GUAM ENVIRONMENTAL PROTECTION AGENCY

THIRD ANNUAL REPORT ON THE MARINE

BENTHIC ALAGE AND CORAL COMMUNITIES

AT BIOLOGICAL MONITORING STATIONS AROUND GUAM

by

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ABSTRACT

Fourteen biological stations, within the Guam Environmental Protection Agency Biological Monitoring Program, were surveyed using the point-quadrat method to determine the percent cover and frequency of occurrence of marine benthic algae, corals, macroinvertebrates and substrate. Comparisons were made with the results presented in the First and Second Annual Reports (Rowley, 1981 and 1983) to determine if changes occurred in the reef communities of Guam. Four monitoring stations had significant changes in the percent cover of the various benthic component groups. The Sewer Island station, which is inshore of the Agana Sewage Treatment Plant ocean outfall, and the Alupat station, which is close to a leaking sewage line along Dungca's beach, both had significant increases in algae cover when compared for the three surveys. The Sewer Island and Alupat stations had significantly higher algae cover in the moat zones than the control station at Adelup when analyzed for the present survey. While the determination of the exact cause for these differences was not in the scope of these surveys the possible influence of sewage effluents should be considered for further investigation. Double Reef had an significant increase in invertebrate cover and Jade Shoals had a significant decrease in substrate cover over time. Both stations are located in patch reefs with gradually increasing coral coverage. If determiniation of no significant changes in any of the four major benthic component groups over time is used as a evaluation criteria then the remaining eleven monitoring stations could be considered as being located in stable reef communities.

It is recommended that intensive biological monitoring be conducted in designated priority areas. Additional stations should be established on reef flats close to point and non-point source pollution for comparisons with control areas to determine the impact of ubanization and development. The results of the biological monitoring program should then be correlated with the the chemical and physical analysis of water samples collected by the GEPA Water Monitoring Program.

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LIST OF FIGURES

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Tropical islands such as Guam have many unique and valuable resources associated with its coral reef environments. Inshore commerical and recreational fisheries, aquaculture, tourism, and recreational skin and scuba diving are just a few of the acitivities that are dependent on reefs that are ecologically and aesthetically undamaged. Biological monitoring programs designed to determine the impact of humans and pollution on reef habitats can provide useful information for planning, management and conservation of these priceless resources (Dahl, 1981).

The Guam Environmental Protection Agency Biological Monitoring Program was implemented in 1980 to assess the baseline conditions of representative coral reefs around Guam. Rowley (1981, 1983) presented results of the monitoring program from point-quadrat surveys for a variety of reef zones at nine and then eleven stations respecitively. The program was again expanded to fourteen stations to facilitate comparisons of pristene and sewage impacted reef flats. The purpose of this and subsequent reports is to document any significant changes in percent cover and frequency of occurrence of algae and coral. These components of marine communities are considered important for the integrity and development of coral reefs.

MATERIALS AND METHODS

The locations of the fourteen biological monitoring stations are presented in Figure 1. More detailed maps are included in Rowley (1981, 1983). Stations are grouped into four regions. Region I includes the northwest coast stations from Double Reef to Apra Harbor. Region II includes the southwest coast stations from Agat Bay to Merizo Lagoon. Stations in region III were not sampled as the program emphasis was on gathering data in the more densely populated areas of Region I and II. There are no stations in Region IV because of the lack of urbanization and the limited accessibility of this exposed coastline. The North Gaan station was not sampled this past survey as no permanent marker was in situ. Two new stations were added in the inner and outer reef flat zones at the Adelup and Sewer Island areas.

Information on the survey dates and station and transect locations is presented in Table 1. The variable time intervals between sampling was often a result of unpredictable weather conditions. Stations at Fouha and Umatac had a depth range of several meters since a reef zonation boundary was traversed during the sampling.

