

GUAM ENVIRONMENTAL PROTECTION AGENCY

First Annual Report on the Marine
Benthic Algae and Coral Communities
at Nine Biological Stations around Guam

by
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ABSTRACT

Nine biological stations, within the Guam Environmental Protection Agency monitoring network, were surveyed using the point-quadrat method to determine percent surface cover and frequency of occurrence of marine benthic algae and living corals. Comparisons between the coral communities within the various fringing reef zones demonstrated that percent cover and taxonomic distribution of organisms were affected by habitat zonation. Reef flat zones had less algae and coral than patch reefs. Channel margins and submerged reef margins had the highest algal and coral components in the community composition. Algal turfs were important in the amount of space they occupied, which influenced competing macroalgae and corals.

ACKNOWLEDGEMENT

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INTRODUCTION

This study was initiated to establish baseline data on the surface cover and frequency of occurrence of the components of coral and algal communities at nine biological stations within the Guam Environmental Protection Agency's monitoring network. Point-quadrat studies in conjunction with transect tapes have been conducted around Guam (Randall et al., 1978). A modified version of the methods employed in these studies was utilized for this investigation.

Nine stations were selected that consist of a variety of coral reef environments: reef flat zones, patch reefs, channel margins and submerged reef margins. Comparisons of surface cover and frequency data should reflect basic differences in community composition of the study sites. A range of environmental conditions and stresses are also represented. Alupat inner reef flat, Sewer Island moat zone and Gaan Point submerged reef margin are areas likely to be subjected to nutrient pulses from sewage overflows or outfalls. Fouha Bay and Umatac Bay have heavy sedimentation from river runoff (Randall and Birkeland, 1978). Jade Shoals is close to the shipping and docking facilities at Commercial Port and Dry Dock reef is next to the United States Navy's dry dock. Both stations are inside Apra Harbor where a number of environmental disturbances are possible such as oil and paint spills. Pugua Point or Double Reef is a pristine area removed from urbanization. Babe Island, a lagoonal patch reef, is also located in a undeveloped area.

This study was conducted from October 1980 to February 1981, a period of time when extreme low spring tides occur at night. From April

to August these low tides occur during midday subjecting reef flat organisms to extreme desiccation (Tsuda et al. in Randall et al., 1978). This shift in exposure during low tides is responsible for the seasonality in tropical algal communities. The response to these tidal changes was not addressed in this study.

This report is the first in a yearly series. It is intended to provide background data on the benthic algal and coral communities in a variety of coral reef zones around Guam. Surface cover and frequency of occurrence of these organisms will help identify subtle changes in the environment caused by man induced pollution.

MATERIALS AND METHODS

The exact locations of the nine biological stations and the placement of the transects are provided in Figures 1 to 8 which were adapted from Randall and Eldredge (1976). A variety of habitat types were represented at the various sites: two reef flats, four patch reefs, two channel margins and one submerged reef margin (Table 1). Pertinent sampling information is also presented.

At each biological station a 25-m transect tape was stretched between two permanent concrete markers. In most cases the transects were entirely in one reef zone. At Fouha Bay and Umatac Bay the transects started on channel margin pinnacles and traversed the margin area to the outer reef flat. At Fouha and Umatac the last three quadrats, out of a total of ten, were in the outer reef flat zone.

A one square-meter quadrat, gridded off to form sixteen points, was used to count substrate, algae, coral and invertebrate surface cover. Every five meters a quadrat was placed at a pre-designated meter location to the left and right side of the transect line. Substrate included sand, sediment, hard rocks, and dead coral rubble without algae. Algae and coral categories included all species that were observed in situ. Small turf algae were classified by the predominant division represented such as blue-green, brown or red turf unless they were described as attached to coral rubble and hard rock substrate. Macro-invertebrates were also recorded.

Percent cover was calculated by totaling the number of points a particular species was recorded (n) and dividing by the total possible

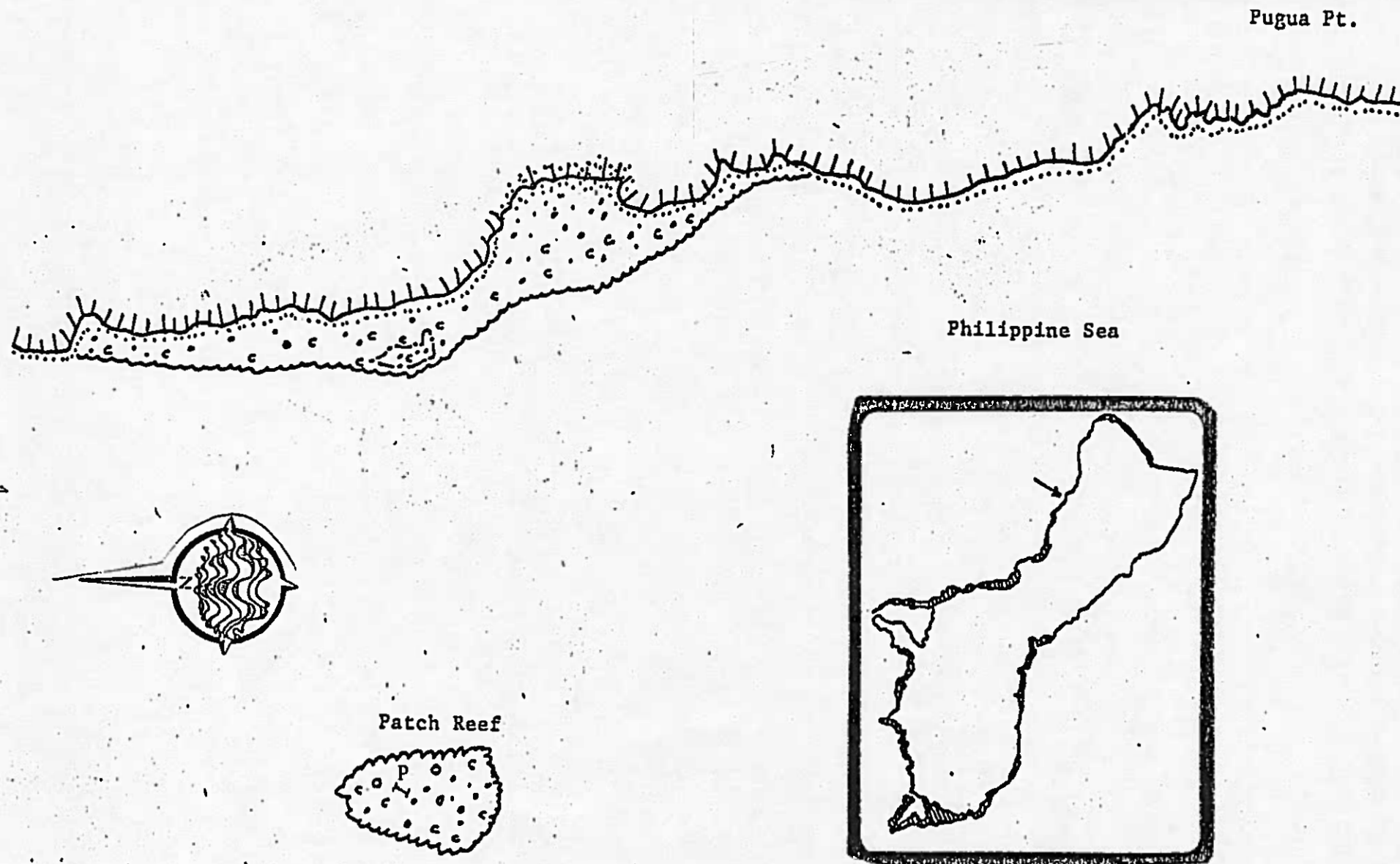


Figure 1. Double Reef patch reef (P) biological station in the Pugua Point complex.

