4	80	O			15				1	
B-4	80	O			1	14				1
B-4	80	O				16				
B-5	--	S				16				
B-5	--	S				15	1			
B-5	--	S			12	1		3		
B-5	--	S				14	2			
B-5	--	S				15			1	
B-5	--	S	3			13				
Total Points: Inner Reef Platform					2	46				
Total Points: Outer Reef Platform			11		39	56	3	5	12	18
Total Points: Reef Slope (25ft)			3		12	74	3	3	1	
% Substrate: Inner Reef Platform					4	96				
% Substrate: Outer Reef Platform			8		27	39	2	4	8	13
% Substrate: Reef Slope (25ft)			3		13	77	3	3	1	
Transect C:										
C-1	15	I	5			11				
C-1	15	I	5			11				
C-1	15	I	11	2		3				
C-2	30	O	10		2	1	2			1
C-2	30	O	8			7			1	
C-2	30	O	2	3	8			1	2	
C-3	45	O	2	10	1			2	1	
C-3	45	O	2		5			8	1	
C-3	45	O	1	1	8	4		1	1	
C-4	--	S				15	1			
C-4	--	S				16				
C-4	--	S		1	1	14				
C-4	--	S	1		1	14				
C-4	--	S			3	11	1		1	
C-4	--	S			3	11	2			

Table 2. Continued.

Station no.	Distance from Shore in meters	Reef Type*	A	B	C	D	E	F	G	H
Total Points: Inner Reef Platform			21	2	25					
Total Points: Outer Reef Platform			25	14	24	12	2	12	6	1
Total Points: Reef Slope			1	1	8	81	4		1	
% Substrate: Inner Reef Platform			44	4	52					
% Substrate: Outer Reef Platform			26	15	25	13	2	13	6	1
% Substrate: Reef Slope (25ft)			1	1	8	84	4		1	

Station no.	Distance from Shore in meters	Reef Type*	A	B	C	D	E	F	G	H
Transect D:										
D-1	7	I	11	2		3				
D-1	7	I	3			11			2	
D-1	7	I			16					
D-2	22	O	6			10				
D-2	22	O	2		6			8		
D-2	22	O	13			3				
D-3	37	O			8	3		5		
D-3	37	O				8	8			
D-3	37	O			5			10	1	
D-4	--	S				16				
D-4	--	S			1	15				
D-4	--	S		1		15				
D-4	--	S				15	1			
D-4	--	S				16				
D-4	--	S		2		14				
Total Points: Inner Reef Platform			14	2	16	14		2		
Total Points: Outer Reef Platform			21		19	24	8	23	1	
Total Points: Reef Slope (25ft)				3	1	91	1			
% Substrate: Inner Reef Platform			29	4	33	29			4	
% Substrate: Outer Reef Platform			22		20	25	8	24	1	
% Substrate: Reef Slope (25ft)				3	1	95	1			
Transect E:										
E-1	20	I				16				
E-1	20	I	3			13				
E-1	20	I	7			9				
E-2	40	O	2	12		2				
E-2	40	O			15		1			
E-2	40	O			16					
E-3	60	O			12			2	2	
E-3	60	O			14		1	1		

Table 2. Continued.

Station no.	Distance from Shore in meters	Reef Type*	A	B	C	D	E	F	G	H
E-3	60	0	1		2	13				
E-4	80	0		1	8			7		
E-4	80	0			14		1	1		
E-4	80	0		1	14			1		
Total Points: Inner Reef Platform			10			38				
Total Points: Outer Reef Platform			3	14	95	15	3	12	2	
% Substrate: Inner Reef Platform			21			79				
% Substrate: Outer Reef Platform			2	10	66	10	2	8	1	
All Transects Combined:										
Total Points: Inner Reef Platform			87	9	70	119	1		2	
Total Points: Outer Reef Platform			92	30	177	150	16	67	22	22
Total Points: Reef Slope (25ft)			5	8	30	366	14	6	3	
% Substrate: Inner Reef Platform			30	3	24	41			1	
% Substrate: Outer Reef Platform			16	5	31	26	3	12	4	4
% Substrate: Reef Slope (25ft)			1	2	7	85	3	1	1	

A QUANTITATIVE ASSESSMENT OF MARINE PLANTS

by

Susanne C. Wilkins

A baseline marine assessment of an area of Obyan Bay, Saipan, reef platform and the reef front slope along the 6- to 8-meter contour was conducted on December 10-16, 1988. The objective of this portion of the study was to assess the benthic flora of this area.

Methods

Marine plants and substrate were quantified by using the point-quadrat method described by Wilkins (1987) along a total of 9 transects, A-E as shown in Figures 1 and 2, pp. 4-5. Transects A through E ran from shore to near the seaward edge of the outer reef platform and varied in length from 70 meters for Transects A and B, to 45 meters, 40 meters, and 80 meters for Transects C, D, and E, respectively. The transects on the reef front slope are considered part of Transects A through D and are thus labeled with the same letters. They were 50-m long and ran along the 6- to 8-meter contour, perpendicular to transects on the reef platform.

The point-quadrat method provides data from which a rapid general assessment of percent cover and frequency of occurrence of any of the algal species is possible. Thus, distribution patterns, evenness or patchiness of the benthic algal species, can easily be recognized. The benthic plant assemblages were analyzed by tossing a 25x25-cm gridded quadrat at 10-m intervals along the length of each transect. Four parallel rows of nylon cord were tied across each dimension of the frame, so that 16 intersecting points were contained with the quadrat. Each plant species was recorded at every point it occurred. If algal turf was encountered under the points, then whatever was present, e.g., sand, dead 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.

Results and Discussion

Results of this study are presented in Tables 1 and 2. A total of 33 species of marine plants were quantified within the area of the Transects A through E. These transects were subdivided into inner and outer platform

zones as indicated by the distance from shore (Table 1). The transects along the reef front, A through D, had a total of 23 marine plant species. Highest percent plant coverage (22.2-46.5%) was recorded in the outer zones of the reef platform. Percent plant coverage along the transects on the reef front slope varied from 19.7% along Transect D to 38.4% along Transect B.

According to Cloud (1959) some of the western reefs of Saipan are typical truncated reef flats which are barely awash at low tide. Most of the areas, especially areas close to the reef edge, are affected by strong currents as a result of wave transport from the reef margin to the inner reef platform. Internal erosion has reduced many inner reef zones to pavement-like surfaces, patchily veneered by algal turf, sand, rubble, and only very few corals. Relatively depressed inner moat zones were noted at Transects C and E. Algae such as Cladophoropsis sp., Gelidiopsis intricata, two species of Sphacelaria, and Jania capillacea represent the prominent turf-forming species. The outer zones of the reef platform generally have elevated reef edges of richer organic growth. Increased coral and articulated coralline algal coverage provide topographic relief and habitats for a variety of organisms.

Turbinaria ornata was generally common in the outer platform zones as was Neogoniolithon frutescens. Liagora sp. was common throughout the entire study area but was especially abundant along the reef front slope.

Literature Cited

Cloud, P. E., Jr. 1959. Submarine topography and shoalwater ecology, Part 4, of geology of Saipan, Marianas Islands. U.S. Geol. Surv., Prof. Paper 280 K, pp. 366-445.

Wilkins, S. de C. 1987. A quantitative assessment of marine plants. pp. 33-46. In R. H. Randall (ed.), A marine survey of the northern Tanapag reef platform. Univ. Guam Mar. Lab., Tech. Rept. 87.

Table 1. Frequency and percent cover of the benthic flora of five transects (A, B, C, D, and E). Each transect was subdivided into inner and outer zone as indicated by the distance from shore. Plain numbers indicate percent coverage; numbers in parentheses indicate frequency of occurrence converted to percent (see Methods in text). Algal species occurring epiphytically on other algae or occurring in the vicinity of the transect are marked with an X.

	TRANSECTS									
	A		B		C		D		E	
	0-40	40-70	0-40	40-70	0-25	25-45	0-20	20-40	0-40	40-80
CYANOPHYTA										
Hormonthanmion enteromorphoides Bornet & Thuret	1.2(20)		X				4.2(33)			1.2(20)
Microcoleus lyngbyaceus (Kutz.) Crovan		X		2.1(33)		4.2(67)		3.1(50)		X
Schizothrix calcicola (Ag.) Gomont		2.1(33)	1.2(20)	2.1(33)		2.1(33)				1.2(20)
Schizothrix mexicana Gomont	X				3.1(50)					
CHLOROPHYTA										
Acetabularia moebii Solms-Lenbach									3.1(50)	
Boergensenia forbesii (Harv.) Feldmann		X		4.2(67)					3.1(50)	
Cladophoropsis sp.	5.0(40)		5.0(60)		6.2(50)					
Caulerpa serrulata (Forsk.) J. Ag.						2.1(33)		X		
Dictyosphaeria cavernosa (Forsk.) Boerg.				X		2.1(33)		3.1(50)	1.6(25)	
Dictyosphaeria versluysii W. v. Bossee		2.1(33)				6.2(67)				
Halimeda opuntia (L.) Lamx.										
PHAEOPHYTA										
Dictyota friabilis Setch.								6.2(100)		
Lobophora variegata (Lamx.) Womersley						2.1(33)				
Ralfsia pangoensis Setch.	X				3.1(50)		2.1(33)			
Sphacelaria furcigera Kutz.					3.1(50)	2.1(33)	4.2(67)	3.1(50)	X	2.5(40)
Sphacelaria tribuloides Menegh.	3.8(60)	4.2(67)	1.2(20)		6.2(100)					1.2(20)
Turbinaria ornata (Turner) J. Ag.		6.2(67)		4.2(33)		6.2(33)				1.2(20)
RHODOPHYTA										
Amphiroa foliacea Lamx.		4.2(33)		2.1(33)		X		3.1(50)		
Centroceras minutum Yanada				2.1(33)		2.1(33)				
Ceramium gracillimum Griff. & Gard.		X						3.1(50)		X
Ceramium maxatlenese Dawson						4.2(67)				
Gelidiopsis intricata (Ag.) Vichers		2.1(33)	2.5(20)	2.1(33)	3.1(50)	4.2(67)	6.2(100)		6.2(50)	2.5(40)
Gelidium pusillum (Stackh.) LeJolis		2.1(33)		2.1(33)				6.2(100)		
Herposiphonia tenella (C. Ag.) Naegeli			X			2.1(33)				
Hydrolithon reinboldii (W. v. Bosse & Foslie) Foslie						2.1(33)				1.2(20)
Hypnea pannosa J. Ag.					3.1(50)					
Jania sp.				2.1(33)		2.1(33)		X	X	
Jania capillacea Harvey		4.2(67)		4.2(67)	6.2(100)	X	2.1(33)	6.2(50)		2.5(40)

Table 1.Continued.

