

GUAM ENVIRONMENTAL PROTECTION AGENCY

Second Annual Report on the Marine
Benthic Algae and Coral Communities
at Biological Monitoring Stations around Guam

by

Dana Marie Rowley

Staff Biologist



ABSTRACT

Eleven biological stations, within the Guam Environmental Protection Agency Biological Monitoring Program, were surveyed using the point-quadrat method to determine the percent surface cover and frequency of occurrence of marine benthic algae and living corals. Comparisons were made with the results presented in first annual report (Rowley, 1981) to determine if changes occurred in the reef communities of Guam. No significant differences in total percent cover of substrate, algae, coral and macroinvertebrates were demonstrated between stations and surveys. The monitored stations on Guam appear to be maintaining stable reef communities. Recommendations are presented for expanding the monitoring program.

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INTRODUCTION

Tropical islands such as Guam have a multitude of unique resources associated with coral reef and lagoonal environments. "Coral reefs provide fish, other animals and seaweeds as food for local people. They protect the coastline from waves and make natural harbours. They are a source of materials for construction and for handicrafts, provide tourism and recreational areas, and have potential for aquaculture (Dahl, 1981)." Biological monitoring programs of environments impacted by human activities and pristine areas can provide valuable information for planning, management and conservation of these natural resources.

The Guam Environmental Protection Agency Biological Monitoring Program was implemented in 1980 with the gathering of baseline data on the existing condition and structure of representative coral reef habitats around Guam. Rowley (1981) presented results from point-quadrat surveys for a variety of reef zones at nine monitoring stations. This program has been expanded to eleven monitoring stations with the addition of Adelup Point reef flat in Asan and north Gaan Point reef margin in Agat. 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 the coral reefs.

MATERIALS AND METHODS

The locations of the eleven biological monitoring stations are presented in Figure 1. 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 locations of the new stations at Adelup and Gaan Point are shown in Figures 2 and 3 which are adapted from Randall and Eldredge (1976). The previously sampled stations are shown in Figures 1 to 8 in Rowley (1981).

Information on the station location, survey dates and transect locations is presented in Table 1. The variable time intervals between sampling was often a result of unpredictable weather conditions. At Gaan Point the sampling interval was two years because one of the key landmarks was removed by a storm wave and the location of the station marker was difficult to find. Stations at Fouha and Umatac had a depth range of several meters since a reef zonation boundary was traversed during sampling.