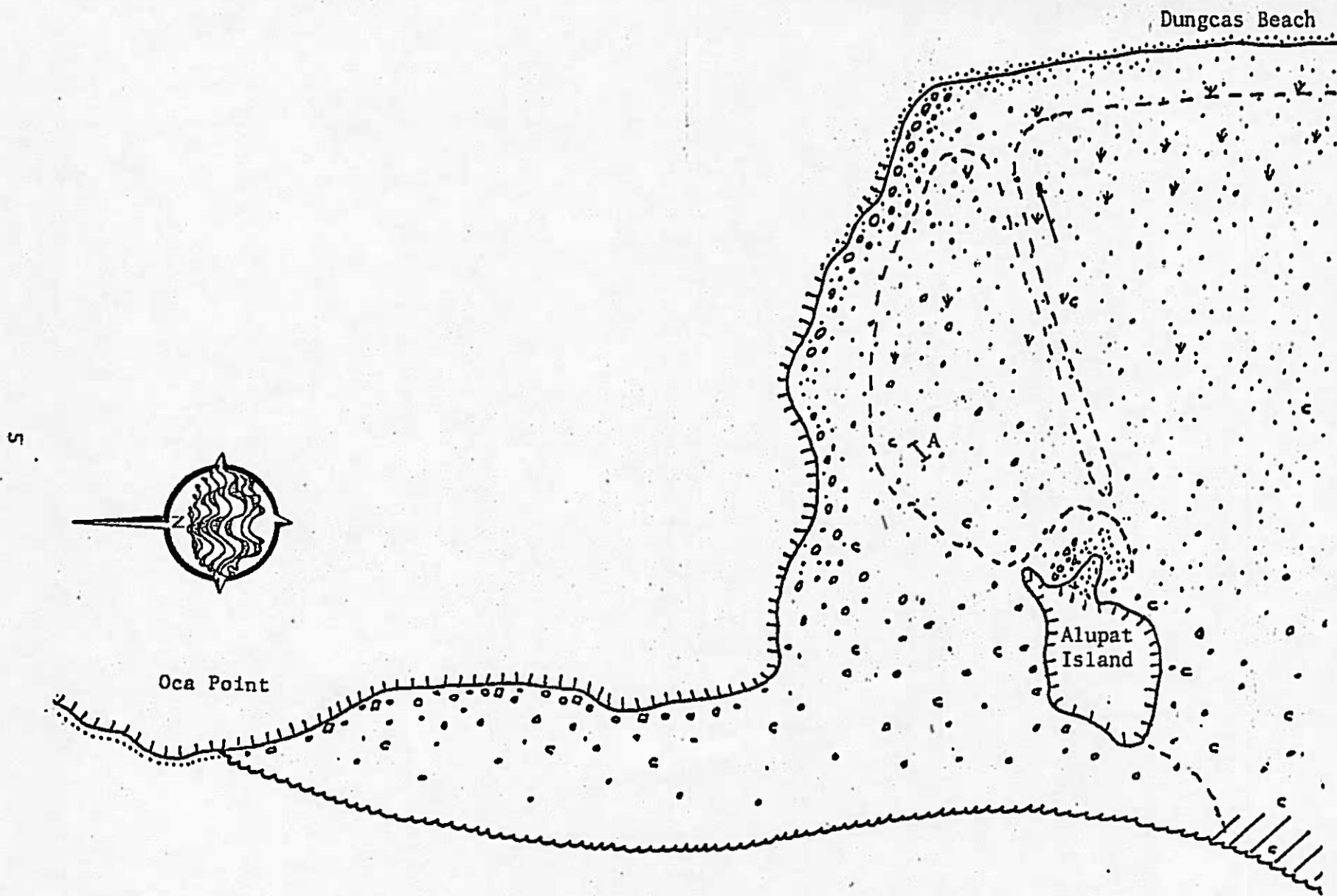


Figure 2. Alupat Island inner reef flat (A) biological station in the Agana complex.

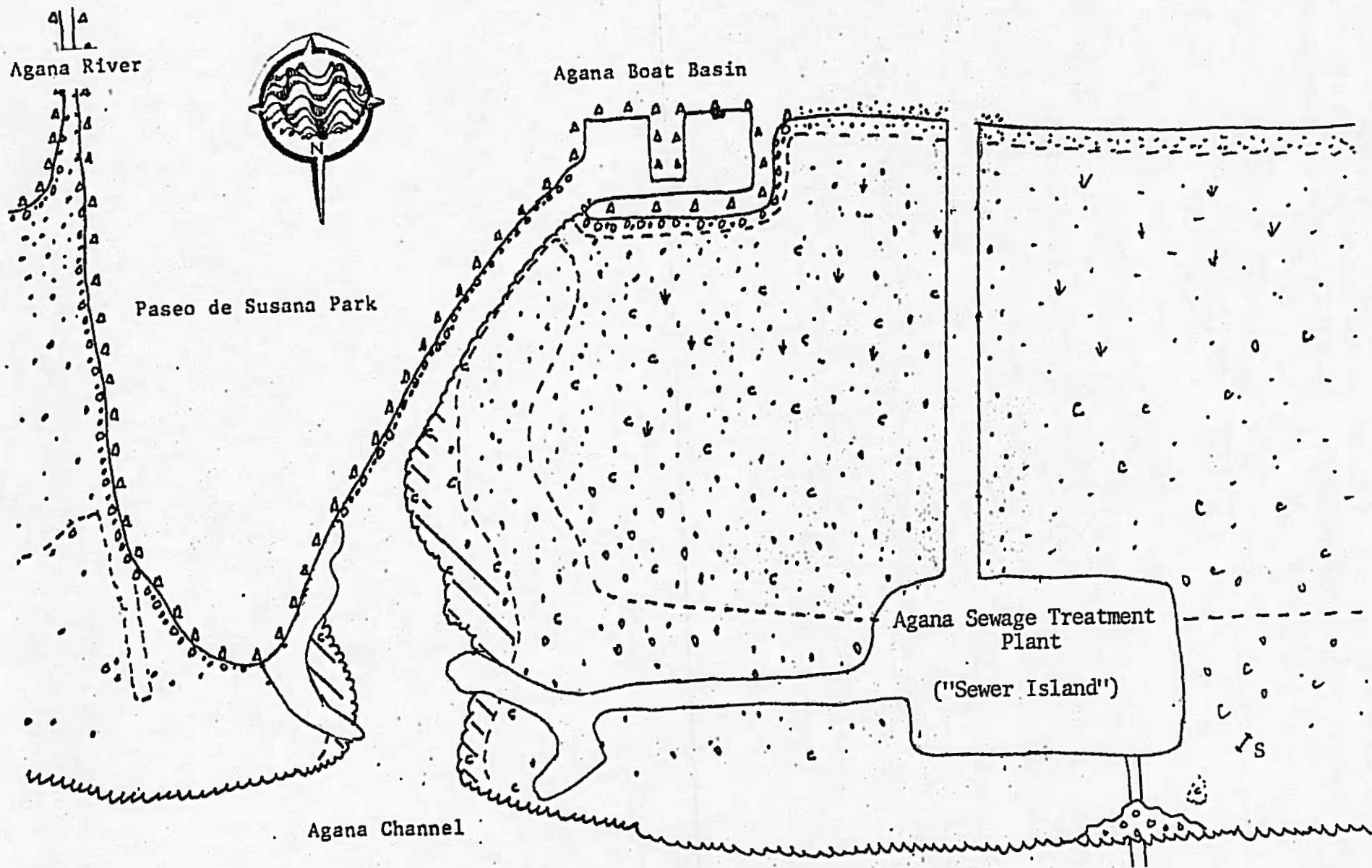


Figure 3. Sewer Island moat zone (S) biological station in the Agana complex.