The point-quadrat method utilized in this survey was adapted from Randall et al., 1978. Compass bearings (Table 1) were used to orient the 25 meter transect tape from the permanent concrete markers. Every five meters, to the right and left of the transect line, a one square-meter quadrat was placed at predesignated

locations. The quadrat frame was gridded off with nylon line to form sixteen internal cross-points. The presence of substrate, algae, coral and macroinvertebrates was recorded as they appeared under these sixteen points. Species names were used as presented in checklists prepared by the Marine Laboratory Staff and Associates (1981). At each biological monitoring station a total of 160 pieces of information were generated for the ten sampling quadrats. Percent cover was then calculated by totaling the number of points a particular species was recorded (n) and dividing by the total number of points (160) and then multiplying by one hundred, i.e., n/160 x 100 = percent cover. Frequency was determined by dividing the total number of quadrats in which a species occurred (n) by the total number of qudarats surveyed (10), i.e., n/10 = frequency.

The data presented on percent cover and frequency of algae, coral, macroinvertebrates and substrate were collected at the fourteen monitoring stations from March to July 1983 predominately in the dry season (December to May). June is typically a transition month. This particular year was extremely dry and numerous forest fires and erosion problems were reported. The wet season on Guam usually runs from July to November. The intertidal and reef flat zones of Guam are subjected to greater desiccation and thermal stress when the majority of extreme low spring tides occur during the mid-day periods from May to August than when they occur during the night from October to March (Tsuda, 1974).

Changes in abundance of several species of Phaeophyta or brown algae were quantified by Tsuda (1974) and related to the seasonal variations in rainfall, salinity and desiccation on the reef flats. At the community level, however, no pronounced seasonal changes in the percent cover of benthic algae at five reef flat locations could be demonstrated (Tsuda et al., 1978). The data collected from each station during the present survey will therefore be compared with an Analysis of Variance test with the results of the first and second surveys regardless of sampling month or climatic season.