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

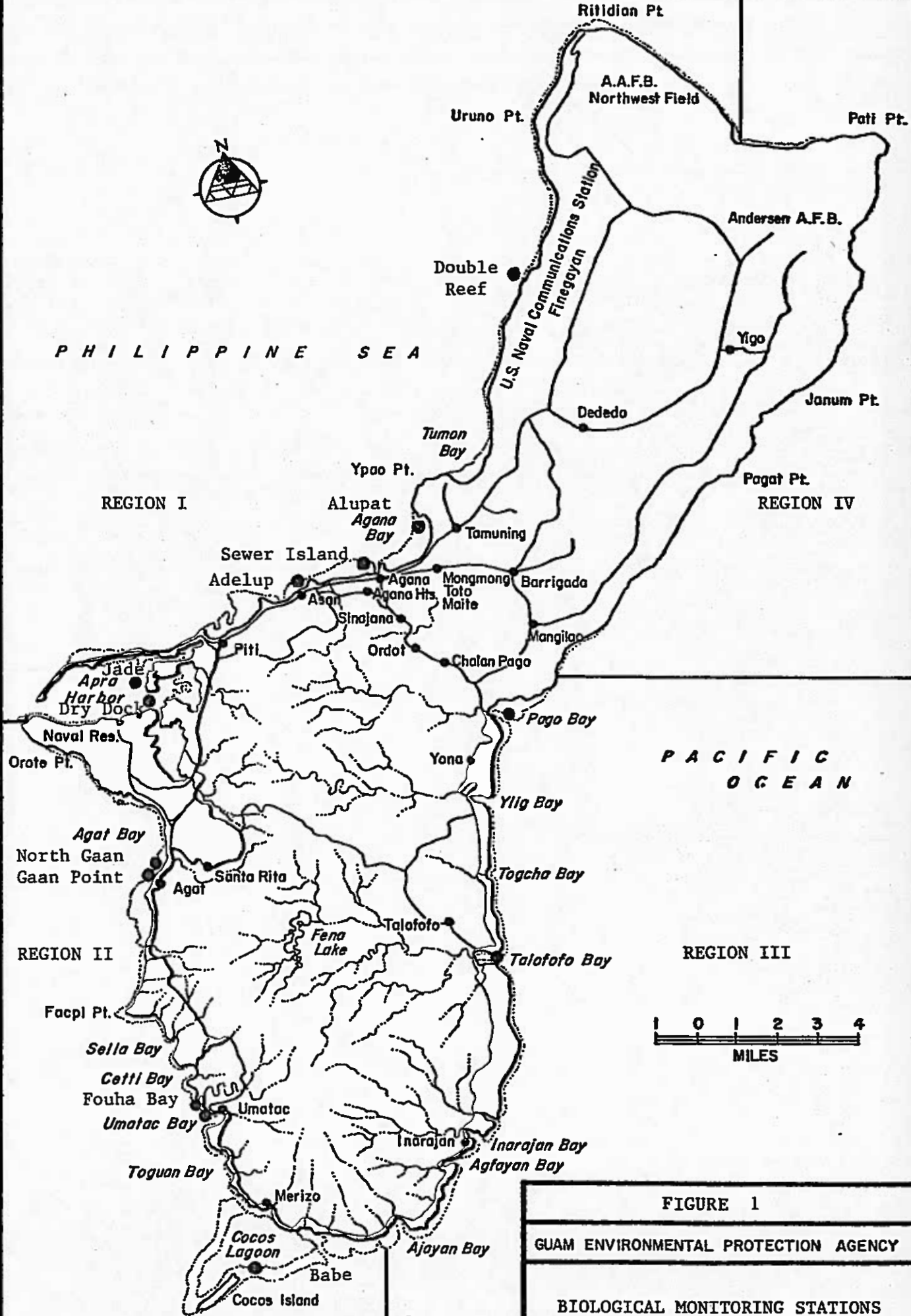


FIGURE 1

GUAM ENVIRONMENTAL PROTECTION AGENCY

BIOLOGICAL MONITORING STATIONS

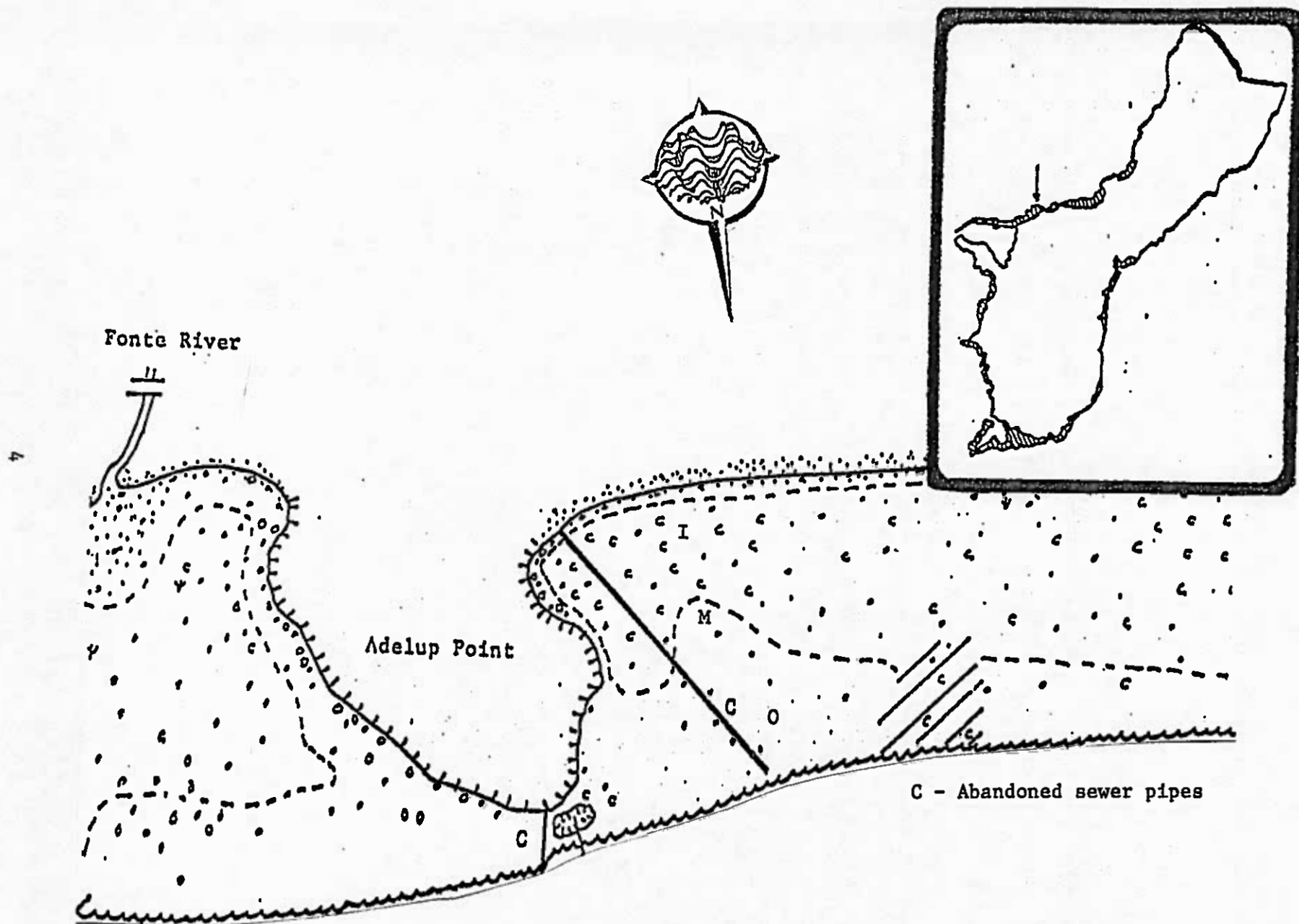


Figure 2. Adelup reef flat biological monitoring stations in the Inner, Moat and Outer Zones (I,M,O).