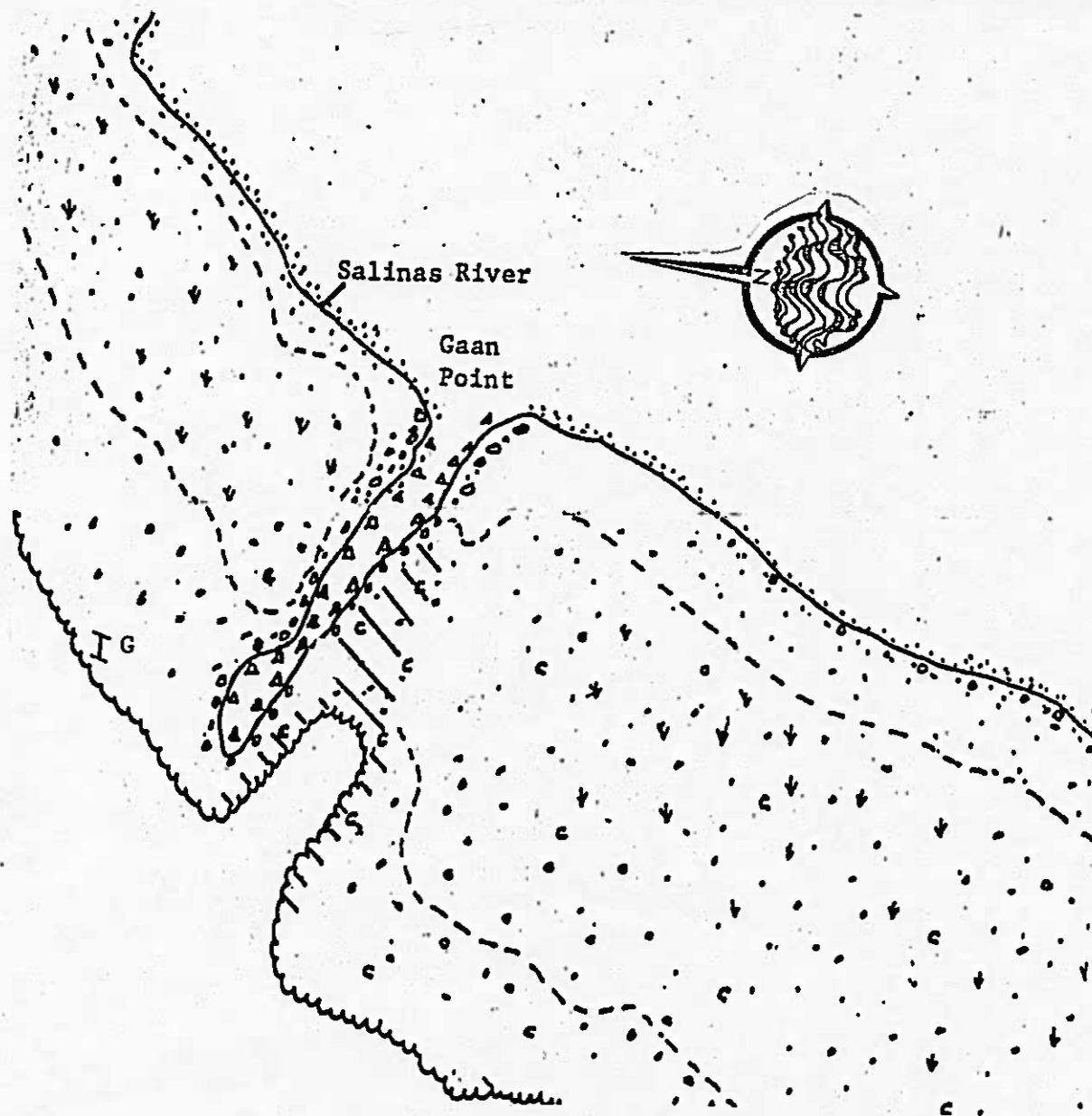


Figure 5. Gaan Point submerged reef margin (G) biological station in the Agat complex.

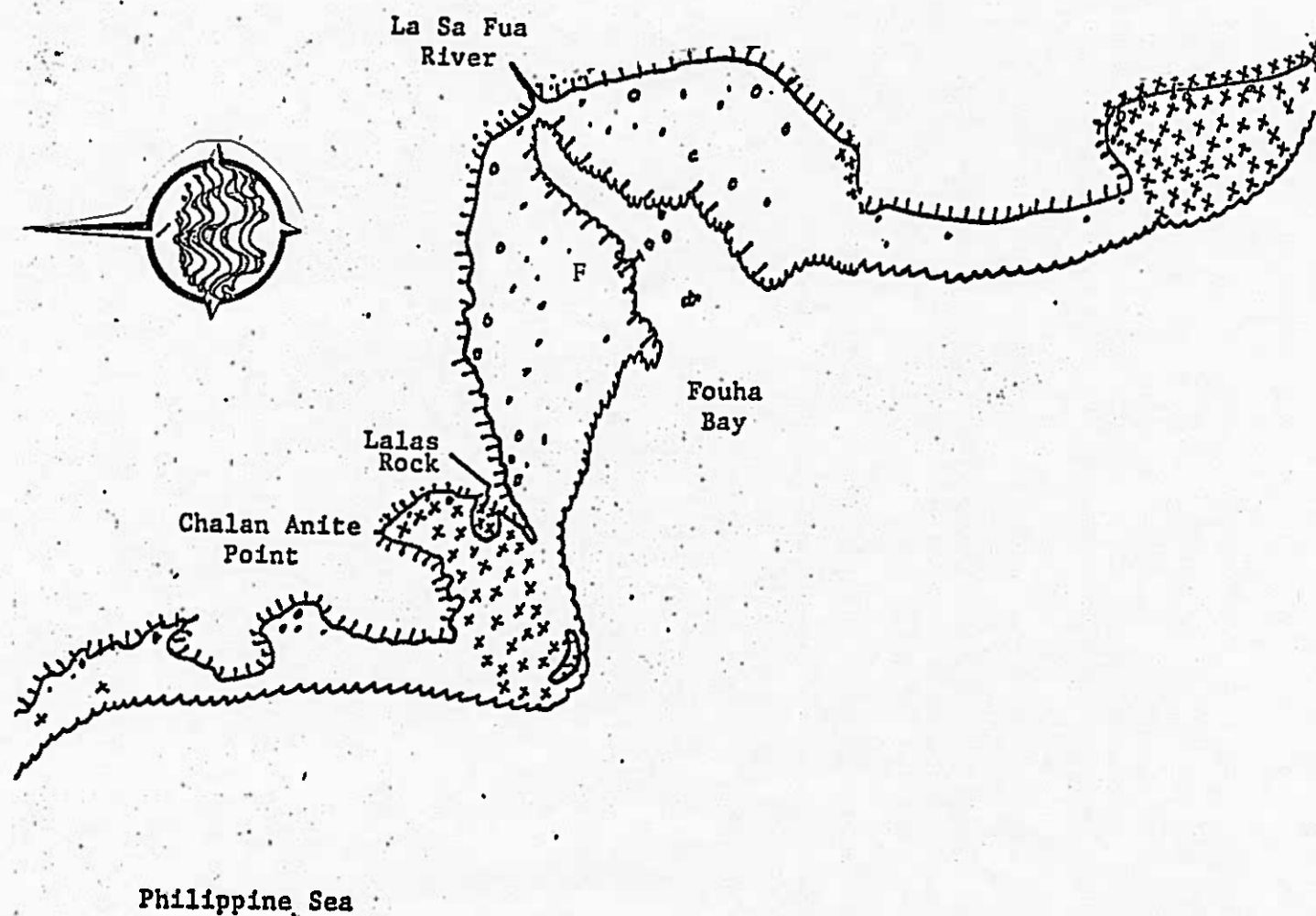


Figure 6. Fouha Bay channel margin (F) biological station in the Umatac complex.