	TRANSECTS									
	A		B		C		D		E	
	0-40	40-70	0-40	40-70	0-25	25-45	0-20	20-40	0-40	40-80
Laurencia sp.								3.1(50)		
Liagora sp.	3.8(60)	4.2(33)	2.5(40)	4.2(33)		X	2.1(33)		1.6(25)	2.5(20)
Neogoniolithon frutescens (Foslie) Setch. & Mason	1.2(20)	6.2(67)			6.2(100)	4.2(33)	4.2(67)	6.2(100)	3.1(50)	3.8(40)
Polysiphonia scopulorum Harv.		2.1(33)		4.2(67)			X			1.2(20)
Porolithon onkodes (Heyd.) Foslie		X				2.1(33)				
Diatom scuz							2.1(33)			
Pavement	47.5(100)	10.4(67)	40.0(100)	20.8(67)	25.0(100)	8.6(67)	39.6(100)	25.0(50)	43.8(100)	
Live coral		4.2(100)				10.4(100)		12.5(100)		2.5(20)
Dead coral	2.5(20)	16.7(100)		10.4(67)			10.4(33)	6.2(50)	17.2(75)	48.8(80)
Rubble	2.5(20)		7.5(40)	8.3(33)	9.5(50)	4.2(33)	6.2(67)	9.4(50)		2.5(20)
Sand	32.5(60)	22.9(67)	37.5(60)	25.0(67)	25.0(100)	14.6(67)	14.6(67)		20.0(75)	17.5(80)
Cobble		4.2(67)	2.5(40)			12.5(100)			3.1(25)	5.0(40)
Snail		2.1(33)					2.1(33)			
Number of plant genera/transect	5	11	5	11	8	15	6	11	5	11
Number of plant species/transect	5	11	5	12	9	16	7	11	5	12
Overall percent plant coverage	15.0	39.7	12.4	35.7	34.9	39.7	27.2	46.5	15.6	22.2
Total number of plant genera 29										
Total number of plant species 33										

Table 2. Frequency and percent cover of the benthic flora of four 50-m transects along the 6- to 8-m contour perpendicular to Transects A through D. Plain numbers indicate percent coverage; numbers in parentheses indicate frequency of occurrence converted to percent (see Methods in text). Algal species occurring epiphytically on other algae or occurring in the vicinity of the transect are marked with an X.

	TRANSECTS			
	A	B	C	D
CYANOPHYTA				
Hormonthanmion enteromorphoides Bornet & Thuret	1.0(17)			
Microcoleus lyngbyaceus (Kutz.) Crovan		2.1(33)	X	
Schizothrix calcicola (Ag.) Gomont	4.2(50)	1.0(17)	3.1(33)	6.2(50)
Schizothrix mexicana Gomont	1.0(17)	1.0(17)		X
CHLOROPHYTA				
Dictyosphaeria versluysii W. v. Bossee	1.0(17)		X	
Halimeda discoidea Decaisne	2.1(33)			1.0(17)
Halimeda opuntia (L.) Lamx.	1.0(17)	9.3(50)	3.1(50)	X
PHAEOPHYTA				
Dictyota bartayresii Lamx.		X	2.1(33)	3.1(33)
Dictyota friabilis Setch.	1.0(17)	2.1(33)		
Lobophora variegata (Lamx.) Womersley	X	2.1(33)		
Sphacelaria furcigera Kutz.	2.1(17)		2.1(33)	1.0(17)
Sphacelaria tribuloides Menegh.		2.1(17)		2.1(33)
Turbinaria ornata (Turner) J. Ag.		1.0(17)		
RHODOPHYTA				
Amphiroa fragilissima (L.) Lamx.		X	1.0(17)	
Ceramium gracillimum Griff. & Gard.			2.1(33)	
Gelidiopsis intricata (Ag.) Vichers		1.0(17)	X	
Hypnea pannosa J. Ag.	1.0(17)		2.1(17)	
Jania sp.	2.1(33)	1.0(17)	2.1(33)	4.2(50)
Jania capillacea Harvey	X	X	1.0(17)	
Liagora sp.	4.2(50)	10.4(67)		2.1(17)
Neogoniolithon frutescens (Foslie) Setch. & Mason		4.2(33)	1.0(17)	
Polysiphonia scopulorum Harv.	3.2(33)			X
Porolithon onkodes (Heyd.) Foslie		2.1(33)	6.2(50)	
Diatom scuz	6.2(67)		10.4(50)	9.4(67)

Table 2. Continued.

	TRANSECTS			
	A	B	C	D
Pavement	47.9(83)	32.3(67)	17.7(67)	38.5(50)
Live coral	6.2(50)	9.3(67)	31.2(50)	9.4(50)
Dead coral	5.2(67)		4.2(33)	5.2(33)
Rubble		3.1(33)	2.1(17)	
Sand	9.4(50)	14.6(50)	4.2(33)	15.6(67)
Soft coral	1.0(17)	1.0(17)		2.1(17)
Snail		1.0(17)		
Sea urchin		1.0(17)		
Sponge			4.2(33)	
Number of plant genera/transect	10	11	11	7
Number of plant species/transect	12	13	11	7
Overall percent plant coverage	23.8	38.4	25.9	19.7

Total number of plant genera 18

Total number of plant species 23

CORALS AND A DESCRIPTION OF THE STUDY AREA

by

Richard H. Randall

Introduction

Reef-building scleractinian, octocorallian, and hydrozoan corals are sessile 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 shoal-water fringing reef environments. 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 these environmental factors, corals can be useful as indicator organisms which reflect the quality of the environment. Assessment of the present coral communities on the shoal-water reef habitats between Puntan Unai Obyan and Puntan Naftan will establish baseline data from which changes in the quality of the reef environment can be determined or predicted. These data will be useful in establishing sound planning practices and management of this reef area 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 and to present a brief physiographic description of the reefs and coastal environment.

Methods

Coral communities were analyzed along transects by using the plotless point-centered or point-quarter technique of Cottam et al. (1953). Five transects were established within the study area by placing a plastic surveyor's tape along the bottom on the reef flat platform and seaward reef front slope locations, as shown in Figures 1 and 2, pp. 4 and 5. Sampling points were then established by throwing a geology hammer from the surface at five-meter intervals along the length of each transect. Throws along Transects A-E on the reef flat platform were made by standing at each five-meter interval facing Puntan Naftan and tossing the hammer over one's shoulder into a five-meter-wide corridor along the Puntan Obyan side of the transect line. Throws along Transects A-D on the reef front slope were made by swimming over each five-meter interval facing toward the sea and tossing the

hammer over one's back into a five-meter-wide corridor on the landward side of the transect line. Where the thrown hammer came to a 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 structure parameters:

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

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

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

4. Total percent coverage = $\frac{\text{total density of}}{\text{all species}} \times \frac{\text{average coverage value}}{\text{for all species}}$

5. Percent coverage = density of a species $\times \frac{\text{average coverage value}}{\text{for the species}}$

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

7. Frequency = $\frac{\text{Number of points at which a species occurs}}{\text{Total number of points}} \times 100$

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

9. Importance value = $\frac{\text{Relative}}{\text{density}} + \frac{\text{relative percent}}{\text{coverage}} + \frac{\text{relative}}{\text{frequency}}$

Colony size distribution data (Y = arithmetic mean, s = standard deviation, and w = size range) were also calculated from the point-quarter data.

Physiographic Description of the Study Site

The coastal region between Puntan Obyan and Puntan Naftan (Figs. 1 and 2, pp. 4-5) consists of rugged steep slopes and cliffs developed along the seaward margins of low limestone terraces. A halophytic-xerophytic stunted scrub vegetation occupies much of the exposed, solution-pitted limestone surfaces of the slope and cliff faces. Bioclastic beach deposits of reef origin up to 30 meters wide and 900 meters long are developed along the shoreline between Puntan Obyan and Transect B. Smaller patches of beach deposits intermittently interrupt the remaining rocky shoreline between Transect B and Puntan Naftan. Beachrock forms conspicuous outcrops at a number of places along the shoreline, particularly in the vicinity of Transects A and B.

Except for a 400-meter stretch of sea cliffs located between Puntan Naftan and Transect D, the entire costal area of the study site is bordered by a narrow, contiguous fringing reef platform. The reef platform gradually narrows in width from 115 meters near Transect E to a mere fringe 40 meters wide at Transect D. About 200 meters southeast of Transect D, the reef platform disappears altogether along the sea cliffs of Puntan Naftan. Physiographic structure of the reef platform is fairly uniform along its length, consisting of an inner deeper part, ranging in width from 20 meters at Transect D to 40 meters at Transect A, and an outer shallower part, ranging in width from 20 meters at Transects C and D to 50 meters at Transect E. Because of these elevation differences, the reef platform can be divided into two somewhat distinct zones, an outer one that becomes very shallow or even emergent at places during low spring tides and an inner one that retains a shallow moat of water at most places during such times. The outer fringe of the reef flat platform dips downward very gently in a seaward direction forming a wave-washed zone commonly referred to as the reef margin zone. Algal ridge development was conspicuously absent along the entire platform margin. During our fieldwork period, heavy wave assault prevented us from assessing the reef margin zone. Seaward of the reef margin, the downward dip of the platform increases rather abruptly forming the reef front slope zone, which was assessed along the 5-8 meter depth contour during the fieldwork period. A somewhat irregularly-spaced buttress and channel system is developed along most parts of the reef slope within the study area, giving it a topographic relief of up to five meters from channel floors to buttress ridge tops.

