MARINE RECONNAISSANCE SURVEY OF PROPOSED SITES FOR A SMALL BOAT HARBOR IN AGAT BAY, GUAM

Mitchell I. Chernin, Dennis R. Lassuy, Richard "E" Dickinson,
and
John W. Shepard

UNIVERSITY OF GUAM MARINE LABORATORY

Technical Report No. 39

September 1977

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AGAT

CORPS OF ENGINEERS,
U.S. ARMY ENGINEER DISTRICT,
HONOLULU

SMALL BOAT HARBOR STUDY

WEDNESDAY, NOVEMBER 30, 1977 AT 7:30 PM
VILLAGE COMMISSIONER'S OFFICE, AGAT

A public meeting will be held to discuss the various alternative plans developed by the Corps of Engineers for the Agat Small Boat Harbor.

Your attendance and participation will help us determine which alternative is the most responsive to your needs and desires. Six alternatives will be discussed including details of costs, benefits, and impacts. Three of the proposed alternatives are for a 250-boat capacity harbor, and the other three alternatives are for a 350-boat capacity harbor.

All those interested in this study are invited to be present or represented at the meeting. Everyone will be given an opportunity to express their views; however, for accuracy of record all important facts and positions should be submitted in writing to the recording secretary at the meeting.

For additional information or a copy of the draft detailed project report with draft environmental statement on this study, contact the Planning Branch of the Honolulu Engineer District by letter or telephone 438-9526, or the Guam Project Office, U.S. Army Corps of Engineers, Pacific Daily News Bldg, Agana, Guam 96910, telephone 344-5203.

Since the proposed alternative plans may discharge dredged or fill material into the waters of the United States, the requirements of Section 404 of the Federal Water Pollution Control Act of 1972, as amended (Public Law 92-500) will be considered at this meeting.

We request that you bring this notice to the attention of all persons interested in the study and look forward to seeing you at the meeting.

F. M. Pender, LTC
for F. M. PENDER
Colonel, Corps of Engineers
District Engineer

This study was authorized by Congress under Section 107 of the River and Harbor Act of 1960, as amended.

PUBLIC MEETING

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Mitchell I. Chernin, Dennis R. Lassuy, Richard "E" Dickinson,
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John W. Shepard

Submitted to

U. S. Army Corps of Engineers

Contract No. DACW84-77-C-0061

Technical Report No. 39

University of Guam Marine Laboratory

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Thanks are also extended to the Guam Environmental Protection Agency for making available data on water quality at the Nimitz study area, and especially to Mr. Timothy Determan of that agency.

We also thank Mrs. Teresita C. Balajadia who typed the final report.

INTRODUCTION

The University of Guam Marine Laboratory was contracted by the U. S. Army Corps of Engineers to perform an underwater and surface reconnaissance survey and mapping of three study areas considered as possible construction sites for a small boat basin in Agat Bay, Guam. The proposed sites, on the west coast of Guam, include Bangi Point, Nimitz Beach, and the Taleyfac River areas (Fig. 1). Three additional sites (Gaan Point, Rizal Beach, and Namo River mouth) also under consideration were extensively surveyed by Eldredge, Dickinson, and Moras (1977). The Marine Laboratory was requested to provide the following information:

1. Preliminary mapping and delineation of marine habitats found in the area;

2. Descriptions of the qualitative conditions of the marine environment at the study sites;

3. Discussion of the dominant coral, fish, algal, and invertebrate species found at the study sites;

4. Qualitative observations on water currents, water quality, and local fishing activities at the study sites.

PERSONNEL:

Mitchell I. Chernin, Graduate student, Marine Laboratory, University of Guam (Corals, Currents).

Richard "E" Dickinson, M. S. Graduate, University of Guam Marine Laboratory (Macro-invertebrates, Currents).

Dennis R. Lassuy, Graduate student, Marine Laboratory, University of Guam (Marine Plants).

John W. Shepard, Biology student, University of Guam (Fishes).

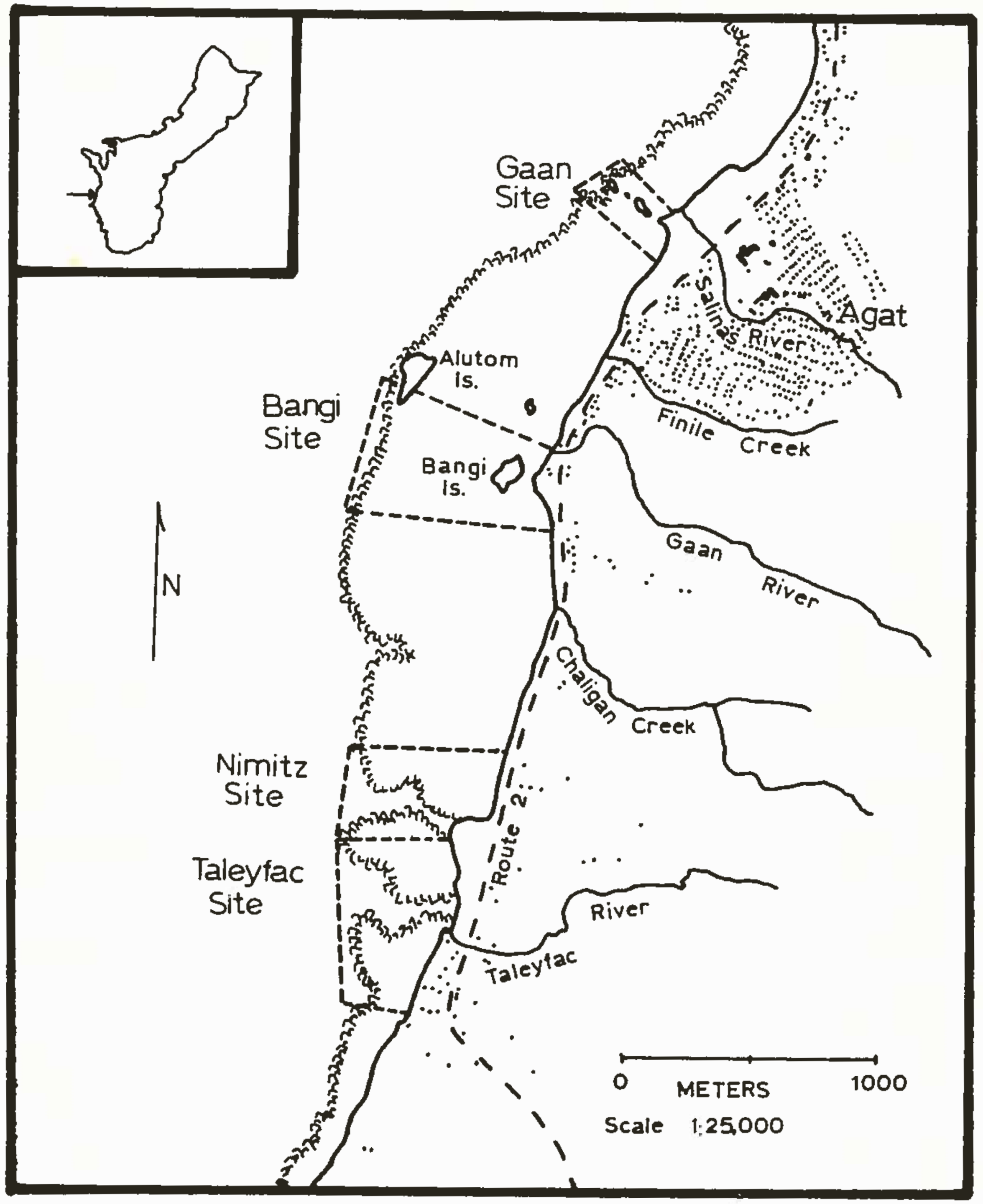

Fig. 1. General location map for the Agat Bay study areas.

METHODS

Censuses of macro-invertebrates, marine plants, corals and fishes were accomplished by making repeated random swims through the major zones of the three study areas and recording the names and relative abundance of each species encountered. For the most part only snorkeling was required; however, in the deeper areas, particularly Nimitz and Taleyfac Channels, SCUBA was used. Access to most of the areas was by walking across the reef flat pavement but access to the channels and parts of the reef front required the use of a boat on several occasions.

This method does not provide statistical data, as quadrats, line transects or nearest neighbor programs would; and these procedures would have required more time than provided for in the contract. Such statistical sampling programs, used alone, can also produce data which omit rare species or even locally common but clumped species which are unevenly distributed. For these reasons we feel that our "overview approach" was appropriate to the Scope of Work.

The diversity and habitat preference of many of the macro-invertebrates, particularly their patchy distribution, does not allow the assignment of a particular abundance value such as dominant, common, occasional or rare. For this reason the species list provided indicates only the name and location of the organisms observed. Specimens not easily identifiable <u>in situ</u> were brought back to the University of Guam Marine Laboratory for identification.

The relative abundances of marine plants at the three study sites were determined as follows: abundant (A), clearly dominant (or co-dominant) in at least one major area of the study site; common (C), abundant, but not dominant, in at least one (but not all) major zones in the study site; occasional (O), individuals, patches or clumps observed in only a single small area or observed in scattered places 5-10 times during the site survey; and rare (R), 1-5 specimens observed at the entire site. Specimens not identifiable in the field were brought back to the University of Guam Marine Laboratory for positive identification. Microscopic analysis of the dominant turfs and "fuzzes" enabled a far more complete species checklist than is often accomplished. Therefore, comparisons of the diversity of marine benthic plants between this and past studies in the Agat area are biased toward greater species diversity in this study.

The relative abundance of corals was determined by use of a modified system designed by R. H. Randall. From the viewpoint of the investigator, a relative abundance value was assigned as follows: dominant (D), a species occurring most frequently throughout the study area; abundant (A), a species frequently observed and widely distributed throughout the study area; common (C), a species which can usually be found throughout most of the study area; occasional (O), a species observed only in a particular biotope in the study area; uncommon (U), a species observed at infrequent intervals within a particular biotope; and rare (R), a species whose occurrence is reflected in one to five observations and is nearly always restricted to a specific locality within a biotope. At all sites individual species of coral were collected and brought to the University of Guam Marine Laboratory for identification. The checklist of corals was further supplemented by previous field observations made by R. H. Randall.

The relative abundance of fish species observed was determined as follows: abundant (A), clearly dominant (or co-dominant) in the site, or occurring in large aggregations at some point within the site; common (C), occurring regularly throughout the site, or dominant within a restricted portion of the site; occasional (O), observed infrequently throughout the site, or as a total of less than ten individuals within a restricted area of the site; and rare (R), observed three or fewer times during the survey of a site. Cryptic species were deemphasized in this study as ichthyocides, which allow accurate enumeration of these fishes, were not used. A small multi-prong spear was employed to obtain specimens of species which were difficult to identify *in situ*. These specimens were then brought to the University of Guam Marine Laboratory for identification.

Current directions across the reef flat during falling and rising tides were determined by the use of fluorescein dye patches released at approximately 25- or 50-m intervals along transects at each of the study sites, and the general direction of dye movement was recorded. Dye patch determinations in Nimitz and Taleyfac Channels were done on the surface and approximately 1 meter off the bottom at low and high tide, and the general direction of dye movement was also recorded.

RESULTS AND DISCUSSION

Description of Study Sites

The Bangi Point site, the northernmost site of the three surveyed, exhibits irregular zonation in the inner and outer reef flats. The substrate of the outer reef flat is reef-rock pavement with scattered boulders and local boulder tracts; some sand and gravel can be found in local holes and depressions. The inner reef flat has a thin covering of sand, gravel, coral-algal-mollusk rubble, and scattered boulders in a well developed moat. Local exposures of reef rock are common. Corals are widely scattered to locally abundant on the inner reef flat and mostly absent on the outer reef flat except in local holes and depressions. Seagrasses are scattered to locally abundant on the inner reef flat (Randall and Eldredge, 1976).

The reef margin is completely emergent during low tides but is constantly washed by waves and is not subject to desiccation, as are parts of the reef-flat platform. Algal ridge development is also lacking along much of the reef margin, which is not surprising since Agat Bay is situated on a lee coast and not exposed to steady vigorous wave action or refracted swell (Eldredge, Dickinson, and Moras, 1977).

The reef front has low-profile coral development which may indicate the periodic occurrence of destructive wave action. The substratum along the reef front, near the reef margin, is virtually devoid of loose rubble or sand. This observation suggests episodic occurrences of destructive wave action, particularly during storms.

The Nimitz Beach site (Fig. 2) is divided into the Northern Reef Flat and Center Reef Flat by Nimitz Channel. The inner reef flat adjacent to the north side of Nimitz Channel (Northern Reef Flat) is characterized by scattered seagrass beds. There are a few corals and the substratum is mostly a thin sand layer with scattered boulders over a flat reef-rock pavement. The outer reef flat and reef margin have similar morphologic features to those of the Bangi Point site. The reef flat on the south side of the channel (Center Reef Flat) is exposed at low tides and lacks the seagrass development characteristic of the Northern Reef Flat. The Center Reef Flat is characterized by an elevated boulder-rubble zone centrally located. The remaining area of the flat is monotonously flat reef-rock pavement with a thin veneer of sand and gravel. A shallow and narrow channel with beach-derived deposits runs along the beach front for its entire length.

Nimitz Channel (Fig. 2) varies in depth from less than a meter at the beach face to nearly 20 m at the mouth. The channel walls are characterized by large *Porites* heads and numerous algal species. The

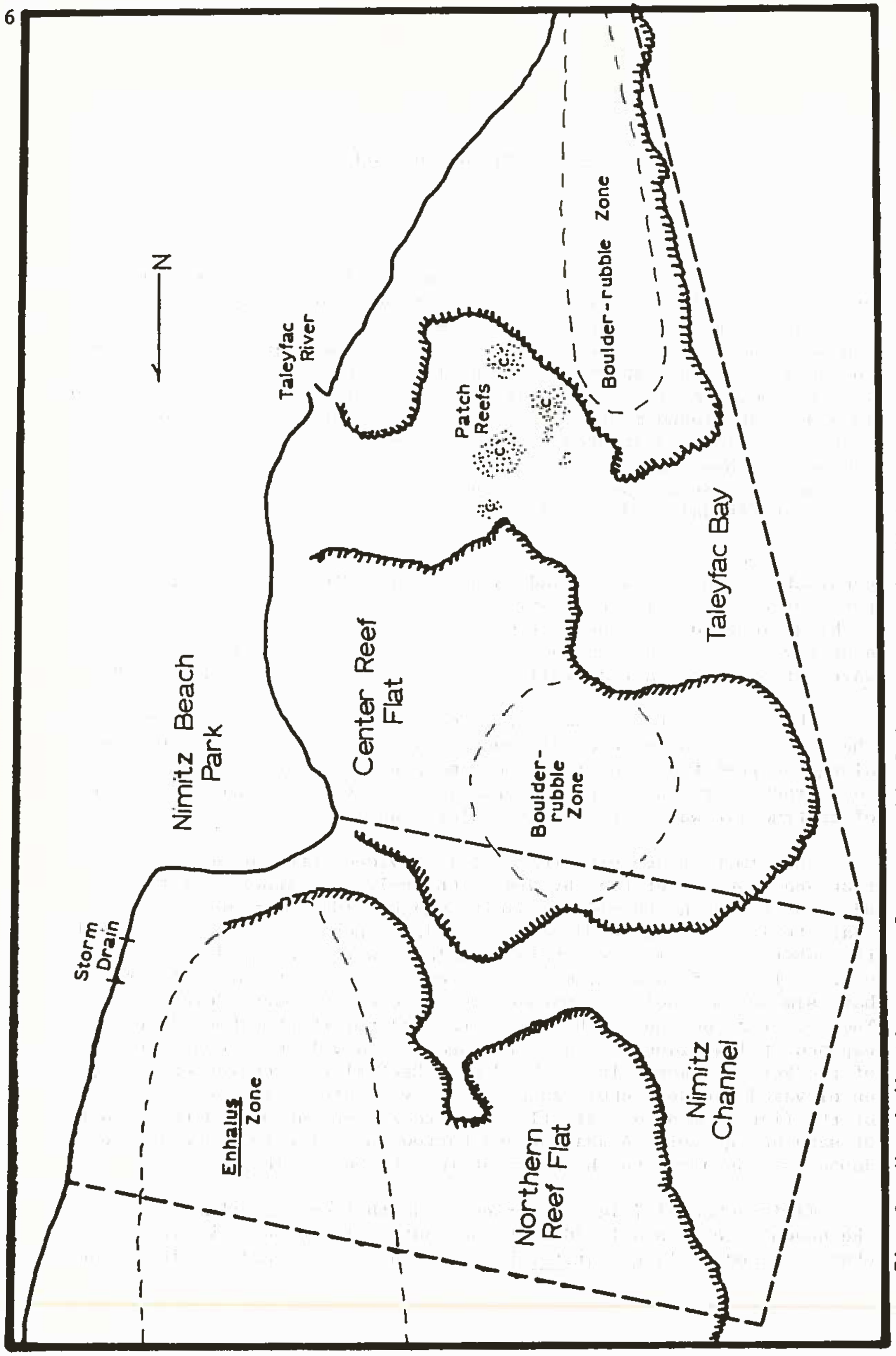

Fig. 2. Map indicating general topographical features at the Nimitz and Taleyfac study sites. Heavy dashed lines indicate site boundary.

south wall of the channel is morphologically different from the north wall, with a greater number of crevices and overhangs. This is particularly evident near the channel mouth. The bottom of the channel is sand and silt with low algal diversity and no coral because of lack of suitable substrate. The inshore portion of the channel bottom is composed of beach-derived sediments, whereas the deeper portion of the channel near the mouth consists of reef-derived deposits. There is an increasing diversity gradient towards the mouth of the channel, with the reef front on either side of the mouth exhibiting nearly 100% coral coverage.