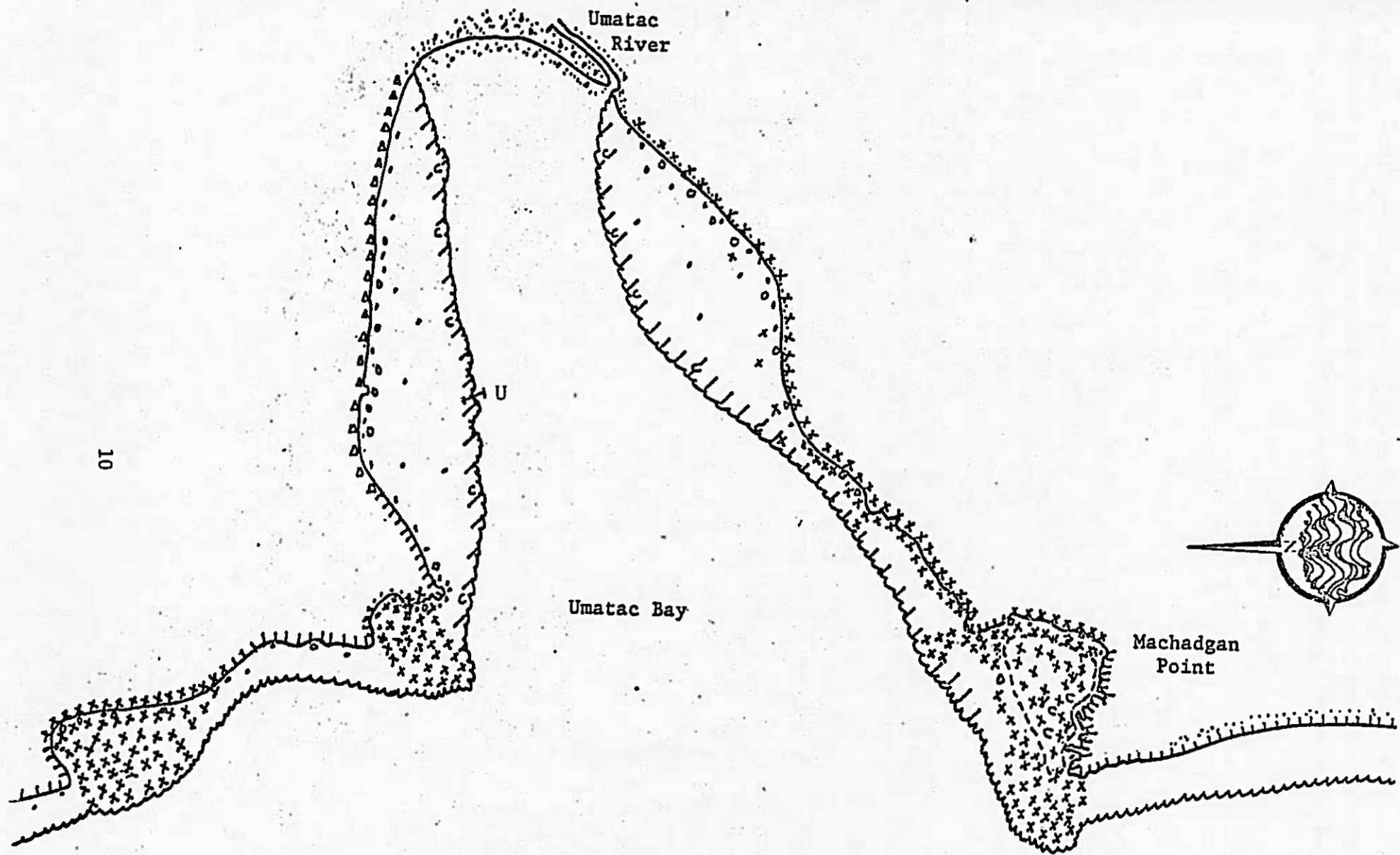


Figure 7. Umatac Bay channel margin (U) biological station in the Umatac complex.

Philippine Sea

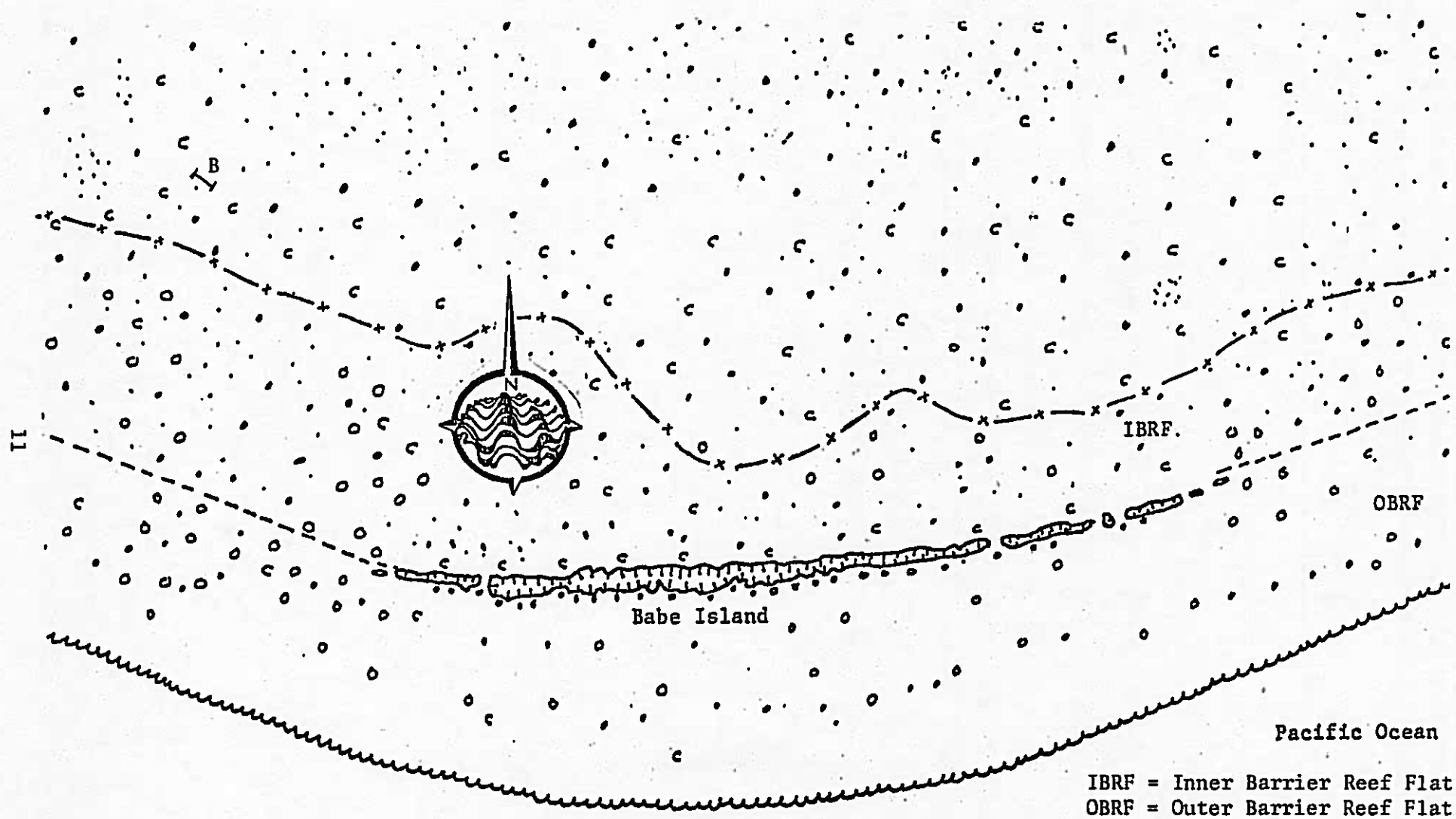


Figure 8. Babe Island patch reef (B) biological station in the Merizo complex.

Table 1. Location, date of survey, transect compass bearing and depth of the nine biological stations in north-western and south-western locations around Guam.

Location	Date of Survey	Transect Bearing	Depth (meters)
<u>North-west Stations</u>			
Pugua Point:			
Double Reef Patch Reef	2-25-81	30°	4.0
Agana:			
Alupat - Inner Reef Flat	12-01-80	225°	.7
Sewer Island - Moat Zone of Reef Flat	12-01-80	42°	.9
Apra Harbor:			
Jade Shoals - Patch Reef	10-24-80	270°	1.5 to 2.1
5 Dry Dock - Patch Reef	1-21-81	302°	1.0 to 3.0
<u>South-west Stations</u>			
Agat:			
Gaan Point - Submerged Reef Margin	12-10-80	280°	3.0
Umatac:			
Fouha Bay - Channel Margin	10-28-80	345°	.6 to 5.4
Umatac Bay - Channel Margin	1-22-81	325°	.6 to 6.1
Merizo:			
Cocos Lagoon - Babe Patch Reef	2-11-81	150°	1.7

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 quadrat points in which a species occurred (n) by the total number of quadrats surveyed (10), i.e., $n / 10 = \text{frequency.}$

RESULTS

The percent cover and frequency of occurrence of algal species are presented for the north-western stations in Table 2 and for the south-western stations in Table 3. Overall percent cover of the taxonomic groups can be compared between stations in Figure 8. The Cyanophyta were poorly represented at all of the nine stations. The Chlorophyta were rare (less than 2%) at all stations except at Gaan Point where Halimeda incrassata was common (15%). Members of the Phaeophyta were present at all locations. Phaeophyta macrophytes were most abundant at Alupat inner reef flat, Sewer Island moat zone, Fouha Bay and Umatac Bay channel margins. Dictyota bartayresii had greater than 10% cover at the Sewer Island and Babe Island stations. Padina tenuis had greater than ten percent cover at the Alupat station. The percent cover of Rhodophyta macrophytes was rather low for all stations when compared with the Phaeophyta macrophytes. Branched and encrusting crustose coralline algae were the most abundant at Gaan Point (26.3%). The Fouha Bay station had 14.4% crustose coralline surface cover while the Double Reef station had 10% crustose coralline surface cover. The remaining stations had less than 5% cover by the reef building Rhodophyta.