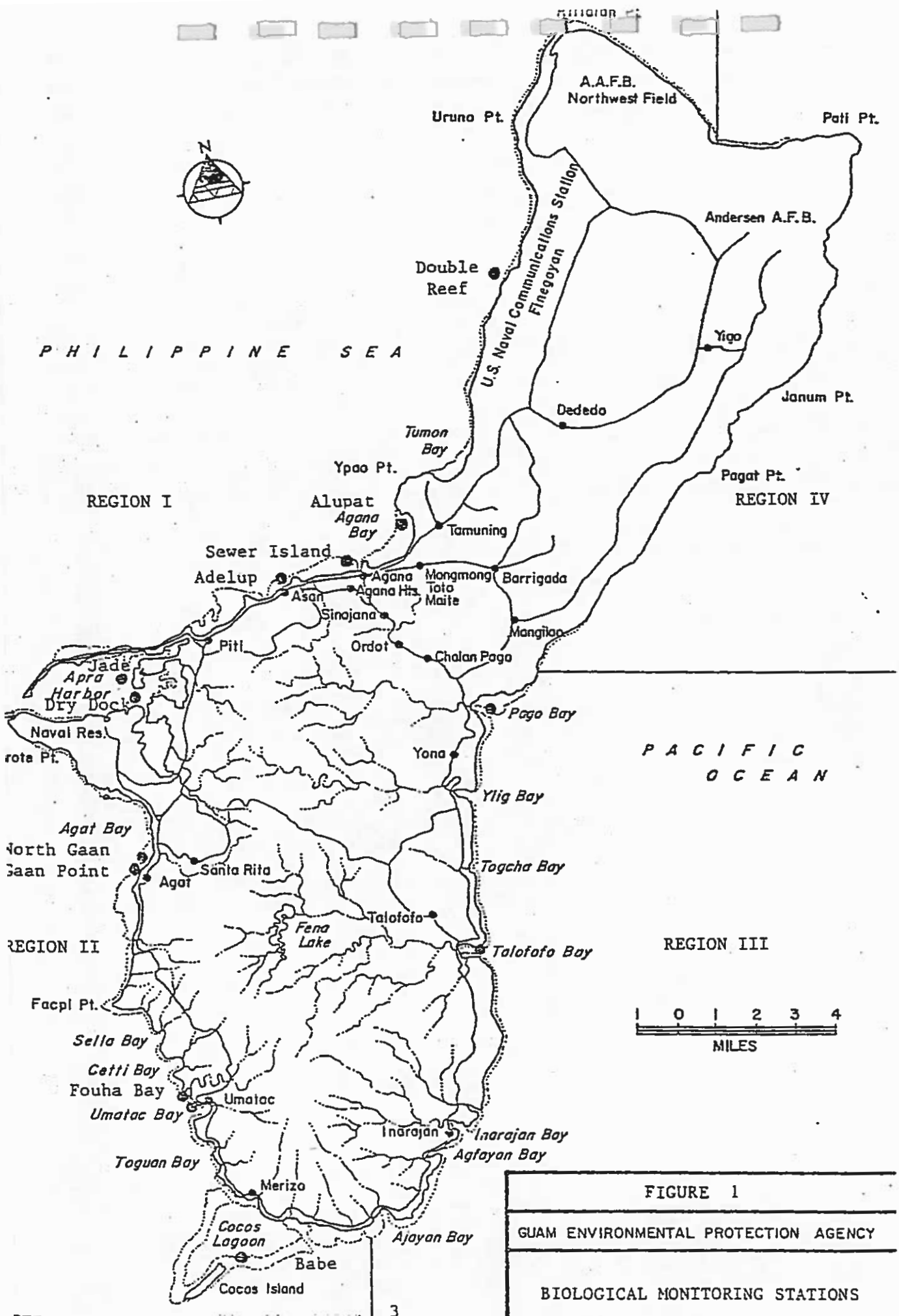

FIGURE 1

GUAM ENVIRONMENTAL PROTECTION AGENCY

BIOLOGICAL MONITORING STATIONS

EFERENCE: BOP STREET ATLAS OF GUAM

ble 1. Location, survey dates for the first, second and third annual reports, interval between sampling, transect compass bearings and depth of the fourteen biological stations along the northwest and southwest coasts of Guam.

cation	Survey Sampling Dates First	Second	Third	Interval (Months)	Bearing (Degrees)	Depth (Meters)
RTHWEST						
tch Reefs:						
ra Harbor- de Shoals	10-24-80	9-18-81	1-26-83	16	270	1.5 - 2.1
y Dock	1-21-81	10-07-81	2-02-83	16	302	1.0 - 3.0
gua Point- uble Reef	3-25-81	3-24-82	7-28-83	16	030	4.0
ef Flats:						
ana- upat/Inner	12-01-80	3-17-82	6-01-83	15	225	.7
ver /Inner			6-08-83			.3
/Moat	12-01-80	3-23-82	6-08-83	15	042	.9
/Outer			6-08-83			.2
an- elup/Inner		6-17-81	6-15-83	24	270	.3
/Moat		6-24-81	6-15-83	24	270	.6
/Outer		6-17-81	6-15-83	24	270	.3
UTHWEST						
ef Margin:						
at- an Point	12-10-80	12-20-82	6-22-83	6	280	.9
annel Margin:						
atac- uha Bay	10-28-80	3-19-82	3-23-83	12	345	.6 - 2.4
atac Bay	1-22-81	10-30-81	4-06-83	18	325	.6 - 6.1
ch Reef:						
rizo- be Island	2-11-81	8-04-82	4-27-83	6	150	1.7

RESULTS

Algae and coral species are considered the major developmental features of coral reefs. The patterns of occupation of space by these components determines the overall appearance and structure of specific reef communities.

The percent cover and frequency of occurrence of algae species are presented in Table 2 for the northwest coast stations and in Table 3 for the southwest coast stations. Tables 4 and 5 present the total percent cover and frequency of occurrence of algae species found in the inner, moat and outer reef flat zones for Adelup and Sewer Island reef flats, respectively. The multitude of factors that affect algae abundance on Guam (Tsuda, 1974) make it difficult to make definitive statements about changes in species composition that occur from year to year.

The percent cover and frequency of occurrence of coral species recorded within the quadrats surveyed at the northwest coast stations are presented in Table 6. The species recorded at the southwest coast stations are in Table 7. Tables 8 and 9 present the total percent cover and frequency of occurrence of coral species found in the inner, moat and outer reef flat zones for Adelup and Sewer Island reef flats, respectively.

The total percent cover results of the quadrat surveys were summarized into the four major component groups of substrate, algae, coral and macroinvertebrates for each of the fourteen stations (Table 10) for the three survey periods. At some stations the change in percent cover of a component was greater than ten percent. To test the significance of these changes over time a one-way Analysis of Variance (single classification ANOVA) test was computed. The number of points occupied in each quadrat (ten replicates) was compared between the three survey periods for each component group at every station. The results of these comparisons are presented in Table 11.