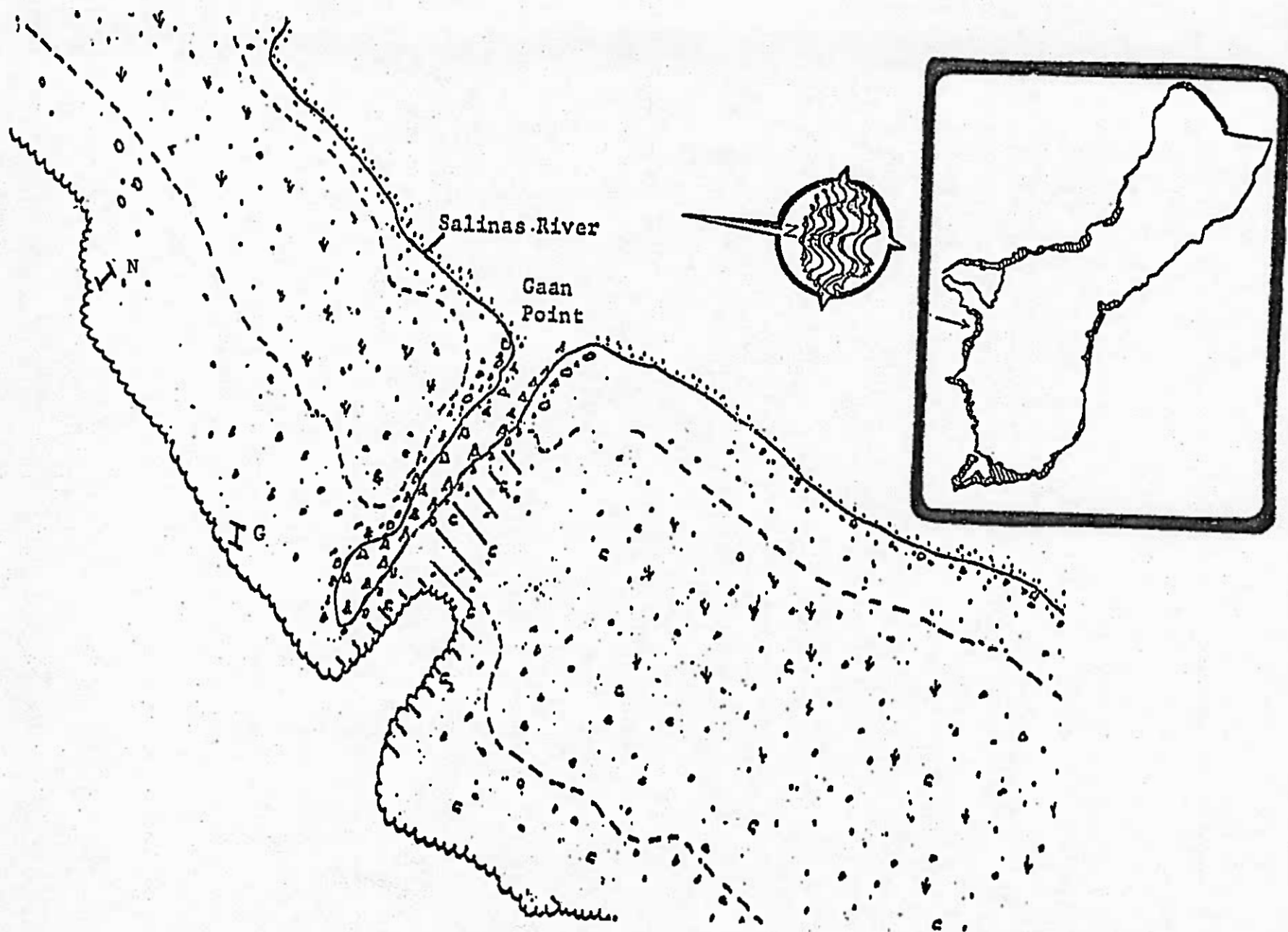


Figure 3. North Gaan Point (N) and Gaan Point (G) submerged reef margin biological monitoring stations in Agat Bay.

Table 1. Location, survey dates for the first and second annual reports, transect compass bearings and depth of the eleven biological stations along the northwest and southwest coast of Guam.

Location	Sampling Dates		Interval (Months)	Transect Bearing (Degrees)	Depth (meters)
	First Survey	Second Survey			
<u>Northwest Stations:</u>					
Pugua Point:					
Double Reef - Patch Reef	3-25-81	3-24-82	13	030	4.0
Agana:					
Alupat - Inner Reef Flat	12-01-80	3-17-82	16	225	.7
Sewer Island - Moat Zone	12-01-80	3-23-82	16	042	.9
Asan - Adelup Point:					
Inner Reef Flat		6-17-81		270	.3
Moat Zone		6-24-81		270	.6
Outer Reef Flat		6-17-81		270	.3
Apra Harbor:					
Jade Shoals - Patch Reef	10-24-80	9-18-81	11	270	1.5 to 2.1
Dry Dock - Patch Reef	1-21-81	10-07-81	8	302	1.0 to 3.0
<u>Southwest Stations:</u>					
Agat:					
North Gaan - Reef Margin		11-26-82		280	1.8
Gaan Point - Reef Margin	12-10-80	12-20-82	24	280	.9
Umatac:					
Fouha Bay - Channel Margin	10-28-80	3-19-82	17	345	.6 to 2.4
Umatac Bay - Channel Margin	1-22-81	10-30-81	8	325	.6 to 6.1
Merizo:					
Babe Island - Patch Reef	2-11-81	8-04-82	17	150	1.7

macroinvertebrates were 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., $n/160 \times 100 = \text{percent cover}$. Frequency was determined by dividing the total number of quadrats in which a species occurred (n) by the total number of quadrats surveyed (10), i.e., $n/10 = \text{frequency}$.

The data presented on percent cover and frequency of algae, coral, macroinvertebrates and substrate were collected at the eleven monitoring stations from September 1981 to December 1982. Some stations were sampled during the wet season (July to November) and others during the dry season (December to May). The intertidal and reef flat zones of Guam are subjected to greater desiccation and thermal stress when a majority of extreme low spring tides occur during the mid-day from May to August than when they occur during the night from October to March (Tsuda, 1974). Tsuda (1974) quantified changes in abundance of several species of Phaeophyta (brown algae) and related it to variations in rainfall, salinity and desiccation. 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 was compared with the results of first survey regardless of sampling month or climatic season.

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 for algae species are presented in Table 2 for the northwest coast stations and in Table 3 for the southwest coast stations. The algal component data for the three reef flat zones in west Adelup is included in Table 4. 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 total percent cover of benthic algae as grouped by taxonomic division and functional category are compiled in Table 5. The total percent cover of macrophytes and turfs were compared using a Wilcoxon signed ranks test for two groups (Sokal and Rohlf, 1969) with all year classes combined. This test showed no significant difference in the occupying of space by these two functional groups. When the data was broken down for each annual survey the data in the first report showed no significant difference between the percent cover of macrophytes compared with turfs. In the second survey there were significantly more macrophytes than turf percent cover at the $p \geq 0.05$ level. The explanation for this difference in surface cover of algal groups is not apparent.

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

Species Name	Pugua Point Double Reef	Alupat Reef	Agana Sewer Island	Jade Shoals	Apra Harbor Dry Dock Reef
CYANOPHYTA					
<u>Hormothamnion enteromorphoides</u> Bornet & Thuret		.1 (1.3%)			
<u>Microcoleus lyngbyaceus</u> (Kutz.) Crouan	.1 (.6%)		.1 (.6%)		
<u>Schizothrix calcicola</u> (Ag.) Gomont	.1 (.6%)				
CHLOROPHYTA					
6 <u>Caulerpa racemosa</u> (Forsk.) J. Ag.			.1 (.6%)		
<u>Caulerpa serrulata</u> (Forsk.) J. Ag.			.5 (11.3%)		
<u>Halimeda opunita</u> (L.) Lamx.	.3 (3.8%)	.1 (.6%)			.4 (5.0%)
<u>Tydemania expeditionis</u> W. v. Bosse				.1 (.6%)	
<u>Boodlea composita</u> (Harv.) Brand		1.0 (21.3%)			
PHAEOPHYTA					
<u>Dictyota bartayresii</u> Lamx.		.2 (1.3%)	.9 (10.6%)		
<u>Dictyota patens</u> J. Ag.					.2 (2.5%)
<u>Lobophora variegata</u> (Lamx.) Womersley			.7 (6.9%)		
<u>Padina tenuis</u> Bory		.9 (16.3%)	.6 (6.3%)		.5 (6.3%)
<u>Turbinaria ornata</u> (Turner) J. Ag.	.4 (2.5%)		.3 (1.9%)	.1 (.6%)	.2 (1.3%)
Unid. brown branching			.6 (8.8%)		
RHODOPHYTA					
<u>Galaxaura fasciculata</u> Kjellm.				.2 (3.8%)	.1 (.6%)
<u>Galaxaura marginata</u> Lamx.	.4 (6.3%)			.1 (.6%)	.1 (1.3%)
<u>Gelidiella acerosa</u> (Forsk.) Feldmann & Hamel		.2 (2.5%)			

Table 2. continued.