The calculated frequency data is presented in Tables 2 and 3. When the percent cover and frequency were high an even distribution or dominance of a specific alga was demonstrated. An example of this is Dry Dock reef which had a 1.0 frequency (all 10 quadrats) of hard substrate with algal turf cover. Gracilaria edulis and Turbinaria ornata at the Gaan Point station had moderate frequencies when compared to surface cover. A low frequency and a high percent cover is indicative of patchy distribution of the alga along the transect line. At Umatac Bay Dictyota bartayresii

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

Species Name	Pugua Point	Agana		Apra Harbor	
	Double Reef	Alupat Reef	Sewer Island	Jade Shoals	Dry Dock Reef
CYANOPHYTA					
<u>Schizothrix calcicola</u> (Ag.) Gomont blue-green turf	.2 (1.3%)				
CHLOROPHYTA					
<u>Halimeda</u> sp.			.1 (.6%)		
<u>Halimeda incrassata</u> (Ellis) Lamx.					
<u>Halimeda opunita</u> (L.) Lamx.	.2 (1.3%)				.2 (1.9%)
<u>Tydemania expeditionis</u> W. v. Bosse					
<u>Dictyosphaeria cavernosa</u> (Forsk.) Boerg.					
<u>Neomeris vanbosseae</u> Howe					
PHAEOPHYTA					
<u>Dictyota bartayresii</u> Lamx.		.7 (8.8%)	.7 (12.5%)	.1 (.6%)	
<u>Padina tenuis</u> Bory		.9 (10.6%)	.4 (3.8%)	.2 (3.1%)	
<u>Sargassum cristaefolium</u> C. Ag.		.1 (.6%)			
<u>Turbinaria ornata</u> (Turner) J. Ag.	.4 (4.4%)		.2 (1.3%)		.2 (1.9%)
brown turf	.3 (2.5%)		.9 (10.0%)		
RHODOPHYTA					
<u>Galaxaura marginata</u> Lamx.	.2 (2.5%)				
<u>Galaxaura oblongata</u> (E. & S.) Lamx.					
<u>Amphiroa</u> sp.					
<u>Amphiroa fragilissima</u> Lamx.		.1 (.6%)			
<u>Jania</u> sp.					

Table 2. continued

Species Name	Pugua Point Double Reef	Agana		Apra Harbor	
		Alupat Reef	Sewer Island	Jade Shoals	Dry Dock Reef
<u>Peyssonelia rubra</u> (Grev.) J. Ag.	.1 (.6%)		.2 (1.3%)		
<u>Gracilaria arcuata</u> Zanard.					
<u>Gracilaria edulis</u> (Gmel.) Silva					
Branching crustose coralline	.5 (6.9%)		.4 (2.5%)		.1 (.6%)
Red encrusting crustose coralline	.3 (3.1%)		.4 (2.5%)		
red turf	.1 (1.3%)		.1 (.6%)		
Algae - unidentified species					.2 (1.3%)
Coral rubble with algal turf	.7 (5.0%)		.2 (4.4%)	.7 (24.4%)	.5 (7.5%)
Hard rock with algal turf	.4 (8.8%)	.2 (1.3%)		.6 (21.9%)	1.0 (35.0%)
TOTAL PERCENT COVER	37.7%	21.9%	39.5%	50.0%	48.2%

Table 3. Species of algae encountered with the point-quadrat method along transects at four biological stations along the south-west coast of Guam. Frequency data precedes percent cover data within parentheses.

Species Name	Agat Gaan Point	Fouha Bay	Umatac Umatac Bay	Merizo Babe Island
CYANOPHYTA				
<u>Schizothrix calcicola</u> (Ag.) Gomont blue-green turf			.1 (.6%)	.1 (.6%)
CHLOROPHYTA				
<u>Halimeda</u> sp.			.1 (.6%)	
<u>Halimeda incrassata</u> (Ellis) Lamx.	.9 (15.0%)			
<u>Halimeda opunita</u> (L.) Lamx.	.3 (3.1%)			
<u>Tydemania expeditionis</u> W. v. Bosse				.1 (.6%)
<u>Dictyosphaeria cavernosa</u> (Forsk.) Boerg.				
<u>Neomeris vanbosseae</u> Howe			.2 (1.3%)	
PHAEOPHYTA				
<u>Dictyota bartayresii</u> Lamx.	.3 (1.9%)		.3 (5.0%)	.6 (11.9%)
<u>Padina tenuis</u> Bory				
<u>Sargassum cristaefolium</u> C. Ag.				
<u>Turbinaria ornata</u> (Turner) J. Ag.	.2 (1.9%)		.3 (1.9%)	
brown turf	.5 (6.9%)	.9 (29.4%)	.7 (25.0%)	
RHODOPHYTA				
<u>Galaxaura marginata</u> Lams.				
<u>Galaxaura oblongata</u> (E. & S.) Lamx.		.2 (2.5%)	.2 (1.9%)	
<u>Amphiroa</u> sp.		.4 (6.3%)		
<u>Amphiroa fragilissima</u> Lamx.			.2 (1.3%)	
<u>Jania</u> sp.	.1 (.6%)			

Table 3. continued

Species Name	Agat Gaan Point	Umatac Fouha Bay	Umatac Bay	Merizo Babe Island
<u>Peyssonelia rubra</u> (Grev.) J. Ag.	.1 (.6%)	.4 (5.0%)		
<u>Gracilaria arcuata</u> Zanard.			.1 (1.3%)	
<u>Gracilaria edulis</u> (Gmel.) Silva	.6 (6.3%)	.4 (3.1%)	.1 (1.3%)	
Branching crustose coralline	.8 (24.4%)		.2 (1.3%)	
Red encrusting crustose coralline	.2 (1.9%)	.7 (14.4%)	.2 (1.3%)	
red turf		.8 (13.8%)	.4 (3.8%)	
Algae - unidentified species				
Coral rubble with algal turf	.5 (6.9%)			.5 (16.3%)
Hard rock with algal turf	.9 (18.1%)			
Sediment and algal turf			.2 (8.8%)	
TOTAL PERCENT COVER	87.5%	74.5%	55.4%	29.4%

had frequency and percent cover values which showed this type of clumped distribution.

The bar graph in Figure 9 does not equal the total algal percent cover for each station because the coral rubble and rock substrate with algal turfs were omitted. These categories were not designated by the investigator in the field to be in any particular taxonomic group; however, they were comprised of members of the Phaeophyta and Rhodophyta (Table 4). Alupat inner reef flat had the lowest total algal turf populations because of the high unconsolidated sand component (61.3%) in the substrate category (Table 4). Sewer Island and Babe Island patch reefs had similar amounts of turf algae. The algal turf at Babe Island patch reef was the result of the "farming" activity of the territorial pomacentrids on the dead Acropora stands. At Double Reef the algal turfs were in direct competition for space with the encrusting corals such as Montipora. Jade Shoals and Dry Dock patch reefs, and Fouha Bay and Umatac Bay channel margins all had similar total percent cover of turfs; perhaps because of the fairly solid substrate that is present at these locations. Gaan Point submerged channel margin had a slightly lower cover of algal turfs than the patch reefs and channel margins.

The percent cover and frequency of occurrence of coral species are presented for the north-western stations in Table 5 and for the south-western stations in Table 6. At Double Reef the Acroporidae are most abundant. Alupat Reef and Sewer Island have low coral coverage because they are both within fringing reef flat zones. The moat zone at Sewer Island does have a higher percent cover than the inner reef flat zone at Alupat Reef. This results from the presence of deeper water and hard substrate which is utilized for attachment. The Poritidae and Agariciidae are well