The Taleyfac River site borders the southern side of the Nimitz study area and therefore the reef flat description is the same. The Taleyfac Channel slopes have large Porites boulder development similar to Nimitz Channel; however, these coral heads are covered by heavy silt deposits from the river. Large coral mounds are scattered in the channel and some become exposed during extreme low tides. The depth around the mounds varies from 10 to 12 m. The channel bottom is similar to the bottom of Nimitz Channel, with mud-silt sediments in the nearshore areas and more reef-derived deposits near the channel mouth. The reef front on either side of Taleyfac Channel lacks the coral growth and diversity found at the Nimitz Channel site. This is probably the result of silt and debris being washed down from the river during heavy rains.

The reef flat adjacent to the south side of the channel is similar to the Center Reef Flat, although the inshore area had thicker mud and silt deposits. This flat is also exposed at low tides and has few live corals. The reef front is shallow with numerous coral pinnacles and has a high coral, algal, and fish diversity.

Macro-invertebrates

A total of 82 species of macro-invertebrates (Table 1) was collected or observed in the Bangi Study site. As mentioned previously, the study site can be divided into three zones, and for the sake of convenience the dominant macro-invertebrates from each zone will be discussed separately.

The more common molluscs along the reef front include the top shell Trochus niloticus; the muricids Drupa ricinus, Drupa morum, and Morula uva; the cowry Cypraea caputserpentis; and the bivalve Tridacna maxima.

The reef margin is completely emergent during low tides and this periodically exposed limestone pavement is virtually devoid of macro-invertebrates. The only exceptions are found in scattered small, shallow pools. These pools support a few organisms, including the urchins Echinometra mathaei and Echinothrix diadema, the burrowing anemone Actinodendron sp., and an occasional blue starfish Linckia laevigata.

Table 1. Checklist of macro-invertebrates (excluding corals) collected or observed at three sites in Agat Bay, Guam.

	BANGI	NIMITZ	TALEYFAC
PORIFERA			
Cinahyra australiensis		X	X
COELENTERATA (corals excluded)			
Anthozoa			
Actinodendron sp.			
Unknown sp.			
ARTHROPODA			
Anomura			
Calcinus laevimanus (Randall)		X	
Dardanus megistos (Herbst)	X	X	
Brachyura			
Atergatis floridus	X		
Calappa hepatica (Linn.)		X	X
Eriphya sebana Rathbun			X
Grapsus tenuicrustatus (Herbst)	X		
Grapsus sp.	X	X	X
Hapalocarcinus marsupialis Stimpson	X		
Percnon sp.	X		X
Majidae sp.		X	
Portunidae sp.	X	X	
Xanthidae sp. 1	X		
Xanthidae sp. 2	X	X	
Macrura			
Callianassidae sp.		X	
Natantia			
Stenopus hispidus (Olivier)	X		
ECHINODERMATA			
Echinoidea			
Diadema savignyi Michelin	X	X	
Echinometra mathaei (de Blainville)	X	X	X

Table 1. (continued)

	BANGI	NIMITZ	TAEYFAC
Echinostrephus aciculatus A. Aggasis	X	X	X
Echinothrix calamaris (Pallas)	X	X	X
E. diadema (Linn.)	X	X	X
Eucidaris metularia (Lamarck)			X
Heterocentrotus mammilatus (Linn.)	X	X	X
Toxopneustes pileolus (Lamarck)	X		
Tripneustes gratilla (Linn.)	X		
Asteroidea			
Acanthaster planci (Linn.)			X
Culcita novaguineae Müller and Troschel	X	X	X
Linckia laevigata (Linn.)	X	X	X
L. multifora (Lamarck)		X	X
Holothuroidea			
Actinopyga echinites (Jaeger)	X	X	X
A. mauritiana (Quoy & Gaimard)	X	X	X
Bohadschia argus (Jaeger)	X	X	
B. bivittata (Mitsukuri)		X	
Holothuria atra Jaeger	X	X	X
H. difficilis Semper	X		
H. edules Lesson		X	X
H. hilla Lesson	X	X	
H. leucospilota Brandt	X	X	X
H. nobilis (Selenka)		X	
H. pervicax Selenka		X	
Stichopus chloronotus Brandt	X	X	X
S. horrens Selenka	X	X	
Synopta maculata (Chamisso & Eysenhardt)	X	X	X
Thelenota ananas (Jaeger)			X
Ophiuroidea			
Ophiocoma erinaceus Müller & Troschel	X		
O. pica Müller & Troschel	X		
MOLLUSCA			
Amphinura			
Unknown sp.	X	X	X
Bivalvia			
Arca ventricosa Lamarck	X	X	X
Chama sp.	X		

Table 1. (continued)

	BANGI	NIMITZ	TAEYFAC
Codakia punctata (Linn.)		X	
C. tigerina (Linn.)	X	X	
Dosinia cf. *D. japonica* (Reeve)		X	
Fragum fragum (Linn.)		X	X
Gafrarium pectinatum (Linn.)	X	X	X
Glycodonta marica (Linn.)		X	
Mytilus sp.	X		
Periglypta reticulata (Linn.)	X		
Pinctada margaritifera Linn.			X
Pinna muricata Linn.		X	X
Quidnipagus palatam Iredale	X	X	X
Scutarcopagia scobinata (Linn.)	X	X	
Septifer bilocularis (Linn.)		X	
Spondylus sp.		X	
Tellina rastella Hanley	X		
Tridacna maxima (Roeding)	X	X	X
Gastropoda			
Astraea rhodostoma (Lamarck)		X	X
Bursa bufonia (Gmelin)	X		
Cantharus fumosus (Dillwyn)	X	X	
Certhium nodulosum Bruguiere	X	X	X
Cerithium sp.		X	X
Cheilea equestris (Linn.)	X		
Conus catus Bruguiere		X	
C. chaldeus (Röding)		X	X
C. flavidus Lamarck		X	X
C. lividus Bruguiere	X	X	X
C. miles Linn.	X		X
C. miliaris Bruguiere		X	X
C. pulicarius Hwass	X		
C. quercinus Solander		X	
C. rattus Bruguiere	X	X	X
C. sanguinolentus Quoy & Gaimard		X	
C. sponsalis Bruguiere	X	X	X
C. virgo Linn.		X	
C. vitulinus Bruguiere		X	
Coralliophila violacea (Kiener)	X	X	X
Cymatium nicobaricum (Roeding)	X		
Cypraea caputserpentis Linn.	X	X	X
C. carneola Linn.	X		
C. erosa Linn.	X		X
C. isabella Linn.		X	
C. lynx Linn.	X		X
Cypraea moneta Linn.	X	X	X
C. poraria Linn.	X		X
Drupa grossularia (Röding)			X

Table 1. (continued)

	BANGI	NIMITZ	TALEYFAC
D. morum Roding	X		X
D. ricinus (Linn.)	X	X	X
D. rubisidaeus (Roding)			X
Drupella cornus (Roding)		X	
Haliotis sp.			X
Imbricaria olivaeformis (Swainson)		X	
I. punctata (Swainson)			X
Lambis lambis (Linn.)		X	X
Latirus sp.	X	X	
Liotina peronii (Kiener)	X		X
Littorina coccinea (Gmelin)	X		
Mancinella tuberosa Roding	X		
Mitra acuminata Swainson	X		
Mitra cucumerina	X		
M. mitra Linn.	X		
Mitra sp.		X	
Morula granulata (Duclos)			X
M. uva (Roding)	X		
Nassa serta (Bruguiere)	X		
Nassarius graniferus (Kiener)	X		
Nerita plicata Linn.	X		X
Oliva annulata Gmelin			X
Patella sp.	X		X
Peristernia nassatula Lamarck			X
Rhinoclavis asper (Linn.)	X	X	X
Sabia conica			X
Strombus gibberulus (Roding)	X	X	
Tectus pyramis (Born)		X	X
Terebra subulata (Linn.)		X	
Terebra sp. 1	X		
Terebra sp. 2			X
Thais armigera (Link)	X		
Trochus maculatus Linn.	X		X
T. niloticus Linn.	X	X	X
Turbo argyrostomus Linn.	X	X	
Vasum Ceramicum (Linn.)			X
V. turbinellus (Linn.)	X	X	X
Verillum sp.			X
CHORDATA			
Ascidiacea			
Ascidia gemmata Sluiter		X	
Total	82	78	69

Total Species for Study: 135

The outer reef flat and rubble zone support a more diverse assemblage of invertebrates. Large limestone boulders, denser coral cover, and deeper water provide refuge for animals. Common organisms here were the pillow starfish Culcita novaguineae; the holothurians Holothuria leucospilosa, H. hilla, and Stichopus horrens; the urchins Echinometra mathaei, Echinothrix diadema, and E. calamaris; and the gastropods Cantharus fumosus, Coralliophila violacea, Cypraea moneta, Nassa serta, and Vasum turbinellus. Also noted were the xanthid crab Atergatus floridus and an unknown portunid crab.

The inner reef flat between Alutom Island and Bangi Island, with its well developed moat and broad sand patches, was found to support a number of organisms. The sand dwelling gastropods Rhinoclavis asper, Strombus gibberulus, and Nassarius graniferus were common. Other invertebrates commonly found where there is less wave action were the holothurians Bohadschia argus and Synapta maculata (the latter was especially common in the seagrass beds); the urchins Tripneustes Gratilla and Toxopneustes pileolus; and the box crab Calappa hepatica. The inner reef flat further south is shallower and the seagrass beds are less extensive; additionally, the substratum is more consolidated and supports fewer organisms.

The shoreline is sandy except along the sides of Bangi Island. The elevated limestone here had a few gastropods, including Nerita plicata and the intertidal littorine Littorina coccinea. Also noted here was the grapsid crab Grapsus tenuicrustatus.

The Nimitz study area showed slightly lower diversity than the Bangi site with 78 species of macroinvertebrates recorded (Table 1). This slight decrease in diversity may be attributed to the morphological differences between the sites as well as increased siltation at the Nimitz site.

The inner reef flat adjacent to the north side of Nimitz Channel (Northern Reef Flat), characterized by scattered Enhalus acoroides beds, showed little diversity. The few organisms noted here included the holothurians Bohadschia bivittata, Holothuria atra, and Stichopus chloronotus; the starfish Linckia laevigata; the sea urchins Echinometra mathaei and Echinostrephus aciculatus; and the gastropods Cypraea moneta and Cypraea isabella (under rocks) and Conus quercinus (common in the sea grass beds).

The reef flat on the south side of the channel (Center Reef Flat) is exposed during low tides and is much less diverse than the reef flat on the north side. Organisms noted more than once included the holothurians Stichopus chloronotus, Holothuria leucospilota, and Actinopyga echinites; the sea urchin Echinometra mathaei; and the gastrpods Rhinoclavis asper, Tectus pyramis, and Cerithium nodulosum.

Few invertebrates were noted along the channel bottom and slopes in the nearshore areas and this is believed to be the result of heavy

siltation. The area near the mouth of the channel was much more diverse. The reef front substratum, near the channel mouth, showed nearly 100% coverage by living corals and the number of reef-associated invertebrates was greater than in nearshore areas. Common gastropods were Trochus niloticus, T. maculatus, Coralliophila violacea, Drupella cornus, and Vasum turbinellus. Other invertebrates noted more than once were the urchins Echinometra mathaei, Echinothrix diadema, and Heterocentrotus mammilatus; the holothurians Stichopus chloronotus and Holothuria edulis; the tiny starfish Linckia multifora; and the bivalve Tridacna maxima.

The Taleyfac River study site showed the lowest diversity of macroinvertebrates, with 69 species recorded (Table 1). This low diversity may be attributed to the thick mud and silt substrate along much of the inner reef flat and channel bottom; however, large coral mounds scattered in the channel provided suitable substrate for a few organisms. Among the holothurians, Stichopus chloronotus was very common and Holothuria atra and H. edulis were also noted. The top shell Trochus niloticus and the bivalve Tridacna maxima were also common.

The reef front at the channel mouth on the south side of Taleyfac Bay was composed mostly of boulders covered with silt. Organisms noted from here were the pearl oyster Pinctada margaritifera; the holothurians Holothuria edulis, Actinopyga mauritiana, and Thelenota ananas; the sea urchins Echinometra mathaei, Echinothrix diadema, Heterocentrotus mammilatus, and Eucidaris metularia; and common gastropods Astraea rhodostoma, Vasum cermicum, Trochus niloticus, and Tectus pyramis.

The reef flat adjacent to the south side of the channel had few organisms because of its subaerial exposure at low tides. Common gastropods included Lambis lambis, Cypraea lynx, C. moneta, Imbricaria punctata. Cerithium sp., and Vexillum sp.; the only common urchin was Echinometra ~~mathaei~~; and common holothurians were Actinopyga echinotes, Holothuria atra, and H. leucospilota.

Marine Plants

A total of 82 species of marine benthic plants (Table 2) was collected or observed at the Bangi study site. The most conspicuous assemblage of marine benthic plants is a well developed bed of the seagrass Enhalus acoroides. The extent of Enhalus distribution observed at the time of this study (Fig. 3) is in general agreement with that shown by Randall and Eldredge (1976). Within this Enhalus zone a total of 24 species was recorded. The majority of these species were observed in the small openings with variable sand-rock substrates within the seagrass bed. The sand substrate of the main body of the bed supports frequently encountered individuals of Avrainvillea obscura and usually a thin film of Schizothrix calcicola. Occurring in common clumps near

Table 2. Checklist of marine benthic plants collected or observed during the Agat Small Boat Harbor Study, June 23 to July 8, 1977 (A=abundant, C=common, O=occasional, R=rare).

	BANGI	NIMITZ	TALEYFAC
CYANOPHYTA			
Hormothamnion enteromorphoides Bornet & Flahault	C	O	O
Microcoleus lyngbyaceus (Kutz.) Crouan	C	C	O
Schizothrix calcicola (Ag.) Gomont	C	A	A
Schizothrix mexicana Gomont	O	C	O
CHLOROPHYTA			
Acetabularia moebii Solms-Laubach	-	-	R
Avrainvillea lacerata Gepp	O	O	O
Avrainvillea obscura J. Ag.	C	A	A
Boergesenia forbesii (Harv.) Feldmann	-	R	-
Boodlea composita (Harv.) Brand	C	C	O
Bryopsis pennata Lamx.	O	-	-
Caulerpa cupressoides (West) C. Ag.	-	O	O
Caulerpa racemosa (Forskal) J. Ag.	O	O	O
Caulerpa serrulata (Forskal) J. Ag.	R	-	O
Caulerpa sertularioides (Gmel.) Howe	-	O	O
Caulerpa taxifolia (Vahl) C. Ag.	-	C	C
Caulerpa verticillata J. Ag.	C	C	C
Chlorodesmis fastigiata (C. Ag.) Ducker	C	C	C
Cladophora sp.	-	O	O
Dictyosphaeria cavernosa (Forskal) Boerg.	C	R	O
Dictyosphaeria versluysii Weber van Bosse	O	O	O
Enteromorpha clathrata (Roth) Ag.	O	-	-
Halimeda discoidea Decaisne	O	C	C
Halimeda gigas Taylor	-	R	R
Halimeda incrassata (Ellis) Lamx.	O	A	A
Halimeda macroloba Decaisne	C	C	C
Halimeda opuntia (L.) Lamx.	A	A	A
Halimeda velasquezii Taylor	C	O	O
Neomeris annulata Dickie	C	C	C
Neomeris vanbosseae Howe	C	C	C
Rhipilia orientalis A. & E.S. Gepp	O	-	-
Rhizoclonium samoense Setchell	O	O	O
Tydemannia expeditionis Weber van Bosse	O	O	-
Udotea argentea Zanard.	-	C	C
Udotea palmetta Decaisne	C	C	C
Valonia fastigiata Harvey	O	-	O
Valonia utricularis (Roth) C. Ag.	O	-	-
Valonia ventricosa J. Ag.	O	O	O

Table 2. (continued)