Species Name	Pugua Point	Agana		Apra Harbor	
	Double Reef	Alupat Reef	Sewer Island	Jade Shoals	Dry Dock Reef
<u>Jania capillacea</u> Harvey	.1 (.6%)		.1 (.6%)		
<u>Peyssonelia rubra</u> (Grev.) J. Ag.		.1 (.6%)			
<u>Acanthophora spicifera</u> (Vahl) Boerg.					.1 (.6%)
<u>Polysiphonia</u> sp.				.2 (4.4%)	
Branching crustose coralline	.2 (1.3%)		.1 (.6%)		.1 (.6%)
Pink encrusting coralline	.3 (1.9%)		.1 (.6%)		.1 (.6%)
Purple encrusting coralline			.2 (1.3%)		
Red encrusting coralline					.1 (.6%)
TURF COMPONENT (unidentified species)					
Mix turf	.5 (7.5%)	.2 (1.3%)			
Brown turf	.8 (13.8%)		.1 (1.3%)	.2 (1.3%)	
Red turf					
Turf on dead coral/rubble					.3 (6.9%)
Turf on pavement		.2 (1.3%)		.6 (8.1%)	.7 (9.4%)
TOTAL PERCENT COVER	38.9%	46.5%	51.4%	19.4%	35.7%

Table 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 within parentheses.

Species Name	Agat		Umatac		Merizo
	North Gaan	Gaan Point	Fouha Bay	Umatac Bay	Babe Island
CYANOPHYTA					
<u>Hormothamnion enteromorphoides</u>	.1 (1.3%)				
Bornet & Thuret					
<u>Schizothrix calcicola</u> (Ag.) Gomont			.1 (.6%)		
Unidentified slimy blue-green			.2 (2.5%)		
CHLOROPHYTA					
<u>Bryopsis pennata</u> Lamx.				.2 (1.3%)	
<u>Caulerpa racemosa</u> (Forsk.) J. Ag.				.1 (.6%)	.1 (.6%)
<u>Caulerpa taxifolia</u> (Vahl) C. Ag.				.1 (.6%)	
<u>Chlorodesmis fastigiata</u>			.1 (.6%)		
(C. Ag.) Ducker					
<u>Halimeda discoidea</u> Decaisne	.3 (2.5%)	.2 (2.5%)			
<u>Halimeda gigas</u> Taylor			.1 (.6%)		
<u>Halimeda incrassata</u> (Ellis) Lamx.	.7 (11.3%)	.7 (19.4%)			
<u>Halimeda opunita</u> (L.) Lamx.	.1 (.6%)	.1 (1.3%)		.1 (.6%)	
<u>Rhipilia sinuosa</u> Gilbert				.1 (1.3%)	
<u>Tydemania expeditionis</u> W. v. Bosse		.1 (.6%)			
<u>Udotea argentea</u> Zanard.				.3 (3.1%)	
<u>Neomeris annulata</u> Dickie				.1 (.6%)	
<u>Neomeris vanbosseae</u> Howe			.2 (1.9%)		
PHAEOPHYTA					
<u>Dictyopteris repens</u> (Okam.) Boerg.			.1 (.6%)		
<u>Dictyota bartayresii</u> Lamx.					.5 (8.1%)
<u>Dictyota patens</u> J. Ag.				.4 (2.5%)	
<u>Lobophora variegata</u> (Lamx.) Womersley				.1 (.6%)	
<u>Turbinaria ornata</u> (Turner) J. Ag.	.1 (.6%)	.3 (2.5%)	.7 (8.8%)	.2 (1.3%)	

Table 3. continued.

Species Name	Agat		Umatac		Merizo Babe Island
	North Gaan	Gaan Point	Fouha Bay	Umatac Bay	
RHODOPHYTA					
<u>Galaxaura fasciculata</u> Kjellm.					.1 (.6%)
<u>Galaxaura marginata</u> Lamx.	.6 (5.6%)	.6 (5.0%)			
<u>Galaxaura oblongata</u> (E. & S.) Lamx.			.3 (4.4%)	.4 (3.1%)	
<u>Jania capillacea</u> Harvey		.4 (2.5%)	.3 (8.1%)	.7 (5.0%)	
<u>Jania</u> sp.		.3 (1.9%)			
<u>Peyssonelia rubra</u> (Grev.) J. Ag.			.1 (.6%)		
<u>Gracilaria arcuata</u> Zanard.				.3 (2.5%)	
<u>Gracilaria edulis</u> (Gmel.) Silva	.6 (7.5%)	.5 (5.0%)		.7 (8.1%)	
<u>Centroceras clavulatum</u> (C. Ag.) Montagne				.3 (1.9%)	
Branching crustose coralline	.9 (15.6%)	.4 (7.5%)	.1 (.6%)	.1 (.6%)	
Articulated crustose coralline				.3 (3.1%)	
Pink encrusting coralline	.7 (15.6%)	.5 (3.8%)	.7 (7.5%)	.5 (6.3%)	.3 (5.6%)
Red encrusting coralline	.4 (3.1%)			.3 (1.9%)	
TURF COMPONENT (unidentified species)					
Mix turf	1.0 (20.6%)	.6 (5.0%)	1.0 (18.8%)	.7 (9.4%)	
Brown turf		.2 (3.8%)	.1 (1.3%)		
Red turf		.4 (2.5%)		.1 (1.3%)	
Green turf			.1 (.6%)		
Turf on dead coral/rubble	.1 (.6%)	.6 (11.9%)			.7 (20.6%)
Turf on pavement				.1 (.6%)	
Turf with sediment			.1 (1.3%)	.5 (13.1%)	
TOTAL PERCENT COVER	84.9%	75.2%	58.8%	69.4%	35.5%

Table 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 within parentheses.