Double Reef had a significant increase in the total percent cover of invertebrates over the three surveys. Jade Shoals had a significant decrease in substrate. Although not significant, the increases in coral coverage at both stations may be related to these observed changes.

Sewer Island and Alupat stations had a significant difference in percent cover of substrate and invertebrates when compared with the ANOVA test over the three surveys. The overall decrease in the percent cover of the substrate is occupanied by a increase in percent cover of algae at both stations.

The majority of stations sampled had no significant changes over time in percent cover for the four major benthic community component groups. Regardless of the many variables that can affect and alter benthic habitats these communities remained statistically the same.

ble 2. Species of algae encountered with the point-quadrat method along transects at four biological stations along the northwest coast of Guam. Frequency data precedes percent cover data.

ecies Name	Pugua Double Reef	Agana Alupat Reef	Apra Harbor Jade Shoals	Apra Harbor Dry Dock
ANOPHYTA				
id. yellow-brown	.2 (1.3%)		.2 (2.5%)	.1 (.6%)
id. red slime		.1 (.6%)		
LOROPHYTA				
ulerpa serrulata				.1 (.6%)
limeda opuntia				.4 (3.1%)
AEOPHYTA				
ctyota patens			.1 (.6%)	.2 (1.3%)
dina tenuis		.1 (.6%)		.1 (.6%)
rbinaria ornata	.1 (.6%)		.1 (.6%)	.1 (.6%)
DDOPHYTA				
laxaura fasciculata			.5 (7.5%)	
laxaura marginata	.2 (1.3%)		.1 (.6%)	.3 (3.8%)
acilaria edulis				.2 (1.9%)
nia capillacea	.1 (.6%)			
rolithon onkodes	.4 (4.4%)		.4 (2.5%)	.3 (1.9%)
anching crustose	.3 (2.5%)		.1 (.6%)	
RF COMPONENT (UNID.)				
s turf	.7 (10.6%)			
own turf			.2 (5.0%)	.1 (.6%)
d turf		.6 (38.8%)		
rf on coral/rubble	.2 (1.3%)	.4 (27.5%)	.3 (6.3%)	.5 (18.8%)
rf on pavement	.2 (1.9%)		.5 (11.3%)	.8 (15.6%)
rf on sand		.1 (5.0%)		
TAL PERCENT COVER	24.5%	72.5%	37.5%	49.4%

ble 3. Species of algae encountered with the point-quadrat method along transects at four biological stations along the southwest coast of Guam. Frequency data precedes percent cover data.

ecies Name	Agat Gaan Point	Umatac Fouha Bay	Umatac Umatac Bay	Merizo Babe Island
ANOPHYTA				
id. slimy blue-green		.2 (1.9%)		.1 (.6%)
LOROPHYTA				
ulerpa racemosa			.2 (1.3%)	.1 (.6%)
ulerpa serrulata				.1 (.6%)
lorodesmis fastigiata		.1 (.6%)		
limeda discoidea	.1 (.6%)	.1 (.6%)		
limeda gigas				.1 (.6%)
limeda incrassata	.6 (6.8%)			
limeda opuntia	.2 (1.9%)			
ptea argentea		.3 (2.5%)		
ctyosphaeria cavernosa	.2 (1.3%)		.1 (.6%)	
pmeris annulata		.1 (.6%)		
AEOPHYTA				
ctyota bartayresii				.3 (3.4%)
ctyota patens			.8 (8.1%)	
pophora variegata	.1 (.6%)			
dina tenuis		.1 (.6%)		
cbinaria ornata	.1 (.6%)	.3 (2.5%)	.4 (2.5%)	
DDOPHTYA				
cinotricha fragilis	.2 (1.3%)		.1 (.6%)	
laxaura marginata	.5 (4.4%)	.1 (.6%)		
laxaura oblongata		.4 (2.5%)	.2 (1.9%)	
lidiella acerosa				.1 (.6%)
agora sp.	.2 (1.3%)			
lia capillacea		.2 (2.5%)	.2 (2.5%)	
ssonelia rubra		.1 (1.3%)		
acilaria edulis	.6 (3.8%)	.3 (1.9%)	.3 (6.3%)	
anthophora spicifera			.1 (.6%)	
F COMPONENT (UNID.)				
turf	.7 (7.5%)	.4 (4.4%)	.1 (.6%)	
wn turf		.4 (13.8%)	.6 (15.6%)	
turf		.1 (.6%)		
f on coral/rubble	.2 (1.3%)			.9 (26.9%)
f on pavement				.1 (.6%)
f with sediment		.3 (10.0%)	.7 (21.9%)	
AL PERCENT COVER	75.8%	61.3%	68.8%	34.5%