	BANGI	NIMITZ	TALEYFAC
PHAEOPHYTA			
Dictyota bartayresii Lamx.	A	A	A
Dictyota friabilis Setchell	O	O	O
Hydroclathrus clathratus (C. Ag.) Howe	R	-	-
Lobophora variegata (Lamx.) Womersley	C	C	C
Padina jonesii Tsuda	O	R	C
Padina tenuis Bory	A	A	A
Ralfsia pangoensis Setchell	O	-	O
Sargassum polycystum C. Ag.	A	A	A
Sphacelaria tribuloides Meneghini	O	-	-
Turbinaria ornata (Turner) J. Ag.	A	C	C
RHODOPHYTA			
Acanthophora spicifera (Vahl) Boerg.	-	R	-
Acrochaetium sp.	R	R	R
Actinotrichia fragilis (Forskal) Boerg.	C	C	C
Amansia glomerata C. Ag.	A	A	C
Amphiroa foliacea Lamx.	C	C	C
Amphiroa fragilissima (L.) Lamx.	A	C	A
Asparagopsis taxiformis (Delile) Collins & Harvey	-	O	C
Centroceras clavulatum (C. Ag.) Montagne	O	-	-
Ceramium fimbriatum Setch. & Gard.	O	O	O
Ceramium huysmannsi Weber van Bosse	O	O	O
Ceramium mazatlanense Dawson	C	C	C
Ceramium sp.	O	O	O
Chondria polyrhiza Collins & Harvey	-	R	-
Dasyopsis pilosa Weber van Bosse	-	-	R
Dasyphila plumarioides Yendo	O	A	A
Desmia hornemanni Lyngbye	O	C	C
Galaxaura fasciculata Kjellman	O	O	O
Galaxaura filamentosa Chou	C	A	C
Galaxaura marginata Lamx.	O	-	O
Galaxaura oblongata (E. & S.) Lamx.	O	C	C
Gelidiella acerosa (Forskal) Feldm. & Hamel	O	O	O
Gelidiopsis intricata (Ag.) Vickers	O	C	C
Gracilaria arcuata Zanard.	O	C	O
Gracilaria edulis (Gmelin) Silva	-	R	R
Halymenia durvillaei Bory	O	-	R
Hydrolithon reinboldii (W.v. Bosse & Foslie) Foslie	C	C	C
Hypnea pannosa J. Ag.	O	O	O
Hypnea esperi Bory	-	-	R
Hypnea sp.	-	-	R
Jania capillacea Harvey	C	C	C
Laurencia sp. 1	R	-	-
Laurencia sp. 2	-	-	R
Leveillea jungermannioides (Mart. & Herv.) Harvey	R	-	O

Table 2. (continued)

	BANGI	NIMITZ	TALEYFAC
Liagora sp.	C	-	-
Lithophyllum kotzchyanum (Unger) Foslie	O	O	-
Lithophyllum moluccense Foslie	A	C	C
Lithoporella pacifica (Heydr.) Foslie	R	-	R
Mastophora sp.	O	-	-
Metagoniolithon graniferum (Harv.) Weber van Bosse	O	R	-
Neogoniolithon foslie (Heydrich) Setchell & Mason	C	-	O
Neogoniolithon frutescens (Foslie) Setchell & Mason	C	C	O
Polysiphonia scopulorum (J. Ag.) Hollenberg	R	-	O
Polysiphonia sp.	C	A	A
Porolithon onkodes Foslie	C	O	C
Pterocladia parva Dawson	O	O	O
Rhodymenia divaricata Dawson	-	-	O
Rhodymenia sp. 1	O	-	-
Rhodymenia sp. 2	-	-	R
Sporolithon schmidtii (Foslie) Gordon, Masaki & Akioka	O	O	O
Tolypiocladia glomerulata (Ag.) Schmitz	-	O	C
Wrangelia argus (Mont.) Montagne	R	-	-
Corallinaceae sp. 1	C	C	C
Corallinaceae sp. 2	-	O	O
SEA GRASSES			
Enhalus acoroides (L.f.) Royle	A	A	O
Halophila minor (Zool.) Hartog	O	C	C
Total	82	74	84

Total Species for Study: 101

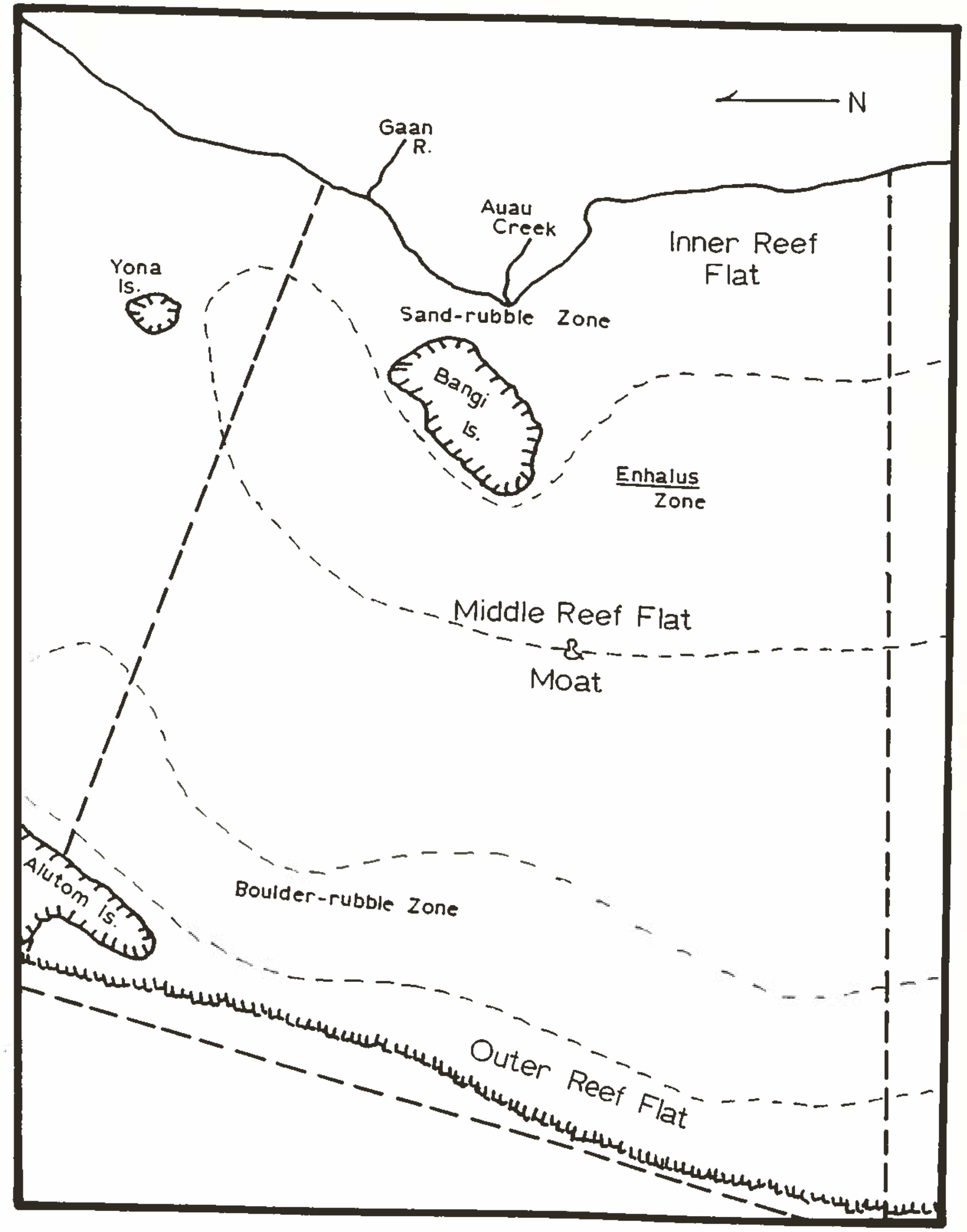

Fig. 3. Map indicating general topographical features of the Bangi site. Heavy dashed lines indicate site boundary.

the seaward edge of the bed is the relatively rare calcareous red alga Metagoniolithon graniferum.

Immediately shoreward of the Enhalus bed is a narrow (1-2 m wide) band of sand with few macro-algae and a thin film of Schizothrix calcicola. Shoreward of this band, in those areas which retain water at low tide, there is a dense coverage of Sargassum polycystum and Padina tenuis. Toward the southern end of the study site this sand zone is much more extensive and does not develop a Sargassum-Padina assemblage. Other common species shoreward of the seagrass bed include Dictyota bartayresii, Halimeda opuntia and Dictyosphaeria cavernosa. Those areas exposed at low tide are generally devoid of macro-algae, with only a few encrusting coralline red algae on the rubble and occasional patches of Ralfsia pangoensis.

As the Enhalus bed begins to become patchy on its seaward edge, frequent individuals of Halimeda macroloba appear and then give way to dense stands of Padina tenuis and Dictyota bartayresii. Algal coverage then drops sharply near the more elevated boulder-rubble zone (Fig. 3), with only a very thin "fuzz" covering most of the periodically submerged solid substrate. A few patches of macro-algae include Lobophora variegata, Actinotrichia fragilis and Neomeris annulata.

Directly seaward of the boulder-rubble zone the outer reef flat is strongly dominated by a mat of Halimeda opuntia and, at the southern end of the study site, Amansia glomerata. Neogoniolithon frutescens, again at the southern end of the site, and Turbinaria ornata are also abundant on the outer reef flat. In small, shallow pockets in an otherwise flat substrate Amphiroa fragilissima and Lithophyllum moluccense are common. Seemingly every available remaining space of solid substrate, often even beneath the mat, is encrusted by coralline red algae.

Along the margin and the immediate reef front Lithophyllum moluccense is clearly the dominant algal species but is often overgrown with Amphiroa fragilissima. Another very common margin species is Chlorodesmis fastigiata. The deeper pockets along the reef front were typically found to be inhabited by several species of Chlorophyta (green algae) including Caulerpa verticillata, Halimeda velasquezii and Neomeris vanbosseae. Wrangelia argus, considered to be a rather rare species (R. T. Tsuda, pers. comm.), was also observed on the reef front at this study site. Although the algal coverage on the margin and reef front appeared to be far lower than most other zones within the site, with the exception of the nearshore sand-rubble zone (Fig. 3), a quite diverse algal community is present, as 51 species were collected or observed from this area alone.

A total of 74 species of marine benthic plants (Table 2) was collected or observed for the Nimitz Channel site, making it the least diverse of the three study sites. The Enhalus bed on the Northern Reef Flat at Nimitz represents the southern limit of the main body of the same extensive seagrass system inhabiting the Bangi site. Species recorded within the bed, then, are generally the same as those mentioned in the discussion of the Bangi site. There did, however, appear to be a higher frequency of Avrainvillea obscura and Halimeda macroloba in and around the area of the bed at Nimitz. As was the case for the Bangi site, the extent of the seagrass bed at the time of this study was observed to be in agreement with that shown by Randall and Eldredge (1976).

An extremely dense stand of Sargassum polycystum extends several meters shoreward of the Enhalus bed with very few other macro-algal species observable. Nearer the channel, however, the dominance of Sargassum polycystum lessens as an area of sand substrate supporting numerous individuals of Avrainvillea obscura and Halimeda macroloba begins to predominate. Approximately 60 m from shore, major algal coverage dissipates with occasional patches of Enhalus acoroides, Sargassum polycystum and Halimeda opuntia persisting. In the shoreward 25 m, only very infrequent clumps of Gracilaria arcuata remain.

Along its southern border, the reef flat is dominated by a wide (10-30 m) band of Galaxaura filamentosa. This band becomes less distinct towards the outer reef flat, which is typically dominated by "mats" of Amansia glomerata and Halimeda opuntia. Other common species on the outer reef flat include Actinotrichia fragilis, Neogoniolithon frutescens, Schizothrix mexicana and Turbinaria ornata. The dominance of the "mat" species dissipates near the margin with several other species beginning to occur, including Lithophyllum molluccense, Amphiroa foliacea and Boodlea composita. At the reef margin, Lithophyllum moluccense and Chlorodesmis fastigiata are the most obvious species, with Galaxaura oblongata dominating the immediate reef front. Other common species along the margin and reef front include Desmia hornemanni, Neomeris vanbosseae and Tolypiocladia glomerulata. Conspicuously missing from the reef front north of Nimitz Channel was the red alga Asparagopsis taxiformis, which was recorded as common to abundant on the reef fronts of the Center Reef Flat and the Taleyfac reef flat.

The sides, or walls, of Nimitz Channel provide a varied environment for the attachment and growth of benthic plants. The variation in depth and the complexity of the walls' morphology create innumerable different habitats in terms of light availibility, a primary factor in the distribution and composition of algal communities. This environmental complexity is reflected in the number of algal species (46) recorded from these walls.

The lower walls of the inner channel are dominated by thick growths of the brown alga Dictyota bartayresii. The edge and uppermost 1-2 meters of the channel walls are strongly dominated by a silky turf composed primarily of a Polysiphonia species and several species of Ceramium, including C. mazatlanense and C. fimbriatum. The upper slopes of both the north and south walls of the channel typically had several Caulerpa species including C. cupressoides, C. taxifolia and C. verticillata. Several species of Halimeda were also recorded here, most commonly H. discoidea. On the lower slopes of both walls, especially in the depth range of 5 to 15 m, H. incrassata was clearly the dominant algal species, often covering virtually 100% of the substrate. The north wall of the channel differed from the south wall most conspicuously by its near-total lack of the red alga Dasyphila plumarioides. This species occurs in abundance in the well-shaded caves and overhangs of the south wall and has been observed to be a food source for the green seaturtle Chelonia mydus (R. H. Randall, pers. comm.)

The sand floor of the inner channel supports small clusters of Halimeda macroloba and occasional patches of Enhalus acoroides and in most areas is covered by a thin film of the blue-green alga Schizothrix calcicola. Metagoniolithon graniferum, considered a rare species (R. T. Tsuda, pers. comm.), was observed in one of the Enhalus patches. The outer channel floor, also a sand substratum, was characterized by the same thin film of Schizothrix calcicola. Few other species of algae were observed, most likely due to the near-total lack of suitable substrate. A second species of seagrass (Halophila minor), however, occurred in fairly common patches.

The margin and reef front of the Center Reef Flat are very similar to that described from the north side of the channel with the previously mentioned exception that Asparagopsis taxiformis, absent on the north, occurs commonly on the reef front south of Nimitz Channel. The wide band of Galaxaura filamentosa of the north reef flat is far less developed on the northern border of the Center Reef Flat, but does again occur on its southern border. Another calcareous red alga, Actinotrichia fragilis, however, seems to occupy a similar niche since it occurs in a similar but less extensive band on the northern border of the Center Reef Flat. In the absence of a well-developed inner reef flat, nearly the entire seaward half of the reef flat resembles the mid-to-outer reef flat of the Nimitz North Reef Flat in terms of algal coverage, i.e., thick mats of Amansia glomerata and Halimeda opuntia with few other conspicuous macro-algae. A small boulder-rubble area (Fig. 2) near the middle of the Center Reef Flat appears to be somewhat more elevated and the mat becomes less dense in this vicinity, allowing a turf of several species to develop. Gelidiopsis intricata, Gelidiella acerosa and Jania capillacea were the most obvious components of this turf.

Further shoreward, Sargassum polycystum begins to replace Amansia glomerata, with Halimeda opuntia also gradually decreasing. Approximately 100 m from shore, Padina tenuis then replaces the Sargassum as the dominant species and occasional individuals of Avrainvillea obscura and Halimeda macroloba also begin to appear. At 50 m these latter two species become the predominant forms and at 30 m the only remaining

algal growth is a general cover of Microcoleus lyngbyaceus. No apparent algal growth was observed in the final 5 to 10 m next to shore.

The Taleyfac site showed the greatest plant diversity of the three sites receiving field attention, as a total of 84 species was collected or observed during the study. This high diversity is, again, probably a reflection of the extremely varied environment of the Taleyfac area. Substrate for attachment and growth varies from the silty mud of the river mouth area through sand, rubble and boulders to the extensive sections of solid rock and coral. The same variation in light availability mentioned in the Nimitz discussion was even more pronounced at the Taleyfac site, as the in situ visibility ranged from near zero in the inner bay to well over 12 m at the mouth of the bay.

In general, the Taleyfac Bay site was very similar to Nimitz Channel but with the added dimensions of the patch reefs and a more extensive shallow reef front area. The dominant algal species were essentially the same along the edge and uppermost one or two meters. Halimeda discoidea was very common on the upper slopes of the walls while Halimeda incrassata clearly dominated the lower slopes, especially below 5 m. Dasyphila plumarioides showed the same distributional pattern as in Nimitz Channel with little or no growth on the north wall and abundant growth in the caves and overhangs of the south wall. At approximately 1 m deep, along the north wall of Taleyfac Bay, a single specimen of the rare (R. T. Tsuda, pers. comm.) alga Dasyopsis pilosa was observed. This specimen represents one of very few specimens of its species collected from Guam to date.

With the exception of a thin film of Schizothrix calcicola, which covered nearly the entire available sand substrate, the only macro-algal species recorded from the floor of the inner bay was Halimeda macroloba. There were no algal species, again with the exception of a Schizothrix film, recorded from the floor of the outer bay. Patches of the seagrass Halophila minor were, however, quite common.

The patch reefs, while adding few new species to the checklist, showed a different pattern of dominance from the walls of the bay. The upper surfaces (1-2 m deep) of the patch reefs nearer the north wall were dominated by two species of brown algae, Dictyota bartayresii and Padina tenuis. Halimeda discoidea and Udotea argentea were also very common on the upper surfaces and slopes. The sides and lower slopes were basically the same as the bay's walls with a strong dominance by Halimeda incrassata. The patch reefs nearer the south wall of Taleyfac Bay do not extend upwards from the floor as high as those nearer the north walls, their upper surfaces being 3-7 m deep. Algal dominance of their upper surfaces is shared by several species including Halimeda discoidea, Udotea argentea, Padina jonesii and Dictyota bartayresii. The most common species along their much abbreviated sides and lower slopes were Halimeda incrassata and Halimeda velasquezii. One other feature of these deeper patch reefs was the preponderance of epiphytes, most notably

Leveillea jungermannioides, on the blades of Udotea and Padina.