Species Name	Inner Reef Flat	Adelup Reef Flat Moat Zone	Outer Reef Flat
CYANOPHYTA			
<u>Schizothrix mexicana</u> Gomont		.1 (.6%)	
CLOROPHTYA			
<u>Halimeda opuntia</u> (L.) Lamx.	.1 (.6%)	.2 (1.9%)	.4 (5.6%)
<u>Boergesenia forbesii</u> (Harv.) Feldmann			.1 (.6%)
PHAEOPHYTA			
<u>Padina tenuis</u> Bory	.7 (6.9%)		
<u>Sargassum polycystum</u> C. Ag.	1.0 (25.6%)		1.0 (28.8%)
RHODOPHYTA			
<u>Jania</u> sp.			.3 (1.9%)
Pink encrusting coralline			.1 (1.3%)
TURF COMPONENT (unidentified species)			
Mix turf		.5 (7.5%)	
Brown turf			.1 (.6%)
Turf on dead coral/rubble		.6 (26.9%)	
TOTAL PERCENT COVER	31.1%	36.9%	38.8%

Table 5. Total percent cover of benthic algae as grouped by taxonomic division and functional category (macrophyte and turf) for the first and second survey periods at the biological monitoring stations.

	<u>Moat - Zone</u>						<u>Patch Reefs</u>						<u>Reef Margin and Slopes</u>					
	<u>Merizo</u>		<u>Alupat</u>		<u>Sewer</u>		<u>Double</u>		<u>Apra Harbor</u>		<u>Dry Dock</u>		<u>Gaan Point</u>		<u>Fouha Bay</u>		<u>Umatac Bay</u>	
	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>	<u>1st</u>	<u>2nd</u>
DIVISION:																		
Cyanophyta	.6	0	0	1.3	0	.6	1.3	1.2	0	0	0	0	0	1.3	0	3.1	.6	0
Chlorophyta	.6	.6	0	21.9	.6	11.9	1.3	3.8	0	.6	1.9	5.0	18.1	14.4	0	3.1	1.9	8.1
Phaeophyta	11.9	8.1	20.0	17.6	17.6	34.5	4.4	2.5	3.7	.6	1.9	10.1	3.8	.6	0	9.4	6.9	4.4
Rhodophyta	0	6.2	.6	3.1	6.3	3.1	13.1	10.1	0	8.8	.6	4.3	33.8	47.4	31.3	21.2	8.4	32.5
Subtotals:																		
Macrophytes	13.1	14.9	20.6	43.9	24.5	50.1	20.1	17.6	3.7	10.0	4.4	19.4	55.7	63.7	31.3	36.8	17.8	45.0
Turf	16.3	20.6	1.3	2.6	15.0	1.3	17.6	21.3	46.3	9.4	43.8	16.3	31.9	21.2	43.2	22.0	37.6	24.4
TOTAL	29.4	35.5	21.9	46.5	39.5	51.4	37.7	38.9	50.0	19.4	48.2	35.7	87.6	84.9	74.5	58.8	55.4	69.4

The percent cover and frequency of occurrence for coral species recorded within the quadrats surveyed at the northwest coast stations are in Table 6. The species recorded at the the southwest coast stations are in Table 7. Adelup reef flat coral data are in Table 8.

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 eleven stations (Table 9). The overall percent change in surface cover between the first and second survey was indicated as an increased (+) or decreased (-) numerical value. At some stations the change in percent cover of a component was greater than ten percent. To test the significance of these changes 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 two survey periods for each component group at every station. There were no significant changes in surface cover of the component groups at any of the biological stations monitored around Guam.

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

Species Name	Pugua Point Double Reef	Alupat Reef	Agana Sewer Island	Jade Shoals	Apra Harbor Dry Dock Reef
CLASS - ANTHOZOA					
ORDER - SCLERACTINIA					
SUBORDER - ASTROCOENIINA					
FAMILY - THAMNASTERIIDAE					
<u>Psammocora contigua</u> (Esper, 1797)			.1 (.6%)		.7 (9.4%)
FAMILY - POCILLOPORIDAE					
<u>Stylophora mordax</u> (Dana, 1846)	.3 (2.5%)				
<u>Pocillopora damicornis</u> (Linnaeus, 1758)			.2 (1.3%)	.3 (2.5%)	.3 (2.5%)
<u>Pocillopora</u> sp.	.1 (.6%)				
FAMILY - ACROPORIDAE					
<u>Acropora aspera</u> (Dana, 1846)			.3 (8.8%)		
<u>Acropora irregularis</u> (Brook, 1892)	.3 (8.1%)				
<u>Acropora nasuta</u> (Dana, 1846)	.9 (11.9%)	.1 (.6%)			
<u>Acropora tenuis</u> (Dana, 1846)	.1 (1.3%)				
<u>Acropora wardi</u> Verrill, 1901	.5 (3.8%)				
<u>Astreopora</u> sp.					.1 (.6%)
<u>Montipora</u> sp. encrusting, similar form, possible color morphs:					
blue	.2 (5.0%)				
yellow	.1 (.6%)				
red	.2 (1.3%)				
green	.3 (3.1%)				
brown	.1 (2.5%)				
<u>Montipora</u> sp. tan with blue centers, spiny	.1 (.6%)				
<u>Montipora</u> sp. tan, large knobs	.1 (1.3%)				
<u>Montipora</u> sp.				.1 (1.3%)	
<u>Montipora</u> sp. brown, purple knobs					.1 (.6%)

Table 6. Continued.

Species Name	Pugua Point Double Reef	Agana Alupat Reef	Sewer Island	Apra Harbor Jade Shoals	Dry Dock Reef
SUBORDER - FUNGIINA					
FAMILY - AGRICIIDAE					
<u>Pavona decussata</u> (Dana, 1846)		.3 (3.8%)	.1 (.6%)	.1 (1.9%)	.7 (13.8%)
<u>Pavona divaricata</u> (Lamarck, 1816)				.3 (2.5%)	.4 (5.0%)
<u>Pavona varians</u> Verrill, 1864	.1 (2.5%)				
<u>Pavona</u> sp.					.1 (1.9%)
FAMILY - FUNGIIDAE					
<u>Fungia scutaria</u> (Lamarck, 1816)	.1 (1.3%)				
FAMILY - PORITIDAE					
<u>Porites andrewsi</u> Vaughan, 1918				.3 (5.0%)	.2 (1.3%)
<u>Porites lutea</u> Milne Edwards & Haime, 1851			.1 (.6%)	.3 (5.0%)	.4 (3.1%)
<u>Porites</u> (Synaraea) <u>iwayamaensis</u> Eguchi, 1938	.1 (.6%)			.8 (33.1%)	.5 (13.8%)
SUBORDER - FAVIINA					
FAMILY - FAVIIDAE					
<u>Favia fava</u> (Forsk., 1775)	.2 (1.3%)				
<u>Favia stelligera</u> (Dana, 1846)	.1 (1.3%)				
<u>Favia</u> sp. tan & yellow	.1 (.6%)				
<u>Favia</u> sp. brown with green centers	.1 (.6%)				
<u>Favites</u> sp.	.1 (.6%)		.1 (.6%)		
<u>Leptoria phrygia</u> (Ellis & Solander, 1786)	.2 (1.3%)		.1 (.6%)		
<u>Echinopora lamellosa</u> (Esper, 1797)	.1 (.6%)				
FAMILY - MUSSIDAE					
<u>Acanthastrea echinata</u> (Dana, 1846)	.2 (1.9%)				

Table 6. Continued.