ble 4. Species of algae encountered with the point-quadrat method along transects at three biological stations located at Adelup reef flat on Guam. Frequency data precedes percent cover data.

ecies Name	Adelup Reef Flat Inner Reef	Moat Zone	Outer Reef
ANOPHYTA			
crocoleus lyngbyaceus			.5 (6.3%)
id. blue-green		.1 (.6%)	
LOROPHYTA			
limeda opuntia	.6 (4.4%)	.2 (1.3%)	.7 (5.0%)
AEOPHYTA			
pophora variegata		.1 (.6%)	
dina tenuis	.6 (10.0%)		
rgassum cristaefolium	.6 (8.1%)		.9 (16.9%)
id. brown algae	.1 (1.3%)		
DDOPHYTA			
Lidiella acerosa		.1 (.6%)	.5 (3.8%)
rolithon onkodes	.2 (1.3%)	.8 (10.6%)	.7 (8.6%)
-d branching crustose		.5 (8.1%)	
RF COMPONENT (UNID.)			
< turf	.1 (1.3%)	.2 (1.3%)	
own turf			.1 (.6%)
-f on coral/rubble		.1 (1.3%)	
-f and sediment		.1 (.6%)	
TAL PERCENT COVER	26.4%	25.0%	41.4%

ble 5. Species of algae encountered with the point-quadrat method along transects at three biological stations located at Sewer Island reef flat in Agana, Guam. Frequency precedes percent cover data.

ecies Name	Sewer Island Reef Flat Inner Reef	Moat Zone	Outer Reef
ANOPHYTA			
rmothamnion enteromorphoides			.4 (2.5%)
rocoleus lyngbyaceus			.1 (.6%)
id. slimy blue-green		.3 (2.5%)	
LOROPHYTA			
ulerpa racemosa		.1 (.6%)	.1 (.6%)
ulerpa serrulata		.4 (2.5%)	
limeda opuntia	.3 (4.4%)		.6 (16.3%)
odlea composita	1.0 (24.4%)		
tyosphaeria cavernosa		.1 (.6%)	
AEOPHYTA			
pophora variegata	.2 (1.9%)	.6 (4.4%)	
lina tenuis	.8 (14.4%)		.5 (4.4%)
rgassum cristaefolium	.1 (.6%)		.4 (3.1%)
rbinaria ornata		.3 (1.9%)	.8 (13.1%)
DDOPHYTA			
idiella acerosa			.2 (1.9%)
ia capillacea	.1 (1.3%)		
rolithon onkodes		.2 (1.3%)	.1 (.6%)
ple encrusting coralline			.7 (7.5%)
F COMPONENT (UNID.)			
turf		.2 (2.5%)	.7 (10.0%)
wn turf			.2 (1.9%)
f on coral/rubble		.9 (41.3%)	.4 (4.4%)
f on pavement		.1 (3.1%)	.2 (1.3%)
AL PERCENT COVER	47.0%	60.7%	68.2%

ble 6. Species of coral encountered with the point-quadrat method along transects at four biological stations along the northwest coast of Guam. Frequency data precedes percent cover data.