Sediment distribution within the study area was somewhat patchy or absent, as expected in reef habitats such as this, where high wave assault and strong currents are prevalent. The outer reef flat platform surface was for the most part swept free of sediment except in local holes and depressions where some coarse sand and rubble accumulation was found. Sediment accumulation was somewhat more prevalent in the inner reef flat platform zone, but even so, was generally patchy in distribution or confined to a layer up to two centimeters thick that was trapped in algal turf communities. Sediment accumulation on the reef front zone was restricted to the floors of channels, holes, and depressions.

Coral Distribution and Community Structure

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 predominant and common species along the transects. The presence of uncommon and rare species, not encountered during the point-quarter analysis, was determined for each transect by making ten-minute snorkel observations along each side of the transect line within the various zones discriminated. 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.

A cumulative total of 72 coral species representing 12 families and 27 genera were recorded from the study area (Table 2). Of the 72 species, 7 were common to all 5 transects, and, of the remaining 65 species, 12 were common to 4 transects, 13 were common to 3 transects, 17 were common to 2 transects, and 23 were found only at single transect locations. Species richness along Transects A-D (all zones combined) ranged from 45 species at Transect C to 36 species at Transect A. Investigations were restricted to only the reef flat platform zones at Transect E, resulting in only 16 species being recorded from there. Within individual reef zones species richness ranged from 2 to 12 in the inner reef flat, 4 to 22 in the outer reef flat, and 20 to 43 in the reef front slope. Coral density (corals/m^2) ranged from 0.20 to 0.55 in the inner reef flat zones, 0.59 to 3.83 in the outer reef flat zones, and 9.25 to 14.35 in the reef front slope zones. Percentage of substrate coverage by corals ranged from 0.25 to 0.94 in the inner reef flat zones, 0.35 to 5.29 in the outer reef flat zones, and 2.82 to 18.89 in the reef front slope zones. In regard to mean coral colony size distribution, largest-sized corals were found in the inner reef flat zones (7.6 to 13.5 cm diam.), intermediate-sized corals on the outer reef flat zones (6.6 to 11.4 cm diam.), and smallest-sized corals on the reef front slope zones (5.6 to 9.1 cm diam.).

In general, values of coral density, percentage of substrate coverage, and species richness were lowest in the reef flat platform zones and highest in the reef front slope zone, whereas mean colony size was smallest in the reef front zones and slightly larger in the reef flat platform zones. Reef platform exposure and elevated water temperatures during low spring tides when water circulation is minimal appear to be the most probable environmental factors responsible for the poor coral development observed in the reef flat platform zones. In relation to community structure on the reef front slope, it should be mentioned that the coral communities there were subject to intense Acanthaster planci predation several years ago (V. Aldan, CNMI Coastal Resources Management, pers. comm.) and are now undergoing recovery. This former predation was quite evident in the presence of numerous dead algal-covered coral colonies, particularly on the lower reef front slope. It was also quite apparent that A. planci predation was much less intense in the more wave-assaulted shallower upper reef front slope zones, resulting in somewhat of a coral refugia there. This upper reef front slope refugia plus lower slope recovery, apparent by the presence of abundant small recruits and rejuvenating spats that survived initial predation, account for the relatively high values of species richness, density, and percentage of substrate coverage recorded there.

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 percent coverage, and importance values for coral species at Transects A through E. Species are listed in order of their importance values.

Transect No., Reef Zone, and 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 Inner Reef Flat (0-40 meters)											
Porites (P.) lutea	9	15.7	18.0	1.4-48.8	0.56	24.00	0.09	32.14	0.395	76.85	132.99
Goniastrea retiformis	5	10.9	4.7	5.9-17.1	0.44	18.86	0.05	17.86	0.011	2.14	38.86
Pocillopora damicornis	3	13.4	7.0	5.3-17.5	0.33	14.14	0.03	10.71	0.052	10.12	34.97
Pocillopora setchelli	3	5.6	3.4	3.5-9.4	0.11	4.71	0.03	10.71	0.009	1.75	17.17
Porites (P.) australiensis	1	18.9	-	-	0.11	4.71	0.01	3.57	0.029	5.64	13.92
Pavona sp. 3	1	8.7	-	-	0.11	4.71	0.01	3.57	0.006	1.17	9.45
Acropora cerealis	1	7.5	-	-	0.11	4.71	0.01	3.57	0.005	0.97	9.25
Porites (P.) lichen	1	5.7	-	-	0.11	4.71	0.01	3.57	0.003	0.58	8.86
Acropora azurea	1	3.9	-	-	0.11	4.71	0.01	3.57	0.001	0.19	8.47
Favia favus	1	3.5	-	-	0.11	4.71	0.01	3.57	0.001	0.19	8.47
Montipora lobulata	1	4.0	-	-	0.11	4.71	0.01	3.57	0.001	0.19	8.47
Stylophora mordax	1	4.0	-	-	0.11	4.71	0.01	3.57	0.001	0.19	8.47
Totals:	28	11.0	11.3	1.4-48.8			0.28		0.514		
Transect A Outer Reef Flat (40-75 meters)											
Porites (P.) lutea	14	7.7	4.8	2.4-20.9	0.86	33.44	1.23	50.00	0.775	54.23	137.67
Goniastrea retiformis	4	9.9	5.5	4.0-16.9	0.43	16.72	0.35	14.29	0.336	23.51	54.52
Acropora digitifera	3	8.0	3.6	4.2-11.3	0.43	16.72	0.26	10.71	0.150	10.50	37.93
Pocillopora setchelli	3	4.1	1.9	2.0-5.5	0.29	11.28	0.26	10.71	0.040	2.80	24.79
Porites (P.) australiensis	1	10.2	-	-	0.14	5.44	0.09	3.57	0.072	5.04	14.05
Acropora cerealis	1	5.9	-	-	0.14	5.44	0.09	3.57	0.024	1.68	10.69
Acropora ocellata	1	5.5	-	-	0.14	5.44	0.09	3.57	0.021	1.47	10.48
Montipora elschneri	1	4.0	-	-	0.14	5.44	0.09	3.57	0.011	0.77	9.78
Totals:	28	7.5	4.3	2.0-20.9			2.46		1.429		
Transect A Reef Front Slope (depth 4-6 meters)											
Millepora platyphylla	2	29.1	28.8	8.7-49.4	0.20	6.45	0.72	5.00	7.07	42.59	54.04

Table 1. Continued.

Transect No., Reef Zone, and 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
Acropora humilis	2	24.3	3.2	22.0-26.5	0.20	6.45	0.72	5.00	3.33	20.06	31.51
Leptoria phrygia	5	4.1	2.5	1.4-7.5	0.40	12.90	1.79	12.50	0.30	1.81	27.21
Montipora elschneri	4	8.9	3.8	5.0-13.7	0.30	9.68	1.43	10.00	1.01	6.08	25.76
Montipora verrilli	5	5.3	2.8	2.4-9.9	0.30	9.68	1.79	12.50	0.49	2.95	25.13
Pocillopora verrucosa	4	5.0	0.7	4.0-5.5	0.30	9.68	1.43	10.00	0.28	1.69	21.37
Acropora nasuta	3	5.3	0.8	4.5-6.0	0.30	9.68	1.07	7.50	0.24	1.45	18.63
Millepora tuberosa	3	6.8	2.0	4.9-8.8	0.10	3.23	1.07	7.50	0.41	2.47	13.20
Goniopora tenuidens	1	19.9	-	-	0.10	3.23	0.36	2.50	1.11	6.69	12.42
Montipora hoffmeisteri	2	15.4	4.2	12.4-18.3	0.10	3.23	0.36	5.00	0.69	4.16	12.39
Montastrea curta	2	4.2	1.4	3.2-5.2	0.20	6.45	0.72	5.00	0.10	0.60	12.05
Favia stelligera	1	14.5	-	-	0.10	3.23	0.36	2.50	0.59	3.55	9.28
Stylophora mordax	2	5.2	1.6	4.0-6.3	0.10	3.23	0.72	5.00	0.16	0.96	9.19
Goniastrea retiformis	1	13.4	-	-	0.10	3.23	0.36	2.50	0.51	3.07	8.80
Pocillopora eydouxi	1	6.5	-	-	0.10	3.23	0.36	2.50	0.12	0.72	6.45
Leptastrea purpurea	1	6.6	-	-	0.10	3.23	0.36	2.50	0.10	0.60	6.33
Porites (P.) lichen	1	5.5	-	-	0.10	3.23	0.36	2.50	0.09	0.54	6.27
Totals:	40	9.0	8.6	1.4-49.4			13.98		16.60		
Transect B Inner Reef Flat (0-35 meters)											
Porites (P.) lutea	18	11.1	5.2	5.3-20.8	0.86	50.29	0.20	75.00	0.24	86.33	211.62
Porites (P.) solida	1	17.5	-	-	0.14	8.19	0.01	4.17	0.03	10.79	23.15
Acropora digitifera	2	3.0	0.3	2.8-3.2	0.29	16.96	0.02	8.33	0.002	0.72	13.08
Acropora ocellata	1	5.3	-	-	0.14	8.19	0.01	4.17	0.002	0.72	13.08
Pocillopora setchelli	1	4.5	-	-	0.14	8.19	0.01	4.17	0.002	0.72	13.08
Psammocora contigua	1	5.3	-	-	0.14	8.19	0.01	4.17	0.002	0.72	13.08
Totals:	24	9.9	5.6	2.8-20.8			0.26		0.278		
Transect B Outer Reef Flat (35-75 meters)											
Porites (P.) lutea	10	9.4	4.6	3.5-17.4	0.63	27.63	0.18	31.25	0.148	42.65	101.53
Goniastrea retiformis	5	12.9	5.5	7.5-21.0	0.88	16.67	0.09	15.63	0.138	39.77	72.07
Acropora digitifera	11	4.2	1.7	2.8-8.8	0.63	27.63	0.20	34.38	0.032	9.22	71.23
Acropora cerealis	2	3.5	0.0	3.5-3.5	0.25	10.96	0.04	6.25	0.003	0.86	18.07
Pocillopora setchelli	2	8.1	1.6	6.9-9.2	0.13	5.70	0.04	6.25	0.019	5.48	17.43

Table 1. Continued.