Species Name	Pugua Point	Agana		Apra Harbor	
	Double Reef	Alupat Reef	Sewer Island	Jade Shoals	Dry Dock Reef
CLASS - HYDROZOA					
ORDER - MILLEPORINA					
FAMILY - MILLEPORIDAE					
<u>Millepora dichotoma</u> Forskal, 1775		.1 (.6%)			
Unidentified coral: Green encrusting with white coenosteum	.1 (.6%)				
? <u>Diploastrea heliophora</u> (Lamarck, 1816)					
Soft coral				.1 (1.3%)	.2 (2.5%)
TOTAL PERCENT COVER					
Live Coral	55.8%	4.8%	13.1%	52.6%	55.1%
Dead Coral/Rubble without Algae	.2 (3.1%)	.9 (18.1%)	.8 (16.9%)	.5 (17.5%)	.3 (4.4%)

Table 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 within parentheses.

Species Name	North Gaan	Agat Gaan Point	Umatac Fouha Bay	Umatac Bay	Merizo Babe Island
CLASS - ANTHOZOA					
ORDER - SCLERACTINIA					
SUBORDER - ASTROCOENIINA					
FAMILY - THAMNASTERIIDAE					
<u>Psammocora contigua</u> (Esper, 1797)	.2 (1.3%)		.1 (.6%)	.2 (1.3%)	
FAMILY - POCILLOPORIDAE					
<u>Stylophora mordax</u> (Dana, 1846)	.3 (1.9%)	.1 (.6%)	.3 (1.9%)		
<u>Pocillopora damicornis</u> (Linnaeus, 1758)	.3 (1.9%)	.1 (.6%)		.3 (1.9%)	.3 (1.9%)
<u>Pocillopora</u> sp. robust branches			.1 (.6%)		
FAMILY - ACROPORIDAE					
<u>Acropora aspera</u> (Dana, 1846)					.5 (16.9%)
<u>Acropora formosa</u> (Dana, 1846)					.4 (4.4%)
<u>Acropora irregularis</u> (Brook, 1892)		.2 (8.1%)			
<u>Acropora nasuta</u> (Dana, 1846)	.1 (.6%)	.1 (1.3%)	.1 (.6%)		
<u>Acropora</u> sp. 1 brown, costal ridges	.1 (.6%)	.8 (8.1%)			
<u>Acropora</u> sp. 2 purple, short axials		.1 (.6%)			
<u>Acropora</u> sp. 3 tubular corallites			.1 (.6%)		
<u>Montipora</u> sp. 1 brown, small spines	.1 (.6%)	.1 (1.3%)			
<u>Montipora</u> sp. 2 blue			.1 (1.9%)		
<u>Montipora</u> sp. 3 purple			.1 (.6%)		
<u>Montipora</u> sp. 4 brown & green	.2 (1.3%)				
SUBORDER - FUNGIINA					
FAMILY - PORITIDAE					
<u>Goniopora</u> sp.	.2 (1.3%)				
<u>Porites andrewsi</u> Vaughan, 1918					.3 (11.3%)
<u>Porites lutea</u> Milne Edwards & Haime, 1851			.3 (5.6%)	.3 (5.0%)	.1 (.6%)
<u>Porites</u> (Synaraea) <u>iwayamaensis</u> Eguchi, 1938		.2 (1.3%)		.5 (12.5%)	

Table 7. Continued.

Species Name	North Gaan	Gaan Point	Fouha Bay	Umatac Bay	Babe Island
SUBORDER - FAVIINA					
FAMILY- FAVIIDAE					
<u>Favia</u> sp. 1 tan, large corallites			.2 (1.3%)		
<u>Favia</u> sp. 2 small, toothed septa			.1 (1.3%)		
<u>Favia</u> sp. 3			.2 (1.9%)		
<u>Favia</u> sp. 4	.1 (.6%)				
<u>Favites</u> sp. 1 tan, paliform lobes		.3 (4.4%)			
<u>Favites</u> sp. 2 tan, green centers			.1 (1.3%)		
<u>Favites</u> sp. 3 fused wall, microatoll			.1 (.6%)		
<u>Favites</u> sp. 4			.2 (6.3%)		
<u>Favites</u> sp. 5 honey-comb corallites				.4 (2.5%)	
<u>Leptoria phrygia</u> (Ellis & Solander, 1786)	.1 (1.3%)	.1 (.6%)	.6 (6.9%)		
<u>Hydnophora microconos</u> (Lamarck, 1816)			.1 (.6%)		
<u>Echinopora lamellosa</u> (Esper, 1797)			.2 (1.3%)	.1 (.6%)	
unidentified sp. 1			.1 (.6%)		
sp. 2 deep corallites, septal ridges				.2 (1.3%)	
sp. 3				.1 (.6%)	
FAMILY - OCULINIDAE					
<u>Galaxea</u> sp.				.1 (.6%)	
CLASS - HYDROZOA					
ORDER - MILLEPORINA					
FAMILY - MILLEPORIDAE					
<u>Millepora platyphylla</u> Hemprich & Ehrenberg, 1834				.1 (.6%)	
Soft coral					.1 (1.9%)
Sea Anenome					.1 (.6%)
TOTAL PERCENT COVER					
Live Coral	13.9%	22.5%	38.9%	26.9%	37.6%
Dead Coral/Rubble without Algae			.1 (.6%)		.4 (9.4%)
Dead Coral with sediment				.2 (1.9%)	

Table 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 within parentheses.