The area of the margin and reef front south of Taleyfac Bay was the most irregular, or elaborate, of the three study sites. The complexity of the margin and reef front at this site allowed algal development similar to certain areas of the margins and reef fronts of both the Nimitz and Bangi sites. For example, the reef front pockets, characterized by the species Caulerpa verticillata, Halimeda velasquezii and Neomeris vanbosseae, are common at the Bangi site and absent from the Nimitz site but do occur at the Taleyfac site. Also very common at Taleyfac (as it was at Nimitz but only occasional at Bangi), was the species Galaxaura oblongata. Other species common along the Taleyfac margin and reef front included Chlorodesmis fastigiata, Asparagopsis taxiformis and Tolypiocladia glomerulata.

The reef flat itself was the narrowest and least diverse of all those investigated in this study. Two species of encrusting brown algae, Ralfsia pangoensis and Lobophora variegata, were common in the boulder-rubble zone. The seaward edge of this zone was inhabited primarily by Padina tenuis, Schizothrix mexicana, Jania capillacea and occasional small mats of Halimeda opuntia. These mats become much more frequent on the outer reef flat, making H. opuntia the dominant algal species in that zone. Shoreward of the boulder-rubble zone only very occasional mats of H. opuntia remain as several coralline red algae and a Polysiphonia-Ceramium turf begin to dominate the reef flat. Approximately 70 m from shore, Sargassum polycystum becomes quite common but soon is replaced by frequent individuals of Halimeda macroloba and Avrainvillea obscura. Occasional clumps of Gracilaria arcuata also begin to appear. At about 40 m from shore, no major macro-algae grow and only a mixed film of Schizothrix calcicola and Microcoleus lyngbyaceus remains.

Corals

The Bangi site showed the lowest diversity (69 species) of the three areas surveyed. The low number of species recorded (Table 3) reflects the absence of a channel at this site, which consequently has less environmental variation than the Nimitz or Taleyfac sites. For the most part, however, the species diversity at the Bangi site is in accordance with similar areas of Agat Bay outlined in Eldredge, Dickinson, and Moras (1977).

The inner reef flat had Pavona sp. 1 and Pavona decussata as its dominant corals, interspersed among the Enhalus beds. Colonies of Pocillopora damicornis and small micro-atolls of Porites lutea were also present. Coral diversity here was not markedly different from the outer reef flat; however, the number of individuals of the species present was greater. This is primarily due to the presence of a deep moat (.5-1.5 m) which is rarely or never emergent. Intuition might suggest that coral

Table 3. Checklist of corals and their relative frequency of occurrence at three sites in Agat Bay, Guam. Symbols for relative frequency are: D=dominant, A=abundant, C=common, O=occasional, U=uncommon, and R=rare.

	BANGI	NIMITZ	TALEYFAC
Stylocoeniella armata (Ehrenberg)		O	
Psammocora contigua (Esper)	O	O	U
Psammocora profundacella Gardiner		O	O
Psammocora (Plesioseris) haimeana Milne Edwards & Haime		O	O
Psammocora (Stephanaria) togianensis Umbgrove	C	C	C
Psammocora sp. 1 (Ramose)			U
Stylophora mordax (Dana)	O	C	C
Seriatopora hystrix (Dana)		O	O
Pocillopora damicornis (Linnaeus)	C	O	O
Pocillopora danae Verrill	O	O	O
Pocillopora elegans Dana	O	U	U
Pocillopora eydouxi Milne Edwards & Haime	U		
Pocillopora ligulata Dana		O	O
Pocillopora meandrina Dana	C	O	O
Pocillopora setchelli Hoffmeister	A	C	C
Pocillopora verrucosa (Ellis & Solander)	C	C	O
Pocillopora woodjonesi Vaughan	O		
Acropora brueggemanni (Brook)	U	U	U
Acropora cf. A. kenti (Brook)	O		
Acropora convexa (Dana)	U		
Acropora delicatula (Brook)		O	O
Acropora echinata (Dana)		R	
Acropora formosa (Dana)	U	O	O
Acropora humilis (Dana)	O	O	O
Acropora hystrix (Dana)	C	O	O
Acropora ~~kenti~~ (Brook)			U
Acropora monticulosa (Bruggeman)	U		
Acropora murrayensis Vaughan	O		
Acropora nana (Studer)	O		
Acropora nasuta (Dana)	C	O	O
Acropora ocellata Klunzinger	U		
Acropora palifera (Lamarck)		O	C
Acropora palmerae Wells	O		
Acropora smithi (Brook)	C		U
Acropora surculosa (Dana)	D	C	C
Acropora valida (Dana)	U		
Acropora wardii Verrill	O		
Acropora sp. 1	U		
Astreopora gracilis Bernard		U	D
Astreopora listeri Bernard			U
Astreopora myriophthalma (Lamarck)			O
Astreopora sp. 1			R
Montipora ehrenbergii Verrill		O	O
Montipora elschneri Vaughan	U		O
Montipora foliosa (Pallus)		D	A

Table 3. (continued)

	BANGI	NIMITZ	TALEYFAC
Montipora hoffmeister Wells	O	O	O
Montipora lobulata Bernard		C	O
Montipora monasteriata (Forskaal)	C		
Montipora patula Verrill	O		
Montipora socialis Bernard			U
Montipora subtilis Bernard			U
Montipora tuberculosa (Lamarck)	O	C	A
Mintipora verrilli Vaughan	C	A	A
Montipora verrucosa (Lamarck)	O	C	C
Montipora sp. 1 (Tuberculate)		U	U
Montipora sp. 2 (Papillate)		U	O
Montipora sp. 3 (Glabrous)			U
Pavona clavus (Dana)	O	D	C
Pavona maldivensis (Gardiner)	U		
Pavona minuta Wells		O	O
Pavona varians Verrill	O	C	C
Pavona (Polyastra) obtusata (Quelch)	C	U	U
Pavona (Polyastra) pollicata Wells		O	U
Pavona (Polyastra) planulata (Dana)	O		O
Pavona (Polyastra) venosa Ehrenberg		U	U
Pavona (Polyastra) sp. 1		O	U
Leptoseris hawaiiensis Vaughan		U	R
Leptoseris incrustans (Quelch)		O	U
Leptoseris mycetoseroides Wells			O
Pachyseris speciosa (Dana)		C	C
Coscinaraea columna (Dana)		R	
Fungia fungites (Linnaeus)		O	O
Fungia paumotuensis Stutchbory		U	
Fungia scutaria Lamarck		O	U
Goniopora arbuscula Umbgrove		O	O
Goniopora columna Dana		U	R
Goniopora sp. 1		U	
Goniopora sp. 2		R	
Porites andrewsi Vaughan	O	A	D
Porites australiensis Vaughan		O	
Porites cocosensis Wells	O	C	C
Porites lichen Dana	A	C	C
Porites lobata Dana	O	C	C
Porites lutea Milne Edwards & Haime	D	D	D
Porites murrayensis Vaughan		O	O
Porites matthaii Wells		C	O
Porites sp. 1		U	
Porites sp. 2		O	
Porites sp. 3		O	
Porites (Synaraea) convexa Verrill		C	C
Porites (Synaraea) hawaiiensis Vaughan		O	O
Porites (Synaraea) horizontalata Hoffmeister	O	O	O
Porites (Synaraea) iwayamaensis Eguchi		C	A
Porites (Synaraea) monticulosa (Dana)		U	

Table 3. (continued)

	BANGI	NIMITZ	TALEYFAC
Alveopora verrilliana Dana		O	U
Alveopora sp. 1			R
Favia complanata (Ehrenberg)			O
Favia favus (Forskaal)		U	U
Favia matthai Vaughan	C		
Favia pallida (Dana)	C	O	O
Favia russelli (Wells)			C
Favia speciosa (Dana)		O	O
Favia stelligera (Dana)	C	A	A
Favites abdita (Ellis & Solander)	O		
Favites flexuosa (Dana)	U	O	
Favites virens (Dana)		U	U
Oulophyllia crispa (Lamarck)		O	O
Plesiastrea versipora (Lamarck)	C	O	O
Plesiastrea sp. 1		U	O
Goniastrea parvistella (Dana)	U	O	O
Goniastrea pectinata (Ehrenberg)		O	O
Goniastrea retiformis (Lamarck)	O	C	C
Platygyra pini (Milne Edwards & Haime)	C	O	O
Platygyra rustica (Dana)	O	D	A
Leptoria phrygia (Ellis & Solander)	C	C	O
Hydnophora microconos (Lamarck)		O	U
Hydnophora tenella Quelch		O	O
Leptastrea purpurea (Dana)	C	A	A
Leptastrea transversa (Klunzinger)		O	O
Cyphastrea serailia (Forskaal)			O
Cyphastrea sp. 1		R	
Echinopora lamellosa (Esper)	U	O	U
Diploastrea heliopora (Lamarck)	U		U
Galaxea clavus (Dana)		O	U
Galaxea fascicularis (Linnaeus)	O	C	O
Acrhelia horrescens (Dana)		R	
Merulina ampliata (Ellis & Solander)		O	O
Lobophyllia corymbosa (Forskaal)	O	O	O
Lobophyllia costata (Dana)	U	O	O
Lobophyllia hemprichii (Ehrenberg)		U	U
Acanthastrea echniata (Dana)	U	U	O
Acanthastrea sp. 1		U	R
Echinophyllia asper Ellis & Solander		O	O
Mycedium sp. 1		U	O
Desmophyllum sp. 1		C	O
Polycyathus verrilli Duncan		U	R
Plerogyra sinuosa (Dana)		U	U
Euphyllia glabroscens (Chamisso & Eysenhardt)		O	O
Heliopora coerulea (Pallas)	C	A	A
Millepora dichotoma Forskaal		C	C
Millepora exaesa Forskaal	O	C	C
Millepora platyphylla Hemprich & Ehrenberg	O	C	C

Table 3. (continued)

	BANGI	NIMITZ	TALEYFAC
Distochopora sp. 1	U	O	U
Tubipora musica (Linnaeus)	U	U	O
Total Species per Study Area	69	110	113

Total Species for all Sites: 144

diversity here should be greater than it is, but the shifting sand substrate and high water temperatures at low tide are not conducive to coral development. It should also be noted that in the deeper portions of the moat, particularly toward the southern boundary of the study area, occasional Acropora colonies were observed.

The outer reef flat is emergent during low tides and therefore coral development is sparse. The few species present were usually observed in deep holes and depressions in the otherwise flat reef pavement. Among the species recorded from this area, small and irregularly shaped colonies of Porites lutea and Porites lichen were dominant. Other common species observed in this area included Pocillopora damicornis, Porites (S.) horizontalata, Porites lobata, and occasional colonies of Acropora wardii and Acropora surculosa. Randall (in Eldredge, Dickinson and Moras, 1977) recorded living fragments of Pocillopora and Acropora colonies, usually found on the reef margin and reef front, on the reef flat platform. Similar occurrences were also noted at the Bangi site as well as the Nimitz and Taleyfac reef flat platforms.

Coral coverage at the reef margin was patchy. Some areas were observed to have as much as 25 percent coverage while other areas had less than 5 percent. This is in agreement with Randall's observations (in Eldredge, Dickinson, and Moras, 1977) for other reef margins in Agat Bay. This patchiness may be partially explained by the presence of small and poorly developed surge channels along the length of the margin. Where these surge channels exist coral coverage is greater, with Pocillopora setchelli, P. meandrina, Acropora nasuta, A. surculosa, Porites lutea, Montipora verrilli, Favia pallida, and F. stelligera as some of the more common species.

The greatest coral diversity and dominance at the Bangi site was recorded from the reef front, with approximately 40% of the species recorded from this site appearing here. Numerous species of Pocillopora, Acropora, Goniastrea, Porites, Favia, and encrusting Montipora were observed. The high diversity and dominance of corals in this region can be attributed to the topographic variation, availability of light, and continuous current movement.

A total of 110 species was recorded from the Nimitz site. The high species diversity can be attributed to the increased number of habitats available along the slopes of Nimitz Channel.

The Northern Reef Flat is the southernmost stretch of the reef flat that includes the Bangi site. The dominant or common species here are basically the same as those recorded for the Bangi site except for the occurrence of Pavona sp. 1 and Pavona decussata, which are not as prevalent on the North Reef Flat. The Acropora colonies noted in the deeper moat areas at the Bangi site were also absent.

The reef front on the north side of Nimitz Channel exhibited nearly 100% coral coverage in localized areas. The dominant species here included the blue coral Heliopora coerulea, large micro-atolls of Porites lutea, Platygyra rustica, and Pavona clavus. Other commonly observed corals included several species of Pocillopora, Acropora, Favia, Leptastrea, Pavona, Acanthastrea, Montipora, Leptoria, Millepora and Goniastrea.

Nimitz Channel exhibited considerable variation in coral diversity and abundance. The bottom of the channel was virtually devoid of corals. The inshore channel bottom did have some isolated heads of Porites lutea but these colonies soon disappeared as the channel became broader and deeper towards the mouth. The sand and silt substrates were obviously not suitable for coral attachment. A definite diversity gradient is apparent along the channel slopes, with the lowest diversity occurring at the inshore areas and the highest occurring along the slopes toward the mouth of the channel. The north and south slopes along the inshore regions of the channel are dominated by Porites and Acropora species with occasional colonies of Pocillopora damicornis, Favia pallida, F. stelligera, Montipora verrucosa, and Platygyra rustica. Further seaward towards the mouth of the channel large colonies of Heliopora coerulea, Platygyra rustica, Porites lutea, Acropora humilis, A. palifera, A. formosa and Millepora platyphylla are common. The most conspicuous coral development along the channel walls was the presence of huge plates of Pachyseris speciosa and Porites (S.) iwayamaensis. The largest colony of Psammacora (S.) togianensis (3.6 m x 1.2 m x 1.8 m) ever observed on Guam (R. H. Randall pers. comm.) was also observed here.

The reef margin and reef front of the Center Reef Flat are similar to the reef margin and front of the Northern Reef Flat. Numerous species of Pocillopora, Acropora, Favia, Pavona, Leptasterea, Montipora, Millepora, and Goniastrea are present.

The reef flat platform of the Center Reef Flat is noticably different from that of the North Reef Flat or Bangi reef flat. There is no well developed inner reef flat area and the entire reef flat platform is emergent at low tide. Occasional small Porites lutea colonies are found in the deep holes and depressions along the outer reef flat but not in the same abundance as at the other flats surveyed. Pavona sp. 1 and Pavona decussata, commonly found on the inner reef flat areas of the Bangi and Northern Reef Flats, are absent here. The southern border of the reef flat platform communicates with the north wall of Taleyfac Channel, where the coral coverage and diversity increases.

The Taleyfac Bay site had the highest coral diversity of the three areas surveyed, with 113 species recorded (Table 3). This high diversity may be attributed to the extensive shallow reef-front and submarine terrace areas. The number of pinnacles, and crevices along the reef front provide a varied environment for coral attachment and growth. The more conspicuous coral species observed included Acropora formosa, A. surculosa, A. wardii, Pocillopora setchelli, Montipora foliosa, Porites andrewsi, P. lutea, P. (S.) iwayamaensis and Millepora platyphylla. Other common species recorded from this area included Favia speciosa, F. russelli, Pavona venosa and Goniastrea retiformis.

The slopes of Taleyfac Channel are similar to Nimitz Channel; however, heavy siltation at the inshore areas prevents any substantial coral development. An interesting characteristic of the channel is the occurrence of patch reefs (Fig. 2). The bottoms of these patch reefs (10-12 m deep) are dominated by Pachyseris speciosa, Porites (S.) horizontalata, P. (S.) iwayamaensis, and P. (S.) convexa. Colonies of Porites lutea, Psammacora (S.) togianensis, Pavona minuta, Lobophyllia corymbosa, L. costata, Goniastrea pectinata, G. parvistella and Leptoseris mycetoseroides are characteristic of the upper areas.

The mouth of Taleyfac Channel did not show the same complexity or diversity in coral development as the mouth of Nimitz Channel. Coral coverage at the Taleyfac Channel mouth was approximately 20-30% as compared to nearly 100% coverage at the mouth of Nimitz Channel. It is apparent that freshwater runoff and silt deposits from the Taleyfac River, coupled with the prevailing current patterns, are the major reasons for the decrease in coral coverage and diversity.

The reef-flat platform at the Taleyfac site was the narrowest surveyed and showed little or no coral development. Besides being exposed at low tides, the inner reef flat is completely covered with a thin layer of mud and silt, making this the least diverse reef flat of the three areas surveyed.

Fishes

A total of 133 species was recorded from the Bangi site (Table 4). The greatest number of species was observed near the reef margin, with species diversity generally decreasing toward shore.