ecies Name	Pugua Point Double Reef	Agana Alupat Reef	Apra Harbor Jade Shoals	Apra Harbor Dry Dock
ASS- ANTHOZOA ORDER- SCLERACTINIA				
SUBORDER- ASTROCOENIINA				
FAMILY- THAMNASTERIIDAE				
mmocora contigua				.4 (7.5%)
FAMILY- POCILLOPORIDAE				
ylophora mordax	.5 (6.9%)			
illopora damicornis			.2 (2.5%)	.4 (5.0%)
illopora eydouxi	.1 (1.3%)			
FAMILY- ACROPORIDAE				
ropora humulis	.3 (1.9%)			
ropora irregularis	.4 (15.0%)			
ropora nasuta	.4 (2.5%)			
ropora palifera	.1 (.6%)			
ropora surculosa	.8 (8.8%)			
ntipora ehrenbergii	.3 (3.8%)			
ntipora Pago Bay grey	.1 (3.1%)			
ntipora sp. tan & blue	.5 (4.4%)			
ntipora sp. encrusting	.1 (1.3%)			
SUBORDER- FUNGIINA				
FAMILY- AGRICIIDAE				
vona decussata		.4 (3.1%)	.4 (2.5%)	.6 (8.1%)
vona divaricata				.6 (10.6%)
vona sp. 2	.3 (3.1%)			
FAMILY- FUNGIIDAE				
ngia scutaria	.1 (.6%)			
FAMILY- PORITIDAE				
rites cylindrica			.5 (5.0%)	
rites lutea	.2 (1.9%)		.4 (3.1%)	.7 (6.3%)
rites (Synaraea) rus	.1 (.6%)		.9 (47.5%)	.5 (8.1%)
SUBORDER- FAVIINA				
FAMILY- FAVIIDAE				
via matthai	.3 (3.1%)			
vites russelli	.2 (1.3%)			
niastrea retiformis	.1 (.6%)			
FAMILY- MUSSIDAE				
bophyllia hemprichii	.2 (1.3%)			
ASS- HYDROZOA ORDER- MILLEPORINA				
FAMILY- MILLEPORIDAE				
llepora platyphylla			.1 (1.3%)	.1 (3.1%)
ft coral	.1 (.6%)			
a anemone	.1 (.6%)			
TAL PERCENT COVER	63.9%	3.1%	61.9%	48.7%

ble 7. Species of coral encountered with the point-quadrat method along transects at four biological stations along the southwest coast of Guam. Frequency data precedes percent cover data.

ecies Name	Agat Gaan Point	Umatac Fouha Bay	Umatac Umatac Bay	Merizo Babe Island
ASS- ANTHOZOA ORDER- SCLERACTINIA				
BORDER- ASTROCOENIINA				
AMILY- ASTROCOENIIDAE				
ylocoeniella ornata	.1 (.6%)			
AMILY- THAMNASTERIIDAE				
ammocora contigua	.2 (1.9%)	.1 (.6%)	.1 (.6%)	
ammocora encrusting		.2 (1.3%)	.1 (.6%)	
AMILY- POCILLOPORIDAE				
ylophora mordax	.2 (1.3%)			
cilloppora damicornis	.2 (1.3%)		.3 (1.9%)	.1 (.6%)
cilloppora sp. robust	.1 (.6%)			
AMILY- ACROPORIDAE				
roppora aspera	.3 (2.5%)			.7 (16.3%)
roppora formosa				.4 (6.3%)
ntipora sp.1 brown	.2 (3.1%)	.1 (.6%)		
ntipora sp.3 purple	.3 (2.5%)	.2 (1.9%)		
ntipora sp.4 br. green	.1 (1.3%)			
ntipora sp.5 tan			.1 (.6%)	
BORDER- FUNGIINA				
AMILY- PORITIDAE				
rites cylindrica				.3 (8.1%)
rites lutea		.3 (11.3%)	.8 (10.0%)	.1 (.6%)
rites (Synaraea) rus	.2 (1.3%)	.3 (5.0%)	.4 (5.0%)	
BORDER- FAVIINA				
AMILY- FAVIIDAE				
via favus		.1 (.6%)		
via sp.1 tan			.4 (2.5%)	
via unid.		.1 (1.3%)		
vites sp.1 tan, pali	.2 (1.3%)			
vites encrusting		.1 (.6%)		
vites unid.		.3 (1.9%)		
otoria phrygia	.1 (1.3%)	.3 (3.1%)		
ninopora lamellosa		.2 (6.9%)		
AMILY- OCULINIDAE				
laxea sp.	.1 (.6%)		.1 (.6%)	
AMILY- MUSSIDAE				
anthastrea echinata			.1 (.6%)	
ft coral			.1 (.6%)	
a anenome			.1 (.6%)	.1 (.6%)
TAL PERCENT COVER	19.6%	35.1 %	23.6%	32.5%
ad coral/rubble w/o algae	3.1%			

ble 8. Species of coral encountered with the point-quadrat method along transects at three biological stations located at Adelup reef flat on Guam. Frequency data precedes percent cover data.