Species Name	Inner Reef Flat	Adelup Reef Flat Moat Zone	Outer Reef Flat
CLASS - ANTHOZOA			
ORDER - SCLERACTINIA			
SUBORDER - ASTROCOENIINA			
FAMILY - THAMNASTERIIDAE			
<u>Psammocora</u> sp. 1		.3 (2.5%)	
<u>Psammocora</u> sp. 2		.1 (1.3%)	
FAMILY - POCILLOPORIDAE			
<u>Pocillopora damicornis</u> (Linnaeus, 1758)		.1 (1.3%)	
FAMILY - ACROPORIDAE			
<u>Acropora</u> sp. 1		.1 (1.3%)	
<u>Acropora</u> sp. 2		.5 (7.5%)	
SUBORDER - FUNGIINA			
FAMILY - AGRICIIDAE			
<u>Pavona</u> sp. 1		.8 (8.8%)	
FAMILY - PORITIDAE			
<u>Porites lutea</u> Milne-Edwards & Haime, 1851			.1 (.6%)
<u>Porites lobata</u> Dana, 1846	.2 (2.5%)		
<u>Porites</u> sp. 1		.2 (1.3%)	
TOTAL PERCENT COVER			
Live Coral	2.5%	24.0%	.6%
Dead Coral/Rubble without Algae	1.0 (23.8%)	.6 (11.3%)	1.0 (17.5%)

Table 9. Total percent surface cover and percent change (%Δ) of the major components of the benthic habitat as determined with the point-quadrat method at the eleven biological stations for the first and second survey periods.

Stations	Substrate			Algae			Coral			Invertebrates		
	<u>1st</u>	<u>2nd</u>	<u>%Δ</u>	<u>1st</u>	<u>2nd</u>	<u>%Δ</u>	<u>1st</u>	<u>2nd</u>	<u>%Δ</u>	<u>1st</u>	<u>2nd</u>	<u>%Δ</u>
<u>Patch Reefs</u>												
Double Reef	5.7	3.1	-2.6	38.3	38.9	+ .6	52.6	55.8	+3.2	3.1	2.5	- .6
Jade Shoals	8.8	26.3	+17.5	50.0	19.4	-30.6	40.0	52.6	+12.6	1.3	1.9	+ .6
Dry Dock	.6	9.4	+8.8	48.2	35.7	-12.5	51.3	55.1	+3.8	0.0	0.0	0.0
<u>Reef Margins</u>												
North of Gaan		2.5			75.2			22.5			0.0	
Gaan Point	2.5	.6	-1.9	87.6	84.9	- 2.7	10.1	13.9	+3.8	0.0	.6	+ .6
Fouha Bay	1.9	.6	-1.3	74.5	58.8	-15.7	23.0	38.9	+15.9	.6	1.9	+1.3
Umatac Bay	0.0	2.5	+2.5	55.4	69.4	+14.0	42.6	26.9	-15.7	2.5	1.2	-1.3
<u>REEF FLATS:</u>												
<u>Inner Flats</u>												
Alupat	74.4	49.4	-25.0	21.6	46.5	+24.9	2.5	4.4	+1.9	1.3	0.0	-1.3
Adelup		62.6			33.1			2.5			1.8	
<u>Moat Zones</u>												
Sewer Is.	46.9	33.8	-13.1	39.5	51.4	+11.9	11.3	13.1	+1.8	1.8	1.9	+ .1
Adelup		39.5			36.9			24.0			0.0	
Cocos	42.5	26.9	-15.6	29.4	35.5	+6.1	26.9	37.6	+10.7	1.3	0.0	-1.3
<u>Outer Flats</u>												
Adelup		60.6			38.8			.6			0.0	

DISCUSSION

Biological monitoring of reefs at selected stations is a useful method for detecting changes that occur in the patterns of space occupation by the living components which affect the overall environmental quality of a community. Dahl (1981) discusses the changes in percent cover of various organisms as indicators of alterations of the coral reef ecosystem. Decreases in total coverage of living corals, soft corals, sponges, and dead standing coral and increases in coral rubble are signs that a reef is being stressed. The damage could be the result of natural events such as typhoons and large waves or man-induced pollution from sewage, industry, mining and construction activities. Increases in the percent cover of sediments from erosion caused by agricultural or construction practices can smother and kill coral colonies. Grigg (1979) states that the most detrimental effects of man's activities appear to be associated with increases in sedimentation, turbidity and eutrophication. The management of coral reef ecosystems and the minimization of undesired impacts is best handled on a case-by-case basis as there are many interrelated factors that influence the growth and development of coral reefs.

Gaan Point submerged reef margin in Agat was identified in Rowley (1981) as a monitoring station with a high percent cover of algae. It was anticipated that a second sampling would show if this high coverage persisted over time. When the percent cover of algae from the ten quadrats along each transect were compared between the first and second surveys with a two-way analysis of variance, no significant differences were found. A location further north of the Gaan Point station was sampled to see if the percent cover of algae

decreased with distance from the influence of the Agat sewage treatment plant outfall, storm drains and the Salinas River. The northern station appeared to have greater coral coverage and less algae than the Gaan Point station, but statistical comparison with a two-way ANOVA showed no significant differences. This procedure was utilized to make percent cover comparisons for all the remaining components. The results showed benthic communities did not change significantly between the two surveys or stations. It is difficult to determine if the Gaan Point area has a naturally high percent cover of benthic algae or one induced from the effects of sewage and storm water input.

In the first annual report Umatac Bay had higher coral coverage than Fouha Bay; in the second survey the reverse situation occurred (Table 9). When percent cover of coral was analyzed using a two-way ANOVA to compare the Umatac and Fouha locations between the two survey years no significant differences were found. A two-way ANOVA test was then run on the algae quadrat data and no significant changes were demonstrated. The Fouha station, in which the transect was surveyed from the channel margin to a depth of 2.4 meters on the channel slope, was located close to station N-3 of Randall and Birkeland (1978). Randall found a percent coral cover of 11.02% in the channel margin and 28.47% in the upper slope zone. The coral coverage for the GEPA station was 23.0% for the first survey and 38.9% for the second survey. The values for the reef slope zones were within ten percent of each other. Differences of this magnitude were not found to be significant in the other comparisons made with the quadrat data in the present survey. These results demonstrated that Fouha and Umatac Bays did not have significant changes in their coral reef communities.

Scott Josiah of the Division of Forestry and Soil Resources at the Guam Department of Agriculture provided the following statistics regarding the increase of fires in the Fouha and Umatac Watersheds (Personal Communication, 1982).