Pomacentrids and labrids were the most frequently encountered fishes along the reef margin and adjacent reef slope. The surgeonfish Acanthurus triostegus was seen in large schools of more than 100 individuals and also composed a significant portion of the fish fauna in this biotope. The boulder-rubble zone on the reef flat exhibited a lower number of both species and individual fishes. Characteristic of this area were small pomacentrids and, during periods of high tide, several species of surgeonfishes. Closer to shore, seagrass beds are the dominant feature and provide cover for a varied assemblage of young fishes. Predominant among the fishes noted to be associated with the beds were parrotfishes (Scarus spp. and Leptoscarus vaigiensis), rabbitfishes (Siganus spp.) and several wrasse species (primarily Stethojulis strigiventer). An extreme paucity of fishes was characteristic of the zone between the seagrass beds and shore along the entire length of the study site. Only three species, the goby Acentrogobius ornatus, juveniles of the mullet Liza vaigiensis, and the ubiquitous wrasse Halichoeres trimaculatus were recorded from this area.

Table 4. Checklist of fishes found at the three Agat study sites. Symbols indicate the relative abundance of the species observed at each site: A=abundant, C=common, O=occasional, R=rare, --- = not observed.

FAMILY/SPECIES	BANGI	NIMITZ	TALEYFAC
ACANTHURIDAE (Surgeonfishes and Unicornfishes)			
Acanthurus glaucopareius Cuvier	R	---	O
A. lineatus (Linnaeus)	---	O	C
A. nigrofuscus (Forsskal)	C	O	C
A. pyroferus Kittliz	---	---	R
A. triostegus (Linnaeus)	A	O	A
A. xanthopterus (Cuvier & Valenciennes)	---	R	R
Acanthurus sp. 1	O	O	C
Acanthurus sp. 2	O	C	O
Naso literatus (Bloch & Schneider)	O	O	O
N. unicornus (Forsskal)	C	O	R
Zebrasoma flavescens (Cuvier & Valenciennes)	---	O	O
Z. scopas (Cuvier)	---	R	R
Z. veliferum (Bloch)	O	O	O
APOGONIDAE (Cardinalfishes)			
Apogon niger Doderlein	R	---	---
A. novaeguineae Valenciennes	---	O	O
A. novemfasciatus Cuvier	C	C	O
A. taeniatus Cuvier	---	R	---
Apogon sp.	---	R	---
Cheilodipterus macrodon (Lacepede)	O	C	---
C. quinquelineatus Cuvier	O	C	C
AULOSTOMIDAE (Trumpetfishes)			
Aulostomus chinensis (Linnaeus)	---	O	---
BALISTIDAE (Triggerfishes)			
Balistipus undulatus (Mungo Park)	O	---	O
Melichthys vidua (Solander)	O	---	---
Pseudobalistes flavimarginatus (Ruppell)	R	---	R
Rhinecanthus aculeatus (Linnaeus)	O	O	O
R. rectangulus (Bloch & Schneider)	C	O	O
Sufflamen bursa (Bloch & Schneider)	C	---	C
S. chrysopterus (Bloch & Schneider)	---	O	O
BLENNIIDAE (Blennies)			
Aspidontus taeniatus Quoy & Gaimard	O	R	R
Cirrhipectes sebae (Cuvier & Valenciennes)	O	---	O
C. variolosus (Cuvier & Valenciennes)	C	---	O

Table 4. (continued)

FAMILY/SPECIES	BANGI	NIMITZ	TALEYFAC
Entomacrodus sp.	O	O	O
Exallias brevis (Kner)	O	---	---
Istiblennius periopthalmus (Valenciennes)	O	---	---
Meiacanthus atrodorsalis (Gunther)	C	C	C
Petroscirtes breviceps (Valenciennes)	---	R	---
Plagiotremus tapeinosoma (Bleeker)	C	O	O
CARANGIDAE (Jacks)			
Carangoides malabaricus (Bloch)	O	C	C
Gnathanodon speciosus (Forsskal)	---	---	R
CHAETODONTIDAE (Butterflyfishes)			
Chaetodon auriga Forsskal	O	O	O
C. bennetti Cuvier & Valenciennes	---	---	R
C. citrinellus Cuvier & Valenciennes	C	O	O
C. ephippium Cuvier & Valenciennes	O	O	O
C. kleini Bloch	---	R	---
C. lunula (Lacepede)	O	O	O
C. melanotus Bloch & Schneider	O	---	O
C. mertensii Cuvier & Valenciennes	---	C	O
C. ornatissimus Cuvier & Valenciennes	O	O	O
C. punctatofasciatus Cuvier	---	O	R
C. quadrimaculatus Gray	O	---	---
C. reticulatus Cuvier & Valenciennes	O	R	O
C. trifasciatus Mungo Park	O	O	O
C. ulietensis Cuvier & Valenciennes	---	O	O
C. unimaculatus Bloch	O	R	---
Forcipiger flavissimus Jordan & McGregor	R	---	R
Heniochus acuminatus (Linnaeus)	---	O	---
H. chrysostomus Cuvier & Valenciennes	---	R	O
Megaprotodon trifascialis (Quoy & Gaimard)	O	---	R
CIRRHITIDAE (Hawkfishes)			
Cirrhitus pinnulatus (Bloch & Schneider)	O	---	R
Paracirrhites arcatus (Cuvier & Valenciennes)	R	---	---
P. forsteri (Bloch & Schneider)	C	---	---
ELEOTRIDAE (Sleepers)			
Eleotroides strigatus (Broussonet)	R	O	O
eleotrid species	R	---	---
FISTULARIIDAE (Cornetfishes)			
Fistularia petimba Lacepede	O	O	O

Table 4. (continued)

FAMILY/SPECIES	BANGI	NIMITZ	TALEYFAC
GERREIDAE (Mojarras)			
Gerres argyreus (Bloch & Schneider)	O	---	O
GOBIIDAE (Gobies)			
Acentrogobius ornatus (Ruppell)	C	C	C
Amblygobius albimaculatus (Ruppell)	O	C	O
Pogonoculius zebra Fowler	O	---	---
Ptereleotris microlepis (Bleeker)	R	O	O
P. tricolor Smith	O	A	---
gobiid sp. 1	R	---	---
gobiid sp. 2	R	---	R
gobiid sp. 3	---	O	R
gobiid sp. 4	---	C	C
gobiid sp. 5	---	---	R
HOLOCENTRIDAE (Squirrelfishes & Soldierfishes)			
Adioryx diadema (Lacepede)	O	---	O
A. tiere (Cuvier & Valenciennes)	O	O	R
Adioryx sp.	O	---	---
Flammeo sammara (Forsskal)	C	A	O
Myripristis adustus Bleeker	---	O	O
M. kuntee Cuvier	---	C	C
KYPHOSIDAE (Rudderfishes)			
Kyphosus cinerascens (Forsskal)	R	---	---
LABRIDAE (Wrasses)			
Anampses caeruleopunctatus Ruppell	O	---	O
A. twisti Bleeker	---	O	---
Bodianus axillaris (Bennett)	---	O	O
Cheilinus chlorourus (Bloch)	O	O	R
C. rhodochrous Gunther	C	C	C
C. trilobatus Lacepede	C	O	O
Cheilio inermis (Forsskal)	O	O	---
Coris aygula Lacepede	---	---	R
Epibulus insidiator (Pallas)	O	O	O
Gomphosus varius Lacepede	O	O	O
Halichoeres centiquadrus (Lacepede)	O	O	R
H. margaritaceus (Cuvier & Valenciennes)	C	O	C
H. marginatus Ruppell	C	O	C
H. trimaculatus (Quoy & Gaimard)	A	C	C
Hemigymnus fasciatus (Bloch)	---	R	R

Table 4. (continued)

FAMILY/SPECIES	BANGI	NIMITZ	TALEYFAC
Hemigymnus melapterus (Bloch)	O	O	O
Labrichthys unilineata (Guichenot)	---	O	---
Labroides bicolor Fowler & Bean	---	R	R
L. dimidiatus (Cuvier & Valenciennes)	C	O	O
Macropharyngodon meleagris (Cuvier & Valenciennes)	---	---	R
Pseudocheilinus hexataenia (Bleeker)	---	R	---
Stethojulis bandanensis (Bleeker)	O	O	O
S. strigiventer (Bennett)	C	O	O
Thalassoma amblycephala (Bleeker)	O	R	---
T. fuscum (Lacepede)	O	---	O
T. hardwickei (Bennett)	O	C	R
T. lutescens (Lay & Bennett)	---	O	R
T. quinquevittata (Lay & Bennett)	C	O	O
LETHRINIDAE (Emperors)			
Gnathodentex aureolineatus (Lacepede)	---	R	O
Lethrinus harak (Forsskal)	O	O	O
Lethrinus sp.	O	R	---
Monotaxis grandoculis (Forsskal)	---	---	O
LUTJANIDAE (Snappers)			
Aphareus furcatus (Lacepede)	O	O	O
Lutjanus fulvus (Bloch & Schneider)	C	C	C
L. kasmira (Forsskal)	R	---	R
Lutjanus sp.	---	---	R
Macolor niger (Forsskal)	---	---	R
MONACANTHIDAE (Filefishes)			
Amanses scopas (Cuvier)	O	---	---
Cantherhines pardalis (Ruppell)	C	---	O
Oxymonacanthus longirostris (Bloch & Schneider)	---	O	O
Prevagor melanocephalus (Bleeker)	---	R	O
MONODACTYLIDAE (Fingerfishes)			
Monodactylus argenteus (Linnaeus)	---	---	R
MUGILIDAE (Mullets)			
Liza vaigiensis (Quoy & Gaimard)	O	O	O
MUGILOIDIDAE (Sandperches)			
Parapercis cephalopunctata (Seale)	---	---	R

Table 4. (continued)

FAMILY/SPECIES	BANGI	NIMITZ	TALEYFAC
MULLIDAE (Goatfishes)			
Mulloidichthys flavolineatus (Lacepede)	C	C	C
M. vanicolensis (Cuvier & Valenciennes)	---	O	R
Parupeneus barberinus (Lacepede)	O	O	O
P. bifasciatus (Lacepede)	---	O	O
P. cyclostomus (Lacepede)	O	O	O
P. spilurus (Bleeker)	C	O	O
P. trifasciatus (Lacepede)	R	C	C
MURAENIDAE (Moray Eels)			
Echidna nebulosa (Ahl)	---	R	---
Gymnothorax meleagris (Shaw & Nodder)	R	---	---
Gymnothorax sp.	R	---	---
OPHICHTHIDAE (Snake Eels)			
ophichthid species	R	---	---
OSTRACIONTIDAE (Trunkfishes)			
Ostracion meleagris Shaw	O	---	O
PEMPHERIDAE (Sweepers)			
Pempheris oualensis Cuvier & Valenciennes	---	C	O
POMACANTHIDAE (Angelfishes)			
Centropyge flavissimus (Cuvier & Valenciennes)	---	O	O
Holacanthus trimaculatus Lacepede	R	---	R
Pygoplites diacanthus (Boddaert)	---	R	R
POMACENTRIDAE (Damselfishes)			
Abudefduf coelestinus (Cuiver & Valenciennes)	C	C	C
A. sordidus (Forsskal)	O	---	---
A. vaigiensis (Quoy & Gaimard)	---	---	O
Amblyglyphidodon curacao (Bloch)	---	C	O
Amphiprion chrysopterus Cuvier	---	---	R
A. melanopus Bleeker	---	R	R
A. perideraion Bleeker	---	R	---
Chromis agilis Smith	---	---	R
C. bicolor Macleay	---	---	O
C. caerulea (Cuvier)	O	C	O
Dascyllus aruanus (Linnaeus)	O	C	C
D. reticulatus (Richardson)	---	---	O
D. trimaculatus (Ruppell)	---	O	R

Table 4. (continued)

FAMILY/SPECIES	BANGI	NIMITZ	TALEYFAC
Glyphidodontops glaucus (Cuvier)	---	O	O
G. leucopomus (Lesson)	A	C	C
G. traceyi (Woods & Schultz)	---	C	O
Plectroglyphidodon dickii (Lienard)	C	---	R
P. imparipennis (Vaillant & Sauvage)	C	---	---
P. lacrymatus (Quoy & Gaimard)	O	R	C
P. leucozona (Bleeker)	C	---	---
P. phoenixensis (Schultz)	O	---	---
P. johnstonianus Fowler & Bean	O	---	---
Pomacentrus pavo (Bloch)	---	C	---
P. vaiuli Jordan & Seale	C	C	C
Pomachromis guamensis Allen & Larson	C	---	---
Stegastes albifasciatus (Schlegel & Muller)	O	O	O
S. lividus (Bloch & Schneider)	C	O	O
S. nigricans (Lacepede)	---	O	O
Stegastes cf. *fasciolatus* (Ogilby)	A	R	C
PRIACANTHIDAE (Bigeyes)			
Priacanthus hamrur (Forsskal)	---	R	---
SCARIDAE (Parrotfishes)			
Ctenoscarus bicolor (Ruppell)	O	---	R
Leptoscarus vaigiensis (Quoy & Gaimard)	R	---	---
Scarus chlorodon Jenyns	O	C	O
S. frenatus Lacepede	O	O	O
S. sordidus Forsskal	C	O	C
S. venosus Cuvier & Valenciennes	---	---	R
Scarus sp. 1	O	---	---
Scarus sp. 2	C	C	O
Scarus sp. 3	---	O	R
Scarus sp. 4	---	---	R
Scarus sp. 5	R	---	---
SCOLOPSIDAE (Monocle Breams)			
Scolopsis cancellatus (Cuvier & Valenciennes)	O	O	O
SCORPAENIDAE (Scorpionfishes)			
Scorpaenodes guamensis (Quoy & Gaimard)	---	R	---
Scorpaenopsis diabolus (Cuvier & Valenciennes)	---	---	R
Synanceia verrucosa Bloch & Schneider	---	R	R
SERRANIDAE (Groupers and Sea Basses)			
Aethaloperca rogaa (Forsskal)	---	---	R
Cephalopholis argus (Bloch & Schneider)	R	---	---

Table 4. (continued)

FAMILY/SPECIES	BANGI	NIMITZ	TALEYFAC
Cephalopholis pachycentron (Cuvier & Valenciennes)	---	---	R
C. urodelus (Bloch & Schneider)	C	---	O
Epinephelus merra Bloch	O	R	R
SIGANIDAE (Rabbitfishes)			
Siganus argenteus (Quoy & Gaimard)	O	C	O
S. spinus (Linnaeus)	C	C	C
S. guttatus (Bloch)	O	O	---
SPHYRAENIDAE (Barracudas)			
Sphyraena sp.	O	---	---
SYNGNATHIDAE (Pipefishes)			
Corythoichthys intestinalis (Jordan & Seale)	---	O	O
SYNODONTIDAE (Lizardfishes)			
Saurida gracilis (Quoy & Gaimard)	R	O	O
TETRAODONTIDAE (Puffers)			
Arothron immaculatus (Bloch & Schneider)	R	---	---
A. nigropunctatus (Bloch & Schneider)	R	---	---
Canthigaster bennetti (Bleeker)	O	O	O
C. solandri (Richardson)	C	C	C
C. valentini (Bleeker)	---	R	R
TRIPTERYGIIDAE (Triplefins)			
tripterygiid species 1	---	---	O
tripterygiid species 2	---	---	O
ZANCLIDAE (Moorish Idol)			
Zanclus cornutus (Linnaeus)	O	---	O
Total Species	133	129	154

Total Number of Species in Overall Survey: 206

The Nimitz site was found to possess the generally poorest fish fauna of the three areas studied. The 129 species recorded during the reconnaissance of the channel and adjacent reefs would seem comparable to the only slightly higher number of species found at the Bangi site, but the total number of individuals seen was notably less. This is due mainly to the depauperate nature of the fish fauna occurring in the channel proper. The unconsolidated sand-mud floor of the channel was found to support an extremely limited number of fishes; most of those which did occur belonged to the family Gobiidae. Other fishes found in this habitat included the highly mobile jacks (Carangoides) and mojarras (Gerres). Also present were a small number of goatfishes (Mulloidichthys). The reef bordering the channel to the north exhibited a fish distribution much the same as that discussed above for the Bangi site. Pomacentrids and labrids dominated the reef margin, and species diversity decreased from the margin toward shore. The seagrass beds were found to support several gobiid species which were not noted in the Bangi beds but were otherwise quite similar. The reef flat along the southern edge of the channel was quite diverse, with 85 species recorded from this area alone. Again, damselfishes and wrasses were the dominant groups found along the outer reef flat and margin. The relatively bare sand-silt zone close to shore was noted to be virtually devoid of fishes. Burrowing gobies and occasional goatfishes were characteristic of the reduced fauna in this habitat.