ecies Name	Adelup Reef Flat Inner Reef	Moat Zone	Outer Reef
ASS- ANTHOZOA			
DER- SCLERACTINIA			
UBORDER- ASTROCOENIINA			
FAMILY- POCILLOPORIDAE			
cillopora damicornis		.2 (1.3%)	
FAMILY- ACROPORIDAE			
ropora aspera		.1 (.6%)	
UBORDER- FUNGIINA			
FAMILY- AGRICIIDAE			
vona decussata	.5 (13.1%)		
vona divaricata		.4 (10.6%)	
FAMILY- PORITIDAE			
rites lobata		.3 (3.8%)	
UBORDER- FAVIINA			
FAMILY- FAVIIDAE			
vites sp.1 pali		.1 (.6%)	
vites sp.2	.2 (1.3%)	.4 (3.1%)	
TAL PERCENT COVER	14.4%	20.0%	0.0%
ad coral/rubble w/o algae		.5 (16.9%)	

ble 9. Species of coral encountered with the point-quadrat method along transects at three biological stations at Sewer Island reef flat on Guam. Frequency data precedes percent cover data.

ecies Name	Sewer Island Reef Flat		
	Inner Reef	Moat Zone	Outer Reef
ASS- ANTHOZOA DER- SCLERACTINIA UBORDER- ASTROCOENIINA			
FAMILY- THAMNASTERIIDAE ammocora contigua		.1 (.6%)	.2 (1.3%)
FAMILY- POCILLOPORIDAE cillopora damicornis		.4 (4.4%)	
FAMILY- ACROPORIDAE ropora aspera		.4 (9.4%)	
TAL PERCENT COVER	0.0%	14.4%	1.3%

Table 10. Total percent surface cover of the major components of the benthic community as determined with the point-quadrat method at the fourteen biological stations for the first, second and third survey periods.

Stations	Substrate			Algae			Coral			Invertebrates		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Patch Reefs												
Double Reef	5.7	3.1	1.3	38.3	38.9	24.5	52.6	55.8	63.9	3.1	2.5	10.6
Jade Shoals	8.8	26.3	0.0	50.0	19.4	37.5	40.0	52.6	61.9	1.3	1.9	.6
Dry Dock Reef	.6	9.4	.6	48.2	35.7	49.4	51.3	55.1	48.7	0.0	0.0	1.2
Cocos Lagoon	42.5	26.9	30.7	29.4	35.5	34.5	26.9	37.6	32.5	1.3	0.0	1.9
Reef Margins												
Gaan Point	2.5	.6	3.1	87.6	84.9	75.8	10.1	13.9	19.6	0.0	.6	1.9
Fouha Bay	1.9	.6	0.0	74.5	58.8	61.3	23.0	38.9	35.1	.6	1.9	3.7
Umatac Bay	0.0	2.5	4.4	55.4	69.4	68.8	42.6	26.9	23.6	2.5	1.2	3.0
REEF FLATS:												
Inner Flats												
Adelup		62.6	57.6		33.1	26.4		2.5	14.4		1.8	1.9
Sewer Island			48.2			47.0			0.0			5.0
Moat Zones												
Adelup		39.5	51.9		36.9	25.0		24.0	20.0		0.0	3.2
Sewer Island	46.9	33.8	21.9	39.5	51.4	60.7	11.3	13.1	14.4	1.8	1.9	3.1
Alupat	74.4	49.4	24.4	21.6	46.5	72.5	2.5	4.4	3.1	0.0	0.0	0.0
Outer Flats												
Adelup		60.6	57.5		38.8	41.4		.6	0.0		0.0	1.2
Sewer Island			30.0			68.2			1.3			.6

ble 11. One-Way Analysis of Variance (Single Classification ANOVA) test result for the total number of points occupied in each of the major component groups of the benthic community compared over time for the three surve The abbrieviation "ns" means not significant and " p < " means the F probability significance level.