Transect No., Reef Zone, and 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 damicornis	1	5.5	-	-	0.13	5.70	0.02	3.13	0.004	1.15	9.98
Pocillopora eydouxi	1	4.9	-	-	0.13	5.70	0.02	3.13	0.003	0.86	9.98
Totals:	32	7.4	4.7	2.8-21.0			0.59		0.347		
Transect B Reef Front Slope (depth 4-6 meters)											
Stylophora mordax	4	7.7	11.1	2.0-24.4	0.40	10.81	0.93	10.00	1.11	39.36	60.17
Goniastrea edwardsi	6	4.1	1.8	2.4-7.5	0.50	13.51	1.39	15.00	0.21	7.45	35.96
Galaxea fascicularis	4	5.6	2.0	4.0-8.5	0.30	8.11	0.93	10.00	0.25	8.87	26.98
Platygyra pini	3	4.7	1.4	3.0-5.5	0.30	8.11	0.70	7.50	0.13	4.61	20.22
Pavona sp. 3	3	4.6	1.1	3.5-5.7	0.20	5.41	0.70	7.50	0.12	4.26	17.17
Porites (P.) lichen	2	6.4	3.0	4.2-8.5	0.20	5.41	0.46	5.00	0.16	5.67	16.08
Goniastrea retiformis	2	4.9	3.0	2.8-7.0	0.20	5.41	0.46	5.00	0.10	3.55	13.96
Favites russelli	2	4.3	1.8	3.0-4.2	0.20	5.41	0.46	5.00	0.07	2.48	12.89
Pocillopora verrucosa	2	4.1	0.1	4.0-4.2	0.20	5.41	0.46	5.00	0.06	2.13	12.54
Leptastrea purpurea	1	8.8	-	-	0.10	2.70	0.23	2.50	0.14	4.96	10.16
Leptoria phrygia	1	7.3	-	-	0.10	2.70	0.23	2.50	0.10	3.55	8.75
Montipora verrilli	1	6.0	-	-	0.10	2.70	0.23	2.50	0.07	2.48	7.68
Porites (P.) australiensis	1	6.0	-	-	0.10	2.70	0.23	2.50	0.07	2.48	7.68
Acropora digitifera	1	5.0	-	-	0.10	2.70	0.23	2.50	0.05	1.77	6.97
Favia pallida	1	4.9	-	-	0.10	2.70	0.23	2.50	0.04	1.42	6.62
Favia matthai	1	4.9	-	-	0.10	2.70	0.23	2.50	0.04	1.42	6.62
Montastrea curta	1	3.9	-	-	0.10	2.70	0.23	2.50	0.03	1.06	6.26
Acanthastrea echinata	1	3.5	-	-	0.10	2.70	0.23	2.50	0.02	0.71	5.91
Favia stelligera	1	3.0	-	-	0.10	2.70	0.23	2.50	0.02	0.71	5.91
Fungia (P.) scutaria	1	3.5	-	-	0.10	2.70	0.23	2.50	0.02	0.71	5.91
Oulaphyllia crispa	1	2.4	-	-	0.10	2.70	0.23	2.50	0.01	0.35	5.55
Totals:	40	5.1	3.6	2.0-24.4			9.25		2.82		
Transect C Inner Reef Flat (0-25 meters)											
Porites (P.) lutea	10	10.1	5.9	2.4-19.6	0.50	42.86	0.19	55.56	0.20	47.62	146.04
Porites (P.) australiensis	2	21.6	2.2	20.0-23.1	0.17	14.57	0.04	11.11	0.14	33.33	59.01
Goniastrea retiformis	4	7.6	5.3	2.4-13.4	0.17	14.57	0.07	22.22	0.05	11.90	48.69

Table 1. Continued.

Transect No., Reef Zone, and 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
Pocillopora setchelli	1	12.4	-	-	0.17	14.57	0.02	5.56	0.02	4.76	24.89
Pocillopora damicornis	1	7.1	-	-	0.17	14.57	0.02	5.56	0.01	2.38	22.51
Totals:	18	10.8	6.4	2.4-23.1			0.34		0.42		
Transect C Outer Reef Flat (25-45 meters)											
Porites (P.) lutea	5	10.0	3.9	4.6-14.7	0.75	33.33	0.47	31.25	0.41	64.06	128.64
Acropora azurea	8	4.3	1.2	2.4-6.0	0.75	33.33	0.76	50.00	0.12	18.75	102.08
Goniastrea retiformis	2	6.2	0.2	6.0-6.3	0.50	22.22	0.19	12.50	0.06	9.38	44.10
Pocillopora damicornis	1	8.4	-	-	0.25	11.11	0.09	6.25	0.05	7.81	25.17
Totals:	16	6.6	3.4	2.4-14.7			1.51		0.64		
Transect C Reef Front Slope (depth 4-6 meters)											
Millepora platyphylla	5	28.9	24.0	2.4-54.0	0.40	10.81	1.32	12.50	13.47	71.31	94.62
Stylophora mordax	5	3.8	2.6	2.0-7.9	0.40	10.81	1.32	12.50	0.21	1.11	24.42
Leptoria phrygia	4	5.9	2.7	3.5-8.5	0.30	8.11	1.06	10.00	0.33	1.75	19.86
Psammocora digitata	1	32.9	-	-	0.10	2.70	0.26	2.50	2.26	11.96	17.16
Porites (P.) lutea	2	6.6	1.0	5.9-7.3	0.20	5.41	0.53	5.00	0.19	1.01	11.42
Acropora monticulosa	2	5.0	2.8	2.0-7.0	0.20	5.41	0.53	5.00	0.12	0.64	11.05
Acropora nasuta	2	5.0	1.4	4.0-6.0	0.20	5.41	0.53	5.00	0.11	0.58	10.99
Pocillopora elegans	1	22.8	-	-	0.10	2.70	0.26	2.50	1.09	5.77	10.97
Goniastrea retiformis	2	4.5	0.6	4.0-4.9	0.20	5.41	0.53	5.00	0.08	0.42	10.83
Pocillopora verrucosa	1	12.8	-	-	0.10	2.70	0.26	2.50	0.34	1.80	7.00
Pavona varians	1	9.4	-	-	0.10	2.70	0.26	2.50	0.18	0.95	6.15
Acropora surculosa	1	6.5	-	-	0.10	2.70	0.26	2.50	0.09	0.48	5.68
Echinopora lamellosa	1	5.9	-	-	0.10	2.70	0.26	2.50	0.07	0.37	5.57
Pavona duerdeni	1	5.3	-	-	0.10	2.70	0.26	2.50	0.06	0.32	5.52
Favia favus	1	4.9	-	-	0.10	2.70	0.26	2.50	0.05	0.26	5.46
Goniastrea edwardsi	1	4.9	-	-	0.10	2.70	0.26	2.50	0.05	0.26	5.46
Galaxea fascicularis	1	3.9	-	-	0.10	2.70	0.26	2.50	0.03	0.16	5.36
Acropora digitifera	1	3.0	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31
Cyphastrea microphthalma	1	3.0	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31
Favia matthai	1	2.8	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31
Favia stelligera	1	3.0	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31

Table 1. Continued.

Transect No., Reef Zone, and 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
Leptastrea purpurea	1	2.8	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31
Montastrea curta	1	3.5	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31
Montipora verrucosa	1	3.5	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31
Pavona sp. 3	1	3.5	-	-	0.10	2.70	0.26	2.50	0.02	0.11	5.31
Totals:	40	9.1	12.2	2.0-54.0			10.50		18.89		
Transect D Inner Reef Flat (0-20 meters)											
Porites (P.) lutea	11	13.9	6.4	5.9-24.7	0.75	75.00	0.50	91.67	0.91	96.81	263.48
Porites (P.) australiensis	1	8.8	-	-	0.25	25.00	0.05	8.33	0.03	3.19	36.52
Totals:	12	13.5	6.3	5.9-24.7			0.55		0.94		
Transect D Outer Reef Flat (20-40 meters)											
Acropora digitata	4	10.8	3.8	5.0 15.1	0.50	15.38	0.95	25.00	0.96	18.15	58.53
Pocillopora setchelli	3	9.7	2.3	7.0-11.2	0.75	23.08	0.72	18.75	0.52	9.83	51.66
Acropora monticulosa	1	32.4	-	-	0.25	7.69	0.24	6.25	1.97	37.24	51.18
Acropora azurea	3	7.1	3.4	4.9-11.0	0.50	15.38	0.72	18.75	0.33	6.24	40.37
Acropora squarrosa	2	9.7	0.4	9.4-9.9	0.50	15.38	0.48	12.50	0.35	6.62	34.50
Goniastrea retiformis	1	23.0	-	-	0.25	7.69	0.24	6.25	0.99	18.71	32.65
Leptastrea purpurea	1	7.5	-	-	0.25	7.69	0.24	6.25	0.10	1.89	15.83
Acanthastrea echinata	1	6.0	-	-	0.25	7.69	0.24	6.25	0.07	1.32	15.26
Totals:	16	11.4	7.2	4.9-32.4			3.83		5.29		
Transect D Reef Front Slope (depth 4-6 meters)											
Favia stelligera	6	6.8	7.1	2.4-20.9	0.40	12.50	2.15	15.00	1.49	23.6›	51.19
Millepora platyphylla	1	25.8	-	-	0.10	3.13	0.36	2.50	1.88	29.89	35.52
Goniastrea retiformis	5	5.1	3.6	1.4-9.0	0.40	12.50	1.79	12.50	0.51	8.11	33.11
Leptoria phrygia	3	7.5	7.8	2.4-16.5	0.20	6.25	1.07	7.50	0.82	13.04	26.79
Acanthastrea echinata	4	4.0	0.5	3.5-4.6	0.30	9.38	1.43	10.00	0.18	2.86	22.24

Table 1. Continued.