Surveys within the Taleyfac site yielded 154 species of fishes, 78% of the overall species total recorded in this study. This high diversity of fishes appears to be a reflection of the correspondingly high diversity of habitats within the study area. The mouth of the Taleyfac River provides a small estuarine zone at the head of the bay. Although this rather featureless area is relatively bare of fishes, several gobiid species were observed. Included was one yet-unidentified goby [species] which was found nowhere else in the Agat area. South of the river mouth, a narrow mud zone borders the shore and is bordered in turn by a broader zone of silty sand and occasional low upcroppings of reef pavement. Only 11 species were recorded here, with gobies, juvenile surgeonfishes, and small wrasses comprising the majority of the fishes seen. The floor of the main channel is similar in most respects to that of Nimitz Channel, and exhibited a similar fauna. Gobies were the predominant fishes found in this area. Unique to the Taleyfac channel is a series of patch reefs dispersed across its center. The fish populatons surveyed on these reefs combined elements of the reef flat proper and the reef margin. Pomacentrids were the fishes most frequently encountered; Stegastes sp. was the dominant damselfish species. The reef flat to the north of the channel is shared with Nimitz Channel and is treated in the account of that site. The reef flat bordering Taleyfac Bay to the south possesses a varied population of fishes. Like most of the reef areas treated above, species diversity is highest at the reef margin and lowest near shore. The inner reef flat is relatively devoid of fishes. Small scarids, labrids, and pomacentrids were the best represented forms from near shore to the outer reef margin. The outer reef slope fauna was richest of all those treated in this study. Extensive knolls, pinnacles, holes and coral growth provide cover for the 96 species which were enumerated in this zone. The acanthurids, labrids and pomacentrids were the most speciose groups observed.

None of the areas studied support a significant commercial fishery, but all are exploited on a small scale. Nimitz Beach is popular with sports fishermen and is probably the most heavily fished of the three sites. Fishing activities noted in the vicinity included casting from shore for small jacks (<u>Carangoides</u>), seining with a small two-man net, spearfishing, and casting of thrownets for goatfish (<u>Mulloidichthys</u>) and juvenile mullet (<u>Liza</u>). Virtually no fishing activities were observed in Taleyfac Bay, but interviews with local residents revealed that some occasionally fish by hook and line from the reef near shore. The main catch item was said to be <u>Lutjanus fulvus</u>, a common snapper in the inner reaches of the bay. Once during the survey a large-mesh gill net was observed in place along the southern edge of the channel. A large surround net was also seen on shore near the water's edge. The reef proper is probably visited on occasion by spearfishermen. Little evidence of fishing activity was found at the Bangi site. However, men were seen on several days spearfishing along the reef margin. The bulk of their catch consisted of surgeonfishes (<u>Acanthurus</u> spp.) and squirrelfishes (<u>Adioryx</u> and <u>Myripristis</u> spp.).

In general, it is thought that the present fishing activities in the Agat area have little effect on the resident fish populations.

<u>Currents</u>

Three transects were established at low tide from the outer reef flat to the beach face at the Bangi site (Fig. 4). The dye patches along Transect I all flowed in a north to northeast direction. This indicates that the water mass in this section of the flat flows through the moat area and drains out to sea at Gaan Point, where a deep reef cut is present. Previous field work (Eldredge, Dickinson, and Moras, 1977), has shown a strong longshore current moving from Alutom and Yona Islands towards the Gaan peninsula and out to sea.

Transect II (Fig. 4), centrally located on the Bangi flat, appeared to be the zone where a reversal in current direction began to develop. Except for a dye patch adjacent to the south side of Bangi Island and a dye patch released at the edge of the outer reef flat, the general flow of water was westerly towards the reef margin. The dye patch on the south side of Bangi Island flowed toward the longshore current that moves south to Nimitz Channel. The easterly movement of the dye patch released at the edge of the outer reef flat resulted from strong surf action across the reef margin at the time of injection.

Dye patches along the third transect (III, Fig. 4) indicate that the general flow of water is southerly, with the water mass draining seaward via a cut in the reef flat approximately 5 m south of the transect. Occasional dye patches which flowed north were probably the result of wind effect, as a southerly wind with strong gusts was apparent during the dye release times for this transect.

At high tide, only Transect I was duplicated and a second transect (IIA; Fig. 5) was run midway between Transects II and III. A distinct tidal reversal in current direction along Transect I occurred at this time with the obvious southerly flow of water. The current continued moving south (Transect IIA) and the water drained seaward at the deep cut along the southern boundary of the study site as it did during low tide.

Two transects (IV and V, Fig. 6) were established on the reef flats of the Nimitz site during high tide. Transect IV, on the Northern Reef Flat, showed a northwesterly movement of water, whereas Transect V, on the Center Reef Flat, showed a south to southwesterly flow of water. It is apparent that surface water entering Nimitz Channel during a rising tide (Paths A & B; Fig. 6), separates and flows onto the two reef flats. Water from the channel, entering the Northern Reef Flat, drains seaward over the reef margin, whereas, water from the channel, entering the Center Reef Flat, is partially deflected towards Taleyfac Channel.

Dye patch directions during a falling tide on the Northern Reef Flat (Paths 1,2,3,4; Fig. 7) indicate a flow reversal with changing tide. Water from the reef flat flows into Nimitz Channel and feeds the westerly surface current (Path C, Fig. 7). There does not appear to be a flow reversal with changing tide for the Center Reef Flat. Dye patches released on a falling tide continued to flow in a south-southwesterly direction as they did on a rising tide. There is a strong westward current flow in Taleyfac Channel (Path C, Fig. 8) and this probably draws water from the Center Reef Flat regardless of tidal flow.

Dye patches released in three areas near the bottom of Nimitz Channel (Paths A', B', & C'; Fig. 7) indicate a subsurface flow seaward on rising and falling tides. The presence of this subsurface current seems to indicate that some of the water from the Bangi site, particularly the longshore current south of Bangi Island, is drained via this system.

A current pattern similar to the one established at the Nimitz site during high tide exists for the Taleyfac Bay site. The surface water entering Taleyfac Channel during a rising tide (Paths A & B, Fig. 9) does not separate but only flows south across the reef flat and drains seaward across the reef margin (Transect VI, Fig. 9); however, on a falling tide a reversal occurs and the flow is northerly towards the channel (Paths 1,2,3,4; Fig. 8). A subsurface flow (Paths A' & B', Fig. 8), primarily created by the Taleyfac River drainage, is well established. The water from Nimitz Channel which flows across the Center Reef Flat on rising tides (Transect V, Fig. 6) is also drained seaward via this subsurface current.

Water Quality

Records furnished by the Guam Environmental Protection Agency indicate that coliform bacteria content at the Nimitz Beach site is moderate. This is in part due to a storm drain on the Northern Reef Flat adjacent to Nimitz Channel which drains a chicken farm during heavy rains. There were no fecal coliform bacteria records for the Bangi or Taleyfac sites. It is possible, however, that coliform content at the Taleyfac Bay site would be of the same order of magnitude as that of the Nimitz site since the Taleyfac River drains a residential and agricultural basin.

Visual turbidity estimates indicate the Taleyfac Bay area to have the highest turbidity of the three areas surveyed. This is primarily the results of the Taleyfac River drainage of inland mud and silt sediments into Taleyfac Channel. Nimitz Beach and Nimitz Channel also have a relatively high visual turbidity estimate because of the recreational use of the area. The lowest turbidity estimate was at the Bangi site because there is no inland drainage system and the recreational use of the area is limited to an occasional fisherman.

Determinations for dissolved oxygen, phosphate, nitrite and nitrate were not done because of contractual limitations; however, certain assumptions can be made. It is reasonable to expect dissolved oxygen concentrations at all three sites to be of the same order of magnitude as for other leeward reefs on Guam. Phosphate, nitrite and nitrate values may be slightly higher than usual for leeward reefs at the Taleyfac Bay site because of inland agricultural drainage via the Taleyfac River, but these values are probably well within the Environmental Protection Agency's guidelines.

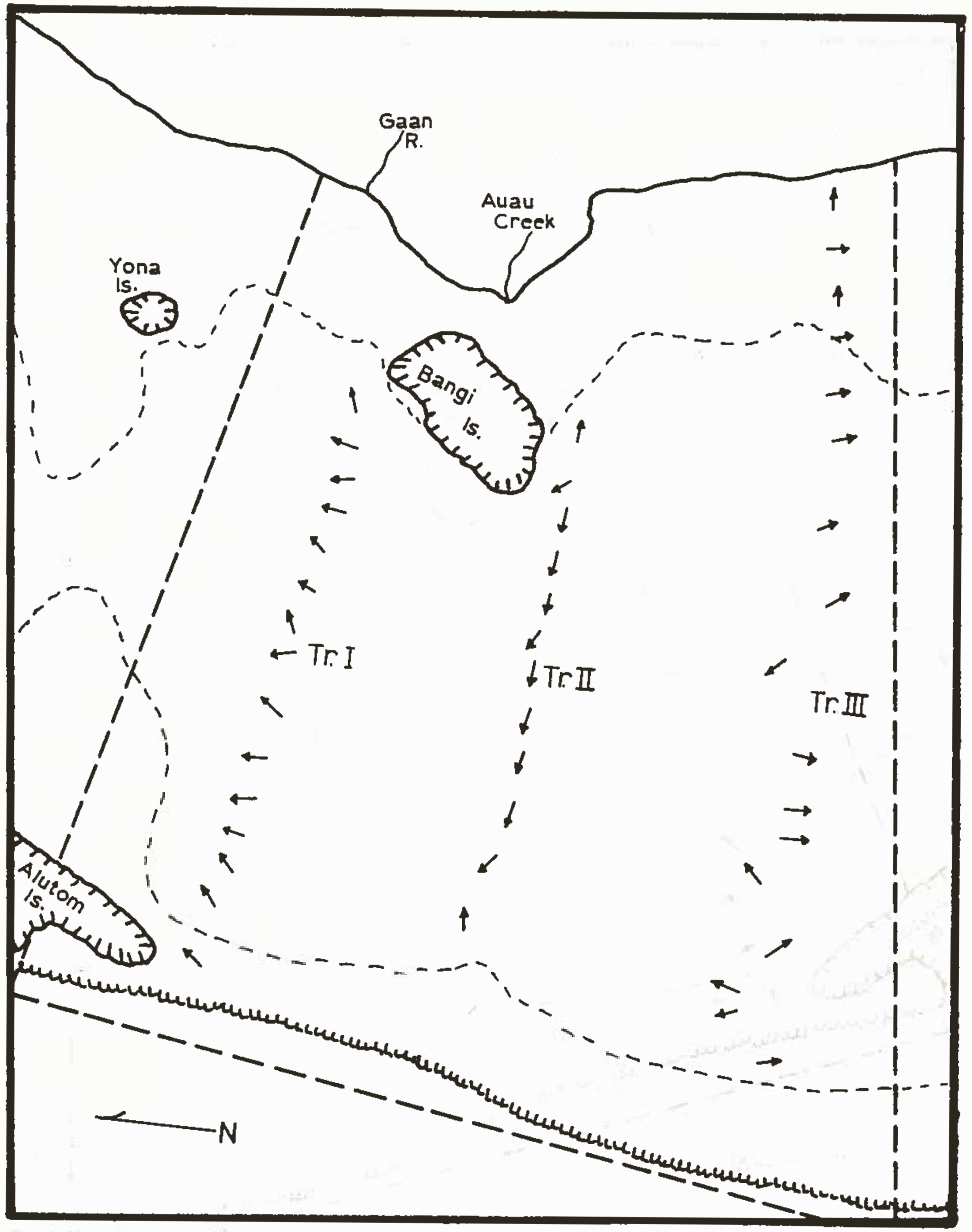

Fig. 4. Current movement along three transects at the Bangi site at low tide. Arrows indicate general direction of current flow. Thin dashed lines indicate areas of exposure at low tide.

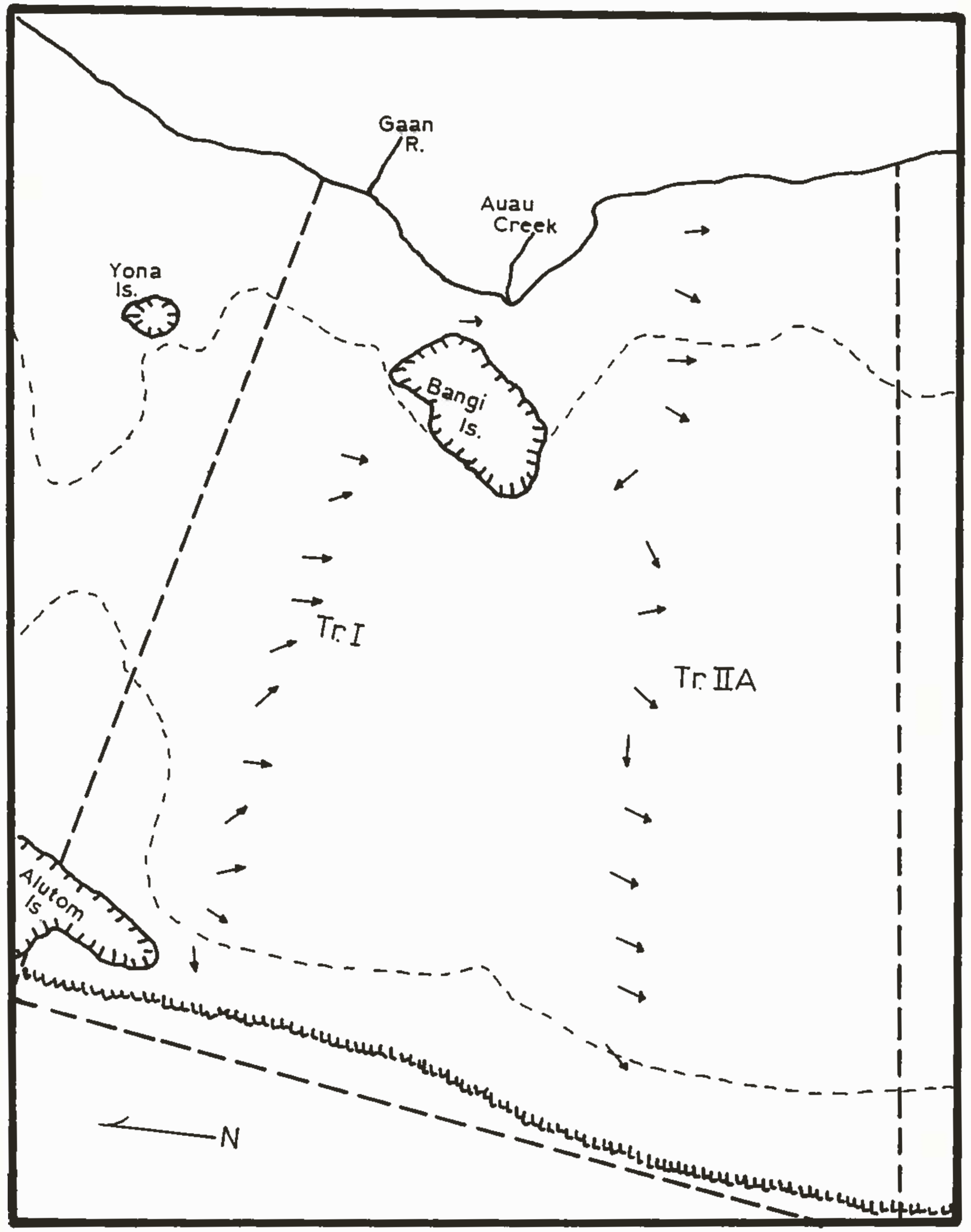

Fig. 5. Current movement along two transects at the Bangi site at high tide. Arrows indicate general direction of current flow Thin dashed lines indicate areas of exposure at low tide.

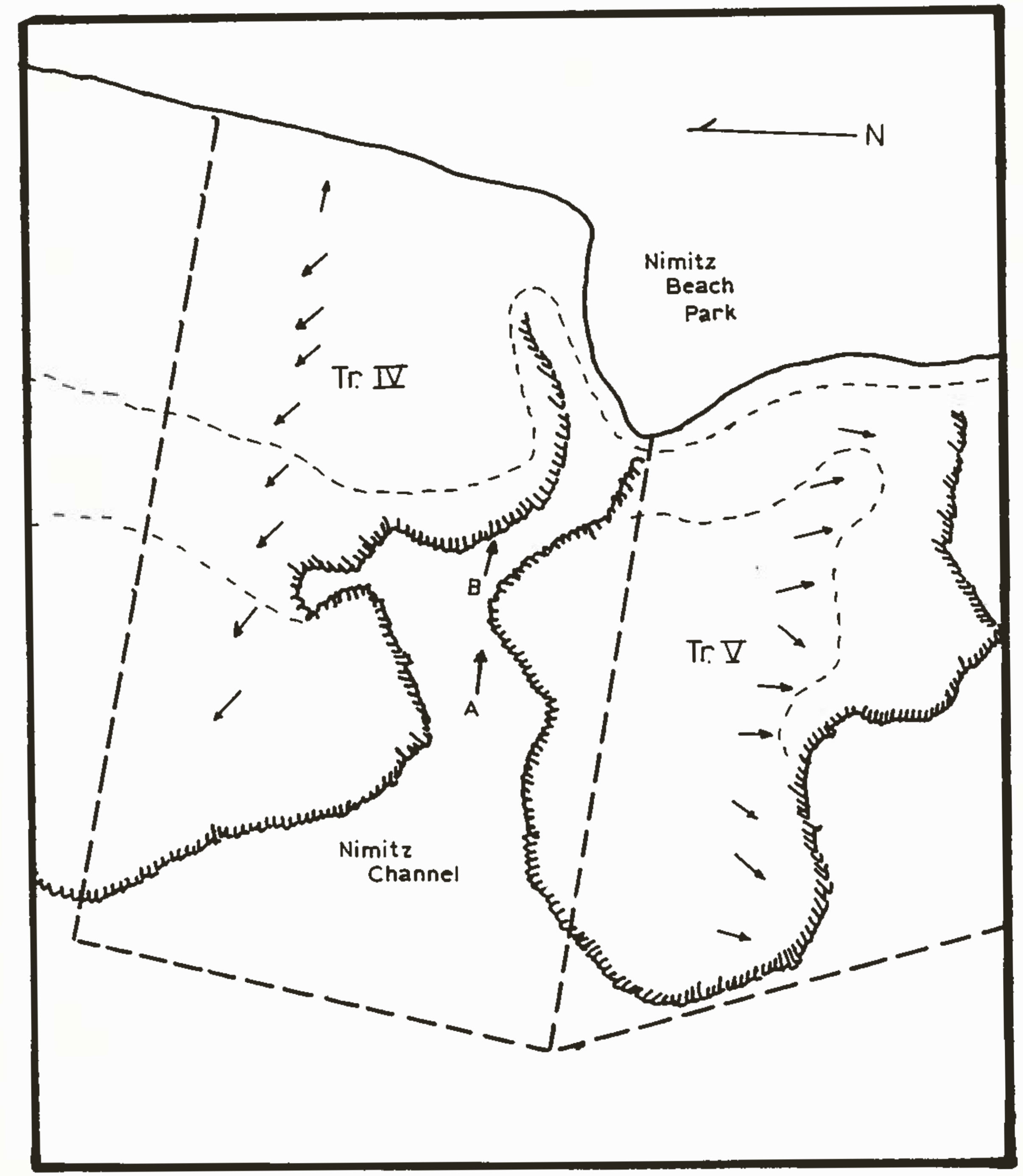

Fig. 6. Current movement on the Northern (Tr. IV) and Center (Tr. V) reef flats and Nimitz Channel during high tide. Arrows indicate general direction of current flow. Thin dashed lines indicate areas of exposure at low tide.