FIRE OCCURRENCE TOTALS 1979 - 82

FOUHA BAY WATERSHED (1,046 ACRES)					UMATAC BAY WATERSHED (1,531 ACRES)			
YEAR	NO. FIRES	ACRES BURNED	AVERAGE ACRES/FIRE	PERCENT BURNED	NO. FIRES	ACRES BURNED	AVERAGE ACRES/FIRE	PERCENT BURNED
1982	30	568.0	18.9	54.3	39	207.1	6.1	13.5
1981	35	381.9	10.9	36.5	55	327.5	6.0	21.4
1980	12	263.3	21.9	25.1	16	113.2	7.1	7.4
1979	14	53.3	3.8	5.1	9	47.2	5.2	3.1

The data shows a general increase in the total number of acres burned in both watersheds between 1979 and 1982. These fires occur predominantly in the dry season. If the burned areas do not regain their vegetative cover rapidly, a certain amount of eroded soil could wash down the watershed and into the bays. Randall and Birkeland (1978) investigated the sedimentation rates that occurred at Fouha Bay. They found that as the suspended sediment load decreased along the shore to seaward gradient, the complexity of the coral community and abundance of corals increased. They found that suspended sediment load was one of the major factors that influenced community structure. If the sedimentation rates increased in Fouha and Umatac Bays the distribution and abundance of the corals could become affected.

Double Reef and Cocos Lagoon are considered pristine coral reef ecosystems and have been recommended as sites for marine reserves (Stojkovich, 1977).

Protected natural areas provide opportunities for recreation, photography and scientific research. Monitoring of pristine areas is important for obtaining descriptive information on baseline conditions that can be compared with impacted areas. At Double Reef the percent cover of coral and algae remained virtually the same between the two surveys (Table 9). Since the patch reef is only accessible by boat, the major potential source of pollution is habitat destruction by dynamite fishermen. The Cocos - Babe patch reef is classified in Table 9 as a moat habitat because of the shallow water depths found at the station compared to the other patch reef sites. The staghorn coral Acropora aspera caused the overall increase in coral cover between the two surveys. Both Double Reef and Babe Island stations are stable coral reef communities.

In Apra Harbor coral coverage increased at Jade Shoals and Dry Dock patch reefs. The Jade Shoals station was dominated by Porites (S.) iwayamaensis, while Dry Dock reef was dominated by Pavona decussata, Porites (S.) iwayamaensis and Psammocora contigua. The Marine Lab Staff and Students (1977) conducted a baseline report for the Commercial Port area and surveyed Jade Shoals. They found Porites (S.) iwayamaensis and Porites (S.) convexa dominated the northwest side of the patch reef forming an almost unbroken expanse of even-topped columnar colonies. Comparisons of these two studies show that the Apra Harbor reefs seem to be stable ecosystems. These reefs could be in a stressed state from increased shipping activities and associated effects such as oil spills but are able to maintain existing levels of coral coverage. Monitoring of these two stations will provide useful information to determine if changes occur in these reef communities.

Reef flats are marine communities most likely to reflect the influences of man's urbanization. Storm drains, sewage outfalls and recreational activities such as fishing and reef walking are examples of man-induced impacts. In Rowley (1981) the Alupat inner reef flat and Sewer Island (Sagun Sirena Island) moat zone were sampled. These stations are located in two different reef zones and are not directly comparable. In the Alupat reef area there is high density housing along the coast and foot traffic on the reef. There are also occasional problems with sewer line overflows during heavy rains and fresh water input from storm drains. The area close to the station was dredged to form a shallow boat channel to Alupat Island which may have affected current patterns in the immediate vicinity.

The Agana reef flat near the sewage treatment plant has been subjected to a number of disturbances during the past ten years. Jones and Randall (1971) surveyed the currents of the Agana outfall area and found that the majority of the water movement was in a westerly direction; however, water was also transported by wave energy over the reef margin and generated the long shore currents. With the dredging and accompanying filling of the reef flat for construction of the Agana Sewage Treatment Plant in 1976 the flow dynamics of the currents on the reef flat were altered. The Sewer Island biological station was located such that diluted sewage from the existing outfall could under certain conditions wash over the reef margin to the shallow reef flats and exert an influence on the communities found there.

In this survey the reef flat monitoring was expanded to include the inner, moat and outer zones of the Adelup reef flat. Adelup reef flat is currently a recreational area with healthy coral growth. In the upcoming third sampling

period Alupat and Sewer Island reef flats will be surveyed for all three zones. It will be worthwhile to compare these three reef flat ecosystems to see if any significant changes in community structure occur with varying degrees of human influence.

CONCLUSIONS

Coral reefs are described as being resilient ecosystems capable of rapid recovery rates from natural disturbances (Pearson, 1981 and Colgan, 1981). No significant changes in percent surface cover of the four major component groups occurred at any of the GEPA monitoring stations or between the two survey periods. These results indicate that the coral reefs around Guam are maintaining stable marine communities. After five years of biological monitoring of the Truk Airport runway expansion project, no definitive trends were observed in species richness or percent cover of benthic organisms except at a location where siltation from dredging was the heaviest (Amesbury et al., 1982). Abnormal silt accumulations caused a decline in the percent cover of corals and inhibited their recolonization. This data suggests that marine communities can adjust to subtle changes in the water quality resulting from suspended particulate matter and nutrients without statistically noticeable changes. Severe perturbations were shown to alter the ability of the coral reef inhabitants to recover quickly from stress. The GEPA Biological Monitoring Program will be continue to determine if any long-term changes are occurring. If major alterations in the reef structures are evident, the causative factors will be identified and classified as natural or man-induced disturbances.

RECOMMENDATIONS

1. Expand the biological monitoring program to include stations in Region III (i.e.: Pago and Talofofo Bay).
2. Expand the biological monitoring of pristine and impacted reef flats to facilitate comparisons of the biological communities with the existing water quality conditions (i.e.: Agana, Agat and Asan reef flats).
3. Conduct more frequent biological monitoring of Umatac and Fouha Bays to determine if the increased number of acres burned in the watersheds is causing changes in the coral communities.
4. Survey intensively the Gaan Point area in Agat to determine if the high percent cover of algae is a natural phenomena. The existing outfall should be repaired to facilitate the discharge of effluent at the appropriately designed outfall depth.
5. Begin biological monitoring at Adotgan Point (Apra Harbor) at the future site of the Navy Ammunition Wharf to enable comparisons of data collected before, during and after the construction activities. This should provide useful information for future environmental impact analysis evaluations.

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