Transect No., Reef Zone, and Coral Species	Size Distribution (Colony diameters in cm) n	Ȳ	s	w	Frequency	Relative Frequency	Density (per m²)	Relative Density	Percent Cover	Relative Percent Cover	Importance Value
Montipora verrilli	3	4.9	2.6	2.0-7.0	0.30	9.38	1.07	7.50	0.24	3.82	20.70
Pavona sp. 3	2	8.2	2.4	6.5-9.9	0.20	6.25	0.72	5.00	0.39	6.20	17.45
Psammocora sp. 1	2	6.0	0.4	5.7-6.3	0.20	6.25	0.72	5.00	0.20	3.18	14.43
Acropora digitifera	2	3.5	0.7	3.0-4.0	0.20	6.25	0.72	5.00	0.07	1.11	12.36
Platygyra pini	2	4.3	0.4	4.0-4.6	0.10	3.13	0.72	5.00	0.10	1.59	9.72
Favia matthai	2	2.8	0.6	2.4-3.2	0.10	3.13	0.72	5.00	0.05	0.79	8.92
Pavona varians	2	2.4	0.0	2.4-2.4	0.10	3.13	0.72	5.00	0.03	0.48	8.61
Montipora ehrenbergii	1	6.3	-	-	0.10	3.13	0.36	2.50	0.11	1.75	7.38
Acropora humilis	1	6.0	-	-	0.10	3.13	0.36	2.50	0.10	1.59	7.22
Coscinaraea sp. 1	1	3.2	-	-	0.10	3.13	0.36	2.50	0.03	0.48	6.11
Favia pallida	1	3.5	-	-	0.10	3.13	0.36	2.50	0.03	0.48	6.11
Pocillopora setchelli	1	3.0	-	-	0.10	3.13	0.36	2.50	0.03	0.48	6.11
Pocillopora verrucosa	1	3.5	-	-	0.10	3.13	0.36	2.50	0.03	0.48	6.11
Totals:	40	5.6	5.0	1.4-25.8			14.35		6.29		
Transect E Inner Reef Flat (0-30 meters)											
Montipora ehrenbergii	1	46.0	-	-	0.17	8.50	0.01	5.56	0.191	76.71	90.77
Porites (P.) lichen	7	3.8	1.5	2.4-6.9	0.50	25.00	0.08	38.89	0.010	4.02	67.91
Pocillopora damicornis	4	7.9	4.6	2.0-13.0	0.33	16.50	0.05	22.22	0.028	11.24	49.96
Goniastrea retiformis	2	3.7	1.8	2.4-5.0	0.33	16.50	0.02	11.11	0.003	1.20	28.81
Leptoria phrygia	1	8.8	-	-	0.17	8.50	0.01	5.56	0.007	2.81	16.87
Platygyra pini	1	7.9	-	-	0.17	8.50	0.01	5.56	0.005	2.41	16.47
Acropora surculosa	1	5.5	-	-	0.17	8.50	0.01	5.56	0.003	1.20	15.26
Favia pallida	1	2.4	-	-	0.17	8.50	0.01	5.56	0.001	0.40	14.46
Totals:	18	7.6	10.1	2.0-46.0			0.20		0.249		
Transect E Outer Reef Flat (30-80 meters)											
Porites (P.) lutea	12	5.2	2.8	2.4-13.1	0.50	25.00	0.57	30.00	0.15	19.21	74.21
Goniastrea retiformis	5	11.5	3.3	6.9-15.0	0.30	15.00	0.24	12.50	0.26	33.29	60.79
Pocillopora damicornis	10	5.7	2.9	2.0-11.0	0.30	15.00	0.47	25.00	0.15	19.21	59.21
Acropora azurea	4	5.2	2.0	3.7-8.0	0.20	10.00	0.19	10.00	0.04	5.12	25.12
Pocillopora eydouxi	3	6.4	1.8	5.3-8.5	0.20	10.00	0.14	7.50	0.05	6.40	23.90
Pocillopora setchelli	1	12.4	-	-	0.10	5.00	0.05	2.50	0.06	7.68	15.18

Table 1. Continued.

Transect No., Reef Zone, and 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
Acropora digitifera	2	7.7	1.6	6.5-8.8	0.10	5.00	0.09	5.00	0.04	5.12	15.12
Goniastrea edwardsi	1	7.5	-	-	0.10	5.00	0.05	2.50	0.02	2.56	10.06
Acropora cerealis	1	3.7	-	-	0.10	5.00	0.05	2.50	0.01	1.28	8.78
Leptoria phrygia	1	1.4	-	-	0.10	5.00	0.05	2.50	0.001	0.13	7.63
Totals:	40	5.2	2.0	3.7-8.0			1.90		0.781		

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

Transects	A			B			C			D			E	
Reef Zones	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF
Taxon														
Class - ANTHOZOA														
Order - SCLERACTINIA														
Suborder - ASTROCOENIINA														
Family - ASTROCOENIIDA														
Stylocoeniella armada (Ehrenberg)						X								
Family - THAMNASTERIIDAE														
Psammocora contigua (Esper)				X							X			
Psammocora digitata Milne Edwards & Haime									X					
Psammocora superficiales Gardiner												X		
Psammocora sp. 1									X			X		
Family - POCILLOPORIIDAE														
Stylophora mordax (Dana)	X		X			X			X		X			
Seriatopora hystrix (Dana)						X								
Pocillopora damicornis (Linnaeus)	X				X		X	X					X	X
Pocillopora danae Verrill													X	
Pocillopora elegans Dana				X	X	X			X		X			
Pocillopora eydouxi Milne Edwards & Haime			X		X	X						X		X
Pocillopora ligulata Dana									X			X		
Pocillopora setchelli Hoffmeister	X	X	X	X	X	X	X		X		X	X		X
Pocillopora verrucosa (Ellis & Solander)			X			X			X		X	X		
Family - ACROPORIDAE														
Acropora azurea Veron & Wallace	X		X				X	X			X			X
Acropora cerealis (Dana)	X	X	X		X				X		X	X		X
Acropora digitifera (Dana)		X	X	X	X	X			X		X	X		X
Acropora humilis (Dana)			X						X			X		
Acropora irregularis (Brook)						X			X			X		
Acropora monticulosa (Bruggemann)									X		X	X		
Acropora nasuta (Dana)			X						X					
Acropora ocellata (Klunzinger)		X		X								X		
Acropora palifera (Lamarck)													X	
Acropora smithi (Brook)									X			X		
Acropora squarrosa (Ehrenberg)									X		X			
Acropora surculosa (Dana)						X								

Table 2. Continued.

Transects	A			B			C			D			E	
Reef Zones	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF
Taxon														
Acropora tenuis (Dana)						X			X			X	X	
Montipora ehrenbergii Verrill		X									X	X	X	
Montipora elschneri Vaughan			X						X					
Montipora hoffmeisteri Wells		X							X					
Montipora lobulata Bernard	X													
Montipora tuberculosa (Lamarck)						X								
Montipora venosa (Ehrenberg)			X											
Montipora verrilli Vaughan			X			X					X	X		
Montipora verrucosa (Lamarck)									X					
Montipora sp. 1			X						X					
Montipora sp. 2												X		
Suborder - FUNGIINA														
Family - AGARICIIDAE														
Pavona duerdeni Vaughan									X					
Pavona varians Verrill			X						X			X		
Pavona sp. 1			X											
Pavona sp. 2			X											
Pavona sp. 3	X					X			X			X		
Family - SIDERASTREIDAE														
Coscinaraea sp. 1												X		
Family - FUNGIIDAE														
Fungia (Pluractis) scutaria (Lamarck)						X								
Family - PORITIDAE														
Goniopora tenuidens Quelch			X											
Porites (Porites) australiensis Vaughan	X	X	X			X	X		X	X		X		
Porites (Porites) lichen Dana	X		X			X			X			X	X	
Porites (Porites) lutea Milne Edwards & Haime	X	X	X	X	X	X	X	X	X	X		X		X
Porites (Porites) solida (Forskal)				X										
Porites (Synaraea) rus (Forskal)						X					X	X		

Table 2. Continued.

Transects	A			B			C			D			E	
Reef Zones	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF
Taxon														
Suborder - FAVIINA														
Family - FAVIIDAE														
Favia favus (Forskal)	X		X						X		X			
Favia matthai Vaughan			X			X			X		X	X		
Favia pallida (Dana)						X						X	X	
Favia stelligera (Dana)			X			X			X			X		
Favites russelli (Wells)						X								
Oulophyllia crispa (Lamarck)						X								
Goniastrea edwardsi Chevalier						X			X					X
Goniastrea retiformis (Lamarck)	X	X	X		X	X	X	X	X		X	X	X	X
Platygyra daedalea (Ellis & Solander)			X						X					
Platygyra pini Chevalier						X			X			X	X	
Leptoria phrygia (Ellis & Solander)			X			X			X		X	X	X	X
Hydnophora microconos (Lamarck)									X			X		
Montastrea curta (Dana)						X			X		X	X		
Leptastrea purpurea (Dana)			X			X			X		X			
Cyphastrea microphthalma (Lamarck)			X						X					
Echinopora lamellosa (Esper)									X					
Family - OCULINIDAE														
Galaxea fascicularis (Linnaeus)						X			X		X	X		
Family - MUSSIDAE														
Acanthastrea echinata (Dana)						X					X	X		
Lobophyllia corymbosa (Forskal)						X			X					
Class - HYDROZOA														
Order - MILLEPORINA														
Family - MILLEPORIDAE														
Millepora dichotoma Forskal									X		X			
Millepora platyphylla Hemprich & Ehrenberg		X	X			X			X			X		
Millepora tuberosa Boschma			X											

Table 2. Continued.