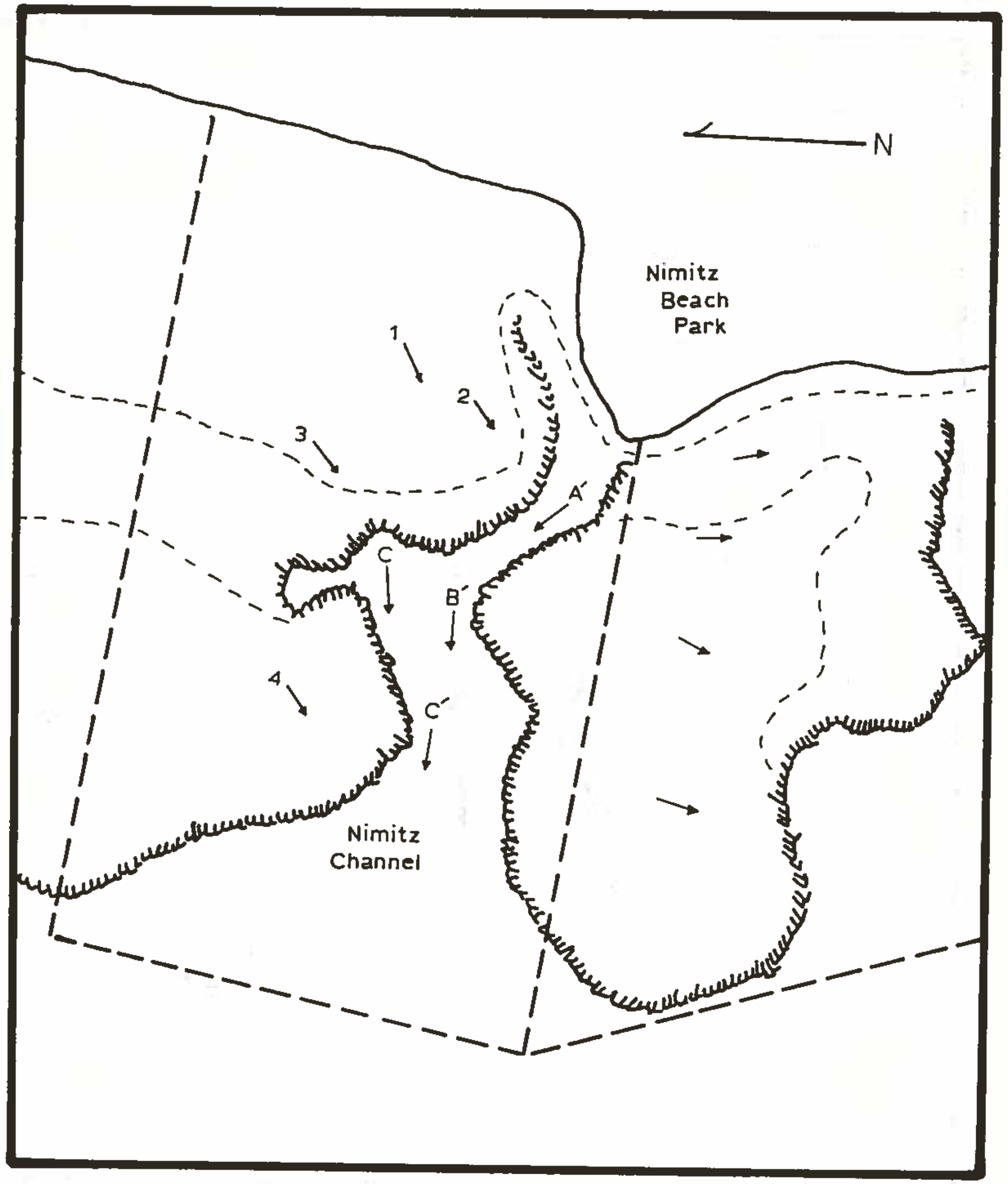

Fig. 7. Current movement on the Northern and Center reef flats and Nimitz Channel during a falling tide. Paths A', B', and C' represent the general direction of a subsurface current during falling and rising tides.

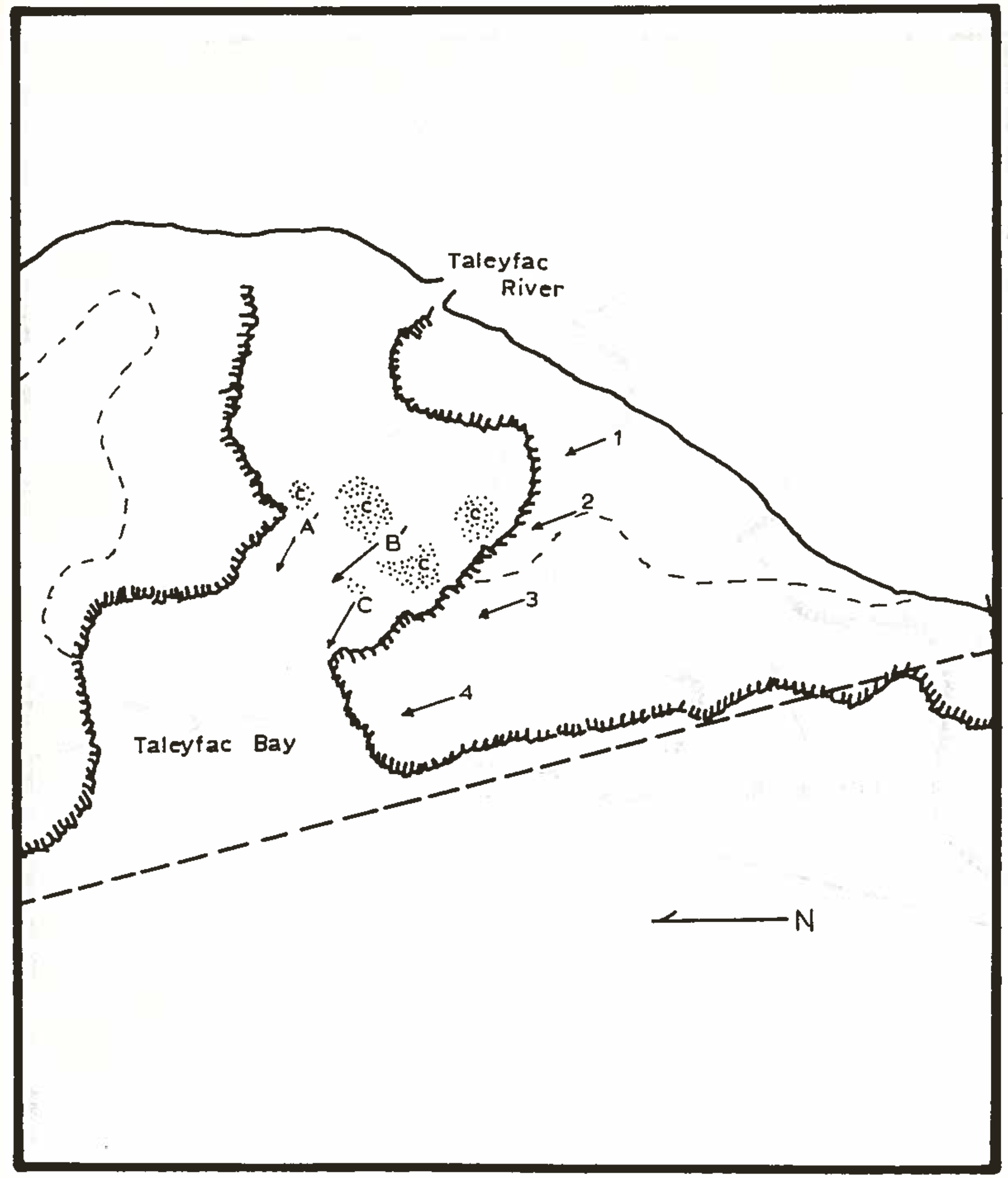

Fig. 8. Current movement on the Taleyfac reef flat and Taleyfac Bay during a falling tide. Paths A' and B' represent the general direction of a subsurface current during falling and rising tides.

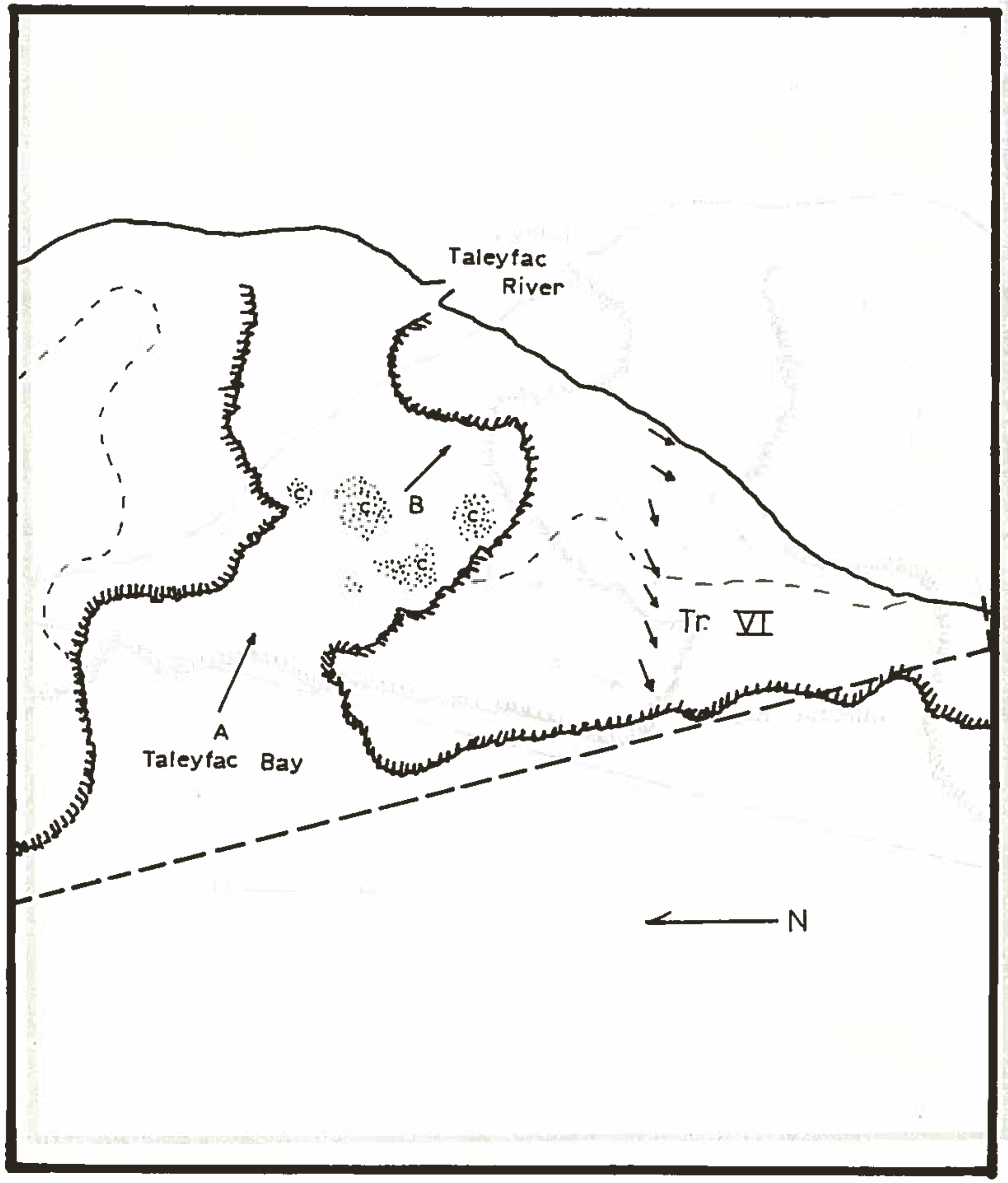

Fig. 9. Current movement on the Taleyfac reef flat (Tr. VI) and Taleyfac Bay during a rising tide. Arrows indicate general direction of current flow.

CONCLUSIONS AND RECOMMENDATIONS

A brief overview of the three additional sites (Rizal Beach, Namo River, and Gaan Point), considered as possible locations for a small boat basin in Agat Bay, Guam is in order. A more complete description of the sites can be found in Eldredge, Dickinson, and Moras (1977).

The Rizal Beach site has a narrow reef flat which is partially exposed during low tide. The substrate is mostly coral rubble with the algae Padina tenuis comprising approximately 50% of the cover. This area is virtually devoid of live coral because of devastation during Typhoon Pamela (May, 1976). This site is exposed to south swells, usually associated with tropical storms and typhoons, and corals broken off from the reef front are washed up and onto the reef flat.

The entire reef flat at the Namo River site is covered with a thick layer of mud and silt as a result of runoff from the Namo River during the rainy season. There is virtually no macro-algal or coral coverage on the reef flat. As was the case at the Rizal Beach site, the Namo River site is subject to destructive wave action. This is perhaps best evidenced by the quantity of broken coral fragments along the submarine terrace and those washed up and onto the reef flat.

The Gaan Point site may be divided into two areas; the area north of Gaan peninsula and the area south of the peninsula. The area north of the peninsula is characterized by large out-croppings of limestone boulders. The substrate of the inner reef flat consists of a mud-silt mixture, with scattered coral rubble. There is no live coral, and patches of Enhalus acoroides are scattered. The area to the south of the peninsula has a greater diversity of marine life than the north side as evidenced by the rich assemblage of invertebrate fauna. A natural channel runs parallel to the peninsula and it appears to be the major drainage for the reef flat between Gaan Point and Bangi Point.

The three southern-most areas under consideration (Bangi Point, Nimitz Beach, and Taleyfac Bay), appear to be the most diverse in marine flora and fauna. Extensive dredging would be required at the Bangi Point site and a large portion of the marine community would be destroyed either as a direct result of dredging operations or indirectly as current carried sediment deposits on the reef facies.

The mouth of Nimitz Channel and the submarine terrace at Taleyfac Bay are frequently visited by diving enthusiasts because of their rich coral diversity. Any dredging activity would decrease this diversity as a result of dredge-derived sediments transported to these areas by the subsurface currents in the Nimitz and Taleyfac Channels. Nimitz

Beach is also extensively used as a recreational area by a large number of residents and construction activities would temporarily inhibit use of this area.

Of the northern areas, Rizal Beach and the Namo River sites show the lowest biological diversity; however, these areas have no protection from destructive wave action during storms, making entrance into a channel difficult, especially for small boats. Extensive dredging would also be required as no well-developed channels exist at either of these sites.

In reviewing all six alternatives, it appears that the Gaan Point site would be the most adequate location for a small boat basin. A natural channel through the reef flat would decrease dredging operations and the area is partially protected from southern swells during storms by Alutom Island, making entrance into the channel less difficult during increased wave activity. This area is also not as diverse in marine flora and fauna as the Bangi, Nimitz, or Taleyfac sites and is not presently utilized as a recreational facility.

For whichever site is chosen, it is strongly recommended that dredging operations be kept to a minimum and extensive detailed current studies be done to determine which areas would most likely be affected by siltation. Every precaution should be immediately implemented to avoid any longterm negative impact to the area.

LITERATURE CITED

Eldredge, L. G., R. Dickinson, and S. Moras (eds.). 1977. Marine survey of Agat Bay. University of Guam Marine Laboratory, Technical Report 31. 251 p.

Randall, R. H., and L. G. Eldredge. 1976. Atlas of the reefs and beaches of Guam. Coastal Zone Management Office, Agana, Guam. 191 p.

APPENDIX

An abbreviated survey of the fish populations in the vicinity of the Gaan Point sewer outfall was conducted during the latter part of August 1977 to supplement data collected at the three main study sites treated in this report.