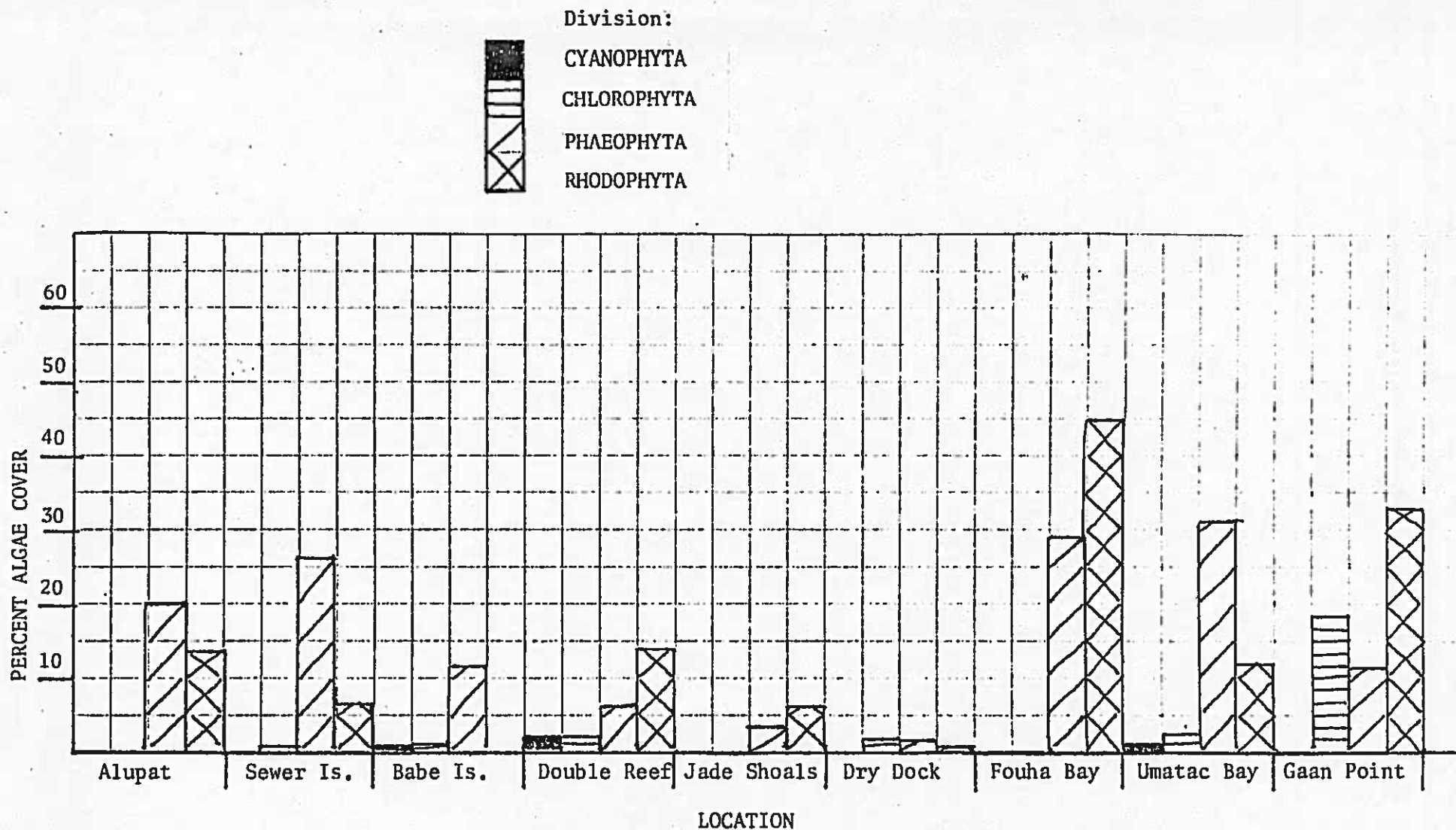


Figure 9. Percent cover by taxonomic group of the benthic algae at the nine biological stations around Guam. Unidentified algae, coral rubble and hard rock substrate with algal turfs attached are excluded because taxonomic determinations in the field were not made.

Table 4. Percent cover of algal turfs on coral rubble and hard rock substrates compared with other brown and red algal turfs surveyed at the nine biological stations grouped by zonation within the fringing reef.

Location	Mixed Turf on Rubble and Hard Rock	Brown Turf (Phaeophyta)	Red Turf (Rhodophyta)	TOTAL
Reef Flats:				
Alupat Island	1.3	0.0	0.0	1.3
Sewer Island	4.4	10.0	.6	15.0
Patch Reefs:				
Babe Island	16.3	0.0	0.0	16.3
Double Reef	13.8	2.5	1.3	17.6
Jade Shoals	46.3	0.0	0.0	46.3
Dry Dock	42.5	0.0	0.0	42.5
Channel Margins:				
Fouha Bay	0.0	29.4	13.8	43.2
Umatac Bay	8.8*	25.0	3.8	37.6
Submerged Reef Margin:				
Gaan Point	25.0	6.9	0.0	25.0

*this value represents sediment ladden algal turf.

Table 5. Species of coral encountered with the point-quadrat method along transects at five biological stations along the north-west coast of Guam. Frequency data precedes percent cover data within parentheses.

Species Name	Pugua Point Double Reef	Agana Alupat Reef	Sewer Island	Apra Harbor Jade Shoals	Dry Dock Reef
CLASS - ANTHOZOA					
ORDER - SCLERACTINIA					
SUBORDER - ASTROCENTINIIA					
FAMILY - THAMNASTERIIDAE					
<u>Psammocora contigua</u> (Esper)			.3(1.9%)		.4(8.1%)
FAMILY - POCILLOPORIDAE					
<u>Stylophora mordax</u> (Dana)	.4(3.1%)				
<u>Pocillopora damicornis</u> (Linnaeus)		.3(1.9%)		.1(1.3%)	.4(5.0%)
<u>Pocillopora</u> (thick branches)	.1(1.9%)				
FAMILY - ACROPORIDAE					
<u>Acropora aspera</u> (Dana)			.4(5.0%)		
<u>Acropora humilis</u> (Dana)	.1(1.3%)				
<u>Acropora irregularis</u> (Brook)	.2(5.6%)				
<u>Acropora palifera</u> (Lamarck)	.1(2.5%)				
<u>Acropora tenuis</u> (Dana)	.1(1.3%)				
<u>Acropora</u> sp. 1 (brown)	.7(13.1%)				
<u>Acropora</u> sp. 7 (thick)	.2(1.9%)				
<u>Acropora</u> sp. 3 (blue tips)	.3(1.9%)				
<u>Montipora</u> green-encrusting	.3(6.9%)				
<u>Montipora</u> brown-small knobs	.4(4.4%)				
<u>Montipora</u> blue-encrusting	.3(3.1%)				
<u>Montipora</u> (less spiny)	.1(.6%)				
SUBORDER - FUNGIINA					
FAMILY - AGRICIIDAE					
<u>Pavona decussata</u> Dana		.4(2.5%)		.3(1.9%)	.8(13.8%)
<u>Pavona divaricata</u> (Lamarck)					.5(5.0%)
<u>Pavona varians</u> Verrill	. (.6%)				
FAMILY - FUNGIIDAE					
<u>Fungia</u>	.1(.6%)				

Table 5. Continued.

Species Name	Pugua Point	Agana		Apra Harbor	
	Double Reef	Alupat Reef	Sewer Island	Jade Shoals	Dry Dock Reef
SUBORDER - FUNGIINA (continued)					
FAMILY - PORITIDAE					
<u>Porites andrewsi</u> Vaughan				.4(8.1%)	.1(.6%)
<u>Porites lutea</u> Milne-Edwards & Haime				.2(3.1%)	.4(4.4%)
<u>Porites (Synaraea)</u> <u>iwayamaensis</u> Eguchi	.3(1.9%)		.3(1.9%)	.8(25.0%)	.5(8.1%)
Unidentified					
<u>Leptoria</u> ?			.1(.6%)		
encrusting coral					.1(1.9%)
encrusting <u>Favia</u> ? very spiny	.1(.6%)				.1(.6%)
paliform lobe	.2(1.3%)				
CLASS - HYDROZOA					
ORDER - MILLEPORINA					
FAMILY - MILLEPORIDAE					
<u>Millepora platyphylla</u> Hemprich & Ehrenberg				.1(.6%)	.1(.6%)
<u>Millepora</u> thick					.1(1.9%)
Dead Coral/Rubble without Algae	.2(4.4%)	.8(8.1%)	.2(16.9%)		
Soft Corals					.1(1.3%)
Total Percent Cover (Hard Corals)					
Live	52.6%	2.5%	11.3%	40.0%	51.3%
Dead/Rubble	4.4%	8.1%	16.9%		
Soft Corals					1.3%

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

Species Name	Agat Gaan Point	Fouha Bay	Umatac Umatac Bay	Merizo Babe Island
CLASS - ANTHOZOA				
ORDER - SCLERACTINIA				
SUBORDER - ASTROCOENIINA				
FAMILY - POCILLOPORIDAE				
<u>Pocillopora damicornis</u> (Linnaeus)	.2(1.3%)	.1(.6%)	.2(1.3%)	.3(2.5%)
FAMILY - ACROPORIDAE				
<u>Acropora aspera</u>				.4(5.6%)
<u>Acropora formosa</u>				.5(9.4%)
<u>Acropora</u> (?)	.4(5.0%)			
<u>Acropora</u> blue tips		.3(3.1%)		
<u>Montipora</u> (?)	.1(.6%)		.1(.6%)	
FAMILY - PORITIDAE				
<u>Porites andrewsi</u> Vaughan				.1(8.1%)
<u>Porites lutea</u> Milne-Edwards & Haime		.1(.6%)	.5(11.9%)	.2(1.3%)
<u>Porites</u> (Synaraea) <u>iwayamaensis</u> Eguchi	.2(1.3%)		.7(26.9%)	
Unidentified				
Coral	.1(1.3%)	.6(10.0%)	.2(1.3%)	
<u>Leptoria</u> ?	.1(.6%)	.3(5.0%)		
<u>Favia</u> ?		.4(2.5%)	.1(.6%)	
encrusting		.1(.6%)		
Dead Coral without Algae (<u>Acropora</u>)				.9(17.5%)
Total Percent Cover				
Live	10.1%	22.4%	42.6%	26.9%
Dead/Rubble				17.5%

represented at both Apra Harbor stations. At Gaan Point the Acroporidae are most abundant even though the total coral cover is only 10 percent. Umatac Bay has high percent cover of Poritidae while Fouha Bay has a high percent cover of corals unidentified by the investigator. The Babe Island station has high Acroporidae cover.