Transects		A			B			C			D			E	
Reef Zones		IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF	RF	IRF	ORF
Taxon															
Total species per transect zone		12	10	30	7	8	34	6	4	43	2	22	35	10	10
Total genera per transect zone		8	6	14	4	4	21	4	4	19	1	14	16	8	5
Total species per transect			36			39			45			43			16
Total genera per transect			14			22			19			18			8
Total species for the study area	72														
Total genera for the study area	27														

CONSPICUOUS EPIBENTHIC MACROINVERTEBRATES

by

Barry D. Smith

Methods

Populations of conspicuous epibenthic macroinvertebrates were sampled along seven transects established on reef flat platform and reef front systems of the Obyan-Naftan reef complex (see Figs. 1 and 2, pp. 4-5). Species of macrobenthos occurring within 1 m of the transect line were identified and enumerated by an observer swimming along the line. Data were recorded for 5-m segments of the line. Thus, transects consisted of *n* rectangular quadrats, each of which covered an area of 10 m^2.

Areas adjacent to the transects were also examined to record the presence of species inhabiting the reef but not occurring within the selected study sites. Remains of dead macroinvertebrates were noted when present, but they were not quantified.

Results

Reef Flat Platform

Echinoderms were the predominant benthic macroinvertebrates on all transects. The sea cucumbers Holothuria atra and Stichopus chloronotus were the most abundant echinoderms on the reef flat platform (Tables 1 and 2). These organisms exhibited a general pattern of increasing abundance from the inner reef to the outer reef on all transects except Transect D, where there was no significant difference in densities. Bohadschia argus was found in an inner reef area of Transect A where there was sufficient sediment accumulation for it to burrow partially in the sand.

Echinoids were generally restricted to the outer reef flat. Echinothrix diadema and Echinometra mathaei were scattered on the outer reef, where they occupied crevices and grooves in the substrate. The single exception to this pattern occurred on Transect A, were one Diadema savignyi was associated with a large rock on the inner reef, near the boundary with the outer reef. No asteroids were observed on the reef flat platform.

Obyan-Naftan reef supports a diverse community of molluscs. Predatory gastropods of the orders Mesogastropoda and Neogastropoda were predominant in terms of diversity, constituting some 77% of the total number of gastropod species present. The greatest diversity was exhibited by the family Conidae, which was represented by nine species belonging to the vermivorous guild of the genus Conus. Only four species of browsing detrital and suspension feeders from the orders Archaeogastropoda and Mesogastropoda were observed on the transects. The most abundant gastropod on the reef flat was the introduced marine snail Trochus niloticus . The giant clam Tridacna maxima was the only living species of bivalve encountered on reef flat transects.

Other than echinoderms and molluscs, few macrobenthos were observed on the reef flat. At the western end of the reef flat complex, the crab Grapsus

cf. tenuicrustatus was associated with intertidal beach rock on Transect E, and the anemone Heteractis cf. macrodactylum occurred in subtidal depressions on the outer reef. Two species of sponges were recorded on the inner reef on Transects A and E.

Reef Front

The Obyan-Naftan reef front was characterized by a diverse echinoderm assemblage (Table 3). Unlike the reef flat, however, echinoids were more abundant than holothurians. The boring sea urchin Echinostrephus cf. aciculatus was present in the highest density, occurring in clusters crowded on the walls of small channels in the reef. Echinometra mathaei and Echinothrix diadema were scattered in crevices in the reef framework.

Although holothurians were not abundant on the reef front, the species that inhabited this zone were the same as those that were found on the reef flat. Conversely, the reef front provided habitat for two species each of asteroids and crinoids, classes of echinoderms not represented on the reef flat. The seastars Culcita novaeguineae and Linckia multifora were represented by individual specimens. Two species of nocturnal crinoids, Comanthus cf. parvicirrus and Comatella cf. maculata, were observed hiding in the interstices of the reef framework.

Alcyonacean corals occurred on the reef front in abundances approaching those of the echinoids. Sinularia spp. were the most abundant and most widely distributed soft corals. Lobophytum spp. were present in lower numbers.

Epibenthic molluscs were slightly less diverse on the reef front than on the reef flat. Only one of the eight species of Conus inhabiting the reef front was also found on the reef flat. A total of 12 species of predatory neogastropods and 4 species of archaeogastropods were encountered on the reef front transects. Although no mesogastropods were found in the 400 m^2 surveyed, species such as the triton trumpet Charonia tritonis were observed in adjacent areas (Table 4).

The reef front provided apparently favorable habitat for the giant clam Tridacna maxima. Fifty clams ranging in size from 30-180 mm ($\bar{x}$ = 73.2; s = 42.4) in length were observed in the sampled area.

Table 4 presents a list of species of macroinvertebrates observed in the vicinity of the transects on the Obyan-Naftan reef but not found within the sampled area. Examination of this list reveals that of the 85 species of macroinvertebrates observed on the reef system, 25 species were never encountered on the transects.

Discussion

Although it may at first appear that an unusually large number of species were missed by the sampling method employed during this survey, a closer examination of the data indicates that the method was adequate to characterize the macroinvertebrate fauna of the area. Of the 25 species never encountered on transects, 5 species inhabited rocky intertidal limestone along the shore. Of the remaining 20 species not quantified on transects, 9 were collected from cryptic habitats. Therefore, only 11 species representing some 13% of the total did not occur within the sampled area.

The Obyan-Naftan reef complex is similar to other fringing reefs on

Saipan and throughout Micronesia. A survey of nearby Laulau Bay (Pacific Basin Environmental Consultants, 1984) provided similar descriptive results, although no quantitative samples of macrobenthos were made. While Laulau Bay supported a more diverse community of molluscs (97 species) than Obyan reef (59 species), a greater number of echinoderm species were recorded at Obyan (14 species) than at Laulau Bay (12 species). One note of particular interest is the discussion of large numbers of the coral-eating crown-of-thorns starfish Acanthaster planci at Laulau Bay in 1984. This species was not observed on Obyan-Naftan reef during the present study.

Studies of Tanapag reef platform (Neill, 1985; Potter, 1987) also produced results similar to the present study. The Tanapag reef is far more extensive than Obyan reef, and consequently, it provides a greater diversity of habitats and macroinvertebrate species. The high densities of ascidians, cerithiids, and buccinids found at Tanapag did not occur at Obyan reef.

Obyan reef supported 41 of the 120 species of molluscs that Fujioka (1984) reported for Saipan. Of the remaining species, all have been recorded in recent literature (Vermeij et al., 1983; Pacific Basin Environmental Consultants, 1984; Neill, 1985; Potter, 1987), except Charonia tritonis.

Even based on a study of as short a duration as this, it is obvious that the macroinvertebrate populations on Obyan-Naftan reef provide important resources in subsistence fishing. The topshell Trochus niloticus, which was introduced to Saipan from Palau in the 1930s (South Seas Government, Fisheries Experiment Station, 1939), is well established and supports a limited fishery. This species attained densities comparable to the highest reef flat densities found on Guam (Smith, 1987). During the field work of this study, local fishermen were observed capturing Octopus sp. in the area between Transects A and E. Thus, the importance of such an ecosystem includes socio-economic values as well as ecological parameters.

References Cited

Fujioka, Y. 1984. Molluscan fauna of Saipan Island. Bull. Biol. Soc. Hiroshima Univ. 50:11-15.

Neill, J. B. 1985. Macroinvertebrates. pp. 37-53. In R. H. Randall (ed.), A marine survey of the Tanapag reef platform adjacent to Unai Papau. Univ. Guam Mar. Lab., Misc. Rept. 48.

Pacific Basin Environmental Consultants, Inc. 1984. Biological and physical survey of Bahia Laulau, Saipan. Final report prepared for Planning/Energy Office, Commonwealth of the Northern Mariana Islands. vii + 159 pp.

Potter, T. S. 1987. Macroinvertebrates. pp. 70-126. In R. H. Randall (ed.). A marine survey of the northern Tanapag reef platform, Saipan, Mariana Islands. Univ. Guam Mar. Lab., Tech. Rept. 87.

Smith, B. D. 1987. Growth rate, distribution and abundance of the introduced topshell Trochus niloticus Linnaeus on Guam, Mariana Islands. Bull. Mar. Sci. 41(2):466-474.

South Sea Government, Fisheries Experiment Station. 1939. Experiments on transplantation of top shells. Rept. Fish. Exp. Sta., South Seas Govt. 2:121-126. [In Japanese]

Vermeij, G. J., E. A. Kay, and L. G. Eldredge. 1983. Molluscs of the northern Mariana Islands, with special reference to the selectivity of oceanic dispersal barriers. Micronesica 19:27-55.

Table 1. Mean densities of benthic macroinvertebrates along transects on Obyan reef flat. Data are mean ± standard deviation (number of 10-m^2 quadrats). Each transect was divided into inner reef flat (IRF) and outer reef flat (ORF) zones. An asterisk (*) indicates the occurrence of dead individuals observed but not censused along the transect. TNC = Too Numerous to Count.