Two transects were established across the Gaan reef flat, one (Transect A) approximately 100 m to the north of the sewer outfall, and the other (B) about 70 m to the south. Each transect extended from shore to the reef margin (Fig. A-1). A tape marked in centimeters was placed along the transects and all fishes observed within one meter on either side of the tape were recorded on waterproof paper. Counts of fishes were made during periods of high tide. The number of fishes recorded within each 20-m increment of the transect tape provided the quantitative data shown in Figs. A-2 and A-3. Table A-1 lists the species and numbers of individuals observed.

As discussed in the Methods section on page 3, transects were not established at the Bangi, Nimitz or Taleyfac sites. An overall view at these sites enabled a far more complete species checklist than is accomplished when transects are done. Therefore, comparisons of the diversity of fishes between the Bangi, Nimitz, and Taleyfac sites and the Gaan site are biased towards greater species diversity at the former areas.

A total of 50 species belonging to 24 families was recorded from the study site. As mentioned above, the transects extended only to the reef margin, thus excluding the reef front biotope where a greater diversity of fishes would be expected. The families with the greatest representation, both in terms of number and species diversity, were the Labridae and Pomacentridae. Together, the members of these families made up 24% of the species and 66% of the total number of individuals observed on the transects. The most common species was the wrasse *Halichoeres trimaculatus*, which comprised 20.7% of the fishes recorded. The damselfishes *Glyphidodontops leucopomus* (11.2%) and *Stegastes albifasciatus* (10.6%) were also important elements of the visible fish fauna. The density of fishes counted was remarkably similar between the two transects, averaging .92 fish per m^2 on Transect A and .93 fish per m^2 on Transect B.

This survey is not sufficient for an environmental impact statement as regards future construction on the Gaan Point reef. A more comprehensive analysis of the fish population, as well as detailed studies of the corals, invertebrates, marine algae, and current patterns in the vicinity, would be necessary in order to accurately assess the effects of any construction activities.

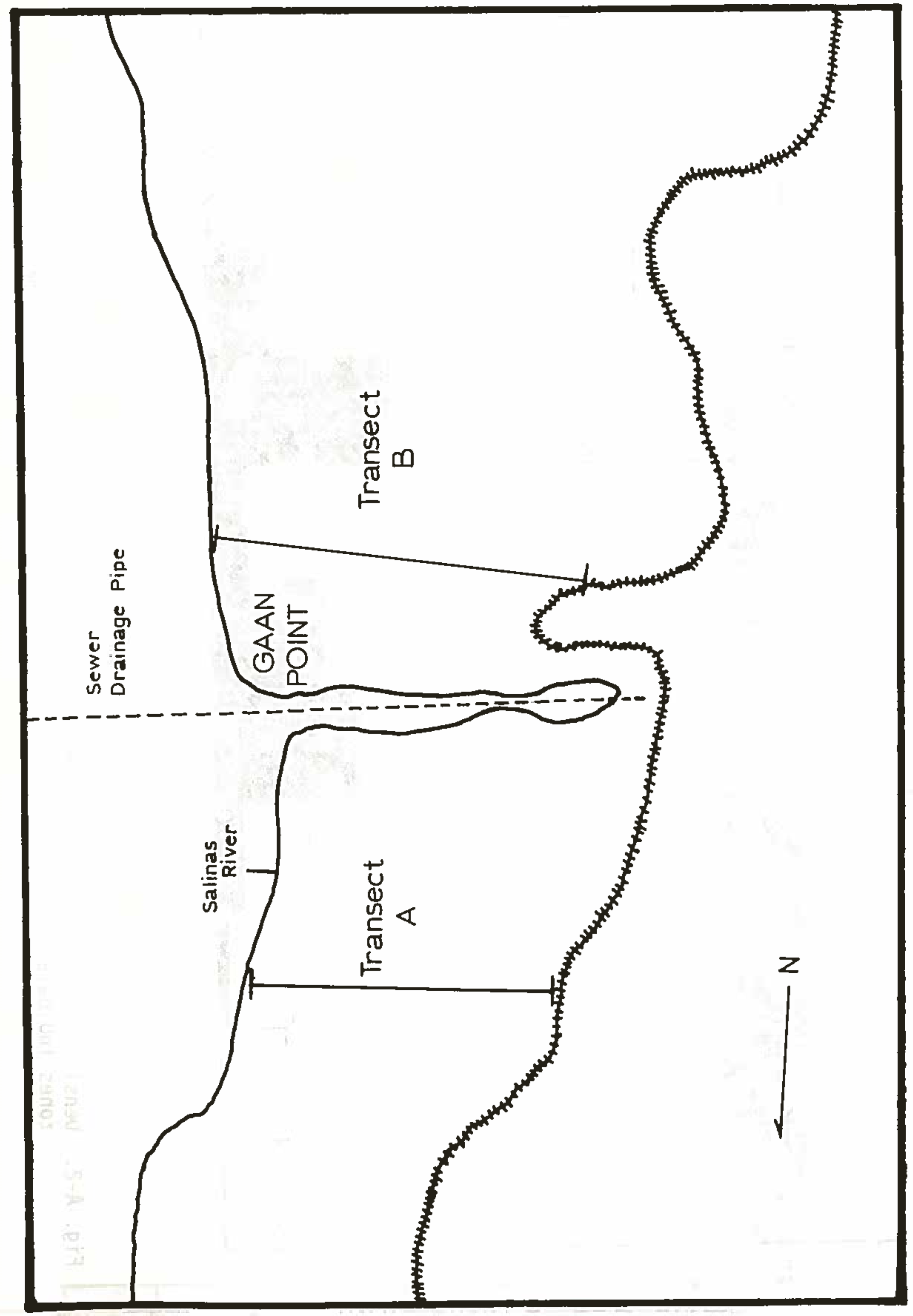

Fig. A-1. Location of two fish transects at the Gaan site.

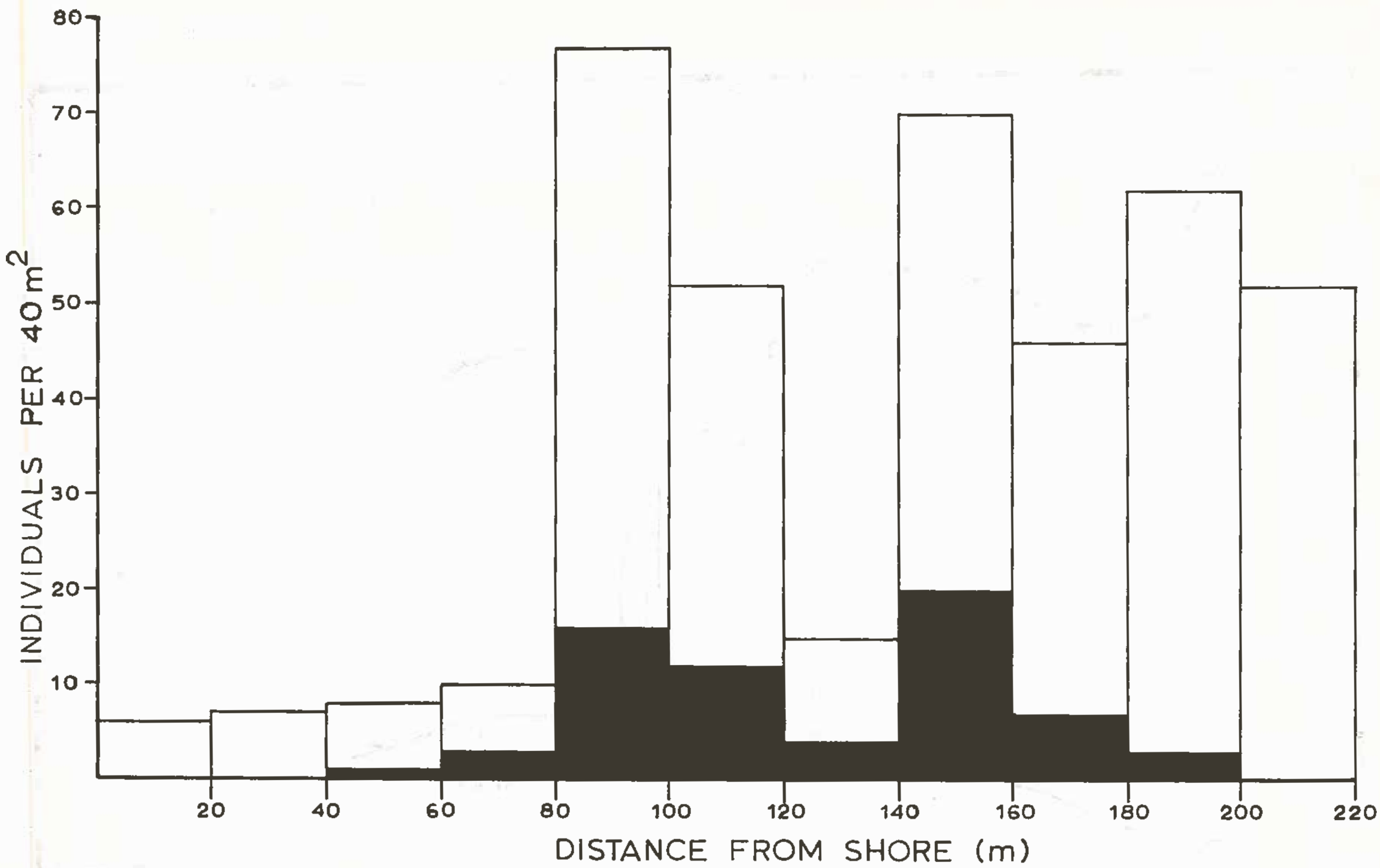

Fig. A-2. Density of fishes in each 20-meter transect interval of Transect A (Fig. A-1). Shaded zones indicate abundance of the dominant species Halichoeres trimaculatus.

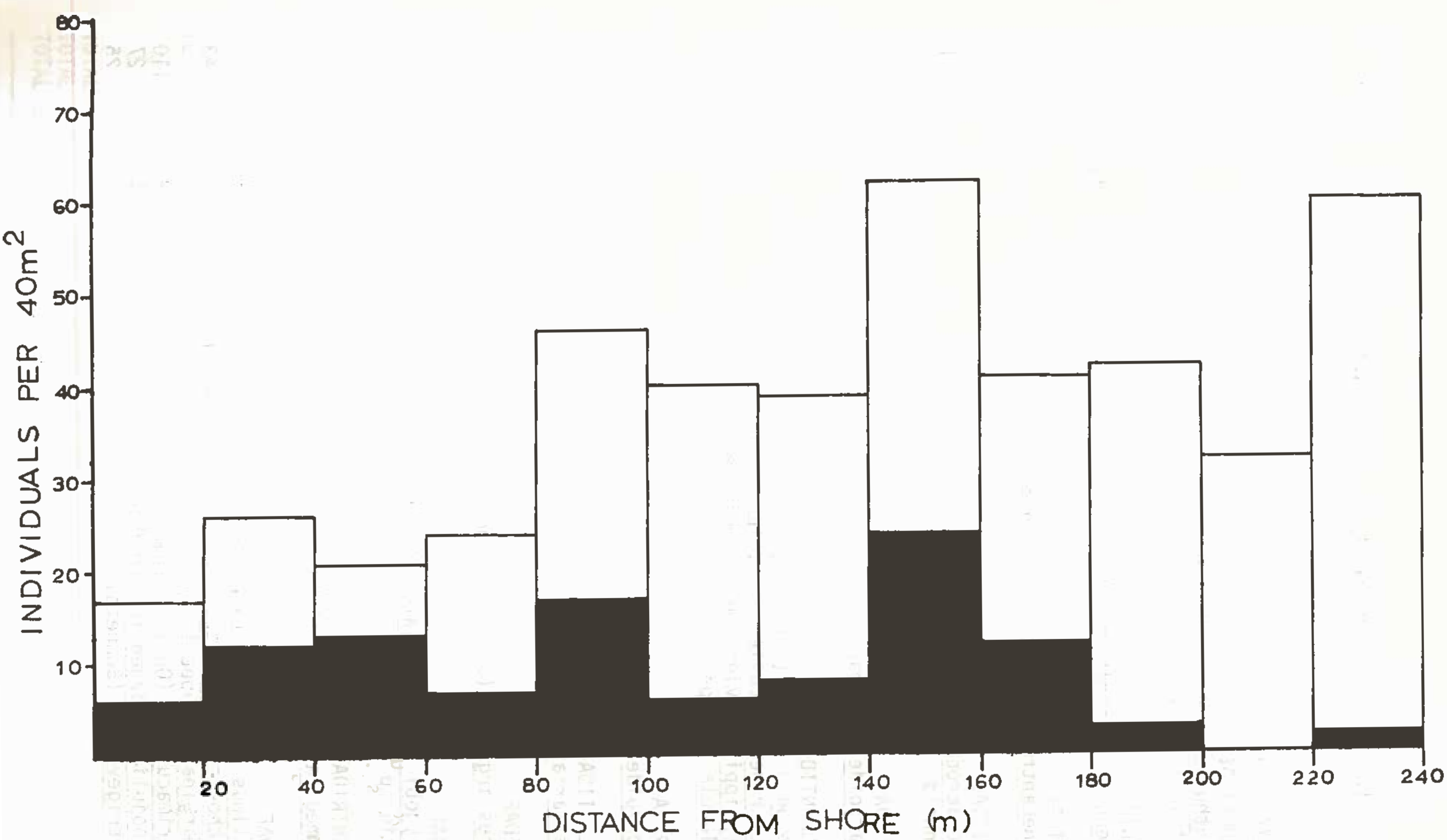

Fig. A-3. Density of fishes in each 20-meter transect interval of Transect B (Fig. A-1). Shaded zones indicate abundance of the dominant species Halichoeres trimaculatus.

Table A-1. Fishes observed at the Gaan Point sewer outfall, August, 1977.

FAMILY/SPECIES	TRANSECT A	TRANSECT B
ACANTHURIDAE		
Acanthurus lineatus (Linnaeus)	4	1
A. triostegus (Linnaeus)	5	13
APOGONIDAE		
Apogon novemfasciatus Cuvier	20	13
BALISTIDAE		
Rhinecanthus aculeatus (Linnaeus)	2	1
BLENNIIDAE		
Entomacrodus sp.	-	12
blenniid spp. (2)	3	1
CARANGIDAE		
Carangoides malabaricus	5	4
CHAETODONTIDAE		
Chaetodon auriga (Forsskal)	1	2
C. citrinellus Cuvier and Valenciennes	5	8
C. ephippium Cuvier and Valenciennes	1	1
C. lunula (Lacepede)	2	-
ELEOTRIDAE		
Eleotroides strigatus (Broussonet)	-	2
FISTULARIIDAE		
Fistularia petimba Lacepede	1	-
GERREIDAE		
Gerres argyreus (Bloch & Schneider)	2	-
GOBIIDAE		
Amblygobius albimaculatus (Ruppell)	1	-
gobiid sp.	10	3
HOLOCENTRIDAE		
Flammeo sammara (Forsskal)	-	7
LABRIDAE		
Cheilinus trilobatus Lacepede	1	2
Halichoeres margaritaceus (Cuvier & Valenciennes)	12	43
H. marginatus Ruppell	2	-
H. trimaculatus (Quoy & Gaimard)	66	110
Stethojulis bandanensis (Bleeker)	4	27
S. strigeventer (Bennett)	17	25

Table A-1. (continued)

FAMILY/SPECIES	TRANSECT A	TRANSECT B
LETHRINIDAE		
Lethrinus harak (Forsskal)	5	1
LUTJANIDAE		
Lutjanus fulvus (Bloch & Schneider)	3	-
MONACANTHIDAE		
Cantherhines pardalis (Ruppell)	1	-
MUGILIDAE		
Liza vaigiensis (Quoy & Gaimard)	9	-
Mugil sp.	28	-
MULLIDAE		
Mulloidichthys flavolineatus (Lacepede)	2	1
Parupeneus barberinus (Lacepede)	1	3
P. bifasciatus (Lacepede)	1	-
P. spilurus (Bleeker)	4	1
MURAENIDAE		
Gymnothorax pictus (Ahl)	3	-
POMACANTHIDAE		
Pomacanthus imperator (Bloch)	-	1
POMACENTRIDAE		
Abudefduf coelestinus (Cuvier & Valenciennes)	-	2
Dascyllus aruanus (Linnaeus)	9	3
Glyphidodontops glaucus (Cuvier)	17	29
G. leucopomus (Lesson)	48	47
Stegastes albifasciatus (Schlegel and Muller)	41	49
S. nigricans (Lacepede)	8	1
SCARIDAE		
Scarus sordidus Forsskal	12	2
Scarus spp. (3)	2	14
SIGANIDAE		
Siganus argenteus (Quoy & Gaimard)	6	-
S. spinus (Linnaeus)	16	-
SYNGNATHIDAE		
Corythoichthys intestinalis (Jordan & Seale)	1	3
TETRAODONTIDAE		
Canthigaster bennetti (Bleeker)	8	6
C. solandri	15	9
TOTAL SPECIES	40	32
TOTAL INDIVIDUALS	404	447

TOTAL SPECIES/INDIVIDUALS OBSERVED IN SURVEY: 50/851