The relationship between percent cover and frequency allows for determination of patchiness or distribution of corals in an area. As evident from Tables 5 and 6, some corals are clumped in isolated spots of the transects while others are found growing throughout the survey area. Many factors could affect this distribution such as chemical properties of the seawater, physical topography of the area, current direction and velocity.

Percent cover values for the various constituents were lumped into four major categories: substrate, algae, coral and invertebrates. The total percent cover of the benthic constituents at the nine stations is presented in Table 7. Invertebrates were rare to absent for most stations. The proportions of the four categories varied depending on the location within zones on the fringing reef. Alupat inner reef flat, Sewer Island moat zone and Babe Island patch reef had the greatest amounts of sand substrate. Gaan Point submerged reef margin, Fouha Bay and Umatac Bay channel margins, and Jade Shoals and Dry Dock patch reefs had higher algae and coral surface cover values. Physical factors that might account for these differences were not quantified in this study. The submerged reef margin and channel margin stations were the deepest within the reef zones surveyed.

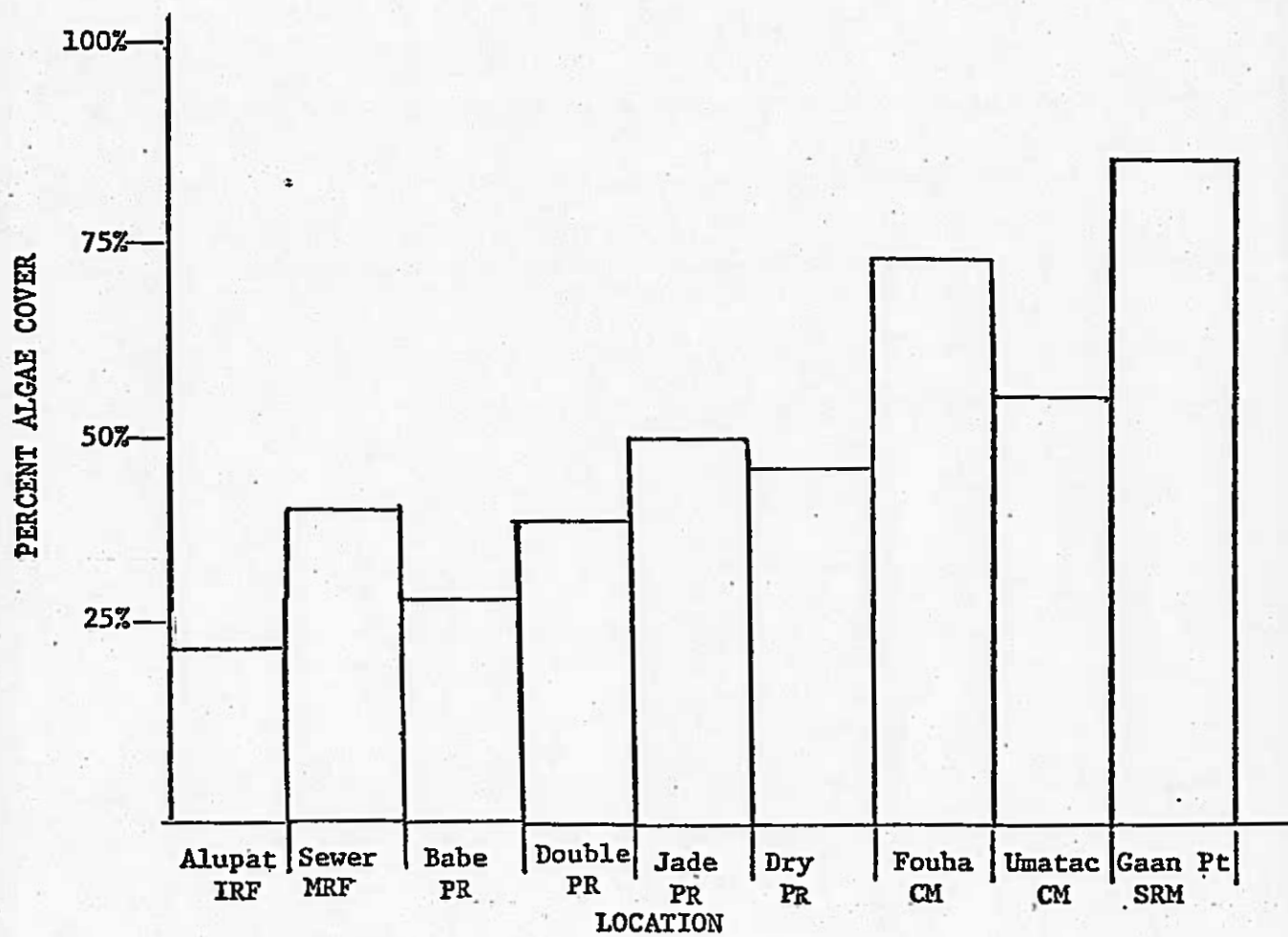
Figure 10 compares the average percent cover of benthic algae at the nine biological stations by reef zonation. Reef flat zones have the

Table 7. Average percent surface cover of the major constituents of the benthic habitat determined from the point-quadrat method at nine biological stations.

Location	Substrate	Algae	Coral	Invertebrates
Pugua Point:				
Double Reef Patch Reef	6	38	53	3
Agana:				
Alupat - Inner Reef Flat	74	22	3	1
Sewer Island - Moat Zone of Reef Flat	47	40	11	2
Apra Harbor:				
Jade Shoals - Patch Reef	9	50	40	1
Dry Dock - Patch Reef	1	48	51	
Agat:				
Gaan Point - Submerged Reef Margin	3	87	10	
Umatac:				
Fouha Bay - Channel Margin	2	74	23	1
Umatac Bay - Channel Margin		55	42	3
Merizo:				
Cocos Lagoon - Babe Patch Reef	42	30	27	1