	Transect A		Transect B		Transect E	
	IRF	ORF	IRF	ORF	IRF	ORF
Phylum Protozoa						
Baculogypsina sphaerulata (Parker & Jones)	TNC	TNC	TNC	TNC	TNC	TNC
Phylum Porifera						
Cinachyra australiensis (Carter)	0.25±0.71(8)					
Dysidea cf. *herbacea* (Keller)					0.33±0.52(6)	
Phylum Cnidaria						
Heteractis cf. *macrodactylum* (Haddon & Shackleton)						0.20±0.42(10)
Phylum Mollusca						
Trochus niloticus Linnaeus		0.86±1.46(7)		0.13±0.35(8)		1.30±1.64(10)
Dendropoma maxima Sowerby	1.75±4.95(8)		2.14±3.98(7)	1.13±2.23(8)		
Cerithium nodulosum Bruguiere	0.13±0.35(8)					
Cypraea moneta Linnaeus		0.29±0.49(7)		0.25±0.46(8)		0.90±1.52(10)
Cymatium nicobaricum (Roeding)	0.13±0.35(8)					
Bursa bufonia (Gmelin)					1.00±2.45(6)	
Morula granulata (Duclos)					0.67±1.63(6)	
Morula squamosa (Pease)						
Morula uva (Roeding)	0.63±1.77(8)	0.29±0.49(7)				0.20±0.63(10)
Muricodrupa funiculus (Wood)					0.17±0.41(6)	
Latirus polygonus barclayi (Reeve)		0.14±0.38(7)				
Peristernia nassatula (Lamarck)		0.14±0.38(7)			0.17±0.41(6)	
Vasum turbinellus (Linnaeus)	0.38±0.74(8)	0.43±1.13(7)			0.83±1.60(6)	0.40±0.84(10)
Conus chaldaeus Roeding	0.25±0.71(8)					
Conus ebraeus Linnaeus	0.63±1.77(8)		0.57±1.13(7)	0.13±0.35(8)	1.00±1.55(6)	0.10±0.32(10)
Conus flavidus Lamarck				0.38±0.74(8)		
Conus lividus Hwass	*			0.13±0.35(8)		0.10±0.32(10)
Conus miles Linnaeus				0.25±0.46(8)		0.20±0.42(10)
Conus miliaris Hwass					0.33±0.82(6)	0.20±0.42(10)
Conus rattus Hwass	0.13±0.35(8)					
Conus sanguinolentus Quoy & Gaimard						0.20±0.42(10)
Conus sponsalis Hwass			0.29±0.75(7)		0.17±0.41(6)	
Placobranchus ocellatus van Hasselt					0.33±0.82(6)	
Tridacna maxima (Roeding)	0.38±0.74(8)	0.14±0.38(7)				
Phylum Arthropoda						
Grapsus cf. *tenuicrustatus* (Herbst)					0.17±0.41(6)	

Table 1. Continued.

	Transect A		Transect B		Transect E	
	IRF	ORF	IRF	ORF	IRF	ORF
Phylum Echinodermata						
Bohadschia argus Jaeger	0.13±0.35(8)					
Holothuria atra Jaeger	1.25±1.39(8)	2.57±1.90(7)	1.29±1.11(7)	3.13±1.45(8)	0.33±0.52(6)	3.50±2.64(10)
Stichopus chloronotus Brandt	0.50±0.76(8)	3.57±2.44(7)				1.50±1.27(10)
Diadema savignyi Michelin	0.13±0.35(8)					
Echinometra mathaei (de Blainville)				0.13±0.35(8)		1.10±1.29(10)
Echinothrix diadema (Linnaeus)		1.00±1.41(7)		0.25±0.46(8)		0.20±0.42(10)

Table 2. Mean densities of benthic macroinvertebrates along transects on Obyan-Naftan reef flat. Data are mean ± standard deviation (number of 10-m^2 quadrats). Each transect was divided into inner reef flat (IRF) and outer reef flat (ORF) zones. An asterisk (*) indicates the occurrence of dead individuals observed but not censused along the transect. TNC = Too Numerous to Count.

	Transect C		Transect D	
	IRF	ORF	IRF	ORF
Phylum Protozoa				
Baculogypsina sphaerulata (Parker & Jones)	TNC	TNC	TNC	TNC
Phylum Porifera				
Cinachyra australiensis (Carter)				
Dysidea cf. herbacea (Keller)				
Phylum Cnidaria				
Heteractis cf. macrodactylum (Haddon & Shackleton)				
Phylum Mollusca				
Trochus niloticus Linnaeus		0.20±0.45(5)		
Dendropoma maxima Sowerby				
Cerithium nodulosum Bruguiere				
Cypraea moneta Linnaeus	0.50±0.58(4)	1.00±0.71(5)		
Cymatium nicobaricum (Roeding)		0.20±0.45(5)		
Bursa bufonia (Gmelin)		0.20±0.45(5)		
Morula granulata (Duclos)			0.25±0.50(4)	
Morula squamosa (Pease)				
Morula uva (Roeding)	0.25±0.50(4)	0.40±0.89(5)		
Muricodrupa funiculus (Wood)				
Latirus polygonus barclayi (Reeve)				
Peristernia nassatula (Lamarck)				
Vasum turbinellus (Linnaeus)	0.50±1.00(4)	0.20±0.45(5)		
Conus chaldaeus Roeding				
Conus ebraeus Linnaeus	0.25±0.50(4)	0.20±0.45(5)	0.75±0.96(4)	0.33±0.58(3)
Conus flavidus Lamarck				
Conus lividus Hwass		0.20±0.45(5)		
Conus miles Linnaeus				
Conus rattus Hwass		0.20±0.45(5)		
Conus sanguinolentus Quoy & Gaimard				
Conus sponsalis Hwass				
Placobranchus cf. ocellatus van Hasselt				
Tridacna maxima (Roeding)				
Phylum Arthropoda				
Grapsus cf. tenuicrustatus (Herbst)				

Table 2. Continued.

	Transect C		Transect D	
	IRF	ORF	IRF	ORF
Phylum Echinodermata				
Bohadschia argus Jaeger				
Holothuria atra Jaeger	0.25±0.50(4)	3.00±2.00(5)	6.50±3.00(4)	5.00±4.58(3)
Stichopus chloronotus Brandt		1.20±0.84(5)		
Diadema savignyi Michelin				
Echinometra mathaei (de Blainville)		0.60±0.55(5)		
Echinothrix diadema (Linnaeus)		0.40±0.89(5)		

Table 3. Mean densities of benthic macroinvertebrates along transects on the reef front of Obyan-Naftan reef. Data are given as mean ± standard deviation of organisms counted in ten 10-m^2 quadrats. An asterisk (*) indicates the occurrence of dead individuals observed along the transect but not censused.

	Transect A	Transect B	Transect C	Transect D
Phylum Porifera				
orange sponge	0.2 ± 0.42			
Phylum Cnidaria				
Heteractis cf. crispa (Ehrenberg, 1834)		0.1 ± 0.32		
Lobophytum spp.	0.5 ± 1.27	0.1 ± 0.32		0.2 ± 0.42
Sinularia spp.	1.4 ± 2.17	3.5 ± 4.77	1.9 ± 1.66	1.6 ± 2.23
Phylum Annelida				
Sabellastarte sanctijosephi (Gravier)	0.1 ± 0.32			
Phylum Mollusca				
Clangulus clanguloides Wood				*
Tectus pyramis (Born)	0.1 ± 0.32	0.3 ± 0.48	0.2 ± 0.63	0.3 ± 0.67
Trochus niloticus Linnaeus	0.3 ± 0.67	0.3 ± 0.48	0.1 ± 0.32	
Astraea rhodostoma Lamarck	0.1 ± 0.32	0.1 ± 0.32	0.2 ± 0.42	0.1 ± 0.32
Turbo argyrostomus Linnaeus		0.2 ± 0.42	0.1 ± 0.32	
Latirus nodatus (Gmelin)	0.1 ± 0.32			
Drupa rubusidaeus Roeding			0.1 ± 0.32	
Vasum ceramicum (Linnaeus)		0.1 ± 0.32		
Vasum turbinellus (Linnaeus)	0.1 ± 0.32			
Conus balteatus Sowerby				0.1 ± 0.32
Conus distans Hwass		0.2 ± 0.42		
Conus flavidus Lamarck				0.3 ± 0.48
Conus imperialis Linnaeus	0.1 ± 0.32		0.1 ± 0.32	
Conus litoglyphus Hwass	0.2 ± 0.42			0.2 ± 0.42
Conus litteratus Linnaeus	*			
Conus miles Linnaeus	0.3 ± 0.48	0.1 ± 0.32		0.4 ± 0.52
Conus moreleti Crosse				0.2 ± 0.42
Tridacna maxima (Roeding)	0.3 ± 0.82	0.7 ± 1.06	1.0 ± 0.94	2.0 ± 1.76
Phylum Arthropoda				
Dardanus megistos (Herbst)	1.3 ± 0.48	0.1 ± 0.32	0.1 ± 0.32	0.1 ± 0.32
Phylum Echinodermata				
Comanthus cf. parvicirrus (Muller)		0.1 ± 0.32	0.4 ± 0.70	
Comatella cf. maculata (Carpenter)			0.1 ± 0.32	
Actinopyga mauritiana (Quoy & Gaimard)	0.1 ± 0.32	0.1 ± 0.32		
Bohadschia argus Jaeger			0.1 ± 0.32	
Holothuria atra Jaeger	0.1 ± 0.32			
Stichopus chloronotus Brandt	0.8 ± 1.03	0.5 ± 0.71	0.5 ± 0.71	2.0 ± 1.25

Table 3. Continued.