ation	Substrate	Algae	Coral	Invertebrates
tch Reefs:				
uble Reef	ns	ns	ns	Fs = 4.34 p <.025
de Shoals	Fs = 3.63 p <.05	ns	ns	ns
y Dock Reef	ns	ns	ns	ns
cos Lagoon	ns	ns	ns	ns
ef Margins:				
an Point	ns	ns	ns	ns
uha Bay	ns	ns	ns	ns
atac Bay	ns	ns	ns	ns
ef Flats:				
ner Flats-elup	ns	ns	ns	ns
wer Island				
at Zones-elup	ns	ns	ns	ns
wer Island	Fs = 9.18 p <.001	Fs = 3.56 p <.05	ns	ns
upat	Fs = 7.34 p <.005	Fs = 20.59 p <.001	ns	ns
ter Flats-elup	ns	ns	ns	ns
wer Island				

DISCUSSION

The Sewer Island and the Alupat stations were intentionally located in 1977 close to potential sources of sewage effluents. The Sewer Island station is inshore from the Agana Primary Sewage Treatment Plant Ocean Outfall and is often in the lee of prevailing wind and currents. The Alupat station is in the vicinity of leaking sewage lines at Dungca's Beach. It is possible that over time the influence from the outfall and leaking sewage lines could be affecting the benthic communities on the reef flats in these two areas. This input in the form of dissolved nutrients or trace elements may not be large enough to detect with monthly water sampling, however it may be enough to supplement algal growth. Both stations may also be influenced by nearby storm drains and river mouths which are nonpoint sources of freshwater and land derived materials.

To test the hypothesis that sewage may be affecting the benthic communities in the moat zones of the Sewer Island and Alupat reef flats a new station was sampled on the south side of Adelup Point. During this third sampling survey all three stations were sampled within a week of each other during June 1983. When these stations were compared with a one-way ANOVA a highly significant difference ($F_s = 26.65$, $p < .001$ $[2.27] = 9.02$) for algae coverage was demonstrated.

To further test where the significance occurred another ANOVA test was calculated with Sewer Island and Alupat data combined and compared against the control station at Adelup. This also yielded a significant difference ($F_s = 50.2209$, $p < .001$ $[1,28] = 13.5$). Variations in general conditions between areas such as geoloical formations, water circulation and tidal levels all affect overall water quality and ultimately the benthic communities. Human activities on the reef flats such as net fishing and reef walking also have accompanying disturbances. Herbivorous inshore fish populations could also be playing a role in modifying the reef flat habitat. Although many factors could have caused these significant differences between the three stations the influence of sewage can not be ruled out.

It should be noted that Gaan Point continues to have the highest percent cover of algae of any station sampled. This particular station is located approximately 300 meters away from the Agat Primary Sewage Treatment Plant. During times of heavy rain and storm water runoff this plant is bypassed and raw sewage overflows into the ocean and dillutes itself on the reef margin. This phenomena has been occurring since 1976 which makes it difficult to determine if the benthic community in the vicinity has naturally high algae cover or if algal growth is enhanced by the sewage effluent.

The percent cover and frequency of occurrence of individual species of algae and coral (Tables 2 - 9) were not compared statistically for the three surveys. Future computerization of the data may show some tendencies for patchy or clumped distribution of species at the fourteen monitoring stations.

It is recommended that data analysis which statistically shows changes in percent cover of algae at a particular station over time should be surveyed more intensively to determine the causes of these results. Stations located close to human activity such as sewage effluent or storm drains should be compared with stations in control areas upstream of the anticipated point and non-point sources to determine the causative factors. The approach utilized should incorporate biological community assessment, water quality analysis, current studies and geological comparisons.

This series of biological monitoring annual reports was intended to establish some baseline data on percent cover of the major benthic components and the overall condition of selected reef areas around Guam. Now that some preliminary trends are emmerging it is necessary to follow through with some detailed analysis of priority areas. From the data presented it appears that the reef flats which are in close proximity to human impact are the areas most likely to change with increased urbanization and development. It is important to develop a monitoring program that has specific objectives designed to establish the extent that man's activities are influencing coral reef communities.

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