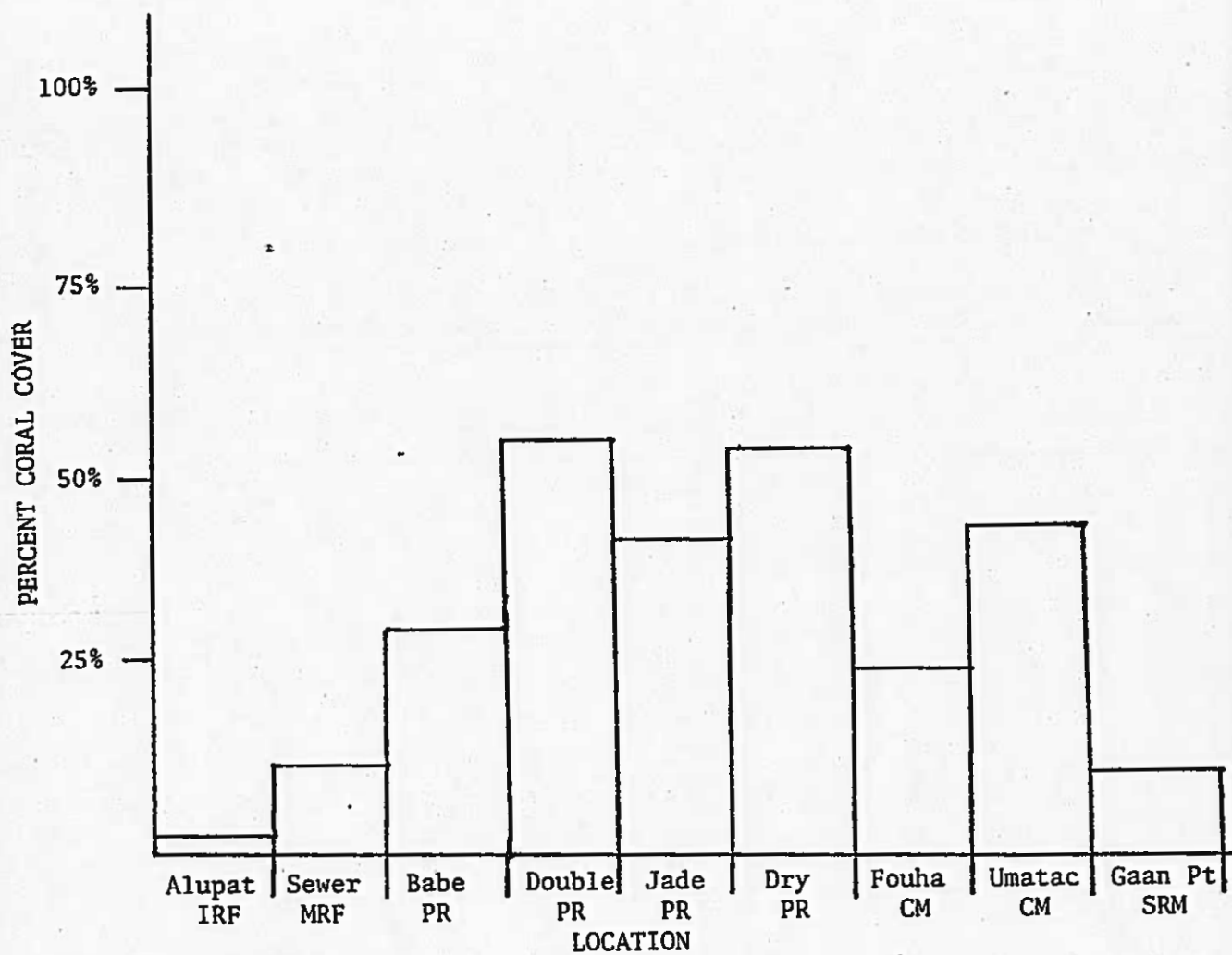
lowest total percent cover of all algal components. The four patch reef stations have mean percent cover of algae of 41.5% with a range from 30 to 50%. The two channel margin sites and the submerged reef margin site have the highest percent algal cover.

Figure 11 compares the average percent cover of living corals at the nine biological stations by reef zonation. Reef flat zones and the submerged reef margins have the lowest percent cover of coral. The four patch reefs have a mean percent cover of coral of 42.6% with a range of 26.9 to 52.6%. The highest percent coral cover is at Double Reef and Dry Dock Reef.



IRF = Inner Reef Flat
 PR = Patch Reef
 MRF = Moat Zone Reef Flat
 CM = Channel Margin
 SRM = Submerged Reef Margin

Figure 10. Average percent cover of benthic algae at various biological stations as grouped by reef zonation designations.



IRF = Inner Reef Flat
 PR = Patch Reef
 MRF = Moat Zone Reef Flat
 CM = Channel Margin
 SRM = Submerged Reef Margin

Figure 11. Average percent cover of live coral at various biological stations as grouped by reef zonation designations.

DISCUSSION

In the Agana Complex it was evident that Alupat biological station was in the inner reef flat zone because of the high substrate value and the low coral cover. Algae was the predominant cover because of its ability to grow on loose unconsolidated rubble. Sewer Island station is located in the seaward reaches of the moat zone close to the periphery of the outer reef flat zone. As expected, the sand substrate cover was lower in the moat zone than in the inner reef flat zone. The algae and coral cover increased because of the slightly deeper water which prevented complete exposure at low tide.

Within the Apra Harbor complex both Jade Shoals and Dry Dock reef are representative of typical submerged reef margins on a patch reef. The algae and coral percent cover is comparable at both stations. The actual species composition is different, presumably because of differences in the physical make-up of the reef. Dry Dock reef is subjected to greater wave action than Jade Shoals. Both reefs appear to be healthy and productive.

The Agat complex is exemplified by the Gaan Point submerged reef margin. There is high abundance and relative distribution of benthic algae in the Nimitz Beach reef area reported by Chernin et al. (1977). The high algal percent cover at the Gaan Point station can either be attributed to natural occurrence or to the increased nutrients from the Gaan Point Sewage Outfall. Further investigations are anticipated to indicate this phenomena.

In the Umatac complex the Umatac Bay northern channel margin has a higher percent cover of corals, nearly twice as much, as Fouha Bay.

Although Umatac Bay is typically turbid, the direct influence of the Umatac River is not as pronounced as the La Sa Fua River in Fouha Bay. The proximity of the river mouth to the channel margin in Fouha Bay and the accompanying fresh water intrusion and sediment fallout is probably responsible for the lower coral cover. Fouha Bay does have approximately 25% more algae cover than Umatac Bay.

The Merizo complex is represented by one station at the patch reef northeast of Babe Island. The substrate surface cover value is high, which is similar to the Agana reef flat values. Coral and algae cover at this station are equivalent.

The Pugua Point or Double Reef complex is the most pristine and undisturbed station. The percent cover of substrate, algae, coral and invertebrates is similar to Jade Shoals and Dry Dock patch reefs. Even though these values are analogous, the fact that Double Reef is exposed and on the north-western coast and Jade Shoals and Dry Dock reef are both enclosed within Apra Harbor is important to consider. This is especially true for coral species that inhabit exposed versus protected reefs. Species composition of algal communities also reflect these differences.

Zonation within the fringing reef is the most critical factor in determining the distribution of marine benthic algae and corals. Availability of suitable substrate is also important in algal and coral distribution and the attachment of organisms. The increased amount of nutrients near sewage outfalls appears to supplement algal growth, specifically for the calcifying algae. Sedimentation does not seem to be detrimental to algal growth but does have effect on coral growth.

Smith et al. (1973) found that the distribution of community components in Kaneohe Bay, Hawaii, depended on four factors: topographical relief, circulation and surge, substrate availability, and depth (light penetration). The presence and absence data for various species of algae, coral, echinoderms and fishes were recorded by the environmental factors they were subjected to. Benthic algae distribution was correlated with circulation and depth. Corals were dependent on substrate, relief and circulation. The distribution of reef fishes was related to relief and circulation. Echinoderms sought out specific substrates such as sandy areas. Smith et al. (1973) also related these factors to specific locations within the reef framework system. Algae, which was most dependent on circulation for nutrient absorption, was most abundant in fore reefs, patch reef slopes and high energy reef flats. Corals, which need suitable substrate for attachment, were located in the fore reef, patch reef slopes and high energy reef flats. Fish, which need topographical relief for shelter, were found to inhabit slopes of patch and fringing reefs and also fore reefs.

These same patterns were evident in this study. Both Alupat and Sewer Island reef flats have good circulation to support algal communities but lack large quantities of hard substrate which are important for coral recruitment and attachment. Double Reef, Jade Shoals, Dry Dock Reef, and Umatac Bay all have high coral cover and good substrate, relief and circulation. They are also within reef zones associated with coral growth. Babe Island patch reef is really more of a lagoonal community with limited substrate, but corals such as the Acroporidae and Poritidae manage to secure themselves and flourish in the shifting sandy bottom. Fouha Bay should have higher coral growth but the channel margin station is close to the La Sa Fouha River mouth and is subjected to the introduction of fresh-water and river sediments, thus coral growth may be somewhat suppressed. Gaan Point, Agat, is one station

that may be of concern ecologically. The station is in close proximity to the Agat Sewage Treatment Plant outfall pipe which was damaged in 1976 by Typhoon Pamela and is currently discharging treated sewage onto the reef margin. The coral cover is very low at Gaan Point considering it is a submerged reef margin and has good relief and circulation. The algae cover was 87 percent and mostly calcareous algae. This indicated to this investigator that the community structure of the area may have been off-set by dissolved nutrients which the algae absorb, incorporate into their tissue, and utilized for increased growth. Fresh water intrusion from the treatment facility and storm water runoff may also be stressing the reef. The actual cause of the high algae cover remains to be demonstrated conclusively.

It is anticipated that the second sampling should elucidate some of the factors responsible for the disproportionate algal growth in some areas that are expected to be capable of supporting high coral cover. It is apparent that a healthy coral reef community will attain a balance between its constituents that occupy and cover the available substrate. If the biological community is stressed by alterations in the physical and chemical properties of the water, certain species tend to have the advantages through adaptability to the changed or polluted conditions. This becomes apparent when the species composition of an area tends toward homogeneity when all other factors indicate heterogeneity could be supported.

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