	Transect A	Transect B	Transect C	Transect D
Echinometra mathaei (de Blainville)	0.3 ± 0.67	1.4 ± 2.12	0.8 ± 1.03	1.5 ± 0.97
Echinostrephus cf. aciculatus A. Agassiz	3.1 ± 1.97	2.5 ± 2.07	2.3 ± 1.42	3.4 ± 2.88
Echinothrix diadema (Linnaeus)		0.4 ± 0.70	0.5 ± 0.71	0.1 ± 0.32
Culcita novaeguineae Muller & Troschel		0.1 ± 0.32		
Linckia multifora (Lamarck)			0.1 ± 0.32	

FISHES

by

Steven S. Amesbury

Methods

Two 5-m transects were set out at each of the 5 transecting locations (A through E) on the Obyan-Naftan reef flat (Figs. 1 and 2, pp.4-5). These 50-m transects ran parallel to the shoreline, with Transect 1 being located on the inner reef flat and Transect 2 on the outer reef flat. At locations A through D, a 50-m transect was also run at 5- to 6-m depth on the reef front.

Fish were enumerated by species within one meter of each side of the 50-m transect line (a total of 100 m^2). At the completion of the enumeration, an additional 15 to 20 minutes were spent recording the presence of additional fish species within the immediate vicinity of the transect line but which were not enumerated on the transect census.

Results

The reef flat fish communities in the Obyan-Naftan area contained a relatively modest number of fish species (a total of 33) and low densities of fish (4 to 77 fish per 100 m^2; Table 1). There was no consistent difference in species richness between the outer and inner reef flat zones, but there was a consistent difference with regard to fish abundance: in each of the five transects there were higher fish densities on the outer reef flat than there were on the inner (Table 1).

Reef flat habitats, and fish assemblages, were very similar throughout the whole Obyan-Naftan area from Transect E to Transect D.

The characteristics of the fish communities on the reef front were quite different from those on the reef flat (Table 2). A total of 67 fish species were seen on the reef front, 31 to 39 species per transect. Fish densities were also high, ranging from 129 to 191 fish per 100 m^2.

Discussion

The species of fish seen on the reef flat transects at Obyan-Naftan are typical for shallow, wave-swept reef flats. Similar species assemblages have been recorded for Guam in similar habitats (Amesbury, 1978). The species assemblages were similar at all five transect locations, and there was no evidence of any disturbance of the fish communities.

The fish communities observed on the reef front transects were also broadly similar from transect to transect. These fish communities are similar to reef front communities outside of Saipan Lagoon (Amesbury et al., 1979),

but are not as rich in species.

There is little in the way of harvestable fish resources on the Obyan-Naftan reef flat. However, on the reef front there are significant numbers of harvestable surgeonfishes and parrotfishes. We were informed that fishermen on Saipan fish in this area. In addition, we observed recreational scuba divers using this area. It would be most desirable that any development of the Obyan-Naftan area be carried out in such a way that fishing and diving opportunities be preserved.

Literature Cited

Amesbury, S. S. 1978. Studies on the biology of the reef fishes of Guam. Univ. Guam Mar. Lab., Tech. Rept. 49. 65 p.

Amesbury, S. S., D. R. Lassuy, R. F. Myers, and V. Tyndzik. 1979. A survey of the fish resources of Saipan Lagoon. Univ. Guam Mar. Lab., Tech. Rept. 52. 58 p.

Table 1. Abundance (no. per 100 m^2) of fishes on Obyan-Naftan reef flat transects. Transect 1: inner reef flat; transect 2: outer reef flat. Fish species observed near the transect but not counted on the transect are marked with a +.

	TRANSECTS									
	E		A		B		C		D	
SPECIES	1	2	1	2	1	2	1	2	1	2
ACANTHURIDAE										
Acanthurus lineatus								+	1	+
Acanthurus nigrofuscus		+	+			1	1			10
Acanthurus triostegus		6	1		1	+	+	1	+	
Naso lituratus		+		+						+
Naso unicornis						+				
BALISTIDAE										
Rhinecanthus rectangulus		2					+	+		
BLENNIDAE										
Salarias fasciatus				+						
CHAETODONTIDAE										
Chaetodon citrinellus		1	3	+	+	+	+	3	1	+
Chaetodon lunula	+									
Chaetodon trifasciatus	+									
FISTULARIIDAE										
Fistularia commersonii						+				
GRAMMISTIDAE										
Grammistes sexlineatus			1							
LABRIDAE										
Gomphosus varius		1								
Halichoeres centiquadrus								+		
Halichoeres margaritaceus			2	21	+	12	7	6	8	9
Halichoeres trimaculatus	+	31	4	2	6	2	1		1	
Labroides dimidiatus		+								
Stethojulis bandanensis		2	1	1	3	2	4	+	1	+
Thalassoma hardwicki		+								
Thalassoma quinquevittatum			+				+			
juveniles		2					1	1		2

Table 1. Continued.

SPECIES	TRANSECTS E 1	E 2	A 1	A 2	B 1	B 2	C 1	C 2	D 1	D 2
MUGILIDAE										
Liza vaigiensis										1
MULLIDAE										
Parupeneus barberinus							+			
Parupeneus bifasciatus		+				+				1
POMACENTRIDAE										
Abudefduf septemfasciatus	+	+								+
Abudefduf sordidus	+									
Chrysiptera glauca		6	1	18		+	+	3		
Chrysiptera leucopoma		4	9	22	10	16	24	25	50	28
Stegastes nigricans	4	21	2					2	1	+
SCARIDAE										
Scarus ghobban		+								
Scarus harid							+	3		+
SERRANIDAE										
Epinephelus merra		+								
SYNODONTIDAE										
Saurida gracilis						+				
TETRAODONTIDAE										
Canthigaster solandri		1	1		2					
Total species observed	6	19	12	8	7	12	13	11	8	15
Total fish abundance on transect (no. per 100 m^2)	4	77	25	64	22	33	38	44	63	49

Table 2. Fish abundance (no. per 100 m^2) on the reef front transects in the Obyan-Naftan area. Species observed in the area but not counted on the transect are marked with a +.

	TRANSECTS			
	A	B	C	D
ACANTHURIDAE				
Acanthurus glaucopareius		+	1	1
Acanthurus lineatus				2
Acanthurus nigrofuscus	16	2		1
Acanthurus olivaceus	+			
Acanthurus triostegus	+	+	1	+
Ctenochaetus binotatus		35	20	11
Ctenochaetus striatus		37	65	45
Naso lituratus	3	+	10	2
Naso tuberosus		+		
Zebrasoma veliferum		+		
AULOSTOMIDAE				
Aulostomus chinensis		+		
BALISTIDAE				
Balistapus undulatus	+	+	+	1
Melichthys vidua	1	+	+	
Rhinecanthus rectangulus	+		1	+
Sufflamen bursa	+	+		1
Sufflamen chrysoptera	1			
CARANGIDAE				
Caranx melampygus				+
CHAETODONTIDAE				
Chaetodon citrinellus	2	2	2	2
Chaetodon ephippium	+	+	+	+
Chaetodon ornatissimus	+			+
Chaetodon punctatofasciatus		+		
Chaetodon quadrimaculatus	+			
Chaetodon trifasciatus			+	+
Chaetodon ulietensis	+			
Forcipiger flavissimus	+		+	+
Forcipiger longirostris				+

Table 2. Continued.

	TRANSECTS			
	A	B	C	D
CIRRHIDAE				
Paracirrhites forsteri		+		
FISTULARIIDAE				
Fistularia commersonii	+			
GOBIIDAE				
Ptereleotris evides	30			
LABRIDAE				
Cheilinus celebicus	+	+	+	
Cheilinus undulatus				1
Coris aygula				+
Epibulus insidiator				+
Gomphosus varius			1	
Halichoeres centiquadrus		+		+
Halichoeres margaritaceus				1
Halichoeres marginatus		1		
Hemigymnus fasciatus				+
Labroides dimidiatus	3	+		
Novaculichthys taeniourus		+		
Stethojulis bandanensis	+	2		1
Stethojulis strigiventer				+
Thalassoma fuscum	1	4	2	
Thalassoma lutescens			+	
Thalassoma quinquevittatum	9	8	7	8
juveniles			3	2
LETHRINIDAE				
Monotaxis grandoculis				+
LUTJANIDAE				
Aphareus furcatus	+			

Table 2. Continued.

	TRANSECTS			
	A	B	C	D
MULLIDAE				
Parupeneus bifasciatus	1	1	+	
Parupeneus chryseredros			1	
Parupeneus trifasciatus	+	1	1	1
POMACANTHIDAE				
Centropyge flavissimus	+	1	+	1
POMACENTRIDAE				
Abudefduf vaigiensis		+		+
Chrysiptera leucopoma	56	5	12	4
Dascyllus reticulatus	+	3	2	
Plectroglyphidodon dickii		+		
Plectroglyphidodon imparipennis	2		1	1
Pomacentrus vaiuli				1
Pomachromis guamensis	62		1	
Stegastes fasciolatus		7		
Stegastes nigricans			2	
SCARIDAE				
Scarus harid	+		2	2
Scarus psittacus	+	+		+
Scarus schlegeli				+
Scarus sordidus	+	22	19	36
juveniles	4	2		
SERRANIDAE				
Cephalopholis urodelus			+	
SIGANIDAE				
Siganus argenteus	+	+		

Table 2. Continued.

	TRANSECTS			
	A	B	C	D
ZANCLIDAE				
Zanclus cornutus		+	2	3
Total No. of Species	35	37	31	39
Total Fish Abundance on Transect (no. per 100 m^2)	191	133	156	129

Acknowledgements

The authors are grateful for financial support received from the Coastal Resources Management (CRM) Office, Saipan, Commonwealth of the Northern Mariana Islands. The Acting Director of CRM, Mr. Robert W. Rudolph, and members of his staff were particularly helpful during our period of fieldwork.

We want to thank Ms. Marie B. Peredo, our Secretary, for typing the draft manuscripts of six different authors and for her help along with Ms. Angela F. Duenas for their help in solving the many problems that arise whenever a project, such as ours, involves so many members and arrangements between several governments.